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As the California High-Speed Rail (HSR) project becomes reality, many communities involved in, or affected by, the California HSR project have considered how to connect the new HSR passenger services to local urban transportation systems - such as bus and light rail systems - and how they can take advantage of HSR accessibility and speed throughout the state. European and other overseas systems have decades of experience in forging connections between HSR and various transportation options. This study examines international HSR stations and identifies patterns in transit connections associated with stations on the basis of size, population levels, and other characteristics. Additionally, a closer examination is made of the lessons that can be learned from a strategic sample of overseas HSR stations, correlated to similar cities in the planned California system. Generally, the findings from the comparison suggest that California cities must make significant strides to approach the level of integration and ease of access to other modes that systems outside the U.S. now enjoy.

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MINETA TRANSPORTATION INSTITUTE

International Lessons for Promoting Transit Connections to High-Speed Rail Systems

MTI Report 12-53

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REPORT 12-53

INTERNATIONAL LESSONS FOR PROMOTING TRANSIT CONNECTIONS TO HIGH-SPEED RAIL SYSTEMS

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EXECUTIVE SUMMARY

The California High-Speed Rail (HSR) project has matured to the point that initial design of segments in the Central Valley was started in 2014, beginning the long process of completing the California HSR program. One significant concern that many communities involved in, or affected by, the California HSR project have is how to connect the new HSR passenger services to local urban transport, such as bus and light rail. The route and stations for the first segment of the HSR system are well known, but many questions remain about how HSR will be integrated into the existing (and future) California transportation system.

Other countries have decades of experience in the integration of their HSR with other transport options. European and Asian HSR offers a wealth of information on how to optimize access to and integration with other transportation options, particularly local public transit systems.

As the California High Speed Rail project moves forward, the quality and quantity of its connections will become an urgent issue. Transportation planners at the state, regional, and local levels are incorporating this new service in their vision of future transportation systems. The purpose of this study is to provide information – based on international experiences – to local and State planners and decision-makers and help introduce HSR services to California and meet local needs and aspirations.

What lessons or standards can be inferred from the international HSR experience? Do the systems of other countries provide a useful means of assessing the integration of HSR and other transportation modes in California? This study is based on looking for patterns in the international experience that might be applied to California. Among the primary objectives of this study were the following:

1. Examining the connections offered at existing HSR stations in Europe and Asia.

2. Determining if there was any basis for developing connection standards based on population size or other criteria for the set of cities studied.

3. Examining options for a sample of California cities that will have high speed rail stations.

4. Comparing these cities to comparably-sized international cities, both qualitatively and quantitatively.

5. Using interviews with local officials and other California-based data sources to determine how well their existing local transportation systems can be integrated with new HSR stations, or improved upon based on the existence of these stations.

6. Drawing conclusions for the California High Speed Rail program that will facilitate its success and maintain focus on the quality and availability of connections to local systems.

DATA AND METHODS USED IN THIS STUDY

This study was based primarily on data from two sources: (1) an international database, developed by the study team, of the characteristics of a total of 64 HSR stations from around the world, assembled and evaluated from the standpoint of connections with other modes, and (2) three case studies of stations in the proposed California HSR system, including a comparison with a station from the database located in a similar city. The database of international HSR stations was primarily analyzed with respect to the relationship between city size (i.e., population), and patterns for transit service. The case studies provided a more detailed comparison between each California city and a similar city in a mature HSR system, and enable more applied observations about how California is proceeding towards the integration of the High Speed Rail System into local transportation options. The comparison cities were selected primarily on the basis of similar populations, urban versus rural/suburban settings and, in the cases of smaller cities, distance from a major urban center. They also reflect the variations in the international HSR experience, represented by three different countries. The cities are not intended to be culturally or economically identical, which would be practically impossible, but they do represent a reasonably similar scope of potential for transit connections.

1. Quantitative Analysis of Benchmark International Stations

A total of sixty-four HSR stations were examined, including stations in Belgium, China, France, Germany, Italy, Japan, Netherlands, South Korea, Spain, Sweden, Taiwan, Turkey, and the United Kingdom. The number of stations chosen from each country varied according to the maturity of the system and the size of the population it serves.

For each international HSR station, quantitative and qualitative data were amassed from existing data sources, including the following parameters:

- Qualitative parameters
  - Location
  - Area density
  - Station activity
- Quantitative parameters
  - Available modes
  - Number of available lines by mode
  - Average service frequency by mode at peak hours
  - Number of HSR stations in the same city

- Other parameters
  - Presence of airport connections
  - Presence of shared bus terminals

Additionally, demographic and geographic data were assembled to help create classes of HSR stations reflecting population, location, and urban density.

These data were analyzed primarily with respect to (1) identifying patterns of distinctive qualitative outcomes associated with HSR stations and (2) identifying patterns of association between station city size (primarily measured by population) and the frequency of various types of transportation options.

2. Matched Comparison Case Studies of California HSR Stations/Cities

Three stations from the proposed California HSR network from a total of twenty-seven proposed stations were selected via purposive sampling and matched with three international counterparts. The stations were strategically selected to reflect the planned California HSR system with respect to: population served, geographical character (e.g., urban v. rural) and the geographic range of the system (Northern California, Southern California, Central Valley). Using these criteria, Los Angeles, Gilroy, and Fresno were selected. These stations were then matched with international counterparts Tianjin (China), Fulda (Germany), and Málaga (Spain).

These pairs of station cities were subject to a more intense and qualitative comparison with respect to integration with other transit options. The comparisons involved data drawn from existing sources as well as interviews with local (California) officials to help learn how connections were envisioned – and being planned and implemented.

MAJOR FINDINGS

Observations from patterns observed among international benchmark stations:

1. Most HSR stations have similar designs, with most differences being caused by a need to accommodate the local geography. Their connectivity infrastructures are influenced by the existing transit network systems' level of development at the time of construction, as well as the local population's transportation habits. In general, the more transit-oriented the city, the higher the connectivity of the station.

2. At stations with access to HSR trains, the level of connectivity to other transit modes depends on how long the station and its high speed rail connections have been available. HSR stations that have recently been introduced, or newly integrated into the HSR system, still do not have the same level of connectivity as stations that have been delivering high speed rail for longer periods of time.

3. Although this is not always explicit in the examined data, HSR stations have bicycle facilities, and generally do an excellent job of marking pedestrian paths into the station and between the station and the connecting modes.

4. Although other forms of transportation are quite commonly available at international stations, the most widely available public transport modes are taxis and buses. Both of these services reach all the rail stations that were examined.

5. Station activity, defined as the number of passengers using the station per hour, is directly related to the local population size. Higher station activity requires higher transit capacity. However, the number of streetcar, tram, light rail, and subway lines connected to a station, as well as their service frequencies, does not appear to be directly affected by population size.

Observations from matched comparisons between California and international HSR stations:

The Los Angeles area and its transportation agencies are fully engaged in a program to reinvent public transport for the region's citizens. Their objectives are enhanced connectivity, an integrated transit system, and improvements in the system's ability to move passengers. The agencies seem well-coordinated and have good prospects for additional funding. Tianjin, which saw a recent explosion in the use of HSR, but is still developing the transit infrastructure that will connect the HSR station to the rest of the city, may provide a useful blueprint.

Comparatively, officials in Gilroy and Fresno are not very far along the path in planning for integrated HSR connections, although they are very mindful of the opportunities. They are operating in a less-than-optimal environment to develop them, due to funding uncertainties and disagreements about priorities for HSR development. Both cities have engaged consultants to help maximize the impact of HSR on ridership and economic development in their respective urban cores. The comparison cities of Fulda and Málaga are much further along in all respects, so the California cities can benchmark their progress against that in Fulda and Málaga as they begin to implement their own plans.

I. INTRODUCTION

Begun in Japan in the late 1960s, High Speed Rail (HSR) systems have become a public transportation and economic development tool capable of linking distant locations at higher speeds. Thanks to advances in rail technology and engineering methods, HSR passenger trains are much faster than traditional trains and have replaced other means of long-distance transportation such as traditional intercity trains and even air travel. HSR systems can be found throughout the world, in countries such as France, Spain, Germany, China, and Japan.

With its higher speeds and integration with local services, HSR offers travelers a safe, fast, convenient, and efficient transportation option. Travel times are dramatically lower than those for comparable air travel services, and lack the inconveniences associated with air travel. While HSR services have been developed in many European and Asian countries, the United States has been very slow to consider HSR projects. The United States intercity passenger rail system, for the most part, operates on freight railroad lines and has not received the benefit of passenger train-focused investments. The result is, for the most part, a poorly performing intercity passenger rail system. Of the existing intercity services, only the Northeast Corridor – between Boston and Washington, D.C. – has HSR segments that are comparable in speed to their international counterparts. Most intercity passenger rail services in the United States are not capable of speeds over ninety miles an hour. It should also be noted that the top-down planning and project implementation process used in Europe and Asia is very different from that in the United States, which has a highly decentralized, and often political, process.

Recently, United States intercity and HSR passenger trains have begun to receive more attention and funding after a long period of inactivity. Although there were advocacy groups all along who championed investment in these modes of transportation, they were not successful in changing political, government, or public attitudes. However, as part of the American Recovery and Reinvestment Act of 2009 (ARRA), funds totaling $8 billion were set aside to help improve intercity passenger rail services.[1] The Federal Railroad Administration received proposals from 24 States applying for these funds and distributed the funds to an assortment of projects throughout the country.[2] In 2011, an additional $2 billion was appropriated by the U.S. Department of Transportation for use in transportation projects, including HSR projects. These funds, and their related programs, have created a large body of new research, plans, designs, and construction projects that will improve intercity passenger rail services by adding capacity, increasing speeds, improving freight and passenger line coordination, removing congestion points, and accomplishing related projects.

Funding for these programs has not continued into 2015. There are now efforts to create new legislative authority to finance improvements to intercity passenger rail in the next transportation authorization bill. A new Rail Title is included in the five-year Transportation Authorization Bill, which passed the House and Senate on December 3, 2015 and was signed by the President on December 4, 2015. The bill reforms Amtrak, and enables intercity passenger rail improvement grants – with funding going to the states and to Amtrak.

This study examined data gathered from 64 international HSR Stations, and focused on the connections to other modes in these locations. Understanding the relationship between connection availability and the size and complexity of cities offers insights to California cities that are considering urban transportation plans and the impacts of new HSR hubs. The study compares three California cities to international counterparts that have similarities, and considers what the cities can expect. It also offers some perspectives on actions they might consider.

Problem Definition

Since the early 1980s, efforts have been underway to develop an HSR project that would link Northern and Southern California through the Central Valley. This project would greatly reduce the travel times between almost all of California's major population centers. Plans for this project, as well as a large amount of environmental research and planning, preceded the President's call for a national transit network. California was well-positioned to request funds for its own project; program-level environmental work had already been completed, and project-level work was well underway. In 2008, California had already passed a $9.95 billion bond for the establishment of a High Speed Rail Project through Proposition 1A, which contained $9 billion for HSR investments. The remaining funds went toward improving existing urban transportation systems that would be linked to the HSR network. The California project has matured to the point that initial design and construction of segments in the Central Valley was started in 2014, beginning the long process of completing the California HSR program. The California High Speed Rail Authority (CAHSRA) expects service to begin in 2022.

One question that many communities involved in, or affected by, the California HSR project have is how the project will connect HSR passenger services to local transport, such as bus and light rail, and how they can take advantage of the system's accessibility and speed. This research sought to create a body of information regarding existing HSR-local system connections at international stations and terminals, determine what lessons can be learned from them, and explore how that experience might be applied in California. The availability and quality of local urban transport connections is an important determinant of the attractiveness of HSR systems. One significant issue is how station sites are connected to the areas they serve. System effectiveness is, in part, determined by the available connections to, and options for, local transport. Travelers who see a variety of modes available at their point of origin and at their destination – such as connections to local bus or metro lines – can choose a combination of transit methods that will meet their time requirements and economic needs.

Intercity and HSR systems are often trunk lines connecting economic activity centers, cities, rural areas, and regional centers with each other over a corridor that is usually three to five hundred miles long. Trunk lines are the primary transportation lines for transit systems, with stations along these lines connecting to local systems such as bus routes. The effectiveness of a trunk line depends on the quality and effectiveness of the connections that are available. Ideally, passengers should be able to reach an HSR station at their point of origin and travel to their final destination using HSR and local transportation methods.

Most airports are designed with large parking capacities under the assumption that most passengers will arrive by automobile. Bus connections are usually available. Very recently, efforts have been made to link airports in some major cities to local rail transportation. HSR, however, is focused on establishing stations close to or within downtown areas. These services rely less on automobile access and more on access through public transportation services. Linking HSR lines to major airports is becoming an important planning consideration, as passengers arriving by air might be served by connecting HSR services that will carry them to their destinations. This could reduce short-distance air services that consume air capacity; these are not as effective as High Speed Rail services that connect to urban centers and other major activity centers.

Connections to HSR stations can be made by using every mode of transportation –

- Pedestrian
- Bicycle
- Automobile (private cars, rented cars, car shares, etc.)
- Taxis
- Local, regional, and express bus routes
- Light rail
- Streetcars
- Metro and subway

Another important aspect of station connections is system quality. Connections to and from HSR stations need to be located in convenient locations and be well-marked with respect to their locations and destinations served. Stops need to be frequent and should coordinate with HSR train arrivals and departures. Connection design criteria should be developed with connection quality and the needs of riders in mind.

As the California High Speed Rail project moves forward, the quality and quantity of its connections will become an urgent issue. Transportation planners at the state, regional, and local levels are incorporating this new service into their vision of future transportation systems. The purpose of this study is to provide local and State planners and decision-makers necessary information as they consider the impacts of HSR on their communities and plan for improved connections.

Study Objectives

The objectives of this study included:

1. Examining the connections offered at existing HSR stations in Europe and Asia.

2. Determining if connection standards should be based on population size or other criteria for the set of cities studied.

3. Examining options for three different California cities that will have high speed rail stations.

4. Comparing these cities to international cities of similar size and circumstances, both qualitatively and quantitatively.

5. Using local interviews to determine how well their existing transport systems can be integrated with new HSR stations, or improved upon as high speed rail becomes available.

6. Drawing conclusions for the California HSR program that will facilitate its success and maintain focus on the quality and availability of connections to local systems.

Examining international transit data and comparing it to HSR plans for three cities in California will help to determine what considerations will be needed when planning for local connectivity. An analysis that determines whether there are any commonalities between international and local settings may offer important information to decision-makers in California regarding station and line planning. This study will provide information on HSR system planning and design, and give local and regional planners comparative statistics for use in station and line planning.

Literature Review

Although relatively little is known about the California HSR system's prospects for connectivity, scholars and practitioners have long emphasized the importance of establishing high levels of connectivity in countries with existing HSR service to a variety of local services. HSR efficiency and, ultimately, ridership "depends critically on its connectedness to local and regional networks, as well as to international and inter-continental networks via airports."[3] Europe and Asia tend to emphasize public transport in their planning and have established rail systems with high levels of connectivity. Universal rail standards, called interoperability, enable conventional trains to share routes with HSR trains.[4]

All countries have not embraced high levels of connectivity between HSR and other transport modes to the same degree. According to Zhon et al., Germany is "by far" the most advanced with respect to linking public transportation to, and connectivity among, transportation modes. German HSR trains are fully integrated with conventional intercity and local rail systems, subways, and bus systems.[5] For example, passengers that use public transit systems in Germany can purchase tickets that are valid across multiple types

of transportation. Full coordination of the operations and financing of public transportation has been implemented through regional public transport authorities since the late 1960s.[6]

Buehler and Puecher commend the German system for the following sorts of multimodal coordination for rail passengers:

- Convenient transfers between bus and rail
- Extensive, high-quality bicycle parking at rail stops
- Park and ride facilities for cars at suburban rail stations
- Bike and car rental programs run by public transport firms[7]

For example, Berlin Central Station serves as a transportation hub for the city. The station connects to the U- and S-Bahn systems, the local bus system, the ICE intercity network, and some regional train lines. This station features five levels: the HSR lines and S-Bahn lines are located on the top level, with the basement level containing all local and regional transportation methods. The levels in between are taken up by an assortment of businesses. The ground level contains the building entrance, as well as access for taxis and buses. The basement level rail lines run north–south and the top level lines run east–west. This design method keeps the local transportation lines from interfering with the intercity, international, and S-Bahn lines. The two train types board in different areas and do not connect to the same rails. Berlin Central Station also connects to two airports – Berlin Schönefeld and Berlin Tegel. The former can be reached by trains that run in thirty-minute intervals, and the latter can be reached by a bus that runs in ten- to twenty-minute intervals. The station also has lockers for bikes and personal use.[8]

France, by contrast, is said to have both "good and poor examples of connectivity."[9] Many cities have extensive stations that cater to multiple modes, yet conventional trains cannot use HSR routes, and ticketing systems vary considerably.[10] Some French stations are not easily accessible by multiple modes, including a few in medium and small-sized cities, where stations can be accessed only by automobile.[11]

Station location is a key consideration with respect to connectivity. In France, the location of the HSR station in Lille provides an effective illustration. Lille, a medium-sized city, serves as the connecting point for London, Paris, and Brussels via the LGV Nord HSR line. Prior to the opening of the LGV Nord line in 1993, Lille was primarily an industrial city with focuses on mining, manufacturing, and textiles. While the LGV Nord line was being planned, Lille's mayor, Pierre Mauroy, pushed for the city to become the midpoint for the line and to locate the station in the city's center. As a result of this, "the municipal government brought together regional and national and private sector funding that became the basis for financing high speed rail capital investments in the Lille region ..."[12] Lille's HSR station, Gare de Lille Europe, also known as "Lille Europe," opened in 1994 and has been credited with the growth and evolution of Lille's economy.

Previous to the station's opening, in 1988, a public-private partnership had commissioned the Office for Metropolitan Architecture (OMA) to design "Euralille," a "vast program consisting of more than 800,000 square meters of urban activities – a new TGV station, shopping, offices, parking, hotels, housing, a concert hall, congress ... " Euralille was to be situated in the center of the city, and OMA would integrate this new project with the existing infrastructure for the Lille Flandres train station, which was a hub for city and regional trains. OMA's plan called for Euralille and the associated HSR station to be "a large, multimodal transportation complex ... "[13] The HSR station in Lille provided enhanced connectivity in the following ways:

- **The VAL (automatic light vehicle)**, the world's first automatic subway (1983), with 60 stops covering 45 km.
- **Two tram lines** with more than 35 stops that connect Lille to Roubaix and Tourcoing.[14]
- **A bus system** that "includes over 65 urban routes, including several providing transport into Belgium."[15]

In Taiwan, the HSR system's relatively slow expansion in ridership has been seen as an effect of placing many stations in exurban areas. The THSR (Taiwan High-Speed Rail) began operation in 2007; the system's route connects the island's northern and southern economic centers, and is credited with expanding "overall accessibility throughout the whole Western coast region of Taiwan."[16] However, five of its eight stations were built in suburbs, well removed from the central commercial areas of their respective cities. Access to these stations is largely confined to automobiles, adding 20 to 40 minutes (each way) to prospective passengers' access to the system.[17] Initial ridership on the system was significantly lower than projected, although it has since increased significantly despite the less than ideal locations of several stations.[18]

Another important component of connectivity – and one that may be of particular importance for stations in California – is the relationship between HSR and air travel. Scholars are increasingly focusing on a potential complementary relationship between air and HSR.[19] Chiambaretto and Decker identified a number of variations of "air-rail intermodal agreements, including (1) interlining agreements, (2) code-share agreements and (3) joint ventures."[20] Interline and code-share agreements permit reservations to be made across both modes at the same time, providing a convenience to passengers and an incentive to travel on both modes. Clewlow, et al. explored the history of how "airport, airline, and rail operator partnerships were formed to enable airport–HSR connectivity."[21] They found that European systems have used a variety of approaches to enhance air-HSR connections. Among the "key factors" they identified were (1) infrastructure – meaning HSR stations located at airports; (2) schedule and frequency – meaning coordinated train-flight timetables; and (3) the market characteristics of the airports – the most successful linkages being those that involve the most dominant international hubs.[22]

Once again, it is Germany that achieved the highest connectivity between air and HSR travel. Coogan finds that the German system has "the most highly developed program to implement the concept of rail as feeder" to Frankfurt Airport.[23] Among the components of

this feeder concept at Frankfurt is the establishment of a cooperative agreement between Lufthansa, a European airline, and German Rail to create and implement the AIRail service, which enables passengers to board high-speed trains in other German cities (Cologne and Stuttgart) with direct service to the Frankfort airport. The air and train systems share ticketing capability, enabling a seamless travel experience for passengers. The system is more attractive than were the existing short-haul flights between the linked cities, resulting in the flights on those routes being eliminated.[24]

Research with a California Focus

Some research relevant to the planned California HSR system has already been completed. As early as 2009, Nuworsoo and Deakin had developed findings about "transforming HSR rail stations [in]to major activity hubs."[25] Their study of existing systems in Europe emphasized the importance of "multimodal accessibility" to include: (a) availability of alternative modes, including non-motorized ones, (b) graded placement of various modal stops at the station's area, and (c) zoning land such that those types that will see more frequent use are centralized near the station platform.[26]

Loukaitou-Sideris et al. explored "planning for complementarity" in "first-tier and second-tier" cities in the California HSR network.[27] This study, focused on how various kinds of California cities might best capitalize on having an HSR station in terms of economic development, also had implications for promoting intermodal connectivity. Their recommendations emphasized that urban planning activities for HSR stations should

> "... include centrally locating stations, enhancing multimodal connectivity and complementarity of different transportation nodes, encouraging greater station-area density, mitigating the barrier effect of parking, and creating an urban design vision and land use plan for the station area that builds on and complements existing local assets."[28]

More recently, Albalate et al. provided an evaluation of "intermodal and intramodal connectivity" for California HSR stations. Their spatial analysis of proposed California HSR stations found that the planned Fresno and Bakersfield stations "are placed in dense areas with high degree[s] of connectivity with existing transport networks."[29] The stations in Burbank and Ontario were found to be among the least integrated. However, this analysis is based on proximity to other existing modes and does not offer insight into how connectivity might be enhanced at a given station.

Zhong et al. offered an analysis of HSR accessibility to multiple modes in Los Angeles, San Francisco, Barcelona, and Madrid. They find that polycentric cities, such as San Francisco and particularly Los Angeles, will be challenged to "reap the benefits of city center connection that HSR offers."[30] Unsurprisingly, they found that "HSR in Madrid and Barcelona have better accessibility for their potential riders than those [stations] in Los Angeles and the Bay Area."[31] However, their analysis does not identify strategies to maximize intermodal connectivity in California stations beyond the general notion of increasing the number of stations in polycentric areas. They do mention the general idea of using HSR stations as a means of "sprawl repair" to help "recenter" urban areas.[32]

Edlin's comparative analysis of French and German stations, with an eye toward California, drew the following conclusions focused on station location:

> "... the experience of both France and Germany suggests to us that we should only consider non-central city stations in California if clear and credible plans are in place *at the time of the construction of the station* to: (1) encourage and steer HSR-supportive development; [and] (2) ensure the establishment of robust transit connections between the new HSR station and existing central business districts (in cases where the HSR station is not located in the economic center of the city)."[33]

In sum, existing literature highlights the importance of creating high speed rail systems with stations that maximize accessibility to multiple modes, but does not portray a clear path toward optimizing that characteristic. Those who have envisioned transit connections in the planned California system emphasized that such accessibility must be optimized in construction plans and not effected after the fact.

Data and Methods Used in This Study

This study is based primarily on data from two sources: (1) an international database of the characteristics from a total of 64 HSR stations from around the world was assembled and evaluated from the standpoint of connections with other modes, and (2) three case studies of stations in the proposed California HSR system were conducted, including a comparison for each station with one from the database located in a similar city. The database of international HSR stations was primarily analyzed with respect to the relationship between city size (population) and transit use, with the goal of identifying patterns of service for cities of different sizes. The case studies provide a more detailed comparison between a California station-city and a similarly sized and purposed city in a mature HSR system. More details about the data and methods are included in the respective analyses.

QUANTITATIVE ANALYSIS OF BENCHMARK INTERNATIONAL STATIONS

Introduction, Purpose and Methodology

Long-distance railway passengers wish to go from their point of origin to their destination with as little delay and confusion as possible. When using rail and public transit, there can be up to three phases: point of origin to departure station, departure station to connecting stations as needed, and arrival station to destination. With respect to HSR systems, the station-to-station phase has been continuously improved over time. Thanks to technological innovations, HSR systems are able to offer better reliability, punctuality, and comfort for travelers. Improvements to, for example, infrastructure, rolling stock, station design, and traffic control are contributing to making HSR a preferable mode for long-distance travel.

HSR transit times have been reduced due to the increases in maximum speeds on these lines. In Japan, in 1964, the top speed for HSR lines was 130 mph. As of 2014, in Europe and China, some HSR lines can reach speeds of up to 236 mph. Other phases of an HSR trip have also evolved in the last few decades. There are now more public transit options available to reach and depart from HSR stations. This makes it possible for passengers

to complete their trips without having to use their own vehicle to reach their departure station or rent a vehicle upon arrival at their destination. HSR stations are functioning as the connections between local, medium, and long-distance transit services. Transit modes like bus, light and regional rail, and subway systems offer local and regional connections at HSR stations and give travelers a way to navigate local roads with unfamiliar conditions – the existing public transit systems were already designed with local geography, traffic conditions, station activity, and popular destinations in mind. These systems can allow visitors to reach their destinations without much interference from local conditions.

This study will analyze to what extent the transit modes servicing HSR stations – from a passenger's point of origin to their departure station and from their destination station to their final destination – are related to the population size of the departure and arrival areas based on international data. The focus here is on the identification of common patterns among stations that can be used to create solutions for problems that can arise during the planning of future HSR terminals. This information will better allow planners to design transit services according to the population of the area they are serving.

The organization of this section is as follow:

1. Define assumptions and indicators
2. Define international HSR stations' selection criteria
3. Search for, collect, and refine international data
4. Analyze data
5. Create mathematical models
6. Identify results

Initial Assumptions, Definitions, Parameters, and Indicators

The concept of connectivity, as related to HSR stations, assumes that local transit systems function as a feeder to and from the HSR trains. Different cities' transit systems have different available services depending on local conditions, but the main features of these transportation systems can be considered similar for the purpose of this study. According to their capacity, transit modes can be grouped as follows:

- Low capacity (under 10 persons)
  - Taxi
- Medium capacity (10–60 persons)
  - Local or urban bus

    - Suburban, express, or regional bus

- High capacity (60–300 persons)
    - Tramway
    - Light rail
- Very high capacity (more than 300 persons)
    - Subway, underground, or metro lines
    - Regional, suburban, or commuter trains

These transportation modes are characterized by a number of features, but for the purpose of this study, two features are considered key in describing the role of each mode: (1) the number of lines available, and (2) the frequency of service to the subject station. The number of available lines is straightforward, but in order to create consistent data sets for the latter measure the average service frequency at peak hours for each station was used. It is quite common for very large cities to have multiple HSR stations servicing a single, large population. In order to account for this, the populations in cities with multiple stations have been divided out evenly to each station.

To better describe the level of connectivity of each HSR station, the following parameters or indicators have been applied:

1. Availability of modes: the number and types of transportation modes available in the region.

2. Number of lines: the number of lines and diversity of destinations within the area a station services.

3. Service frequency of a mode: the number of times that a particular transportation mode in question services each station.

4. The product of the number of lines for, and the frequency of, each mode.

    a. This is an aggregate indicator that gives information regarding the number of opportunities to connect with a local mode, per unit of time, regardless of the destination.

5. Generalized transit offer: This indicator is obtained by taking the product of the number of transit lines and the frequency of services per hour. This is the number of opportunities a traveler has to use a transit service, at arrival or departure, per hour. It aggregates all modes of transit except for taxis.

INTERNATIONAL DATA SEARCH ON CURRENT HIGH SPEED RAILWAY STATIONS

Criteria Definition

A number of parameters were defined at the beginning of the study in order to facilitate an international data search. The following were applied in order to determine the required data to be collected, as well as to assist in the selection of the subject HSR stations:

- Qualitative parameters
  - Location
  - Area density
  - Station activity
- Quantitative parameters
  - Available modes
  - Number of available lines by mode
  - Average service frequency by mode at peak hours
  - Number of HSR stations in the same city
- Other parameters
  - Presence of airport connections
  - Presence of shared bus terminals

In order to obtain a representative collection of HSR passenger terminals, a number of selection criteria were established at the beginning of the study:

- Population
  - Selections should be representative of all ranges of population, from smaller towns to large cities
- Location
  - Selections should be located in a variety of settings, including downtown or city centers, city outskirts, or more rural areas

- Urban density
    - Selections should represent different levels of urban density, ranging from very low to very high

Finally, stations from all countries equipped with HSR lines were considered, regardless of the amount of time their system have been in place, if the population levels in those countries were typical of that associated with HSR service. The more extensive the network in a country, the greater the number of stations selected from that country.

In order to obtain a representative group of stations, examples from all countries with an operating HSR network have been selected. Selection was based on a number of different criteria in order to cover many different typologies and circumstances. These criteria include population range (small towns to large metropolitan areas), station location (terminals located in the city center, at city outskirts, or outside the city), and urban density (low- to high-density.)

Data Search Results

This section of the report will present the results of the examination of data from HSR stations from thirteen countries. This section provides further details about the number of stations examined, their locations and descriptions, their collected parameters, the data collection process, and the tools used to manage this data.

Number of Stations, Locations, and Descriptions

In order to get a comprehensive look at international HSR systems, a total of sixty-four HSR stations were examined. The countries that were researched included Belgium, China, France, Germany, Italy, Japan, Netherlands, South Korea, Spain, Sweden, Taiwan, Turkey, and the United Kingdom. The number of stations chosen from each country varied according to the maturity of the system, the sizes of the populations they serve, and the extensiveness of their HSR networks.

From Belgium, three stations were examined: Brussels South, Antwerpen Central, and Liege-Guillemins. Brussels South Station serves a population of 1,119,000 residents with 1,000 trains that move into and out of the station daily. This station is characterized by its high-density downtown location and high traffic volume. Antwerpen Central Station serves a population of 502,604. This station also has a high-density downtown location. Liege-Guillemins Station, located in Brussels, serves a population of 194,715 with 36,000 passengers using the station daily.

From the relatively new system in China, five stations were examined: Beijing South, Tianjin, Jinan West, Nanjing South, and Shanghai Hongqiao. Each station examined in the Chinese system serves populations ranging from 4,000,000 to 23,000,000. The Beijing South and Tianjin Stations are located in the downtown portions of their respective cities. Jinan West, Nanjing South, and Shanghai Hongqiao stations are located on city outskirts.

From France, eight stations were examined. Two of these stations include airport services. Included in the analysis were Paris North, Charles de Gaulle Airport (T1), Charles de Gaulle Airport (T2), Lyon Saint Exupery, Marseille Saint Charles, Aix en Provence, Nimes, and Valence. The populations that these stations serve range from 66,000 to 12,000,000. Paris North Station sees activity levels as high as 520,500 daily passengers. Other stations, such as Marseille Saint Charles, see top activity levels of around 41,000 daily passengers.

From Germany, eight stations were examined, one of which includes an airport connection: Berlin Central, Cologne Central, Frankfurt Central, Frankfurt am Main Airport, Stuttgart Central, Wurzburg Central, Ingolstadt Central, and Fulda. The populations these stations serve range from 62,000 to 5,600,000. High levels of daily use are observed throughout the system, with as many as 350,000 daily passengers using Frankfurt Central Station. Five stations are located in high-density downtowns, and the remaining three are located on city outskirts.

From Italy, five stations were examined: Roma Termini, Naples Central, Bologna Central, Verona Porta Nuova, and Milano Central. The populations these stations serve range from 265,000 to 4,000,000. There is high daily passenger activity for all stations, reaching as high as 320,000 daily passengers for Milano Central Station. All five stations are located in the downtown areas of their respective cities, which are characterized by high-density development.

From Japan, six stations were examined: Tokyo, Nagoya, Kyoto, Kagoshima Chuo, Hakata, and Fukushima. These stations serve populations ranging from 290,000 to nearly 36,000,000. Tokyo Station, serving a population of over 35 million, has over 380,000 daily passengers. As with Italy, these stations are all located in high-density downtown locations.

From the Netherlands, three stations were examined, one of which allows access to airport services. The stations selected were Amsterdam Central, Schiphol Airport, and Rotterdam Central. These serve populations ranging from 1,200,000 to over two million. Amsterdam Central and Rotterdam Central stations are both located in high-density downtown locations with daily activity of 250,000 and 100,000, respectively. Schiphol Station, located outside of the city of Amsterdam, is integrated into the airport that serves the Amsterdam metropolitan area.

From South Korea, four stations were examined: Seoul, Yongsan, Osong, and Daejeon. The populations served by these stations range from 663,000 to over 25,000,000. Both Seoul and Yongsan Stations are located in the same city in high-density downtown developments. Seoul Station has over 90,000 passengers of daily activity. The remaining stations of Osong and Daejeon Stations are located outside of Cheongju City and on the city skirts of Daejeon, respectively.

From Spain, twelve stations were examined: Madrid Atocha, Madrid Chamartin, Toledo, Ciudad Real, Cordoba Central, Seville Santa Justa, Antequera Santa Ana, Málaga Maria Zambrano, Zaragoza Delicias, Camp de Tarragona, Barcelona Sants, and Albacete. The populations that these stations serve range from 45,000 to just over 6,000,000. Of the seven stations that serve populations over 300,000, six of them are located in high-density

downtown areas. The five remaining stations, each serving populations of less than 300,000, are located either outside of their cities or on the city outskirts. The highest daily passenger activity is seen at the Madrid Atocha Station, with 45,000 daily passengers.

From Sweden, three stations were examined: Stockholm Central, Gothenburg Central, and Malmo Central. These three stations serve populations that range from 664,000 to 2,100,000. All of these stations are located in high-density downtown areas. The main station of Stockholm Central has daily passenger activity of up 170,000 passengers.

From Taiwan, four stations were examined: Taipei, Taoyuan, Chiayi, and Tainan. These stations serve populations ranging from 34,000 to 9,000,000. All of them are located in the downtown areas of their respective cities. The Taipei station has daily passenger activity of up 66,000 passengers; Chiayi station serves a population of 34,000, and has daily passenger activity of up to 11,000 passengers.

From Turkey, two stations were examined: Ankara Central and Konya Central. Both stations serve populations of more than 1,000,000 people, with Ankara Central serving nearly 5,000,000. These stations are located in the downtown portions of their respective cities. Konya station sees activity levels of around 181 daily trains arriving and departing from its platforms.

From the United Kingdom, only the St. Pancras Station in London was examined. This station serves a population of over 15,000,000. Although there are a total of four HSR stations located in London, the St. Pancras station is the main HSR terminus and has about 123,000 daily passengers. The station is located in downtown London.

Parameters

This section of the report will lay out the parameters that were researched in order to obtain a better understanding of international HSR station connectivity. Twenty-five parameters were selected for this section of the study. The parameters are:

1. Country
2. Station name
3. Station city
4. Number of HSR stations located in a particular city
5. City population
6. Metropolitan population
7. Station activity (number of passengers or number of daily trains)
8. Location description (city center, city outskirts, or outside of the city)

9. Taxi service availability
10. Number of urban bus lines
11. Urban bus frequency (in minutes or buses per hour)
12. Suburban/Regional bus service availability
13. Tram or light rail service availability
14. Number of tram or light rail lines
15. Tram or light rail frequency (in minutes or trains per hour)
16. Subway service availability
17. Number of subway lines
18. Subway frequency (in minutes or trains per hour)
19. Regional or commuter train service availability
20. Number of regional or commuter train lines
21. Regional or commuter train frequency (in minutes or trains per hour)
22. Population density
23. Station function
24. Vehicle parking availability

Data Collection Process and Data Management Tools

Data were collected for each station selected for the study. Finding consistent data from each high speed rail system to each other system proved to be an arduous task. Many websites did not have pages translated into English, and/or the information being sought was not available. This report contains the only information that could be documented as valid.

The data collection process began with an internet search for countries, cities, and stations with HSR capabilities. Once stations were identified, each station name was input into Google Earth. This provided a bird's eye view of the station and its surroundings, with information regarding links to local transit services available. Google Earth also helped identify station area population density.

Generally, data for each station was either obtained from or checked and verified by an official transit webpage and/or through Google Earth. Once the information was collected according to study parameters, it was completed and verified, and a satellite image was then copied from Google Maps and pasted into a text document.

Benchmark Analysis Based on Collected Data and Basic Parameters

The collected data for each station is presented in terms of average values in order to keep data consistent from station to station. Local conditions at the station, such as geography, may introduce differences in station design and in the ways that each station facilitates local connections, but most of the stations have strong similarities in terms of transit service arrangements. Systems with larger capacities gave clear and easily comparable data regardless of the city they were in.

After collecting, analyzing, and refining the data several conclusions were reached. Despite the fact that certain cities and stations have unique features, data trends are consistent across the board without considering the differences in detail. Local bus systems, for example, have slight variances in vehicle, design, capacities, and operational periods. Due to the detail level at which information about these services was collected, and after careful examination as to whether these variances could influence outcomes, it was determined that these variances do not affect the study, and the collected data is consistent for the purposes of the study.

Regarding regional bus networks: these lines offer various types of services, such as low-frequency shuttle services or express routes using large buses. Using the parameters described earlier, it was determined that the data from these systems would significantly impact the consistency of the other data. The regional bus lines vary greatly from region to region and are clearly affected by local conditions unique to their regions. Because of this, regional bus systems are being considered only in the sense that they exist and are connected to the HSR system in some way. We did not consider their capacities or frequency of service in the connectivity analysis.

Qualitative Results

After a thorough examination of the available data on the connectivity of European and Asian HSR stations, including the expertise and knowledge of the authors, the following conclusions were reached:

1. The introduction of HSR services in Asia and Europe brought about an increase in the number of public transit users and in the types of transit services available locally for every station examined.[34]

2. Most HSR stations have similar designs offering similar amenities and overall layouts. Most differences are caused by architectural sensibilities and a need to accommodate the local geography. Their connectivity infrastructures are influenced by the existing transit network systems' level of development at the time of construction, as well as the local population's urban transportation habits. In general, the more transit-oriented the city, the higher the connectivity level of the station.

3. HSR station locations, and especially the local level of urban density, have a significant influence on the transit services connected to each station. HSR terminals located in dense areas, like downtowns, have less parking capacity and better connectivity to local transit systems. Stations located in very low-density areas generally have more parking for private vehicles and may offer little connectivity to local transit systems. As population increases and cities become larger and more complex, there is a shift in focus from taxis and bus lines to the subways and commuter train lines that are available in larger cities.

4. At stations with access to HSR trains, the level of connectivity to other local transit modes depends on how long the station and HSR connections have been available. HSR trains that have recently been introduced to an existing station, or newly integrated at an existing station, still do not have the same level of connectivity as stations that have been delivering HSR services for longer periods of time.

5. The most common public transportation mode available is bus service. Buses are available at all of the rail stations that were examined. In addition, taxi services were also available at all of the stations.

6. Bus lines are the most extensive type of intermodal connection. In some cases, a regional bus station has been established adjacent to, or integrated directly into, the HSR station.

7. There are examples of HSR stations becoming a local or regional transportation hub. These stations are not only used by train passengers, but also by other travelers due to the availability of connecting transit modes.

8. The nature of the intermodal connection between air and rail travel apparently influences connectivity behavior, but is beyond the scope of this study.

9. There are also examples of HSR stations that have become destinations for retail, commercial, and business purposes.

HSR Stations' Connectivity versus City Population Size Quantitative Conclusions

The following tables establish the association between the attributes over the sample of HSR cities studied. The transportation modes included in these tables are urban buses, suburban/regional buses, trams/light rails, subways, and regional/commuter trains. More information on these stations can be found in Appendix B.

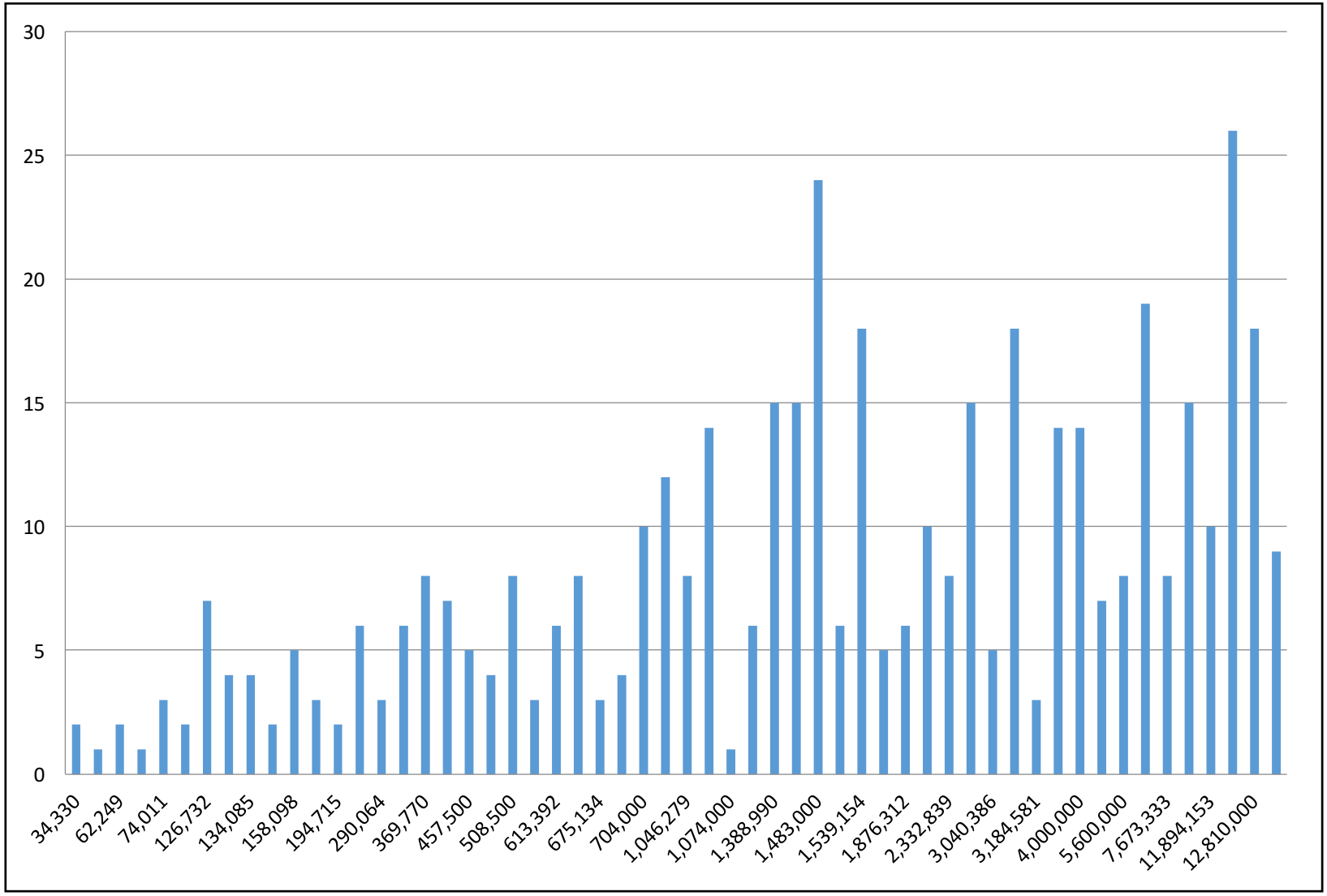

Figure 1. Number of Urban Bus Lines vs. Population ÷ Number of HSR Stations

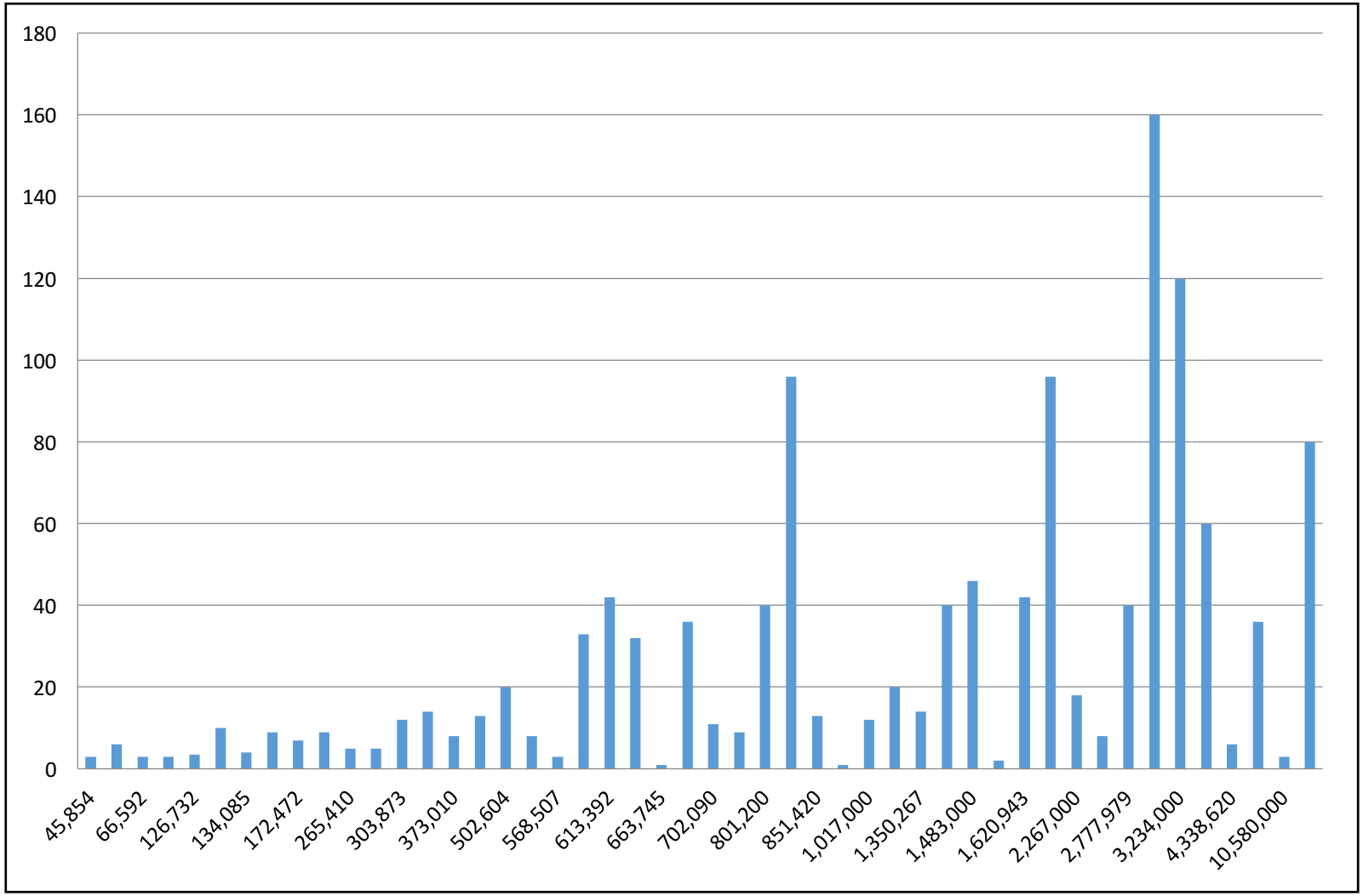

Figure 2. Regional Train Frequency per Hour × Number of Lines vs. City Population

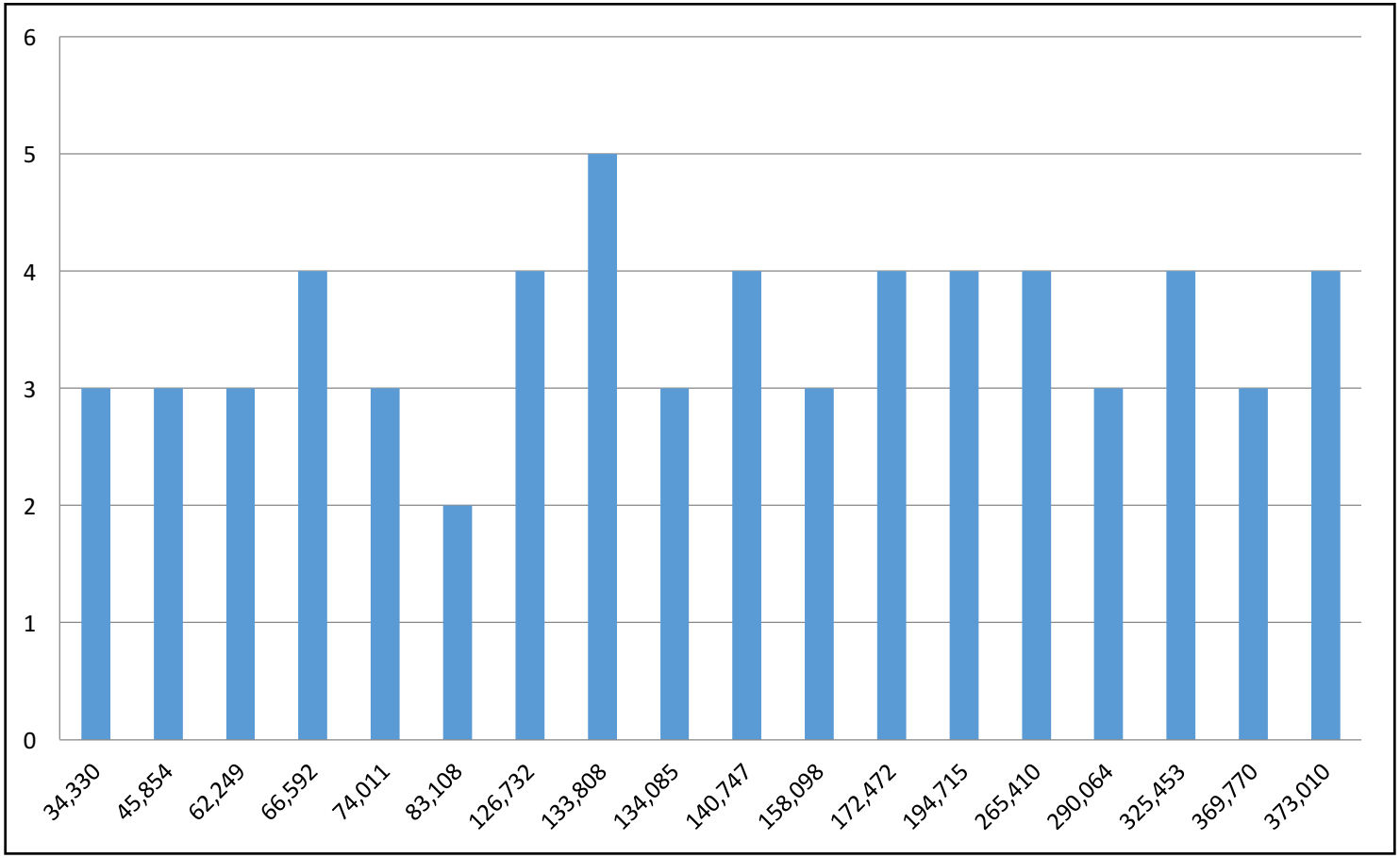

Figure 3. Number of Transit Modes vs. Populations < 400,000 ÷ Number of HSR Stations

Note: The transit modes used in this figure are urban buses, suburban/regional buses, trams/light rails, subways, and regional/commuter trains.

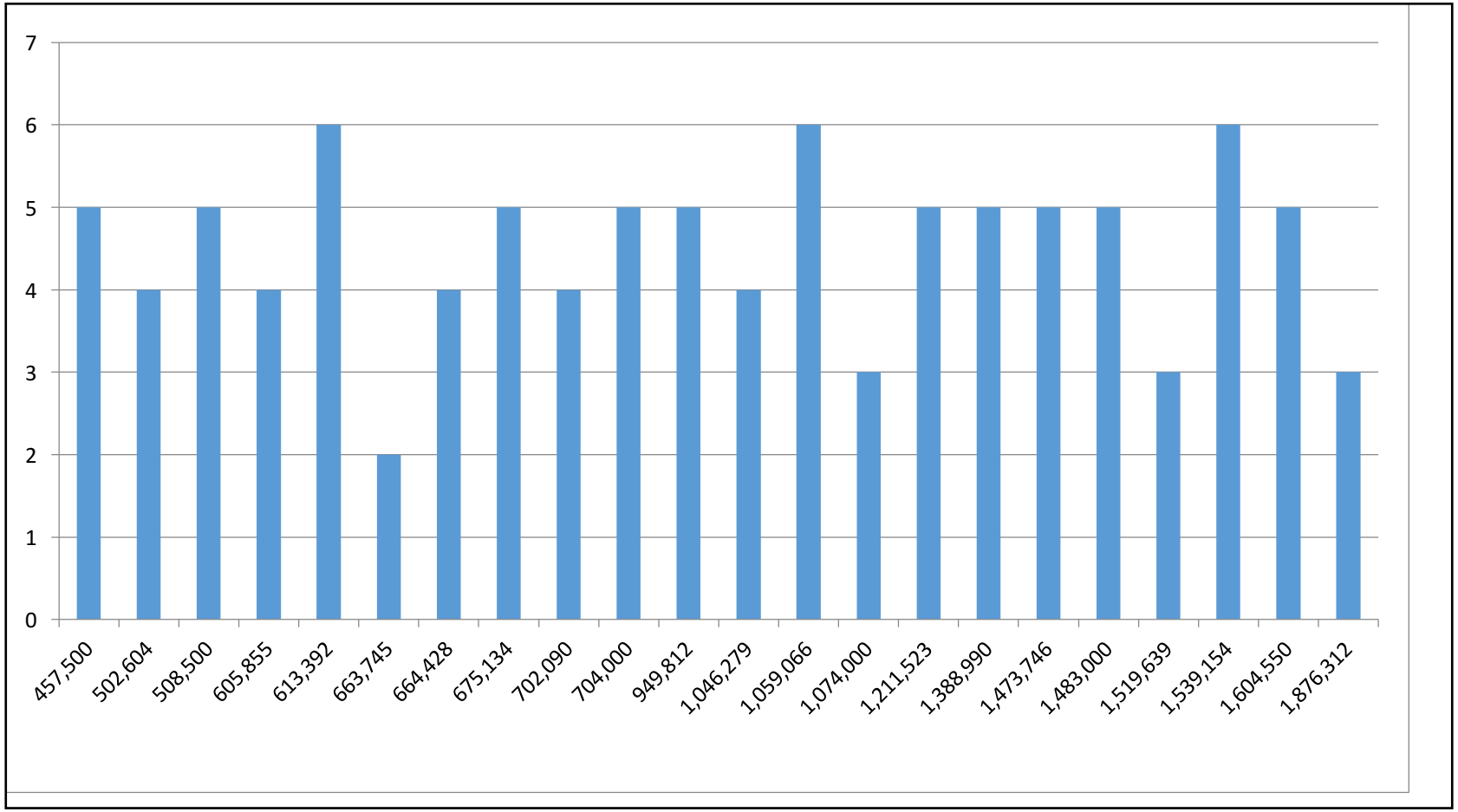

Figure 4. Number of Transit Modes vs. Populations between 400,000 and 2,000,000 ÷ Number HSR Stations

Note: The transit modes used in this figure are urban buses, suburban/regional buses, trams/light rails, subways, and regional/commuter trains.

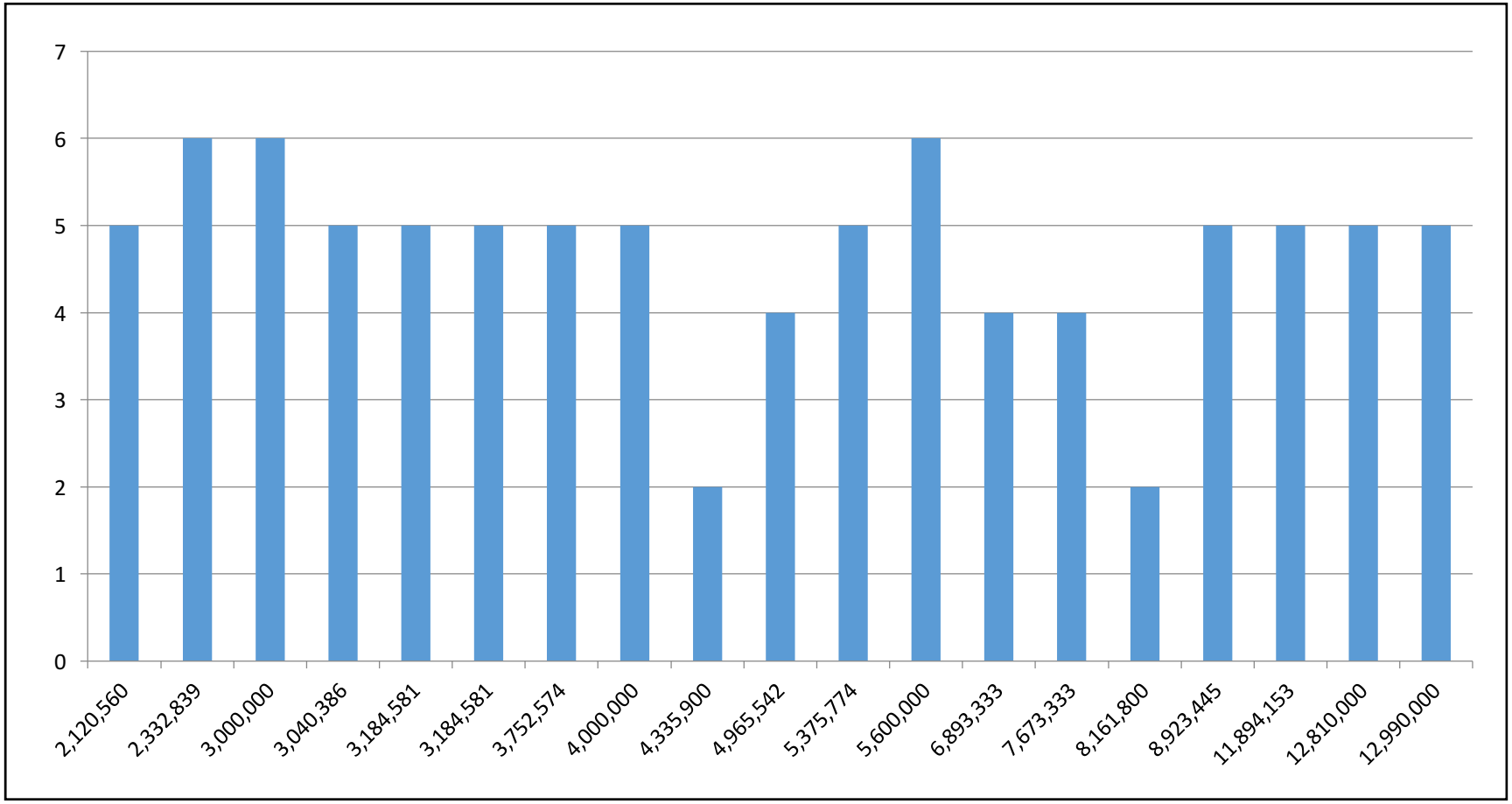

Figure 5. Number of Transit Modes vs. Populations > 2,000,000 ÷ Number of HSR Stations

Note: The transit modes used in this figure are urban buses, suburban/regional buses, trams/light rails, subways, and regional/commuter trains.

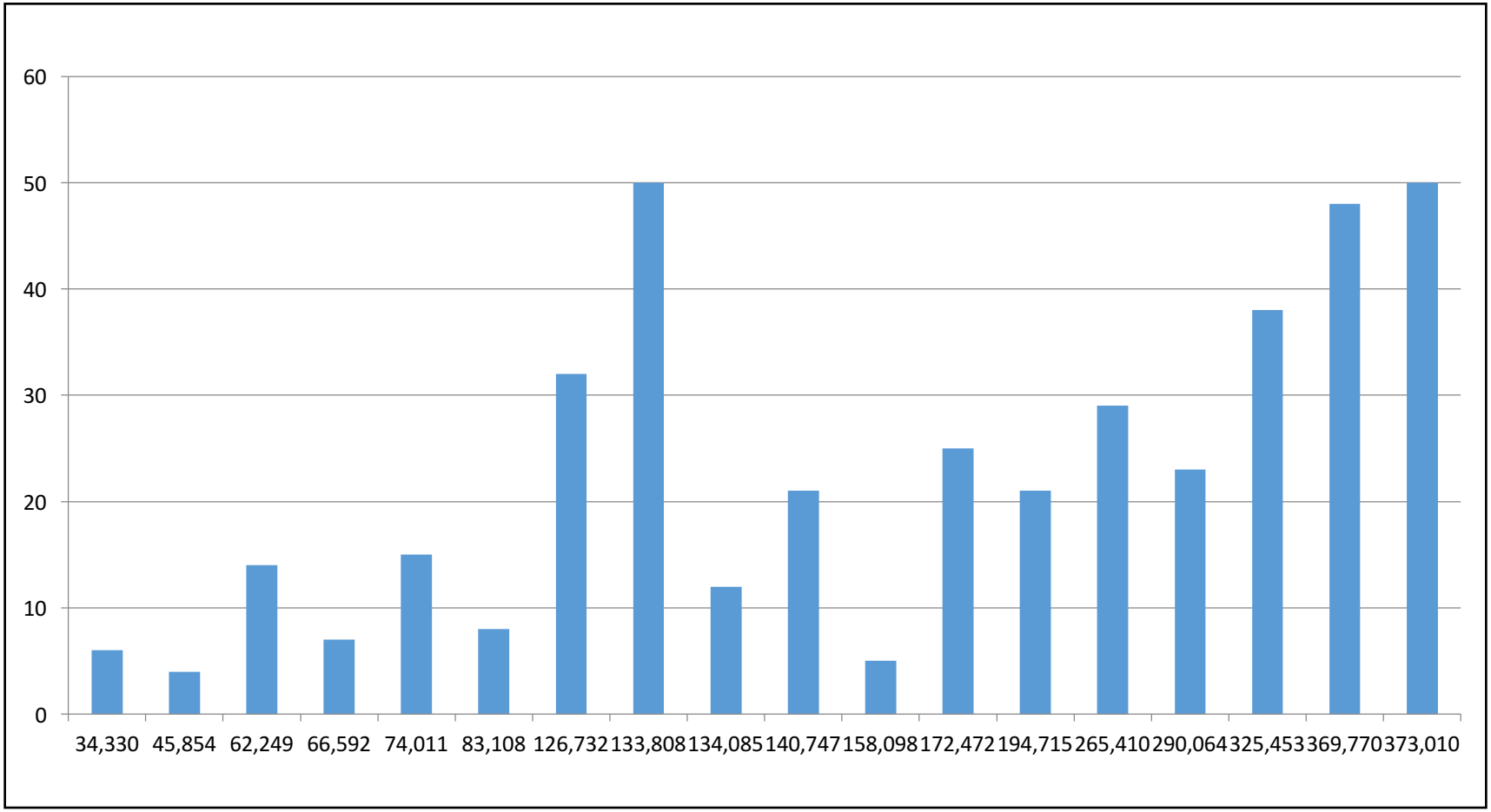

Figure 6. Total Average Service per Hour vs. Populations < 400,000 ÷ Number of HSR Stations

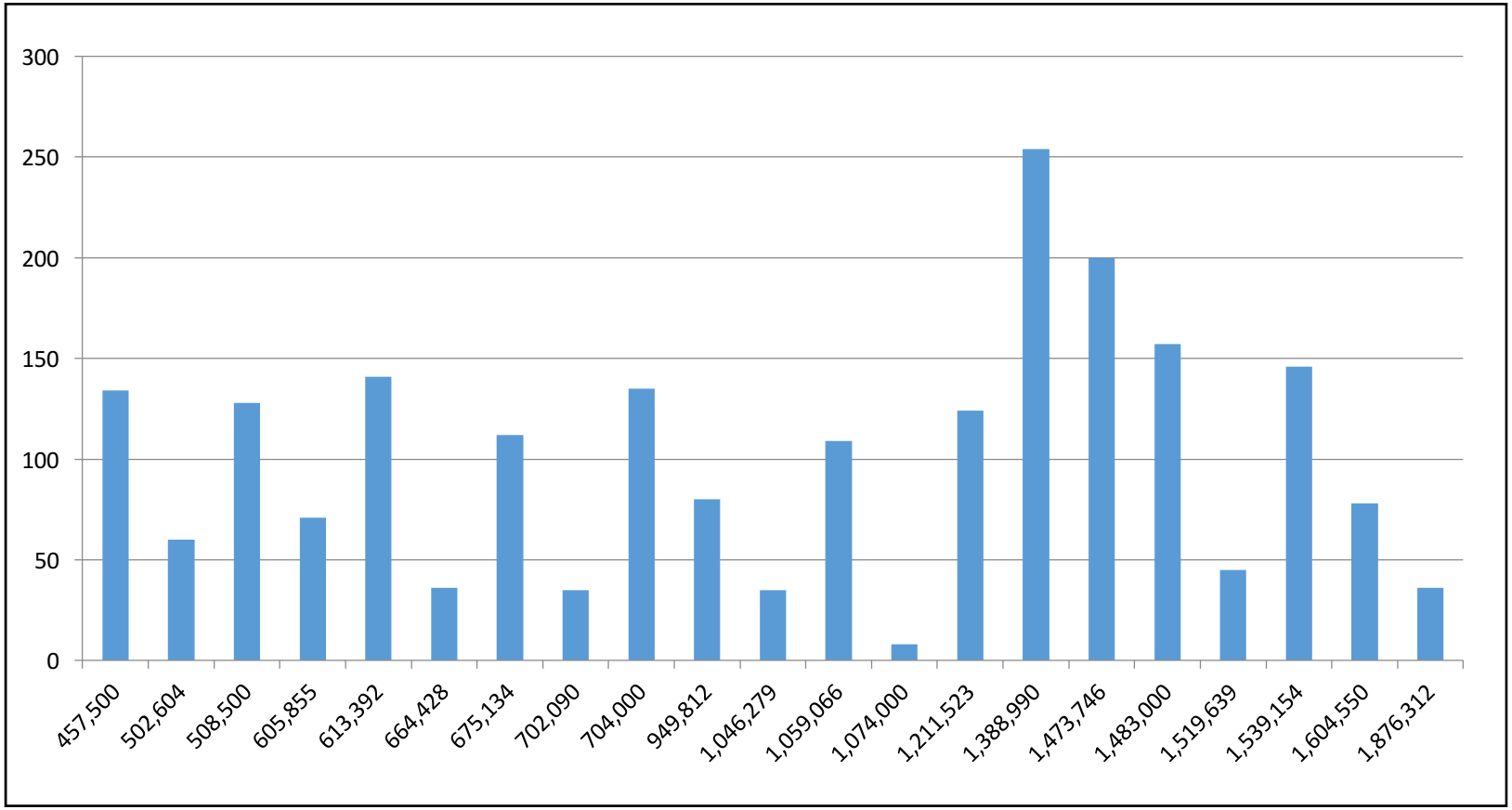

Figure 7. Total Average Service per Hour vs. Populations between 400,000 and 2,000,000 ÷ Number of HSR Station

There is a clear connection between some of the connectivity parameters at a station and the population size of the observed area. Station activity, defined as the number of passengers using the station per hour, is directly related to the local population size. Higher station activity requires higher transit capacity. This translates into a need for more transit modes with higher capacities at the stations that serve cities with higher populations. The number of streetcar, tram, light rail, and subway lines connected to a station, as well as their service frequencies, does not appear to be directly affected by population size. On the other hand, subways are a very large-capacity transit mode that appears almost exclusively at HSR stations in cities with populations of over 500,000.

The correlation between population and connectivity is particularly clear for some modes, such as local bus systems and regional services. Both of these systems function as feeders for HSR stations (Figure 1).

1. Bus services differ depending on local needs, so correlation results were obtained by comparing an aggregate variable, consisting of the product of the number of lines and service frequency, to the local population size.

2. The number of bus lines at a station has a clear correlation to the local population size, but only at the extreme values – that is, for very small or very large populations.

3. Frequency of service is not strongly correlated with population size.

The aggregate variable established shows a clear correlation that can be seen in Figure 1.

Regional trains have different services depending on the needs of the populations they serve. This results in significant differences between train capacity, scheduling, line availability, and so on depending on the location (Figure 2).

a. The number of lines and the frequency of service do not correlate well with population size.

b. Another aggregate variable, created by multiplying the number of lines by the frequency of service, is more strongly correlated.

The clearest correlations to population size are associated with two indicators:

a. The number of different types of transit modes delivering services to and from the HSR terminal.

b. Generalized transit offer – the product of the number of lines and service frequency.

In Figures 3 through 7, the number of modes serving stations increases with population and ranges from two modes at lower populations to six modes at higher populations. Three population size segments can be found with regard to the number of available transit modes at the station:

1. HSR stations in cities with a population lower than 400,000 inhabitants generally have between 3 or 4 available modes;

2. Stations in cities with populations between 500,000 and 1.1 million inhabitants typically have 4 or 5 available modes;

3. Cities with populations greater than 11 million usually have 5 or 6 available modes.

Another indicator that helps demonstrate the correlation between connectivity and population is the generalized transit offer's volume per hour. This function, shown in Figure 8 as the "transit services per hour" compared to the population size, is the number of opportunities at an HSR station, per hour, that a passenger has to take a transit service (except for taxis) regardless of mode or destination. Figure 8 shows the correlation between the generalized transit offers and the populations of the areas served by HSR stations.

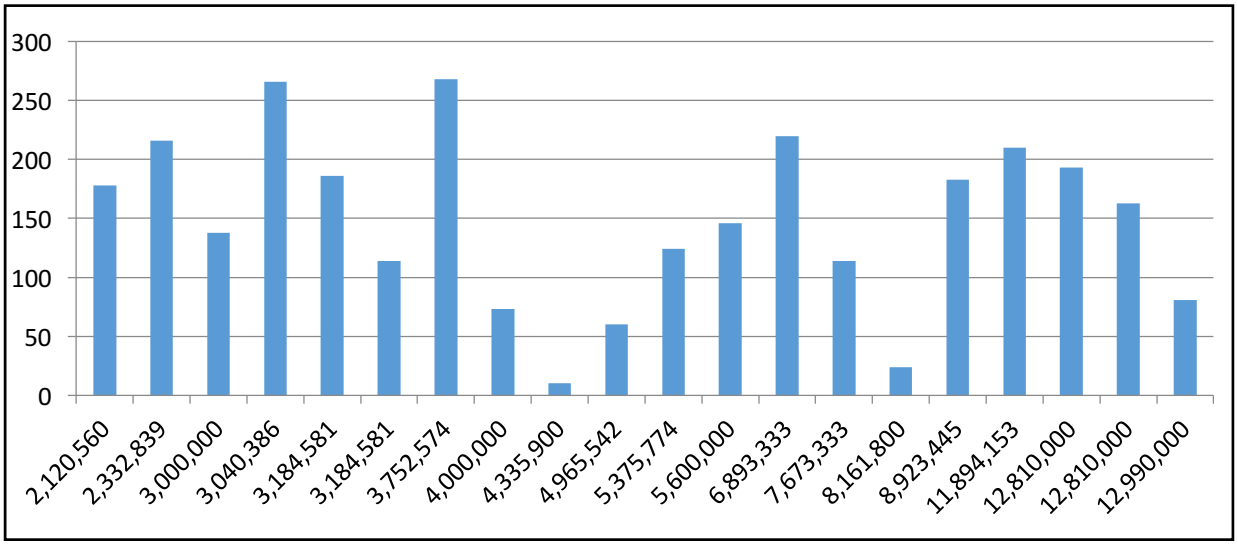

Figure 8. Total Average Service per Hour vs. Populations > 2,000,000 ÷ Number of HSR Stations

Figures 6, 7, and 8 show that the "generalized transit offer" parameter is directly related to the population size. Its value for the different stations shows an increasing trend with the population.

1. In figure 6, for stations in cities with fewer than 400,000 inhabitants, the number of transit services offered per hour was lower than 50.

2. Figure 7 shows "generalized transit offer" values for stations in cities with a population from 400,000 to 2 million. The average number of transit services offered per hour is dominantly between 50 and 100.

3. Figure 8 shows that at stations in cities with populations of over 2 million, the number of transit services offered per hour are over the value of 50 – in some cases, up to 200 services per hour.

II. CASE STUDY OF CALIFORNIA CITY-STATIONS AND FOREIGN COMPARISON CITIES

STUDY SAMPLE

The study's work plan calls for the selection of three stations from the proposed California HSR network from a total of twenty-seven proposed stations. As the selected stations are not intended to comprise a scientific sample from which accurate inferences can be drawn, a "purposive sampling" method has been used. Purposive sampling reflects the information needs inherent in a research question; California subjects and international comparisons will be selected based on similarities in certain areas.[35] As the project calls for selections[36] that reflect the varying kinds of settings for HSR stations, the following criteria were used:

- Phase one stations only, as they will have been planned and developed much sooner than others.
- Stations in areas of varying size in terms of populations served, projected passenger use, potential connectivity, etc.
- Stations in areas of varying character – e.g. suburban, urban, rural, etc.
- Stations that reflect the geographical diversity of the system, i.e., Northern and Southern California, Central Valley, etc.

Using these criteria, the following stations were selected:

- Los Angeles
  - Large city, many boardings, high potential for increased boardings and improved connectivity, located in Southern California.
- Gilroy
  - Small city, suburban/exurban setting, smaller potential for boardings and connectivity, located in Northern California.
- Fresno
  - Medium-sized city, moderate possibility for boardings and connectivity, located in the Central Valley.

These locations optimally reflect the amount of diversity that is inherent in the California HSR system given the resources available for this study. Examining the data from international HSR stations described earlier, the following cities were selected as points of comparison with the California sample stations. These locations optimally reflect the amount of diversity that is inherent in the California HSR system, given the resources available for this study.

Examining the data from international HSR stations described earlier, the following cities were selected as points of comparison with the California sample stations:

- Los Angeles – Tianjin, China
- Gilroy – Fulda, Germany
- Fresno – Málaga, Spain

These comparison cities were selected primarily on the basis of similar populations, urban versus rural/suburban settings and, in the cases of smaller cities, distance from a major urban center. They also reflect a variety of the international HSR experience, representing three different countries. The cities are not intended to be culturally or economically identical, which would be practically impossible, but they do represent a reasonably similar scope of potential for transit connections.

Tianjin, China and Los Angeles, California

	Los Angeles, CA	**Tianjin, China**
Population	10m	13m
Population Density	7,000 per mi^2 (estimated)	3,100 per mi^2
Distance to Closest Major City	N/A	75 mi
Urban Area	503 mi^2	67.5 mi^2
Average Annual Income	$55,909	$50,900
Key Industries	Aerospace, biopharmaceuticals, entertainment, international trade, transportation	Mobile phones, aerospace, alternative energy, shipping/logistics

Tianjin differs from Los Angeles in that there is an even larger metropolitan area (Beijing) only 75 miles away. These two cities are more comparable when Los Angeles County is compared to the metropolitan area of Tianjin. Population density in Tianjin is about 3,100 people per square mile, whereas in Los Angeles it is 7,000 per square mile.

Los Angeles

Los Angeles is the largest city in California and the second largest in the nation. The city's economic engine is powered by a wide array of industry, most notably art and film production. The city itself has a population of over three million, but its combined statistical area boasts a population of over 13 million.[37] Los Angeles is divided into 80 districts and neighborhoods. Between these districts and neighborhoods are several city cores that include Downtown, Hollywood, the Harbor Area, and the San Fernando Valley. Los Angeles is a car-oriented city, as evidenced by its chronic traffic congestion.

Transportation

Seaport

Los Angeles has one of largest seaports in the world, the largest port in the United States. The port ranks number one in the world in terms of the value of shipments coming in. This port is a major part of the economics of the region, and employs over 16,000 people. The top trading partners for this port are China, Japan, South Korea, Taiwan, and Vietnam.[38]

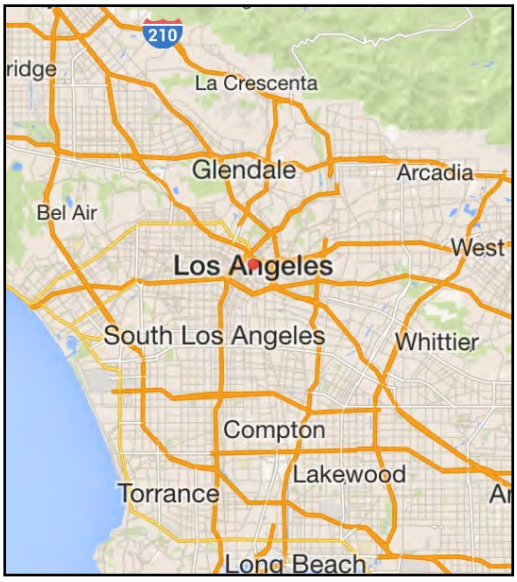

Figure 9. Los Angeles Area Map

Bus Lines

The primary local bus operator in Los Angeles is the Los Angeles County Metropolitan Transportation Authority (LACMTA or LA Metro). This agency also operates the light rail lines serving LA County and serves as the planner, designer, builder, and operator of public transportation in the region. The bus service area is 1,433 square miles, which is covered by 170 bus routes that range from local buses to limited and express services. In February 2014, the system-wide bus ridership nearly reached one million average weekday boardings.

Pedestrian/Bicycles

With Los Angeles being a particularly car-oriented city, bicycle and pedestrian travel make up a small percentage of total travel in the area. LA Metro helps support the bicycle/pedestrian infrastructure by providing access to services that expedite the delivery of passengers in their first and last mile of travel. Amenities that help facilitate this include shuttle services, bike parking, and bike racks on trains and buses. In Los Angeles County there are 167 “bike transit hubs.”[39] These are places where bike parking is available and transit services support bicycle use. Currently there are 144 miles of bikeway in Los Angeles County, with plans to add 831 miles of new bikeway within the next 20 years. Barriers to walking and biking in Los Angeles can be found in the sprawling landscape of the city itself, while the 25 interstate freeways and state routes throughout the area exacerbate the problem of access for pedestrians and bicyclists.[40]

Private Vehicles

Private vehicle use in Los Angeles represents the majority of travel in the region. The infrastructure in place to support the use of private vehicles is well established. Traffic congestion plagues the city of Los Angeles due to an overdependence on vehicles.

Trains

LA Metro provides local rail services in Los Angeles. There are four light rail lines and two subway lines that operate in Los Angeles. LA Metro provides service to eighty stations, providing a coverage area of 87 miles. The average system-wide weekday boardings for the rail system were over 350,000 for February 2014, totaling nearly nine million boardings for the month.[41]

The regional commuter rail operator is a five-county agency, the Southern California Regional Rail Authority (SCRRA) or Metrolink. Metrolink provides commuter rail service to the region through seven commuter rail lines, most of which are routed through Union Station. In addition there are FlyAway shuttles that serve the region's airports (LA International and Burbank) from certain Metrolink Stations. The Metrolink system serves 56 stations throughout the region and connects five (5) counties to the City of Los Angeles and Union Station.[42]

Amtrak (the National Railroad Passenger Corporation) operates three intercity, regional rail passenger services in California under financial arrangements with the State Transportation Department (Caltrans). One of the corridors, the Pacific Surfliner corridor, connects San Diego to Los Angeles and Los Angeles to San Luis Obispo. Amtrak's main Los Angeles terminal is at Union Station. In addition to the state sponsored Pacific Surfliner corridor, Amtrak also operates long-distance trains from Union Station: The routes that serve Union Station head south toward San Diego, north toward Seattle, and east toward Chicago and New Orleans. Caltrans sponsors an extensive network of bus services which extends the reach of the Pacific Surfliner passenger rail corridor.[43]

Figure 10. Tianjin Area Map

Union Station Los Angeles, CA

Union Station is the main rail station in Los Angeles. The station was originally opened in 1939 in order to replace older rail stations in the area; today it serves about 60,000 passengers daily and provides access to regional, commuter, subway, and light rail services. Of Metrolink's seven commuter rail lines, six serve Union Station alongside two local subway lines and one light rail line operated by LA Metro. Several long-distance buses serve the station as well – services like MegaBus and Boltbus provide long-distance bus service north to the Bay Area and east to Las Vegas. There is also a FlyAway bus that provides service to LAX and runs every twenty minutes. Several local and municipal bus routes serve Union Station with services ranging from regular buses to express and rapid-transit services. There are 3,000 parking spaces located at the station, with 24 bike racks and 20 lockers. Expansions for this station are planned to minimize the delays for buses and trains getting into and out of the station.

Tianjin

Urban Bus (lines)	Suburban/Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)
Yes (9)	Yes	Yes (1)	Yes (3)	Yes (1)

Tianjin is a major city located in northern China on the Bohai Bay. This city lies approximately 75 miles south of Beijing and boasts a population of nearly 13 million people. Of the cities being considered in the California HSR project, Tianjin is most similar to Los Angeles in population and proximity to major trade routes via the Pacific Ocean. Tianjin is the largest coastal city in northern China, while Los Angeles is the largest coastal city in the western United States.[44] Not unlike the sprawling metropolis of Los Angeles, Tianjin is considered a dual-core city, a city with two intense major activity centers or downtowns. Tianjin's main urban area is located on the Hai River. This urban area connects to several rivers via the Grand Canal. The second of the cores is located east of the main core on the Bohai Coast. This area, known as Binhai, is particularly aimed at boosting economic vitality through industry and trade. Tianjin is considered a major gateway to and from China's capital of Beijing.[45]

Tianjin's Economy

Tianjin has seen major economic growth over the past two decades due to foreign investment, financial reform, and innovation. Nearly three hundred Fortune 500 companies are located in the specialized area of Binhai. Binhai is considered a Special Economic Zone (SEZ), similar to the SEZs found near Shanghai. Located in Binhai are areas dedicated to the manufacturing, technology, logistics, tourism, and financial industries. Tianjin has a seaport and its own international airport.

The opening of Tianjin to foreign investment has boosted the economy tremendously in terms of nominal GDP and financial revenue. The influx of foreign money into Tianjin's economy has afforded the city opportunities to develop new infrastructure such as roads, rail, and bridges to support further economic growth in the region. With Tianjin being a major player in the transportation of goods to and from China, investment in transportation infrastructure is seen as paramount to sustaining economic growth in the region.

Transportation in Tianjin

Seaport

The Port of Tianjin is one of the largest ports in the world and is the largest in northern China. This seaport handled nearly 500 million tons of cargo in 2013, making it the fourth-largest in the world. The growth of the port has been exponential – in 1993, only 30 tons of cargo were handled there. Support for the shipping industry is bolstered by continued development of roads and rail in the area.

Trams

Trams in Tianjin are a vital part of the local transportation network. The tram was first introduced to Tianjin in the early 1900s and abandoned in 1972 in favor of gasoline-powered vehicles. Due to rapid population growth and urbanization, congestion and pollution became tremendous problems as Tianjin shifted toward being more car-oriented. Recognizing that these problems were being caused by local dependency on cars, the tram was reintroduced to the city in 2007. Tianjin's tram is the main transit connection in the Special Economic Zone located in the urban core of Binhai. Spanning less than five miles, Tianjin's tram system derives its prominence from the connections made with the subway and high-speed rail networks.

Trains/Subways

Tianjin's transportation network is quite robust, and vital to the overall mobility between neighborhoods; it also provides links between the old city core and Binhai. The subway system currently operates four lines, with plans to open twelve more in the future. The current network of train lines was built on an old, already-established system from the 1980s. Renovations to the old network were made in the early 2000s, and operation of the new system began in 2004. New lines were opened in 2006 and 2012. The existing lines cover about 78 miles and service a total of 83 stations.[46] There are plans to extend the service area to the town of Yangliuqing and east to the international airport. Of the four existing subway lines, three serve the HSR station directly. More rail and subway lines are under construction or in planning phases.[47]

Bus

The bus network in Tianjin is quite extensive. Although the subway network is highly utilized, the bus system helps cover the gaps where subway service is not available. Long-distance buses connect travelers with towns and provinces that are not easily accessible by rail. After the addition of high-speed rail, however, demand for long-distance buses has dropped nearly forty percent. The most important long-distance bus station is located less than two miles from the main HSR station in Tianjin's old city center.

HSR Impact on Tianjin

The HSR system that serves Tianjin is part of the Beijing-Tianjin Intercity Railway system operated by China Railway High-Speed (CRH). There are five stations along this particular HSR corridor: Beijing South, Yizhuang, Yongle, Wuqing, and Tianjin. The line that serves Tianjin has been in operation since 2008. Operating at speeds as high as 205 mph, this system was the world's fastest conventional train when it first opened. HSR in Tianjin connects northern China's two largest cities and, with its introduction, travel time from Beijing to Tianjin has decreased from 70 minutes to 30 minutes. As demand has increased over the years, train service has steadily increased; the minimum interval time between trains is now ten minutes. Some trains run non-stop between Beijing and Tianjin as well.

HSR service significantly increased the demand for rail transit between Beijing and Tianjin over the years. Since its introduction, demand has steadily grown every year. The conventional rail service operating between Beijing and Tianjin in 2007 saw just over 8 million passengers for that year. As of 2010, after the installation of HSR lines, ridership has tripled, reaching over 25 million passengers annually. Connectivity projects in both Beijing and Tianjin have risen to prominence with the improvement of rail services between the two cities. Beijing, which already has an extensive local transit network, has improved the efficiency of, and access to, its major HSR stations by increasing the service frequency and capacity of its local networks. Tianjin saw a recent explosion in the use of HSR, but is still developing the transit infrastructure that will connect the HSR station to the rest of the city. This will include more subway lines and the extension of HSR rail service to Binhai.

HSR has improved the business opportunities available in Tianjin: an architectural firm based in Chicago – Skidmore, Owings, and Merrill (SOM) – has created a plan for future development in the Binhai district. SOM's vision for the region is the redevelopment of the coastal industrial zone into a new center of commerce for the city. SOM's plan calls for a mixed-use approach with high-rise buildings, historic neighborhoods, and open spaces alongside a comprehensive road and rail system. Also in this Binhai district plan is the establishment of a high-speed train connection directly to Beijing. Currently, the closest high-speed train connection is in the old city center of Tianjin, and Binhai is connected to high-speed rail through the subway system.

Local Perspectives

Los Angeles embodies many of the characteristics that were present in Tianjin before the introduction of HSR lines. Due to the similarities between these two cities, Los Angeles could potentially enjoy the same benefits from HSR transit as Tianjin. HSR in Los Angeles could attract new businesses, foster better local transit connections, revitalize dilapidated city centers or create new ones, and alleviate the congestion caused by automobiles. High-speed rail has been a major contributing factor in the sustained growth of Tianjin's economy. A concerted effort has been made to bring new business to Tianjin, but HSR and its connectivity to the local transit networks has granted access that was not available when cars dominated the city's landscape. Los Angeles, historically a city plagued by road congestion issues, is working to transform itself through a much expanded light rail, commuter rail, and express bus network. The introduction of HSR linkages to other California activity centers (primarily the Bay Area and the Central Valley) will help to change the perception of Los Angeles into that of a city where mobility can be achieved without a car. Through government and private sector partnerships centered on the evolving public transit system and enhanced by a new HSR system that is well-integrated into the local transportation network, Los Angeles can attract more businesses, residents, and tourists.

Los Angeles is the largest city in California with a population of 7 million and a regional population of 19 million. The High Speed Rail terminal in downtown Los Angeles at Union Station will be the heart of a regional transportation system providing connections to destinations throughout the region. The terminal, an old and historic Southern Pacific Railroad terminal, was purchased by the LACMTA and is being developed as a major commercial, transportation, and retail center very close to the heart of downtown Los Angeles.

LACMTA is also developing a plan for the area immediately surrounding Union Station. The California High Speed Rail Authority has selected Bob Hope Airport/Burbank Station as an interim terminal for High Speed Rail, to be used as access to Union Station is planned and implemented. The planning for this Union Station access is at its earliest stages. The station and its vicinity will be a destination, as well as a regional connection point.

Key Agencies

The key agencies with responsibility for transportation programs and services in Los Angeles include:

- SCAG (Southern California Association of Governments) – the regional planning agency and Metropolitan Planning Organization under Federal transportation programs.
- The SCRRA (Southern California Regional Railroad Authority) or Metrolink – the regional commuter rail carrier.
- LACMTA – the provider of bus and rail public transit services in LA County.
- LADOT (the City of Los Angeles Department of Transportation) – the provider of local shuttles and bus services in LA County.
- CAHSRA (California High Speed Rail Authority) – the organization responsible for planning, environmental clearance, and construction and operation of the High Speed Rail system in California.

A joint management council including these agencies has been set up and meets regularly. There are other county and regional agencies providing planning and public transport operations in the Los Angeles region, but those listed above are responsible for the Los Angeles HSR station and its connections.

None of the stakeholders involved in station and line development wants to run the risk of making an error that needs to be revisited later. Each agency is actively engaged in coordinating its actions toward a highly connected and state-of-the-art Los Angeles terminal area. In addition, there are sensitive issues surrounding the quality of connections that are to be planned, designed, and implemented in the next ten years. One key aspect of their current activity is the fact that the design and location of the HSR lines that will have a Union Station terminal stop are not the current center of attention; these will be delayed as the first high speed rail segment is created with a terminus at Burbank/Bob Hope Airport, well north of Union Station and removed from the heart of the City of Los Angeles. At this point, the agencies are working together to implement a Master Plan for Union Station to reconfigure and expand it for local access and new light rail services. CAHSRA is responsible for building the California HSR line, and executed a Memorandum of Understanding identifying critical projects for which almost a billion dollars of Authority funds are to be allocated. The Memorandum has been adopted by the Authority to create a blended system that will improve the utility of the terminal station. The blended system

would enter the dense areas of the City on existing passenger railroad lines used by Metrolink, and would not require the creation of a new, expensive right-of-way into the City. The site at Union Station, however, may require new construction. Planning for that final segment, however, has not yet begun.

CAHSRA takes part in numerous project development meetings, the Regional Partners Working Group, and other coordinating bodies that share information and statuses, manage potential conflicts, and advance projects that are being planned, designed, or constructed. Design standards that must be adhered to have been made available on the CAHSRA web site, and the Authority reviews all projects that could have an impact on the HSR rights-of-way or services. For any project that could have an impact on its overarching goals, CAHSRA negotiates and executes agreements with the project sponsors, defining design criteria that must be met. The overall objective of this well-integrated system is to provide benefits to all of the key stakeholders as transit ridership increases.

One predicted impact of creating an integrated transit system is large increases in public transit ridership generally, and Metrolink ridership in particular – because its service will be completely reconfigured. As a regional planning agency, the SCAG has placed all of its Transportation projects in its regional plan. SCAG has also recognized the importance of enhancing linkages between destinations and origins for travel in the City and its main rail stations; it has embarked on a study of so-called first mile/last mile linkages.

To address the needed integration, coordination and cooperation among the passenger rail corridors using the “LOSSAN” corridor (Los Angeles-San Diego) – which includes Metrolink, Amtrak, the San Diegan intercity services, and, in the future will include HSR trains – the state has created a new sub-state Joint Powers Authority (JPA), based on the successful Capitol Corridor JPA in Northern California. This new agency will take over management of the San Diegan service, which is currently being managed by the Caltrans Rail Division and will become responsible for corridor coordination. The LOSSAN JPA will be overseen by the Orange County Transportation Authority (OCTA) as a Managing Agency, but will report to a Board representing all of the Counties included in the service. The JPA will execute agreements with Caltrans and Amtrak, which currently oversees San Diegan passenger rail services. There are several additional regional efforts underway aimed at improving service plans and coordination. The Southern California Rail Partners Working Group includes regional rail agencies, as well as the California State Transportation Agency (CALSTA) and the Federal Railroad Administration of the United State Department of Transportation (USDOT). CALSTA has initiated a detailed study, entitled Network Integration Strategic Service, which is a statewide effort to create a statewide rail system vision and create a set of projects that will improve coordination and connectivity. LACMTA is in charge of developing Union Station. The organization realizes that riders only care about accessing their system with as few barriers as possible, not which agency operates any specific transportation mode or route.

LADOT provides shuttle and local connector services in downtown Los Angles and in various activity centers in the County. LADOT hopes for considerable increases in ridership as line connections are improved and HSR is introduced. They consider ridership a critical determinant of success. LADOT is approaching this by looking at the transit system as

a product that needs to be competitively positioned and sold, based on quality. LADOT is also looking at first and last mile concepts as discussed above in the SCAG study associated with its circulator and shuttle systems to improve linkages to initial origins and final destinations. LADOT is concerned that the need for investments is more than the available funding, but believes that, as projects are completed, there will be enough pressure to complete the system and this will bring funds. At this time the feeling is that the process is smoothly coordinated and going well.

Projects

One of the most important projects that will transform Union Station in Los Angeles is the Southern California Regional Interconnector Project (SCRIP). SCRIP has evolved as HSR lines through Union Station are being considered. SCRIP will include solutions for HSR entry and exit at Union Station, and its cost is now estimated at approximately $1 billion. Although some funding had already been arranged for the project, the inclusion of HSR alignment now adds HSR funding into the mix; a final cost estimate and funding decisions have not yet been made.

SCRIP will modify Union Station, now a stub-end station, with run-through tracks, so commuter railroad trains and existing Pacific Surfliner trains can move north–south through the station itself. These new tracks will fundamentally alter the design of local services and infrastructure. Over fifty percent of trains on all of Metrolink's lines that currently terminate at Union Station will be able to move through it, providing more one-seat rides (rides not requiring a transfer to a second train) and linking Northern and Southern LA County with the counties beyond it. The project is currently in the design stage, with definitions for vertical and horizontal alignments, platform access, and track placement underway. SCRIP will require alterations to the existing station in order to provide pedestrian access, via ramps, to train platforms that will accommodate the new run-through tracks. The station's new design will ultimately be determined by platform heights, the locations of the through tracks, and the placement of the HSR tracks. Since the existing station is considered a historic building, all of the planned changes will need to conform to the State of California's Historic Building rules. SCRIP planning will need to address these issues and accommodate the changes needed to allow for increased capacity in the main corridors and a large increase in passenger utilization.

The current stage of the plan is the conversion of the facility so that it can accommodate new services including bus, subway, and metro lines. HSR compatibility will be added as a third-stage modification of the Union Station area.

The multi-stage redesign of Union Station is being managed by LA Metro. The first stage is defined in a public document which was released on June 5, 2014. The project's goals include improving connections to areas at the periphery of the station that will be developed, and to offer a connection to the nearby Los Angeles Civic Center. Today, the station and the 28-foot-wide tunnel that creates access to train platforms is at capacity. The project will provide the capacity needed to accommodate more connections at the station in the form of an underground concourse. More than 3.2 million square feet of commercial and retail space are planned for the site. The second stage is the relocation of an existing bus

facility at Patsaouras Transit Plaza, currently near the east side of Union Station, in order to eliminate traffic conflicts with the increased level of bus operations at Union Station and improve local bus connections. Metro is not yet planning bus connections to HSR via Union Station; HSR planning beyond creating a connection at Union Station is currently on hold, pending alignment decisions affecting the San Fernando Valley and the completion of the Union Station conversion. LA Metro is considering upgrading for HSR ahead of time to avoid service delays.

Ideas for HSR penetration include both above-ground and underground solutions. These options are being considered by the CAHSRA in conjunction with LA Metro and other stakeholders. One option being considered is a new railroad line that runs under Vignes Streret, adjacent to the station, and then heads south toward San Diego. A second option is the creation of a viaduct over the rail yards. Station design will ensure that passengers can easily access the new concourse, regardless of which option is chosen.

Another significant project related to the upcoming conversions is the Regional Connector Transit Project (RCTP), which will connect light rail to Union Station. That project will link LA's light rail lines and offer improved access to Union Station. RCTP is a major investment that will integrate LA's light rail systems and make it possible for passengers to, for example, travel from Long Beach to Pasadena with one ride. It will connect the Metro Blue, Metro Exposition, and Metro Gold lines through downtown LA to Union Station. Using these regional connections, passengers will be able to travel easily to Union Station using light rail lines.

The Los Angeles area and its transportation agencies are fully engaged in a program to reinvent public transport for the region's citizens. Their objectives are enhanced connectivity, an integrated transit system, and improvements in the system's ability to move passengers. The agencies seem well-coordinated and have good prospects for additional funding.

Fulda, Germany and Gilroy, California

This section examines the transportation infrastructures for the urban areas of Gilroy, California and Fulda, Germany.

	Gilroy, CA	**Fulda, Germany**
Population	49,000	65,000
Population Density	1,200 per mi²	1,600 per mi²
Distance to Closest Major City	San Jose – 32mi	Frankfurt – 65mi
Urban Area	16mi²	40mi²
Average Annual Income	$96,088	$43,962
Key Industries	Agriculture, retail	Textiles/clothing, tourism, financial services

Although these two cities are relatively small, they offer important strategic locations for their respective regions. Gilroy is the southernmost city in Santa Clara County. Gilroy's relatively small population and land area provides the region with agricultural products,

primarily garlic and mushrooms, and it has a series of outlet stores that attract shoppers from across the region. Most important with respect to HSR service, Gilroy is located such that people can commute to work in Silicon Valley or the rest of the Bay Area, although commuting times for automobile trips can be burdensome. In any event, approximately 70% of the workforce commutes out of Gilroy, including commutes in approximately 35,000 automobiles.[48]

GILROY

Transportation

Bus Lines

Because of the location and size of Gilroy, bus service is sparse. Local bus service is provided by the Valley Transportation Authority (VTA). There is an express line to Sunnyvale provided by VTA that mainly serves those commuting out of the region. Amtrak, Monterey-Salinas Transit, and San Benito County Express provide regional bus services. The bus services in Gilroy are based mainly on commuter activity. Additionally, Silicon Valley employers such as Google and Yahoo operate private bus services linking some residents to that employment center.

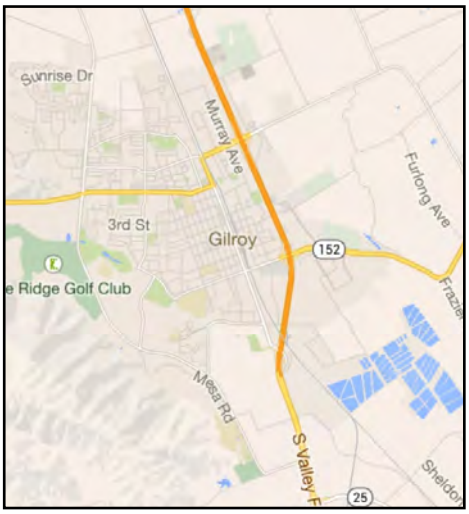

Figure 11. Gilroy Area Map

Pedestrian/Bicycles

Infrastructure for pedestrians is acceptable in the 1.5 square mile downtown area, but there is little development outside of that in support of pedestrian traffic. The lack of infrastructure for pedestrians outside this area is due to the agricultural activity present in the city. Bicycles have a better network of routes throughout Gilroy, some of which connect the city to its northern neighbors of Morgan Hill and San Jose. There are over 20 miles of bike lanes, paths, and routes located in Gilroy. Bicycling as a mode of transportation for commuters is fairly low, though, representing only one to two percent of commuter travel.[49]

Private Vehicles

Private vehicle use is high in Gilroy as many people commute outside of the city for work. Because Gilroy is mainly a suburban and agricultural city, private vehicles tend to dominate the landscape. There are two major freeways in Gilroy, US 101 and SR 152. US 101 connects Gilroy to the Bay Area and Monterey by traversing the city north and south. SR 152 connects Gilroy to the Central Valley going east and Watsonville going west.

Trains

Caltrain serves the city of Gilroy during weekday commute hours, and represents a very modest portion of activity for the region. There are three round-trip trains that service the

area each weekday. There were approximately 436 boardings in 2014 from the Gilroy Caltrain station. Much of the ridership, an estimated 70% between 2001 and 2014, was lost due to improvements to Highway 101 and the lack of service offerings.[50] These figures, of course, are dwarfed by the number of commuters in private automobiles.

FULDA

Urban Bus (lines)	Suburban/Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)
Yes (2)	Yes	No (N/A)	No (N/A)	Yes (6)

Fulda is a relatively small city that boasts a population of nearly 65,000. Fulda is located in central Germany, 65 miles northeast of Frankfurt. Of the cities being considered for the California HSR project, Gilroy is most similar to Fulda in population and distance from a major city (Fulda to Frankfurt, Gilroy to San Francisco – although one smaller city and the Silicon Valley are much closer). Fulda is a very old city, having been founded in 744 A.D.; it is located on the Fulda River between the Rhon and Vogelsberg mountain ranges. Fulda serves as an important rail junction for north–south and east–west train routes in Germany. A major military center during the Cold War, Fulda now plays host to a number of banking and financial services, as well as manufacturing plants for textiles and clothing.[51]

Figure 12. Fulda Area Map

Fulda's Economy

Fulda is an economic, cultural, and political center for the region. Fulda produces myriad items ranging from textiles and various chemicals to food and information technology. Fulda's cultural institutions attract tourists, which helps to bolster the city's economy. Fulda's cultural attractions include cathedrals, museums, local music, and theater arts. Aside from Fulda's attraction as a tourist destination, its location has made it hospitable to the international businesses that are located there.[52]

Transportation

Fulda's transportation network connects through highways and rail to many of the major cities in Germany. Fulda is a junction between routes to Hamburg, Munich, Cologne, Frankfurt, and Berlin. Because of its history, infrastructure was already in place that made Fulda an excellent connection point for various transportation modes.

Trains

Fulda benefits from an established rail system. Fulda station was first opened in 1866, where it served as an important rail junction for the rest of the country. The station was destroyed in World War II and rebuilt afterward. In the 1980s, the station was reconfigured to support HSR lines; its first high speed trains began operation in 1988. Fulda Station is one of the central transit hubs for the German railway network, classified as a Category 2 station. Category 2 stations are important junctions for long-distance travel and may serve a major airport. Fulda station serves both purposes, connecting with a major airport – the Frankfurt Main AM – and functioning as a junction for other long-distance transit modes. Fulda station provides four HSR routes that run trains on schedules that range from hourly to once every two hours. There are also two conventional, intercity train lines and four regional train lines at the station.[53]

Fulda station attracts businesses because of its location, and the ease of access to historical attractions keeps tourism healthy in the city. All nine rail services located at Fulda station attract about 20,000 passengers daily.

Pedestrian/Bicycles

Bicycle and pedestrian infrastructure is a vital part of the German transportation system. Although bicycle space on trains is limited to regional and local train services, bicycle rental stations are located at many train stops. Fulda station has an automated bicycle rental system that provides pedelecs and e-bikes, which are bicycles that provide pedaling assistance via electric motors. These types of bicycles provide an ease of use that makes them more accessible to certain populations, such as the elderly. Combined with the presence of bike paths and infrastructure that supports bicycling, visitors and residents alike can utilize bicycles throughout Fulda.

HSR Impact on Fulda

A typical German HSR station is focused on seamless intermodal transfers, and Fulda Station is no exception. German transit agencies have sought to address issues that affect the first and last mile of travel for passengers, such that transit systems are easier to access from both the start and completion of transit trips via multiple modes. Development spurred on by HSR activity has created the need for bike sharing and car sharing to coordinate with the public transit services. Fulda station's central location and availability of transit services make it a relatively attractive place to visit and/or work.[54]

Local Perspectives

Gilroy supports far fewer jobs than it does residents; there are approximately 78 jobs for each 100 residents. The existing jobs are low-wage or are filled by people who don't live in the city.[55] Gilroy officials see the creation of an HSR station as an opportunity for economic development that will attract new businesses and new residents. Lee Butler, Development Center Manager for the City of Gilroy, says the city sees HSR as promoting "significant potential for economic growth" and "employment intensification" near the city's central corridor.[56] Planners also see potential for either reduced automobile traffic in and through

the city or the mitigation of future increases, as commuters would be able to use HSR services to access Silicon Valley and San Francisco. The hope is that a new HSR station will help create a more vibrant downtown that will increase the use of other local transit modes as well. The station could also eventually be integrated with Monterey County's plan to bring train service from Salinas to San Jose.[57] Converting visitors to the city who wish to take advantage of the shopping outlets and other attractions into users of public transit could also help reduce local traffic, especially on weekends.

The major challenge, from a planning perspective, is where and how to build the HSR station. Although the consensus appears to be that the station will be located in downtown Gilroy, where it could help anchor new employment and residential projects, many questions with regard to transit connectivity remain unanswered. The station is still being planned under a contract recently awarded to Placework, Inc., and is funded through several state and local sources, including the Valley Transportation Authority (VTA). VTA operates existing bus services to and from Silicon Valley, which encompasses the southern Bay Area and includes San Jose, Sunnyvale, Cupertino, and several other cities.

Assuming a downtown location is selected, a major strategic decision that must be resolved is the grade at which the station is to be placed. The existing train facility that connects Gilroy to the greater Bay Area is not considered to be well-integrated into the downtown area; the existing tracks bisect the city with up to ten crossings. Local officials see a major advantage in building the station above street level; doing so would enable various forms of traffic, including pedestrians and bicycles, to cross beneath the train. It would also allow for the connection of water, sewer, and utility lines. These lines cannot transverse the existing rail bed. However, building the HSR station at a higher level might require that the existing Caltrain station also be raised, or moved to a less desirable location. There is also concern that adding an HSR component above street level would choke off the downtown area. Additionally, building a station at a higher grade involves raising the right-of-way, making the route and the station significantly more expensive to build.

Another challenge is how to accommodate the new station's parking needs while at the same time promoting increases in residential and commercial density. CAHSRA has stated that there is a need for up to 6,000 parking spots, which may require the construction of a new and costly parking structure. However, the City of Gilroy would prefer to maximize the use of existing parking capacity in the area. The City may require the creation of a shuttle service that would link the station with the local outlet malls and downtown.

Fulda is an example of what Gilroy could become with the introduction of HSR services. Both Gilroy and Fulda are similar in population size and proximity to major cities, but Gilroy does not have the supporting infrastructure that is present in Fulda. In order for Gilroy to close this gap, the city must support pedestrian and bicycle infrastructure and develop seamless transfers between local trains, HSR, roads, and bus lines. Creation of an HSR station at an above-street level might help the city achieve that goal. City officials are confident that the addition of HSR in Gilroy will create more incentive for businesses to develop there. A robust network of intermodal transfers and the introduction of HSR service can help stimulate growth and development in Gilroy, similar to that seen in Fulda over the past two and a half decades. Gilroy could become a true extension of the Bay Area, with frequent and fast services to San Francisco and Oakland providing less costly residential options for workers in those cities.

City planning and economic development officials in Gilroy are certainly mindful of the potential that the planned HSR station has for both promoting the city's development and enhancing needed connections among transit modes, but they are operating in a less-than-ideal environment to optimize them. The amount of and sources for funding are large unknowns as the City awaits a plan from Placework. Regardless of that plan's outcome, much may hinge on whether funding is eventually identified that would enable the station to be created at a location and, especially, a grade-level, that will enable the readiest access via multiple modes as well as integration of the city's streets and business district.

Málaga, Spain and Fresno, California

	Fresno, CA	Málaga, Spain
Population	509,000	568,000
Population Density	4,417 per mi²	3,716 per mi²
Distance to Closest Major City	N/A	N/A
Urban Area	112mi²	153mi²
Average Annual Income	$42,276	$30,682
Key Industries	Agriculture, manufacturing	Construction, tourism, research

FRESNO

Fresno is the economic hub of California's San Joaquin Valley, and is best known for its agricultural production. The main feature of Fresno's downtown is Fulton Mall, a six-block pedestrian mall that features a large collection of public art. Aside from this mall, the city does not have particularly robust commercial zones. The majority of travel to Fresno is done using private vehicles, taking roughly three hours from San Francisco or Los Angeles.

Transportation

Bus Lines

The Fresno Area Express (FAX) runs sixteen bus lines in the Fresno area. Two percent of local travel in Fresno is done via public transit. Greyhound, which provides intercity bus services throughout the United States, has a terminal located close to the Amtrak train station. Greyhound provides more than a dozen daily departures to the Los Angeles, San Francisco Bay, and Sacramento areas.[58]

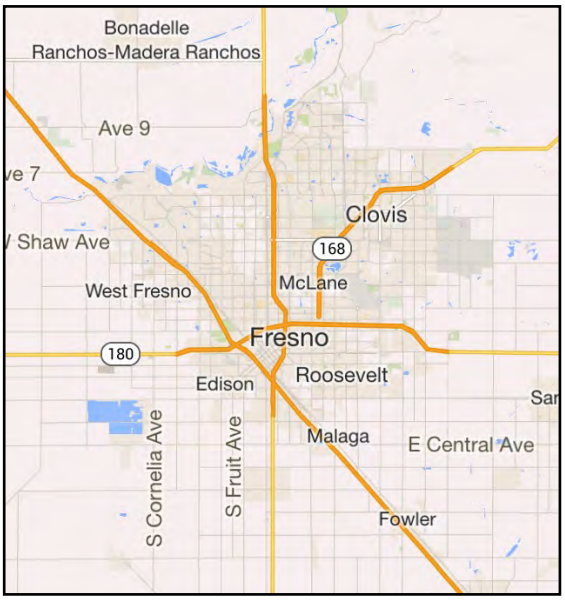

Figure 13. Fresno Area Map

Pedestrian/Bicycles

One percent of travel in Fresno is done with bicycles. In 2011, Fresno earned a Bronze Medal Designation from the League of American Bicyclists that recognized the city for being bicycle friendly. Fresno currently has 137 miles of bikeways, with both short-term and long-term bicycle parking available at various locations throughout the city. FAX buses are equipped with bicycle racks, and bicycles are allowed on Amtrak trains serving the city. Fresno is continuing its efforts to improve bicycle access. FAX is also looking at pedestrian access, particularly in downtown, and defining an improvement program.

Barriers to walking and bicycling in downtown Fresno include freeway and railroad intersections in the middle of the city, as well as the weather – Fresno features extremely hot temperatures in the summer, with temperatures averaging in the high 90s and low 100s, although winters are mild, with average daytime temperature of 56 degrees in December and January and an average low in these months of 38 degrees. Heavy fog in the area, however, often hampers visibility.

Private Vehicles

Fresno is very dependent on private vehicles, which represent ninety percent of travel within the city. Fresno is the intersection point of four freeways: State Route (SR) 41, which runs north–south; SR 99, which runs northwest–southeast; SR 180, which runs east–west; and SR 168, which begins at SR 180 and runs northeast.

Train

Amtrak is the only passenger rail service provider that serves Fresno, running conventional passenger trains several times a day south to Bakersfield and north to the San Francisco Bay Area and Sacramento.

Fresno Train Station

The Santa Fe train station, serviced by Amtrak, is located in downtown Fresno. Built in 1899, the station served both passenger and freight services into the 1960s. With automobile and air travel booming and rail travel declining, the station was closed in 1966. Ten years later, in 1976, citizens of Fresno put the station on the National Register of Historic Places in recognition of its architecture and the role it played as a centerpiece of the city.[59]

Following years of neglect, the City of Fresno purchased the station in 2003 as part of a downtown revitalization plan. The $6 million project sought to return the station to its former glory, and it earned a number of preservation awards. Included was 5,400 square feet of space for passengers and 12,300 square feet of space for lease. The passenger area includes an enclosed waiting room, a ticket counter, and a back office. The office spaces for lease are divided between the first and second floors, generating income and keeping the station busy throughout the day. The station has one side platform and one island platform. In addition, 11 short-term and 98 long-term parking spaces are available.

The station is in the middle of Amtrak's San Joaquin route, which offers four daily round trips to the San Francisco Bay Area and two daily round trips to Sacramento and Bakersfield, with bus connections to Los Angeles and other destinations. The station is also served by Fresno Area Express Line 22. In 2012, the station served an average of 1,080 passengers per day. Fresno's airport, Fresno/Yosemite International Airport, is approximately 6 miles from the downtown Amtrak station.[60] To travel to the airport from the station, one would walk several blocks into downtown and catch the Line 26 bus, which provides a 35-minute trip to the airport.

MÁLAGA

Urban Bus (lines)	Suburban/Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)
Yes (8)	Yes	No (N/A)	No (N/A)	Yes (3)

Málaga is a large port city in Southern Spain's Andalucia region and capital of the Málaga Province. Málaga, thriving on its tourism industry, is the economic hub for the Costa del Sol region. The city, which enjoys a Mediterranean climate, features beaches, hiking trails, historical sites and monuments, museums, and many retail options. Málaga is a compact city, with its center being very pedestrian-friendly. Its seaport is the oldest continuously-running port in Spain, and one of the oldest in the Mediterranean. The port thrives on cruise ships and importation of containers. Fishing activity also occurs from the port.

Transportation

Bus Lines

The EMT (Empresa Malagueña de Transportes) operates 49 local public bus routes in Málaga. Service is frequent, with a majority of the routes passing through or near the city center. This allows for quick and easy connections. Most bus stops give clear route information and many have an electronic display of the time the next bus is due. Local public transport (bus and rail) represents 12.6% of travel.

Figure 14. Malaga Area Map

Pedestrian/Bicycles

Málaga, unlike most other European cities, generally has low bicycle usage. Bicycles represent just 0.4% of travel in the city. Most of the road infrastructure does not include dedicated lanes for bicyclists. At present, Málaga only has 7.5 km of bicycle lanes on its streets. Málaga is dedicated to increasing bicycle usage in the city, both for work and for recreational purposes. The

historical center of Málaga and the harbor are pedestrian and bicycle zones, creating a safe environment for pedestrians and bicyclists. Bicycle rentals and tours are available in the city.[61]

Málaga also has several innovative and eco-friendly forms of transportation. Málaga is well known for its bike taxis, or "trixis." Passengers can board a covered carriage powered by a person riding a bicycle. Because of their small size and narrow configuration, trixis can weave in and out of traffic. This mode of transportation is utilized both as a regular taxi and as a sightseeing service.

Private Vehicles

Private vehicles represent 42% of travel within the city. Málaga has two highway rings: one around the center, and a second on the outside edge of the city. A strong "car culture" leads to heavy congestion within the city, especially in its core.

Train

As with other European cities, train services that serve Málaga are modern, extensive, and efficient. Inter- and intra-city train travel is fairly simple. Two metro lines are under construction, which could decrease private vehicle use in the future.

Málaga Train Station

Málaga's main train station, María Zambrano Station, opened in 2004 and is located southwest of the city center. It serves both local and intercity passenger rail stations. The terminal station is across the street from the city's main bus station and is quite close to the port, as well as to the Málaga Airport. The station contains many features, including a hotel, VIP lounge, car rental offices, travel center, underground parking, tourist information center, cafes, bars, and a shopping center that includes many stores and a cinema with ten theaters. Parking spaces are available as well. The station serves around 6,500 passengers per day.[62]

HSR Impact on Málaga

In addition to the profound impact of HSR on transportation patterns in and around Spain, the HSR stations have been generally found to produce profound urban restructuring.[63] Bellet notes that "the implementation of [high-speed rail] services in Spanish cities has, above all, been interpreted as an excellent opportunity to restructure urban space in a similar way to that achieved with the arrival of the first railways back in the 19th century there."[64] Cities like Cordoba, which lies in the route between Madrid and Málaga, "saw urban regeneration around the HSR station, which was built in the city center."[65] A comparative analysis of the impact of HSR on Spanish cities found Málaga to have benefited highly, particularly in the form of accessibility benefits to residents.[66]

Local Perspectives

Both cities have pedestrian/bicycle-only zones in the center of their cities, with Málaga having several more of these areas. The train stations in both cities are centerpieces of their respective cities, with Fresno's station having earned recognition (and significant Amtrak ridership), while Málaga's is a major transportation hub. The operating hours of both stations are similar, being open from early in the morning to late in the evening. The economic conditions of the two cities are very different; whereas Málaga is a thriving tourist destination, Fresno is more of a residential area, centered around the agriculture industry. Málaga, with its dense design, has many monuments, museums, and cafes, which are much more conducive to walking and cycling than is Fresno.

Even though Málaga is a terminal station with passengers traveling only in one direction, and in spite of its location outside of Málaga's downtown areas, it is much busier than Fresno's station. Málaga's station is served by several rail service providers with frequent headways, and eight of Málaga's forty-nine local bus routes connect to the station. The station also connects to intercity bus lines. In comparison, Fresno is served only by a single rail service provider with six daily round trips and only one of its sixteen local bus routes serve the station. The closest intercity bus station is a half-mile away. Málaga's station is also a destination in itself: it contains a hotel, a mall, a theater, cafes, and bars. Fresno's station is composed of a passenger waiting area with some office space. In Málaga, access to the airport from the train station has quick and frequent rail and bus services, whereas Fresno's connections take longer and have lower frequencies.

Málaga has more innovative options for travelling in the city from the HSR station. There is a Segway (personal mobility) rental site, as well as horse drawn carriages and an abundance of taxis. Fresno is more bicycle-friendly than Málaga, with more bicycle infrastructure currently in place and significantly more miles of bicycle paths, trails, and designated bicycle parking areas, but bicycle use is deterred by the presence of four freeways and two railroads that cut through the city, as well as occasionally extreme weather conditions. Málaga's low cycling rate can be attributed to the lack of bicycle infrastructure.

Recently, the Fresno County Board of Supervisors voted to remove support from the HSR project, primarily due to strong, ideologically based opposition from a majority of that body.[67] The current mayor, Ashley Swearengin, is a staunch supporter of the system and wishes to create an HSR station in downtown Fresno that will maximize development in that area. She sees the future HSR station as something that can help to revitalize the city's downtown area. The major decisions remaining regarding the Fresno HSR system are the station's location and the station's design. The Mayor has steadfastly supported a downtown location at the corner of Mariposa and H streets. Planning efforts are focused on approximately 7,200 acres in that area. It is likely that, over time, Fresno's elected officials will take appropriate steps to accommodate HSR.

Funding for the station will comes from a variety of sources, including around $1 million from the American Recovery and Reinvestment Act (ARRA), a $17 million Transportation Investment Generating Economic Recovery (TIGER) grant from the USDOT, as well as $100,000 Prop 1A funds specifically for HSR development. The key expenditure to date has

been the awarding of a consulting contract for the "High-Speed Rail Station Area Master Plan," which will "chart Fresno's strategy to turn the state and federal investment in high-speed rail into job growth, wealth creation, and downtown development that enriches our community for decades to come."[68] The contract was awarded to AECOM, an international firm with experience in developing HSR stations in other countries.[69]

Much depends on the plans developed by AECOM, but many of the major considerations regarding transit connections have already been identified. According to City planning staff, CAHSRA is "very active" in advocating transit connectivity. The key issue is to what extent the City of Fresno will change the way it defines itself as the project moves forward. As a major Central Valley city with an HSR Station, Fresno can move toward a vison of itself that takes advantage of HSR, improves connectivity to the existing rail lines, and connects its institutions and downtown infrastructure to the rest of California.

As in Gilroy, Fresno city officials and staff are keenly aware of the necessity (and opportunity) to optimize transit and other modal connections with the new HSR station. However, in Fresno concerted political opposition, as well as the uncertainty of funding levels for the station, create a less-than-ideal environment for this to occur. Key decisions about the location and design of the HSR station are being held in abeyance while funding levels and the content of the AECOM plan are sorted through. Fresno will probably never match Málaga, but the station has the potential to both improve downtown Fresno and vastly improve connections to and from it.

CONCLUSIONS AND RECOMMENDATIONS

While there are differences of opinion on affordability, importance, and priority on HSR in California, evidence from international practices can provide an example of what decisions should be considered. Each California city will define its links to the HSR project as it is built and, in some cases, will take steps ahead of time to prepare new services and connections that will meet the needs of their populations and take advantage of the economic development opportunities that will be created by the new statewide connections. The utility of this statewide investment and its impact on local economic development will alter the attractiveness of each area to employers and tourists. Indeed, it will likely create national competition for jobs and economic activity. It can be expected that each city will work at its own pace in considering the impact of an HSR hub and the changes that must be considered in order to take full advantage of the new systems.

Generally speaking, the European and Asian comparison cities of Málaga, Fulda, and Tianjin offer only a glimpse of the true potential for the California stations currently planned for Fresno, Gilroy, and Los Angeles. Already mature and serving in the context of much more heavily used transit systems, the international examples ought to be viewed as future targets by California planners, albeit targets that will become increasingly realistic as the state's population grows, as the HSR project is implemented, and as local decision-makers realize that they can mazimize the benefits of HSR by improving connections.

The more significant lessons gleaned from HSR activities around the world include:

- A trunk line of HSR stations that connects urban areas provides state and local governments with many opportunities to significantly improve local connections available to the public.

- Consideration should be given to improved and better-timed bus connections, setting aside space for taxi and rideshare interfaces, providing bicycle facilities, and creating excellent pedestrian pathways to hub stations and connecting modes.

- The number of lines and modes available is directly related to the size of the urban area and the amount of economic activity generated. For the largest California cities, commuter, light rail, and Metro connections will be important. For smaller cities, improved bus connections must be considered.

- In general, public transport systems at the local level are improved and given more utility when connected to an HSR system. Local decision makers will need to analyze the costs and benefits of any improvements that they consider, as additional funding will be required.

- In the United States, politics and the political process at the national, regional, and local levels affect planning and execution of a High Speed Rail program and influence whether long-term investments in transportation infrastructure are available and are generally agreed to. In California, each location examined has its unique political challenges. This is a marked difference from projects in Europe and Asia, where top-down decision-making is the norm.

- Connection quality deserves a great deal of attention: agencies should promote good signage, create excellent pathfinding, and provide top-notch customer information. Goals should include:
    - Path markings showing where travelers need to go to make their connections;
    - Signs showing where connecting services go;
    - Development of the shortest possible paths between connections;
    - Escalator and elevator availability for level changes;
    - Information for passengers about the locations of connecting services and available destinations;
    - Integrated fare systems to simplify the use of connecting services;
    - These items should be developed in the most convenient and integrated manner possible.

A coordinated approach to the creation of a new HSR system in California, and the establishment of good connection services, is difficult to achieve due to local politics, decentralized decision-making, the lack of easily available resources, and the general lack of consensus on the overall project. The authors believe that the provided case studies offer evidence and guidance to local decision-makers and shows that establishing high-quality connections to new HSR systems in their communities will create jobs, promote economic activity, and help to establish new interregional economic activity. The bottom line is that locations connected by high speed rail that include high-quality local connections succeed in being more attractive to tourists, have more appeal to companies and institutions, and help these areas compete on a national and statewide level.

The efforts currently underway to coordinate efforts between local officials and the California High Speed Rail Authority will benefit from the insights offered in this study. Good connections are essential to maximize the benefits of a new HSR hub. Throughout the world, HSR has established new economic development patterns and assisted in local competitiveness. Unlike traditional passenger rail services, HSR offers speeds that alter the perception of place and distance and can make a significant local impact. Improved local connections will help transform these places.

APPENDIX A: DESCRIPTIVE DATA FOR SELECTED STATIONS

Table 1. Belgian Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Brussels South	1,119,000	Yes (5)	No	Yes (8)	Yes (2)	Yes (20)	High
Antwerpen Central	502,604	Yes (4)	No	Yes (4)	No (N/A)	Yes (20)	High
Liege-Guillemins	194,715	Yes (2)	Yes	No (N/A)	No (N/A)	Yes (9)	Medium-High

Table 2. Chinese Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Beijing South	20,680,000	Yes (19)	Yes	No (N/A)	Yes (1)	No (N/A)	High
Tianjin	12,990,000	Yes (9)	Yes	No (N/A)	Yes (3)	Yes (1)	High
Jinan West	4,335,900	Yes (2)	Yes	No (N/A)	No (N/A)	No (N/A)	Medium
Nanjing South	8,161,800	No (N/A)	No	No (N/A)	Yes (1)	No (N/A)	High
Shanghai Hongqiao	23,020,000	Yes (8)	Yes	No (N/A)	Yes (2)	No (N/A)	High

Table 3. French Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Paris North	2,234,000	Yes (5)	Yes	No (N/A)	Yes (4)	Yes (8)	High
Charles de Gaulle Airport	2,234,000	Yes (5)	Yes	No (N/A)	Yes (1)	No (N/A)	Medium
Part Dieu	484,344	Yes (14)	Yes	Yes (4)	Yes (1)	Yes (13)	High
Lyon Saint Exupery	484,344	No (N/A)	No	Yes (1)	No (N/A)	No (N/A)	Low
Marseille Saint Charles	851,420	Yes (5)	Yes	No (N/A)	Yes (2)	Yes (13)	High
Aix en Provence	158,098	Yes (5)	Yes	No (N/A)	No (N/A)	No (N/A)	Low
Nimes	140,747	Yes (2)	Yes	No (N/A)	No (N/A)	Yes (9)	High
Valence	66,592	Yes (1)	Yes	No (N/A)	No (N/A)	Yes (3)	Low

Table 4. German Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Berlin Central	3,520,000	Yes (10)	Yes	No (N/A)	Yes (1)	Yes (15)	Medium
Cologne Central	1,017,000	Yes (8)	Yes	No (N/A)	Yes (3)	Yes (4)	High
Frankfurt Central	691,518	Yes (8)	Yes	Yes (9)	Yes (2)	Yes (9)	Medium
Frankfurt am Main Airport	691,518	Yes (13)	No	No (N/A)	No (N/A)	Yes (2)	Low
Stuttgart Central	613,392	Yes (6)	Yes	Yes (15)	Yes (8)	Yes (7)	Medium
Wurzburg Central	133,808	Yes (4)	Yes	Yes (4)	No (N/A)	Yes (10)	Medium
Ingolstadt	126,732	Yes (7)	Yes	No (N/A)	No (N/A)	Yes (7)	Medium
Fulda	62,249	Yes (2)	Yes	No (N/A)	No (N/A)	Yes (6)	Medium

Table 5. Italian Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Roma Termini	2,777,979	Yes (15)	No	Yes (2)	Yes (2)	Yes (8)	High
Naples Central	959,574	Yes (14)	Yes	No (N/A)	Yes (3)	Yes (1)	High
Bologna Central	373,010	Yes (7)	Yes	No (N/A)	No (N/A)	Yes (8)	High
Verona Porta Nuova	265,410	Yes (6)	Yes	No (N/A)	No (N/A)	Yes (5)	Medium
Milano Central	1,350,267	Yes (3)	No	Yes (5)	Yes (2)	Yes (7)	High

Table 6. Japanese Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Tokyo	13,220,000	Yes (10)	Yes	No (N/A)	Yes (1)	Yes (8)	High
Nagoya	2,267,000	Yes (15)	Yes	No (N/A)	Yes (2)	Yes (9)	High
Kyoto	1,473,746	Yes (15)	Yes	No (N/A)	Yes (1)	Yes (20)	High
Kagoshima Chuo	605,855	Yes (3)	Yes	Yes (2)	No (N/A)	Yes (11)	High
Hakata	1,483,000	Yes (24)	Yes	No (N/A)	Yes (1)	Yes (23)	High
Fukushima	290,064	Yes (3)	Yes	No (N/A)	No (N/A)	Yes (5)	High

Table 7. Dutch Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Amsterdam Central	801,200	Yes (8)	Yes	Yes (11)	Yes (3)	Yes (20)	High
Schiphol	138,392	Yes (21)	Yes	No (N/A)	No (N/A)	Yes (12)	Medium
Rotterdam Central	617,347	Yes (6)	Yes	Yes (11)	Yes (2)	Yes (16)	High

Table 8. South Korean Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Seoul	10,580,000	Yes (26)	Yes	No (N/A)	Yes (2)	Yes (3)	High
Yongsan	10,580,000	Yes (18)	Yes	No (N/A)	Yes (1)	Yes (7)	High
Osong	663,745	Yes (N/A)	Yes	No (N/A)	No (N/A)	Yes (1)	Low
Daejeon	1,539,154	Yes (18)	Yes	Yes (1)	Yes (1)	Yes (2)	High

Table 9. Spanish Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Madrid Atocha	3,234,000	Yes (18)	Yes	No (N/A)	Yes (1)	Yes (8)	High
Madrid Chamartin	3,234,000	Yes (3)	Yes	No (N/A)	Yes (2)	Yes (6)	High
Toledo	83,108	Yes (2)	No	No (N/A)	No (N/A)	No (N/A)	Medium
Ciudad Real	74,011	Yes (3)	Yes	No (N/A)	No (N/A)	Yes (3)	Medium
Cordoba Central	325,453	Yes (6)	Yes	No (N/A)	No (N/A)	Yes (7)	Medium
Seville Santa Justa	703,021	Yes (6)	No	No (N/A)	No (N/A)	Yes (9)	High
Antequera Santa Ana	45,854	Yes (1)	Yes	No (N/A)	No (N/A)	Yes (3)	Medium
Maria Zambrano (Málaga)	568,507	Yes (8)	Yes	No (N/A)	No (N/A)	Yes (3)	High
Zaragoza Delicias	702,090	Yes (4)	Yes	No (N/A)	No (N/A)	Yes (11)	Medium
Camp De Tarragona	134,085	Yes (4)	No	No (N/A)	No (N/A)	Yes (4)	Low
Barcelona Sants	1,620,943	Yes (7)	Yes	No (N/A)	Yes (2)	Yes (14)	High
Albacete	172,472	Yes (3)	Yes	No (N/A)	No (N/A)	Yes (7)	Medium

Table 10. Swedish Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Stockhom Central	837,031	Yes (10)	Yes	No (N/A)	Yes (7)	Yes (12)	High
Gothenburg Central	509,847	Yes (12)	Yes	Yes (4)	No (N/A)	Yes (4)	High
Malmo Central	303,873	Yes (8)	Yes	No (N/A)	No (N/A)	Yes (6)	High

Table 11. Taiwanese Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Taipei	2,619,000	Yes (15)	Yes	Yes (2)	Yes (2)	Yes (2)	High
Taoyuan	369,770	Yes (8)	Yes	No (N/A)	No (N/A)	No (N/A)	Medium
Chiayi	34,330	Yes (2)	Yes	No (N/A)	No (N/A)	No (N/A)	Medium
Tainan	1,876,312	Yes (6)	Yes	No (N/A)	No (N/A)	No (N/A)	High

Table 12. Turkish Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
Ankara Central	4,388,620	Yes (7)	No	No (N/A)	Yes (1)	Yes (6)	Medium
Konya Central	1,074,000	Yes (1)	No	Yes (2)	No (N/A)	No (N/A)	High

Table 13. British Stations

Station Name	City Population	Urban Bus (lines)	Suburban/ Regional Bus Service	Tram/Light Rail Service (lines)	Subway Service (lines)	Regional/Commuter Train Service (lines)	Station Area Density
St. Pancras	8,174,000	Yes (14)	Yes	No (N/A)	Yes (6)	Yes (9)	High

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Brussels South
https://www.b-europe.com/Travel/Practical/Station%20information/Brussels%20Midi

Antwerpen Central
http://www.belgianrail.be/en/stations-and-train/search-a-station/6/antwerpen-centraal.aspx

Liege-Guillemins
https://www.b-europe.com/Travel/Practical/Station%20information/Li%C3%A8ge-Guillemins

Beijing South
http://www.chinatrainguide.com/beijing-railway-station/beijing-south.html

Tianjin
http://www.chinahighlights.com/china-trains/tianjin-east-railway-station.htm

Jinan West
http://www.chinahighlights.com/china-trains/jinan-west-railway-station.htm

Nanjing South
http://www.chinahighlights.com/china-trains/nanjing-south-railway-station.htm

Shanghai Hongqiao
http://www.chinahighlights.com/china-trains/shanghai-hongqiao-railway-station.htm

Paris North
https://www.raileurope.com/europe-travel-guide/france/paris/train-station/nord-train-station.html

Charles de Gaulle Airport
https://www.raileurope.com/europe-travel-guide/france/paris/train-station/charles-de-gaulle-train-station.html

Part Dieu
https://www.raileurope.com/europe-travel-guide/france/lyon/train-station/part-dieu.html

Lyon Saint Exupery
https://www.raileurope.com/europe-travel-guide/france/lyon/train-station/gare-de-lyon-saint-exupery-tgv.html

Marseille Saint Charles
https://www.raileurope.com/europe-travel-guide/france/marseille/train-station/st-charles-train-station.html

Aix en Provence
https://www.raileurope.com/europe-travel-guide/france/aix-en-provence/train-station/gare-aix-en-provence-tgv.html

Nimes
http://www.gares-sncf.com/fr/gare/frfni/nimes

Valence
http://www.gares-sncf.com/fr/gare/frvaf/valence

Berlin Central
https://www.raileurope.com/europe-travel-guide/germany/berlin/train-station/central-train-station.html

Cologne Central
https://www.raileurope.com/europe-travel-guide/germany/cologne/train-station/cologne-central-train-station.html

Frankfurt Central
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Frankfurt am Main Airport
https://www.raileurope.com/europe-travel-guide/germany/frankfurt/train-station/frankfurt-airport-train-station.html

Stuttgart Central
http://www.stgt.com/stuttgart/trans_main_station_eng.htm

Wurzburg Central
http://www.bahnhof.de/bahnhof-de/Wuerzburg_Hbf.html

Ingolstadt
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Fulda
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Roma Termini
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Naples Central
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Bologna Central
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Verona Porta Nuova
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Milano Central
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Tokyo
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Nagoya
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Kyoto
http://www.kyoto-station-building.co.jp/english/

Kagoshima Chuo
http://www.japanvisitor.com/japan-train-stations/kagoshima-chuo-station

Hakata
http://yokanavi.com/eg/landmark/index/46

Fukushima
http://www.jreast.co.jp/e/stations/e1352.html

Amsterdam Central
http://www.amsterdam.info/central-station/

Schiphol
http://www.schiphol.nl/Travellers/ToFromSchiphol/PublicTransport/ByTrainDomestic.htm

Rotterdam Central
https://www.b-europe.com/Travel/Practical/Station%20information/Rotterdam%20Centraal

Seoul
http://english.visitkorea.or.kr/enu/SI/SI_EN_3_1_1_1.jsp?cid=1265888

Yongsan
http://english.visitkorea.or.kr/enu/SI/SI_EN_3_1_1_1.jsp?cid=1357936

Osong
https://en.rail.cc/osong-station/cheongju/station/13858/2005

Daejeon
http://english.visitkorea.or.kr/enu/SI/SI_EN_3_1_1_1.jsp?cid=1903068

Madrid Atocha
https://www.raileurope.com/europe-travel-guide/spain/madrid/train-station/atocha-train-station.html

Madrid Chamartin
https://www.raileurope.com/europe-travel-guide/spain/madrid/train-station/madrid-chamartin-train-station.html

Toledo
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Ciudad Real
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Cordoba Central
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http://www.adif.es/es_ES/infraestructuras/estaciones/51003/informacion_000061.shtml

Antequera Santa Ana
http://www.adif.es/es_ES/infraestructuras/estaciones/2003/informacion_000016.shtml

Maria Zambrano (Málaga)
http://www.adif.es/es_ES/infraestructuras/estaciones/54413/informacion_000240.shtml

Zaragoza Delicias
http://www.adif.es/es_ES/infraestructuras/estaciones/4040/informacion_000020.shtml

Camp De Tarragona
http://www.adif.es/es_ES/infraestructuras/estaciones/4104/informacion_000021.shtml

Barcelona Sants
http://www.adif.es/es_ES/infraestructuras/estaciones/71801/informacion_000097.shtml

Albacete
http://www.adif.es/es_ES/infraestructuras/estaciones/60600/informacion_000073.shtml

Stockholm Central
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Gothenburg Central
http://www.stationsinfo.se/station/goteborgcentral/

Malmo Central
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Taipei
http://www.metro.taipei/

Taoyuan
http://service.tra.gov.tw/en/CP/11434/Taoyuan.aspx

Chiayi
http://service.tra.gov.tw/en/CP/11434/Chiayi.aspx

Tainan
http://service.tra.gov.tw/en/CP/11434/Tainan.aspx

Ankara Central
http://www.turkeytravelplanner.com/go/CentralAnatolia/Ankara/trans/gar.html

St. Pancras
http://stpancras.com/

APPENDIX B: INTERVIEWEES

California High-Speed Rail Authority

Dan Hoyt, Station Area Planning

Michelle Boehm, Southern California Liaison, California High Speed Rail Authority

Caltrans and related

Kate White, Deputy Secretary, Environmental Policy and Housing Construction, Caltrans

Allison Joe, Deputy Director, California Strategic Growth Council
Kelly Eagan, Transit Connectivity Project Manager, Caltrans

Chris Ratekin, Chief, Transit Planning Branch Office of Community Planning

Los Angeles and related

Jenna Hornstock, Director, Union Station Master Plan, Los Angeles County Metropolitan Transportation Authority

Don Sepulveda, Executive Officer, Regional Rail, Los Angeles County Metropolitan Transportation Authority

Hasan Ikharta, Executive Director, Southern California Association of Governments

Roderick Diaz, Director of Planning and Development, Southern California Regional Rail Authority

Miles Mitchell, Coordination Planning, Los Angeles Department of Transportation

Elissa Konove, Deputy Executive Director, SCRRA

Fresno and related

John Downs, Planning Division Manager, Department of Transportation/FAX

Dan Hoyt, PB Consult

Barbara Steck, Deputy Director, Fresno Council of Governments

Wilma Quan-Schecter, Urban Planning Specialist, City of Fresno

Scott Mozier, Public Works Director, City of Fresno

City of Gilroy and related

Tammy Brownloe, President, Economic Development Corporation, City of Gilroy

Valerie Negrete, Planner, City of Gilroy

Christie Abrams, Gilroy Community Development Director, City of Gilroy

Rick Smelser, Director of Public Works, City of Gilroy

Henry Servine, Transportation Engineer, City of Gilroy

Lee Butler, Development Center Manager, City of Gilroy

Mike Gallant, Transit Planner, Monterey-Salinas Transit

Steven Fisher, Transportation Planner, Santa Clara Valley Transportation Authority

ABBREVIATIONS AND ACRONYMS

ARRA	American Recovery and Reinvestment Act
CAHSRA	California High Speed Rail Authority
CALSTA	California State Transportation Agency
CRH	China Railway High-Speed
EMT	Empresa Malagueña de Transportes
FAX	Fresno Area Express
GDP	Gross Domestic Product
HSR	High Speed Rail
JPA	Joint Powers Authority
LACMTA	Los Angeles County Metropolitan Transportation Authority
LADOT	Los Angeles Department of Transportation
OCTA	Orange County Transportation Authority
OMA	Office of Metropolitan Architecture
RCTP	Regional Connector Transit Project
SCAG	Southern California Association of Governments
SCRIP	Southern California Regional Interconnector Project
SCRRA	Southern California Regional Railroad Authority
SEZ	Special Economic Zone
SOM	Skidmore, Owings and Merrill
SR	State Route
THSR	Taiwan High Speed Rail
TIGER	Transportation Investment Generating Economic Recovery
USDOT	United States Department of Transportation
VTA	Valley Transportation Authority

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