STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT DOCUMENTATION PAGE

DRISI-2011 (REV 10/1998)

1. REPORT NUMBER	2. GOVERNMENT ASSOCIATION NUMBER	3. RECIPIENT'S CATALOG NUMBER
CA-20-3025		

4. TITLE AND SUBTITLE Understanding Modal Access/Egress for California High-Speed Rail Stations	5. REPORT DATE April 2020
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR Susan Shaeen, PH.D., Edward T. Forescher, Adam Cohen	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Berkeley Transportation Sustainability Research Center 2150 Allstron Way, #280 Berkeley, CA 94704	10. WORK UNIT NUMBER
	11. CONTRACT OR GRANT NUMBER
12. SPONSORING AGENCY AND ADDRESS Caltrans DRISI 1727 30th Street, MS 82 Sacramento, CA 95816	13. TYPE OF REPORT AND PERIOD COVERED Final Report (July 2019 to December 2019)
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The California High-Speed Rail Authority is responsible for planning, designing, building and operating the first High-Speed Rail (HSR) in the nation. According to Caltrans, 2018 California State Rail Plan, interregional travel is expected to increase by 50.9 percent to 544 million trips annually by 2040. Much of that may be on a HSR segment that is well connected to a statewide network. Given this forecast in growth, coupled with projected innovations in transportation that could influence traveler behavior (automated vehicles, urban air mobility), this study looked at how users may access HSR stations in the future. The study included a literature review, expert interviews, a focus group, and a discrete modeling analysis. Participants revealed they were familiar with shared mobility, and as knowledge grows, the inclination to use it also grows. This results in HSR stations potentially acting as mobility hubs that integrate a variety of mobility services, which draws people to mixed use areas, encouraging businesses to relocate near the station, and revitalizing areas to help with economic development. HSR may also support local planning, particularly housing, by helping to increase density to support transit-oriented development. Information on the present San Jose--Diridon station, and the future Fresno and Kings/Tulare HSR Stations revealed different results depending on their location and the area's future plans. The city of San Jose is looking at ways to increase bicycle and pedestrian access as the Diridon Station evolves into a HSR station. The city of Fresno is transforming its downtown into a dense, walkable area, supporting many ways to access the future Fresno HSR Station. When the Kings/Tulare HSR station is completed near Highways 198 and 143, most access will be limited to private vehicles, though the Tulare County Transit agency is considering a bus line to increase bus station access. Focus group participants in Kings and Tulare counties reported they relied on private vehicles, and were inclined to use that mode rather than trying a new mode. Participants were optimistic about active modes (bikesharing, Transportation Network Companies), but offered concerns (lack of infrastructure, high temperature, availability of drivers and trustworthiness). Survey and model results reported that parking availability was a critical component, with decreasing or eliminating parking significantly changing results.

17. KEYWORDS	18. DISTRIBUTION STATEMENT	
High-Speed Rail, Access, High-Speed Rail Station, mobility hubs, active modes, bikesharing, Transportation Network Companies.		
19. SECURITY CLASSIFICATION (*of this report*)	20. NUMBER OF PAGES 108	21. COST OF REPORT CHARGED

DISCLAIMER STATEMENT

APRIL 2020

UNDERSTANDING MODAL ACCESS/EGRESS FOR CALIFORNIA RAIL STATIONS

ANALYSIS FROM THE SAN FRANCISCO BAY AREA AND CENTRAL VALLEY MARKETS

SUSAN SHAHEEN, PH.D.
EDWARD T. FORSCHER
ADAM COHEN
ALEX NELMS
EMILY FARRAR
JACQUELYN BROADER

UNIVERSITY OF CALIFORNIA Berkeley Transportation Sustainability RESEARCH CENTER
Berkeley Institute of Transportation Studies

doi:10.7922/G2SN076K

TABLE OF CONTENTS

List of Figures

List of Tables

List of Equations

Acknowledgements

The authors would like to thank the California High-Speed Rail Authority (Authority) and Caltrans for their close collaboration throughout the study. We would also like to thank members of the Transportation Sustainability Research Center (TSRC) who provided invaluable support throughout the study, including the study advisory panel members who provided feedback on the study design and peer reviewed the final report. Thanks also go to all the subject matter experts who agreed to participate in interviews with our team and whose invaluable input strengthened findings presented in this study. The statements and conclusions in this paper are those of the authors and not necessarily those of the Authority or Caltrans. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Executive Summary

The California High-Speed Rail Authority (Authority) is currently planning and building a high-speed rail (HSR) project that will connect the mega-regions of the state. The system, once completed, will extend from San Diego to Sacramento, totaling 800 miles. Currently, the Authority is constructing Phase 1 of the system, a 520-mile stretch that will connect San Francisco to Los Angeles via the Central Valley with a total trip duration under three hours. Goals of the project include increasing mobility throughout the state, improving air quality by shifting people from vehicles and planes to trains that run on renewable energy, reducing travel times, and stimulating job growth.

This report was prepared to help further understanding of perceptions of HSR and provide recommendations for station design, primarily to support HSR's environmental goals. A key unanswered question is how Californians will access and egress HSR stations given: 1) the system's similarities and differences in relation to airports and conventional rail systems; 2) historic dependence on auto travel in the United States and California; 3) mobility innovations, such as shared modes (e.g., transportation network companies [also known as TNCs, ridesourcing and ridehailing], microtransit, and micromobility); and 4) the potential impact of emerging mobility technologies such as automated and shared automated vehicles (AVs and SAVs) and urban air mobility (UAM).

The researchers studied three station areas – Fresno, Kings/Tulare, and San José – that represent a variety of built environments and demographics. The study employed a multimethod approach consisting of a literature review, expert interviews (N = 9), a focus group (N = 8), a user survey (N = 2,256), and a discrete choice modeling analysis to further understanding of how HSR stations will be used, perceptions of HSR, and access/egress modes to HSR stations. A summary of each section of the report is presented below.

Literature Review

Below, we present a summary of key ideas from the literature review:

- HSR stations may serve as both a connection point between different modes in the transportation network (a "node") and a destination for activities (a "place"). Stations must balance providing sufficient space for infrastructure (parking, charging stations, bus stops) and sufficient space for commercial attractions and walkability.
- Density, diversity in land use, and design may impact how people travel, though the extent to which this is true is uncertain.
- Travelers consider many attributes when making travel decisions, such as trip duration and cost. There is limited literature on mode choice related to rail station access and egress.
- While the relationship between conventional rail and HSR can vary by station type and HSR system, the literature indicates that smooth connectivity between the two can help establish HSR stations and promote activity at smaller intermediate stations.
- Interagency planning will likely need to be coordinated to provide a well-designed, well-connected station that is integrated into the surrounding built environment.

- The most inconvenience of the trip, or "friction," occurs when travelers make transfers between modes. Well-designed stations may be able to minimize this friction through a variety of strategies that seek to reduce friction and help travelers plan their trips. These include: providing consistent up-to-date information, reducing wait times, providing amenities, and accommodating passengers with mobility impairments.
- Existing literature recommends that a station's layout should seek to minimize the distance and time needed to transfer between modes, while also enhancing the traveler's experience. The layout should be organized based on a pedestrian's needs and prioritizing active modes and public transit. Station planners should consider compact parking structures and minimizing the parking footprint. Added parking fees do not seem to push travelers to alternative modes, though the fees studied may have been too low.
- The literature suggest cities and government agencies should work together to encourage dense, mixed-use developments around stations; provide walkable streets; and make transfers between public transit and stations convenient.
- Examples of airport-rail station integration exist around the world. The researchers examined three types of spatial integration developed by the Airport Cooperative Research Program.
- More research is needed on: travel behavior at HSR stations, how a station's layout impacts mode accessibility, rail stations in low density and rural areas, and best practices for interagency rail planning.

Expert Interview

Next, the researchers conducted semi-structured expert interview (N = 9) with experts from seven public agencies that are located in the San Francisco Bay Area or the Central Valley. The interviews were conducted in Spring 2018 and found that:

- The expert interview participants were knowledgeable about shared mobility. However, among the community members in their areas, the level of knowledge and usage of shared mobility varied. Residents of San José had access to most shared modes, residents of Fresno were familiar with them, but likely had limited access to services like transportation network companies (TNCS), and residents of Kings/Tulare were most familiar with vanpooling and carpooling.
- Participants were in consensus that HSR could be a valuable economic development tool, both for attracting employment centers and generating revenue around the station area. The participants were eager to know what the pricing structure would be for travel by HSR so that they could better estimate potential ridership.
- The three communities were already participating in local and regional planning processes related to HSR. The interviewees were worried about the project's impacts on housing prices, although some were excited about the potential for the project to encourage more housing developments.
- Regarding the benefits of HSR, the interviewees saw potential for job creation and revitalization. Regarding drawbacks, the interviewees discussed fear of the full system not being realized, an inability to reduce dependency on private vehicle ownership, and that the project would divert money from other public works' needs.

- The expert interview write-up also includes descriptions of station access at each of the three locations and plans to improve station access.

Focus Group

The researchers also conducted a focus group in Hanford, CA in Fall 2018 (N = 8). The focus group was intended to supplement the stated preference survey due to difficulties surveying efforts in Kings/Tulare counties. The following are key highlights from the focus group:

- The researchers conducted a focus group with eight Kings/Tulare area residents regarding HSR, travel patterns, and station investments.
- Optimistically, participants projected using HSR for interstate travel.
- In general, participants were comfortable with exclusively using personal vehicles for intracity and first-mile travel.
- The focus group was cautious in supporting shared modes (e.g., TNCs, scooter sharing), public transit, and active modes for both station travel and general use.
- A participant's perceptions of the travel modes were equally important to their prior experience using modes when they considered how they might travel to and from HSR stations.
- In regard to demographics, expert interviewees were hopeful that auto ownership rates would decline among their communities as a result of HSR. However, they were worried that HSR would widen income inequality gaps that are already present. Experts did not see HSR contributing to demographic shifts in Kings/Tulare counties.

Survey and Modeling

Finally, the researchers designed a stated preference survey to capture respondent preferences for modes to access and egress from HSR stations. Surveys were distributed via survey intercepts and through a Qualtrics panel. After data cleaning to remove unusable responses, duplicates, and incomplete responses, the survey had 2,256 respondents and answers to 7,507 choice experiments. Due to limited computational power, the research team used the bootstrapping method to help estimate the MNL model. The model estimated respondent preferences for using different transportation modes to access or egress from stations, compared against TNCs.

The primary findings from the MNL model estimation are as follows:

- Survey respondents preferred using TNCs to access the station compared to active modes. Respondents were less likely to choose electric bikesharing and scooter sharing compared to pedal-based bikesharing.
- The model results suggest that respondents prefer driving alone to taking a TNC to the station. Respondents did not seem to consider taking private automated vehicles (AVs), and seemed to actively dislike time spent carpooling and carpooling for leisure purposes.
- Respondents were insensitive to parking costs, though the choice experiment limited costs to no more than $11.
- Taxis were slightly preferred over pooled TNCs (e.g., UberPool or Lyft Line), and public transit was slightly preferred over microtransit. Respondents were sensitive to the potential costs of UAM trips and preferred using TNCs.

- Regionally, there were no statistically different results when comparing respondents from the Central Valley against respondents from the SF Bay Area.
- Future research can investigate full trip patterns. For example, researchers could examine the directional commute from the Central Valley to San José or further north in the SF Bay Area, asking sequenced mode choice questions that investigate joint choices between HSR and access/egress modes.

Keywords

High-speed rail, shared mobility, future mobility, mode choice modeling, automated vehicles

Common Terms

This section provides definitions of common shared mobility modes, followed by a table of abbreviations used throughout this report.

Table 1: Definitions of Shared Mobility Modes

Mode	Description
Bikesharing	Travelers access bicycles on an as-needed basis for one-way or roundtrip travel. Users may access bicycles vis-à-vis annual, monthly, daily, or per-trip pricing. Many bikesharing operators cover the costs of bicycle maintenance, storage, and parking. Bikesharing can include different service models including: • **Station-based Bikesharing:** Systems in which users access bicycles via unattended stations offering one-way station-based service (i.e., bicycles can be returned to any station). • **Dockless Bikesharing:** Systems in which users may check out a bicycle and return it to any location within a predefined geographic region. Dockless bikesharing can include Business-to-Consumer or Peer-to-Peer systems enabled through third-party hardware and applications. • **Hybrid Bikesharing:** Systems in which users can check out a bicycle from a station and end their trip by either returning it to a station or a non-station location. Alternatively, users can pick up any dockless bicycle and either return it to a station or any non-station location.
Carsharing	Travelers can use private vehicles without the costs and responsibilities of ownership by joining an organization that maintains a fleet of cars and light trucks deployed in lots located within neighborhoods and at public transit stations, employment centers, and colleges and universities. Typically, the carsharing operator provides gasoline, parking, and maintenance. Generally, participants pay a fee each time they use a vehicle.
Courier Network Services (also known as CNS, app-based delivery services, and flexible goods delivery)	These services offer for-hire delivery of food, packages, and other items. Deliveries are facilitated through internet-based applications or platforms (e.g., website, smartphone app) to connect delivery drivers using a personal transportation mode. These services can be used to pair package delivery with existing passenger trips, be exclusively for for-hire delivery services, or be mixed (for-hire drivers deliver both passengers and packages).
Microtransit	Privately or publicly operated technology-enabled transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing.
Personal Vehicle Sharing	The sharing of privately-owned vehicles where companies broker transactions between vehicle owners and guests by providing the organizational resources needed to make the exchange possible (e.g., online platform, customer support, safety certification).
Ridesharing (also known as carpooling and vanpooling)	The formal or informal sharing of rides between drivers and passengers with similar origin-destination pairings. Vanpooling, specifically, consists of seven to 15 passengers who share the cost of a van and operating expenses and may share driving responsibility.
Rural Air Mobility	An emerging concept envisioning safe, efficient, accessible, and quiet air transportation system for passenger mobility, cargo delivery, and emergency

Mode	Description
	management within or traversing rural and exurban areas. Rural air mobility is part of a broader ecosystem of services known as advanced air mobility (AAM).
Scooter Sharing	Users can access scooters by joining an organization that maintains a fleet of scooters at various locations. The scooter service typically provides gasoline or electric charge (in the case of motorized scooters), maintenance, and may include parking as part of the service. Generally, participants pay a fee each time they use a scooter and trips can be roundtrip or one-way. Scooter sharing includes two types of services: • **Standing Electric Scooter Sharing:** Uses shared scooters with a standing design with a handlebar, deck and wheels that is propelled by an electric motor; and • **Moped-style Scooter Sharing:** Uses shared scooters with a seated-design, electric or gas-powered, generally having a less stringent licensing requirement than motorcycles designed to travel on public roads.
Shared Automated Vehicles (SAVs)	Automated vehicles that are shared among multiple users and can be summoned on-demand or can operate a fixed-route service similar to public transportation. Further information on SAVs can be found in the "Connected and Automated Vehicles" section.
Shared Micromobility	The shared use of a bicycle, scooter, or other low-speed mode that enables users to have short-term access to a mode of transportation on an as-needed basis. Shared micromobility includes various service models and transportation modes, such as bikesharing and scooter sharing.
Shuttles	Shuttle services use shared vehicles (typically vans or buses) that connect passengers from a common origin or destination to public transit, hospitals, employment centers, etc. Shuttles services are typically operated by professional drivers and many provide complementary services to passengers.
Taxi Services	Taxis can offer prearranged or on-demand transportation services for compensation through a negotiated price, zoned price, or taximeter (traditional or global positioning system [GPS]-based). Trips can be scheduled in advance (through a phone dispatch, website), street hail (from raising a hand on the street, taxi stand, or specified loading zone), or e-hail (using a smartphone app).
Transportation Network Companies (TNCs, ridesourcing, ridehailing)	TNCs offer prearranged and on-demand transportation services for compensation in which drivers of personal vehicles connect with passengers. Digital applications are typically used for booking, electronic payment, and ratings.
Unmanned Aerial Systems (UAS)	An aircraft and its associated elements operated with no human on-board; it may be remotely piloted or fully autonomous.
Unmanned Aerial Vehicles (UAV)	Multi-use aircraft with no human pilot aboard, commonly referred to as 'drones'. UAVs can be remotely piloted or fully autonomous. Devices used for cargo delivery typically have four to eight propellers, rechargeable batteries, and attached packages underneath the body of the UAV.
Urban Air Mobility (UAM)	An emerging concept envisioning safe, efficient, accessible, and quiet air transportation system for passenger mobility, cargo delivery, and emergency management within or traversing metropolitan areas. Urban air mobility is part of a broader ecosystem of services known as advanced air mobility (AAM).

Table 2: Commonly Used Acronyms

ACRONYM	DEFINITION
ACE	Altamont Commuter Express
ACRP	Airport Cooperative Research Program
ACS	American Community Survey
ASC	Alternative Specific Constant
AV	Automated Vehicle
BART	Bay Area Rapid Transit
BRT	Buss Rapid Transit
CDG	Charles de Gaulle
DMA	Designated Market Area
EV	Electric Vehicle
HSR	High-Speed Rail
IOS	Initial Operating Segment
LTS	Level of Traffic Stress
MNL	Multinomial Logit
PAC	Project Advisory Committee
SAV	Shared Automated Vehicle
SF	San Francisco
SOV	Single-Occupancy Vehicle
TCAG	Tulare County Association of Governments
TNC	Transportation Network Company
TOD	Transit-Oriented Development
UAM	Urban Air Mobility
VTA	Valley Transportation Authority

Introduction

The California High-Speed Rail Authority (Authority) is responsible for planning, designing, building, and operating the first high-speed rail (HSR) in the U.S. When completed, California HSR will connect the mega-regions of the state, enabling travel between San Francisco and Los Angeles in under three hours. The system will eventually extend to Sacramento and San Diego, totaling 800 miles with up to 24 stations.

The Authority is currently in the process of constructing and implementing the Initial Operating Segment (IOS) of the system, a 171-mile segment between Merced and Bakersfield. Environmental planning is currently underway that would extend the system to the San Francisco (SF) Bay Area and the Los Angeles metropolitan region. This extension is known as Phase One.

In 2018, the California Department of Transportation (Caltrans) released the California State Rail Plan (Caltrans, 2018). According to an analysis comparing travel patterns and projections between 2010 and 2040, Californians took an estimated 361 million annual interregional trips in 2010. This estimate includes all modes of travel. California's busiest interregional travel market exists between the Los Angeles Basin and San Diego County (98.2 million annual person trips), followed by Sacramento to/from the SF Bay Area (42.3 million); the Bay Area to/from the northern San Joaquin Valley (31.2 million); the Los Angeles Basin to the southern San Joaquin Valley (25.1 million); and the Los Angeles Basin to the Central Coast (22.1 million). The state's rail plan forecasts that by 2040, interregional travel will increase by 50.9 percent to 544.7 million trips annually, out of which about 70 percent of the increased demand can be addressed through an efficient rail network, mainly in the mid- to long-distance range. California's mode shift model shows that almost 90 percent of the long-distance travel (200- to 350-mile range) may be partially or entirely on an HSR segment that is well connected to the statewide network.

California's five busiest interregional travel corridors by 2040 are projected to account for over 60 percent of the total 544.7 million interregional person trips by year 2040. See Figure 1 for an illustration of the anticipated growth in interregional personal travel between 2010 and 2040. The five busiest interregional travel corridors by 2040 include:

- Los Angeles Basin to/from San Diego (139.1 million),
- Sacramento to/from SF Bay Area (73.5 million),
- SF Bay Area to/from the northern San Joaquin Valley (48.9 million),

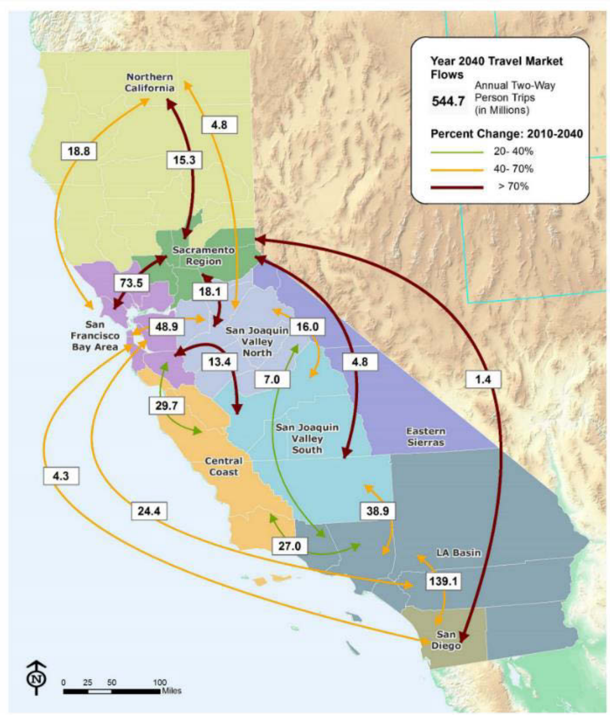

Figure 1: Growth of Interregional Personal Travel, 2010 to 2040
Source: California State Rail Plan

- Los Angeles Basin to the southern San Joaquin Valley (38.9 million), and
- SF Bay Area to/from Central Coast (29.7 million).

The state's rail plan forecasts that several regional pairs are expected to experience over 70 percent increases in interregional travel. These include the SF Bay Area-Sacramento, SF Bay Area-San Joaquin Valley South, Sacramento-San Diego, Sacramento-Northern California, Sacramento-San Joaquin North, and Sacramento-San Joaquin Valley-South pairs.

Given this forecast growth coupled with forecasted innovations in transportation that could influence traveler behavior (e.g., automated vehicles [AVs] and urban air mobility [UAM]), Caltrans and the Authority are interested in understanding best practices for planning HSR stations to accommodate current modal options as well as potential future modal options that may be evolve as HSR is constructed and deployed over the next decade. To help inform future station planning, Caltrans and the Authority are considering best practices for station characteristics that support HSR access and egress such as: intercity/commuter/regional rail systems; shared mobility; active transportation; parking; and opportunities for policy, pricing, design, and other factors to guide modal choice.

To investigate these research areas, Caltrans funded a study to help understand how users may access HSR in the future, thereby providing more informed investment and design decisions.

The researchers and Caltrans established a Project Advisory Committee (PAC) to help inform the study design. The advisory committee selected three station areas for detailed study: 1) San José, 2) Fresno, and 3) Kings/Tulare. See Appendix A for maps of the three locations. These three station areas include a variety of built environments and contexts such as: greenfield development, urban revitalization, and transit-oriented development (TOD). These station areas also represent diverse current and projected future demographics.

The study includes a multi-method approach comprised of a literature review, expert interviews, focus group, survey, and a discrete choice modeling analysis. This report consists of five sections. The report begins with a literature review describing characteristics of station design and travel including: 1) integration concepts, 2) transfer behavior, 3) station layout, 4) station area (i.e., area one quarter of a mile to a mile surrounding the station) considerations, and 5) airport design. The next section contains a summary of expert interviews that were used to fill gaps in the literature review and inform the survey development. The third section summarizes the focus group findings from Hanford, California, where a future HSR station (the Kings/Tulare regional station) is planned for construction outside of Hanford city limits. The fourth section presents the survey and modeling methods and access and egress mode choice estimation results comparing and contrasting individuals in Central Valley and SF Bay Area markets. The final section provides a summary of the report and the research findings.

Literature Review

This literature review contains six sections. First, the literature review discusses concepts behind the integration of various modes. This includes a brief overview of the different roles a train station can take, the influence of the built environment on mobility, theories behind mode choice, connectivity between HSR and conventional rail, and planning. Next, the literature review examines the transfer experience at rail stations and concepts for enhancing the traveler's experience at the station and when transferring modes. The third section focuses on a rail station's layout, focusing on design aspects that minimize transfer time and distance. The fourth section focuses on the one quarter- to one-mile area surrounding the station, describing ideas from the literature on methods to maximize station integration within the surrounding built environment. Next, the literature review provides a typology of spatial integration between airports and HSR and lessons learned from airport-HSR integration in France. The literature review concludes with a discussion of further opportunities for planning HSR stations, improving the accessibility of stations, and strategies to support multimodal integration.

Multimodal Integration Concepts

HSR is designed for the fast movement of people across different geographies. Researchers suggest that HSR can make regional markets function more efficiently by reducing transport frictions between markets, as well as allowing the supply and demand for products, services, and labor to more efficiently match (Nickelsburg et al., 2018; Ureña et al., 2009; van den Berg and Pol, 1998). Transport friction occurs in two main segments of the trip. Friction occurs not only with the traveler's movement on HSR through the long, uninterrupted segments between stations, but also with the traveler's movement between HSR stations and their origins and destinations (i.e., first- and last-mile trips). The first-mile trip is composed of: 1) the access mode taking the traveler from the origin to the station and 2) the traveler using the station to access the train. The last-mile trip is the same, in reverse; it is composed of: 1) the traveler using the station when departing from the train and 2) the mode used by the traveler to access their destination.

An HSR station can reduce transport friction by remaining accessible to multiple modes without compromising the mobility of those using other modes or the surrounding area's attractions. These goals were designated by the Authority in *Urban Design Guidelines* (California High-Speed Rail Authority, and PB PlaceMaking Group, 2011). In addition, an HSR station's accessibility to access and egress modes may impact the success of an HSR station in improving mobility and increasing use of HSR. Surveys and modeling conducted in various regions around the world have shown that intermodal connectivity is often the most important part of the rail trip in terms of satisfaction (Brons et al., 2009; Givoni and Rietveld, 2007; Monzón et al., 2016; Zhen et al., 2018).

To help readers understand HSR integration with other transport modes, the following subsections describe the role of the station in a transportation network, the impact of the surrounding built environment on HSR design, traveler mode choice, conventional rail and HSR connectivity, and inter-agency and regional planning. These concepts will assist readers in understanding the underlying concepts of the remaining sections of the literature review.

Role of Rail Stations in Transportation Networks

Bertolini and Spit, in *City on Rails* (1998), emphasize that a station primarily plays two roles:

- As a **node**, the station is the connection point for different networks — a physical network of transportation infrastructure (e.g., streets or transit lines) and a socio-economic network of behavior, communications, and activities.
- As a **place**, the station or activities in the immediate area function as the destination of the trip — the point of socio-economic value.

Using Wegener and Fürst's (2004) land-use transport feedback cycle (Figure 2), the node and its surrounding network lead to more accessibility and a higher density of activities, encouraging node demand. This cycle happens in the immediate area around the station (e.g., train riders walking to immediate businesses) and at the municipal/regional level (e.g., train riders driving to work on the other side of town).

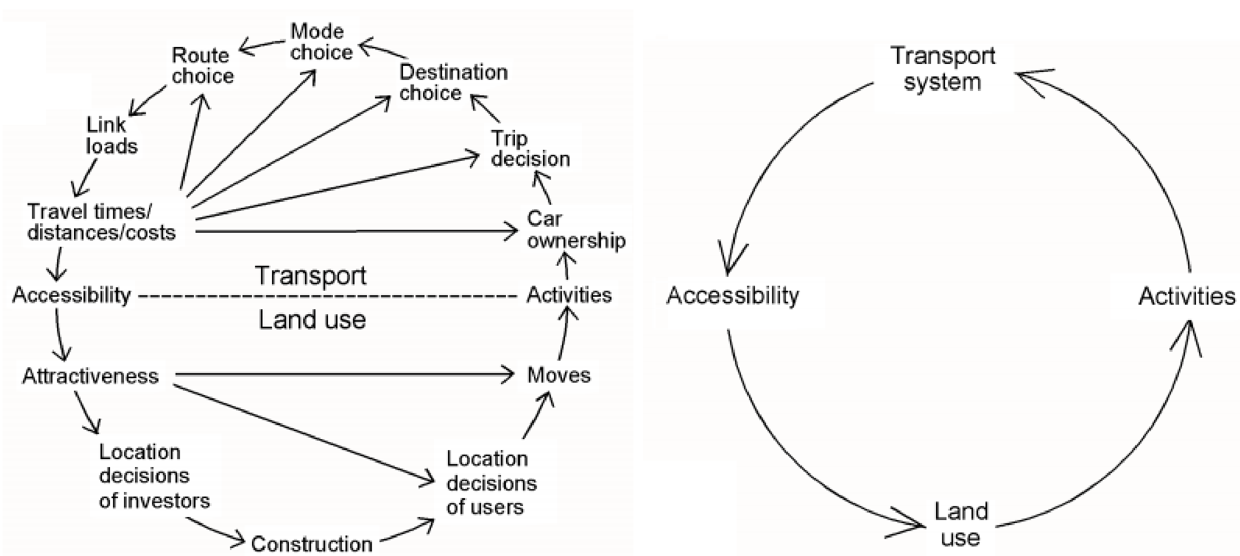

Figure 2. Land-Use Transport Feedback Cycle

Source: Michael Wegener and Franz Fürst, 2004

As the dual roles manifest physically, Bertolini and Spit emphasize that it leads to a physical and functional dilemma. The infrastructure for long-distance modes (e.g., parking, bus stops, local rail tracks) form barriers and consume space that can be used for commercial attractions (Bertolini and Spit, 1998; Cervero, 2002), impacting the station's ability to function as a "place." The growing attractions in the immediate station area require permeable walkways and commercial space (Loukaitou-Sideris, 2013). However, the land-use transport feedback cycle in the immediate station area is restricted if there is a lack of space to accommodate more attractions or accessibility to those attractions. Ideally, planning for HSR stations should balance the need for HSR to function efficiently as a "node" – providing sufficient infrastructure for connections and economic activities – and as a "place" – providing space for accessibility to commercial attractions. The next subsection examines the influence of the surrounding built environment on mobility and mode choice.

Built Environment

In *Travel Demand and the 3Ds: Density, Diversity, and Design*, Cervero and Kockelman (1997) examine how different dimensions of the built environment influence travel demand. The principal dimensions are designated as the three 'Ds':

- **Density**, the amount of socio-economic importance per unit of area (e.g., housing, attractions, jobs);
- **Diversity**, the variety of land use in a given area; and
- **Design**, the street network characteristics.

Their research found that density, land-use diversity, and pedestrian-oriented designs generally encourage non-auto travel; however, they found the influence of these dimensions of the built environment to be fairly marginal. Other studies have come to mixed conclusions on the extent to which the built environment influences travel behavior (Crane, 2000; Ewing and Cervero, 2001, 2010). However, Ewing and Cervero (2010) point out that the combined effect of different aspects of the built environment could have an impact on how people travel.

In a meta-analysis of built-environment travel literature, Ewing and Cervero (2010) determined that the likelihood of travelers completing multimodal trips is most strongly associated with the design and diversity dimensions of built environments. Design in particular is one of the main factors influencing trip length, cost, and modal choice. Design refers to the street or path structure (e.g., grid shape, block size, intersection rate) and mode-specific infrastructure (e.g., sidewalk size, bike lanes, street calming, bus lanes) (Cervero and Kockelman, 1997; Crane, 2000).

Ewing and Cervero (2010) also found that density of people, jobs, and transit stops increases walkability, while high intersection density (the number of intersections in an area), street connectivity, and land use mix encourage transit use. Street connectivity refers to the directness and availability of alternative routes between home and local destinations (Frank and Engelke, 2005; Handy et al., 2003; as cited in Koohsari et al., 2014). These findings indicate that station design and placement are important factors in encouraging multimodal trips and public transit use.

Mode Choice

In the literature, mode choice is grounded in the belief that people make rational choices among competing alternatives to maximize personal utility or net benefit (McFadden, 1981; Train and McFadden, 1978). Travelers compare travel time, travel cost, and other attributes when making travel decisions. Typically, the literature focuses on the trip journey (from point A to B)'s effect on mode choice in terms of generalized costs. In other words, the literature focus on how monetary costs and travel time expenditures impact the modes a traveler chooses to take. Studies indicate that travel time is a negative impact on mode choice while mode frequency is positive (Chakour and Eluru, 2014).

Empirical literature on mode choice, in regard to station access and egress, is limited. Due to data and procedural limitations, there are few studies that directly tie all land-use and built environment factors of point A (origin) and point B (destination) to general modal choice (Boarnet and Crane, 2001; Cervero, 2002). The latter sections of this report will use surveys to generate a modal choice model of access and egress to HSR stations to help aid decision-makers regarding the design of station areas and passenger experiences at stations.

Integration of Intercity, Commuter, and Regional Rail Access

Caltrans and the Authority envision seamless connectivity between HSR and intercity, commuter, and regional rail access. The three HSR stations studied in the report are intended to connect to existing and future conventional rail networks, as follows:

- The Fresno station will connect to existing Amtrak lines, and in the future, the Altamont Commuter Express (ACE).
- The Kings/Tulare station will connect to Amtrak as well, and in the future, with light-rail passenger service along the proposed Cross Valley Rail Corridor.
- The San Jose station will connect to ACE, the Valley Transportation Authority (VTA), Caltrain, and Capitol Corridor (Amtrak). In the future, the Bay Area Rapid Transit (BART) will also connect to the San Jose station.

While the authors were unable to find literature that specifically focuses on the integration of HSR and conventional rail, several papers offer observations on the impacts of HSR on conventional rail and the performance of stations that serve both types of rail.

The literature is inconclusive on the impact of HSR on conventional railway networks and vice versa. Cheng (2010) suggests that the two may be complementary: conventional railways can play the role of regional passenger transportation for distances under 150km, and HSR may lead to a reduction of generalized cost for users of conventional rail. However, in reviewing the literature and conducting analysis, Cheng (2010) found that HSR diverted travel from conventional rail in some countries (Japan, Spain, and Taiwan) and increased rail travel in at least one (France). The study concluded that in Taiwan, connections between the conventional rail system and HSR were under-developed and unable to meet passenger demand for transfer services. The paper recommended service integration between the systems.

Vickerman (2015) suggests that connectivity between conventional rail and HSR may be particularly beneficial for smaller, intermediate stations. The author notes that the performance of these stations in Europe has been generally poor (both in delivering expected passenger numbers and in economic impacts) except in cases where there are good interchange facilities with local rail services. Mohino et al. (2014) likewise suggest that integrating existing railway systems can support HSR integration into the urban fabric. The authors indicate that ex-metropolitan stations with good transport connections can increase the possibilities of generating metropolitan subcenters and economic development. For example, one ex-metropolitan station near Paris attracted significant development, even without the presence of nearby attractions, due to its excellent connections between various transportation modes (metropolitan rail, an airport, roadways) and HSR. The authors also note that the Madrid ex-metropolitan stations are not well connected to conventional rail and have significantly fewer passengers compared to counterparts in London and Paris. The importance for smooth integration between various modes and HSR indicate the need for interagency and regional planning, explored in the next subsection.

Interagency and Regional Planning

Often, a governance dilemma arises when there is a need to seamlessly plan across multiple agencies and levels of geographic scale (i.e., station layout vs station area vs municipality vs regional) (Priemus, 2008). HSR door-to-door trips are constructed of many components, which are in turn provided by separate agencies (Coxon et al., 2018). In an analysis of railway redevelopment projects in Europe, Bertolini and Spit (1998) note that while different parties may have information on similar projects or the developments of other parties, the limited context and speed with which the information becomes out-of-date makes it difficult to learn from others participating in the same process. Similarly, it can be difficult for one agency to understand another agency's perspectives. The methods and economic resources needed to reduce infrastructure space (e.g., trains using the same tracks/grade, buses/trains timed to prevent overlap, underground parking lots) require cross-agency communication — an ongoing issue with United States and California transportation systems (Berkeley Law and UCLA Law, 2013).

Existing studies of the economic development and community benefits of international HSR stations were the result of meticulous, on-going station area planning and joint development opportunities between multiple stakeholders. These included station planners, local government agencies, transportation agencies, national governments, and local business entities. While there is a gap in the literature of studies that evaluate the effects of uncoordinated governance, planning, and policy; the literature on rail stations highlights the need for horizontal/geographic integrated policy (Bertolini and Spit, 1998; Eidlin, 2015; Garmendia et al., 2008), multi-level/vertical integrated policy (Ureña et al., 2009), local economic growth (Murakami and Cervero, 2012), and planning local urban form (Pol, 2008; Priemus, 2008).

Definitions

- **Horizontal policy integration** – Policy objectives are incorporated into the policies of various sectors across one level of government. For example, with this approach, an objective could be implemented through policies at various departments at the state level.
- **Vertical policy integration** – This method takes a top-down approach, mainstreaming policies throughout multiple levels of government (e.g., directives are implemented at the national, regional, and local level).
- **Urban form** – This term is used to describe a city's physical characteristics such as its size, shape, and configuration. On a broader scale, urban form refers to street types and their spatial arrangement or layout. It can also encompass nonphysical aspects such as density.

Sources: Kettner et al.(2015) and Živković (2019)

Overall, the "three D's" and efficient planning coordination are important ideas to consider when planning for HSR stations. The station design and surrounding environment may play a role in deciding the ease with which individuals can use different modes to access the station. The efficiency of active modes and scheduled public transit may be vulnerable to inefficient use of space and poor design, and careful planning and coordination may be need to avoid inadvertently encouraging the use of more flexible, single-occupant modes like private automobiles. This physical dilemma at the station of providing connections for multiple modes while encouraging accessibility and other economic activity will be an ongoing theme when designing HSR stations. The following sections of the literature review seek to provide insight on two key aspects of HSR stations: the behavior of travelers transferring between modes and the design of stations and surrounding environment.

Transfer Experiences at HSR Stations

Although HSR travels rapidly, the trip duration can be compromised by long, cumbersome transfers. Studies indicate that the most inconvenience to travelers can occur during transfers at the station. During this stage of the trip, travelers are not covering distance, and the act of traversing the station may provide discomfort (Hine and Scott, 2000; Nes, 2002; Schakenbos et al., 2016). This section attempts to describe multiple aspects of the transfer experience – specifically, how passengers transfer between modes and how that experience can be improved. In this section, the researchers present a picture of traveler needs and expectations for the transfer process. This section also discusses key target areas for maximizing travel experience such as: reducing boredom, communication, and strategies to improve the experience for passengers with mobility impairments.

Frameworks for Understanding the Transfer Experience

The following subsections explore two frameworks that can help readers understand the transfer experience. First, the researchers describe Peek and van Hagen (2002)'s hierarchy of travel requirements. Next, the researchers present Daamen (2004)'s stages of pedestrian behavior at rail stations.

Basic Traveler Requirements

A variety of characteristics impact a traveler's satisfaction with their transfer experience and journey. Conventional wisdom suggests that simply reducing the duration of the transfer (i.e, decreasing the walking distance between modes and decreasing the time waiting at the platform) are sufficient to meet traveler's needs. However, the literature indicates that other factors impact the experience. For example, a higher frequency of headways does not automatically result in satisfied travelers if the system at large is not providing basic needs (Friman and Fellesson, 2009). Kari Watkin's (2011) surveys indicated that travelers were more concerned about the lack of communication about bus delays than about the delay itself, indicating that travelers may value real-time information more than bus frequency (unless headways were ten minutes or fewer).

To help understand traveler requirements and expectations for railway stations, Peek and van Hagen (2002) conceptualize a framework based on Maslow's hierarchy of needs and Dutch modal studies, displayed in Figure 3. The base of the framework consists of the minimal requirements that travelers expect from any mode: reliable, consistent service (e.g., the mode arriving at the time and location expected, travelers being able to board) and safety. Next in the pyramid, travelers value fast and efficient transfers (e.g. reduced wait times, timed transfers, and consistent timetables), followed by the ease of the transfer (e.g. short walk between modes, understandable station layout).

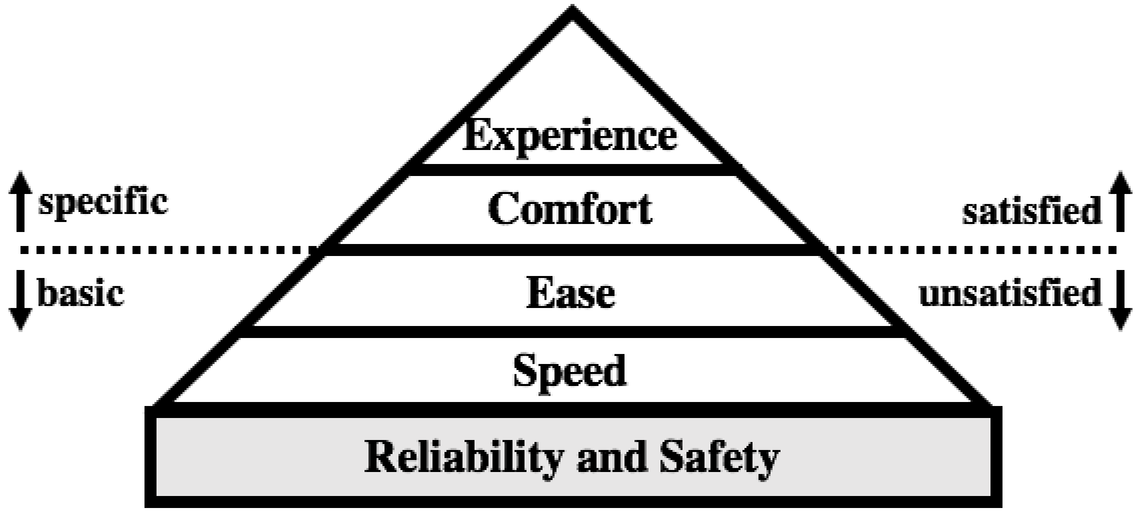

Figure 3: Relationship between passenger requirements and desires in stations

Source: Peek and van Hagen (2002)

With those base expectations met, rail station planners can then target comfort and a positive transfer experience. Surveys corroborated this need for basic expectations to be met first, with results that emphasized that traveler satisfaction came from frequent, reliable service and guaranteed personal safety with less importance placed on physical amenities designed to create comfort (Hernandez et al., 2014; Hine and Scott, 2000; Iseki and D. Taylor, 2010). In addition, unsafe environments have an impact on perceived wait time, especially for female travelers (Fan et al., 2016; Hine and Scott, 2000; Iseki and D. Taylor, 2010).

Stages of the Transfer Trip

The transfer experience typically involves the traveler traversing the station on foot. In *Modelling Passenger Flows in Public Transport Facilities*, Winnie Daamen (2004) divides pedestrian behavior at rail stations into three stages:

- The **strategic stage**, in which travelers decide which activities will be conducted at a station;
- The **tactical stage**, in which travelers choose a route that minimizes distance and time traveled while maximizing comfort; and
- The **operational stage**, in which travelers execute the plans according to a station's geometry, obstacles, and mode interactions.

Each stage is experienced differently depending on the traveler's knowledge of the station, the traveler's potential impairment, and the egress mode chosen. There may also be a limit to how easily and fast a traveler can experience the pedestrian stages, regardless of whether they are familiar with the station. A long, obstacle-filled layout can make a station difficult to traverse. Likewise, a lack of communication about arrival times can prevent speed or ease of transfer and make it difficult for the traveler to plan their trip.

Ideally, the three stages are experienced sequentially without repeating steps and unfold in an efficient station layout (e.g., clearly defined walkways, reduced distances, lack of walking barriers). However, each stage has the potential for travelers to lose time and utility if there is a lack of communication or ease. Travelers can remain at, or return to, the tactical stage if there is a lack of information about where and when their mode's arrival point is. The lack of information is especially detrimental to tourists or travelers with mobility impairments. An experienced traveler, such as a commuter, has more familiarity with the station's layout and timetable, making it easier to select routes and between modes. However, commuters still desire up-to-date arrival times to see how they can reduce travel time and use station facilities (Grotenhuis et al., 2007).

Regarding the operational stage, travelers with multiple parties in the group (e.g., with children), a temporary mobility impairment (e.g., having large luggage, tiredness), or a permanent mobility impairment (e.g., persons with physical and/or cognitive disabilities, the elderly) may have difficulty may need to add additional activities or pick longer routes that can accommodate an impairment. There may also be travelers that struggle to plan a route (Rosenbloom, 2007; Schakenbos et al., 2016). Station planners will need to consider a diverse array of traveler needs when designing the station.

Even with clearly defined information, inconveniences could be preventing travelers from minimizing time and walking distances. Challenges to completing the transfer include: 1) a lack of universal or integrated ticketing systems, forcing travelers to add another activity in the station, and 2) extended distances and barriers between the access/egress mode and the train (Hine and Scott, 2000; Palmer et al., 2011; Olszewski and Wibowo, 2005; Weinstein Agrawal et al., 2008). These additional obstacles can add time to the transfer and increase traveler anxiety, especially for infrequent station users (Van Hagen, 2011; Hine and Scott, 2000). In the next subsection, the researchers summarize studies that examine how travelers move across a station; specifically, how travelers spend time in the station and impacts on their experience.

Traveler Perceptions and Emotions During the Transfer Experience

An individual's transfer experience may be impacted by their perceptions of time, their enjoyment of the trip, and the environment in which they achieve their desired emotional state. The following subsections summarize related ideas from van Hagen (2011)'s thesis on travel waiting experiences.

Perception of Time During the Transfer Experience

Figure 4 displays the typical door-to-door HSR trip with the horizontal axis displaying *time spent* on the journey and the vertical axis displaying *time value* (van Hagen, 2011). *Time value* is a proxy for the utility (i.e., value) the traveler receives from each section of the trip, which is influenced by the distance traveled and level of comfort. *Time spent* is a general representation of the duration of each section of the trip during which a traveler can derive utility. Van Hagen displays that the traveler's highest utility is at their origin, destination, and train ride. These stages of the journey have higher utility due to the travelers being mobile with few immediate concerns.

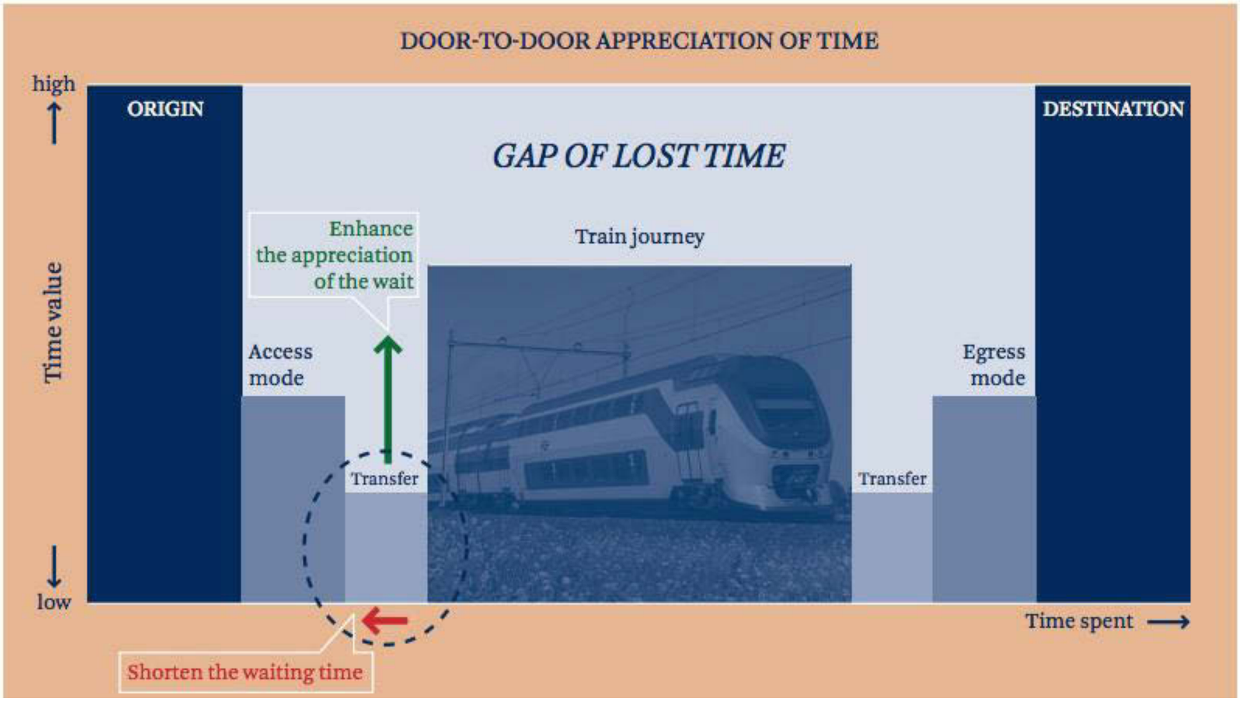

Figure 4. Door-to-Door Appreciation of Time

Source: van Hagen (2011)

In general, there are two methods to improve the time value of the transfer experience: minimizing transfer time and enhancing the station experience. The transfer time can be minimized by:

- Shortening the distance and time to traverse the station and
- Reducing the headways of the egressing mode and/or syncing mode arrival and departure times.

The station experience can be enhanced by:

- Improving communication on departure times and station layout,
- Removing inconveniences and obstacles,
- Ensuring reliability at the station, and
- Providing amenities to improve comfort (van Hagen, 2011; Peek and van Hagen, 2002).

Reducing the amount of time spent transferring has dual benefits. It minimizes the cost and duration of the journey while also enhancing the traveler's time spent at the station (Daamen, 2004; Nuworsoo and Deakin, 2009). However, while minimizing travel time is generally seen as an ideal goal, the next subsection explores how travelers may have different preferences for station characteristics depending on the purpose of the trip and whether they wish to be relaxed or entertained while traveling.

Emotional Phases of the Transfer Process

Van Hagen (2011) uses the reversal theory — developed by Michael Apter (2007) — on the rail station transfer experience to suggest that there are different sets of travelers with different environmental preferences. These passengers can be separated into a "must" group – task-oriented travelers who want to spend as little energy and time on the travel experience as possible – and a "lust" group – recreational-oriented travelers who are less time-sensitive. The first group may find station characteristics such as privacy, spending time usefully, peace, and waiting alone to be desirable. On the flip side, lust passengers may find facilities, service, a warm atmosphere, and a sense of control more desirable. In other words, the purpose of the trip and the emotional state of the traveler may influence their experience and preferences for a rail station's characteristics.

Figure 5 attempts to show the reversal theory applied to must and lust passengers. The redline shows the excitement level of the must passenger, or anxious passenger. This anxious traveler would prefer low arousal and to be in a phase of relaxation (Zhen et al., 2018). In contrast, lust passengers are bored with low arousal and would prefer to be in a phase of excitement.

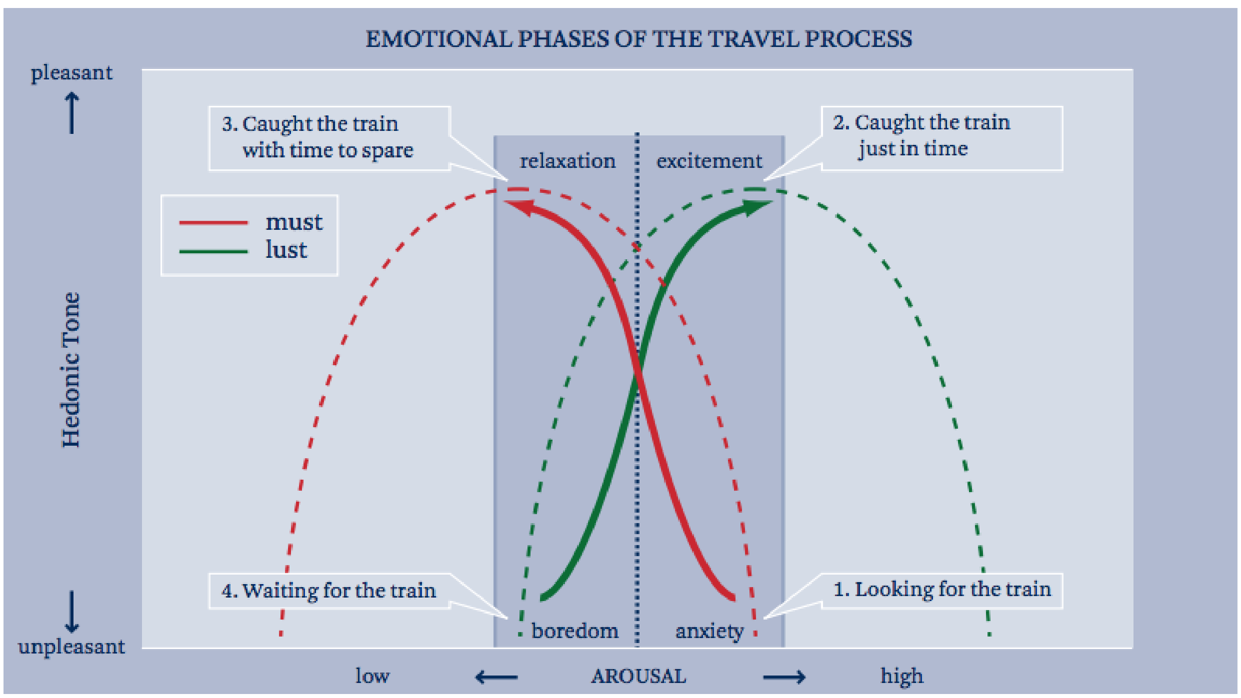

Figure 5: Emotional Phases of the Travel Process

Source: van Hagen (2011)

In summary, travelers may have different perceptions of time spent at the station and different preferences for their travel experience. Planners may need to take into account this diversity when exploring future station designs. Next, the researchers discuss two possible strategies for improving the transfer experience – namely, consistent communication of accurate information and accommodations for travelers with mobility impairments.

Methods to Improve the Transfer Experience

The following subsections outline specific strategies that may improve the experience of travelers transferring between trains or modes at HSR stations.

Communication

Travelers seek the information that puts them in their preferred emotional state (Grotenhuis et al., 2007). Task-oriented travelers seek information that will reduce uncertainty (van Hagen, 2011). These travelers will want information on the station layout, their train's platform location, or the schedule of their egress mode. Accurate information should be accessible throughout the trip in case the traveler makes last-minute changes. Information should be available to the traveler before arriving to the station, in front of the station's entrance, and in the station in case the traveler has to reroute because of an unexpected operational stage or the addition of a new activity (Grotenhuis et al., 2007; Hine and Scott, 2000). Information can be location-based (e.g., layout maps of modes, local transit routes, signs directing to platforms) or time-based (e.g., real-time information systems) (Hernandez et al., 2014). Maps and schedules should be accessible on mobile devices and at the station, both outside and inside (Hine and Scott, 2000; Palmer et al., 2011). Station planners could work with trip planning apps (e.g. Google Maps, Waze, Transit, Baidu, GaoDe) to provide a better digital understanding of station layouts, drop-off points, and schedules (Zhen et al., 2018). Having this information accessible allows travelers to plan station activities and move efficiently.

In contrast, recreation-based travelers desire information that will heighten their experience. These travelers tend to want to know when their mode will arrive (Grotenhuis et al., 2007) and/or the location of station activities (van Hagen, 2011).

Real-time passenger information systems reduce the traveler's perceived wait time. Travelers may be willing to wait longer at the stop, and they may feel safer and have increased overall satisfaction (Grotenhuis et al., 2007; Hernandez et al., 2014; Hess, 2012; Mishalani et al., 2006; Watkins et al., 2011). Surveys have shown that even basic amenities, such as benches or a shelter, produced significant reductions in perceived wait times (Fan et al., 2016; Iseki and D. Taylor, 2010). Next, the researchers provide suggestions to accommodate travelers with mobility impairments.

Accomodations for Mobility Impairments

Travelers with mobility impairments may need additional features to create a satisfactory experience at the station during transfers. Mbatta et al. (2008) suggests features, organized by type of impairment, that can help accommodate travelers with a mobility impairment (see Table ***3***). Actively considering these features in design can improve the station experience for those with mobility impairments and may help integrate accessible locations with the rest of the station. The next subsection provides more general suggestions for improving traveler comfort.

Table 3: Special Features for Different Impairment Groups

Group	Impairment	Physical aid(s) used	Features needed for station accessibility

Mobility 1	Physically fit	N/A	Loading/unloading area
Mobility 2	No use of legs	Wheelchairs, scooters	Clear path, loading/unloading area
Mobility 3	Limited strength, endurance, dexterity, balance, coordination	Wheelchairs, scooters, canes, crutches, walkers, seating, leaning posts, assistants	Clear path, loading/unloading area
Visual 1	Total blindness	Canes, dogs, assistants	Auditory, tactile surface, consistency
Visual 2	Partial blindness	Canes, dogs, assistants	Auditory, tactile surface, consistency, color, contrast, lighting
Hearing	Deafness	Hearing aids	Visual displays
Cognitive	Impaired development, language, comprehensive	N/A	Simple language, consistency, symbols
Language illiterate	Impaired reading, speaking, lack of English skills	N/A	Simple language, symbols

Source: Reprinted from Mbatta et al. (2008)

Improving Traveler Comfort

Re-examining the phases discussed in Figure 3, bored passengers may seek an amenity or any form of stimulus to bring them comfort or a positive experience. Especially when waiting is perceived to be a wasted experience (Gasparini, 1995; van Hagen, 2011; van Hagen et al., 2014). Comfort can take the form of: 1) a pleasant environment, such as architecture, art, walking pathways; 2) reduced crowdedness; 3) safety, such as pedestrian crossings to navigate traffic or protection from crime; and 4) protection from other environmental factors, such as weather, noise, or air pollution (Daamen, 2004). When waiting for a transfer, travelers request a certain level of comfort. Characteristics of stations that can enhance traveler comfort include:

- Facilities (e.g., sheltered waiting, shops),
- A pleasant atmosphere (e.g., architectural layout, cleanliness),
- Amenities (e.g. Wi-Fi),
- Internal destinations (e.g., business class lounge), and
- External destinations (i.e. turning the station into a place) (Zhen et al., 2018)

These characteristics can add value to time spent transferring. Next, this literature review examines station layout design to encourage multimodal integration. Further sections of the literature review will discuss the built environment and infrastructure in the area within a mile of the station.

Station Layout

This section explores how the multimodal integration concepts and transfer behavior manifest in an HSR station's layout and the placement of mode-specific infrastructure. This section focuses on modes that require a high level of accessibility and minimal distance to the station (walking, other active modes, and public transit) and touches upon parking and curb management for vehicular modes.

In general, the station layout should minimize the distance and time between transfer modes while enhancing traveler comfort and experience (Hine and Scott, 2000). The immediate layout should ideally be organized in terms of the pedestrian's access to other modes and the immediate area (Nuworsoo and Deakin, 2009). To encourage short walking distances between transfer modes, the general station layout should be small in size and place high-occupancy, transfer modes within a short walking distance of each other. Table 4 describes station features, the modes that use each feature, and the proximity with which the feature should be placed to the HSR platform.

Table 4: General Infrastructure Placement

Feature	Modes Used	Proximity to HSR platform
Bicycle Parking	Private Bicycles Bikesharing	Closer
Transit Platform	Buses Light Rail	Closer
Rail Platform	HSR Commuter Rail Light Rail	Closer
Dropoff Platform	Drop-And-Ride Ridesourcing Taxis Shared Automated Vehicles (SAVs) Microtransit	Farther
Parking Lot	Private Automobiles	Farther

Sources: Deakin (2008), Eidlin (2015), Ewing and Cervero (2010), Loukaitou-Sideris et al. (2012), Mbatta et al. (2008), Nuworsoo and Deakin (2009), Peek and van Hagen (2002)

Pedestrian Flows

As we discussed in the section on transfer behavior, the HSR station should prioritize the flow of pedestrians that are transferring between modes. Important factors to consider are direct routes and minimized distances (Daamen, 2004; Olszewski and Wibowo, 2005; Palmer et al., 2011; Weinstein Agrawal et al., 2008). Previous surveys suggest that travelers walk to stations to minimize time and distance (Weinstein Agrawal et al., 2008) with walking thresholds around five to ten minutes (Hine and Scott, 2000) and/or a half mile (Weinstein Agrawal et al., 2008).

Parking for Personal Bicycles

Bicycles can be used as an access and/or egress mode to the station. The bicycle trip has two options: (1) as a one-way journey to/from the station with bicycle parking provided or (2) as an access and egress mode at both stations with on-board bicycle storage. Bicyclists prefer to bring their bicycles on the train if they are able to and if there is room. Logistically, there is a limit on the amount of bicycles on the train (Cervero et al., 2013; Pucher and Buehler, 2009).

Bicycle parking comes in the form of: (1) regular, open-air bicycle parking that riders can lock to or (2) guarded parking facilities or lockers (Martens, 2007). Regular parking is cheaper and typically free but is unguarded. Guarded parking facilities or lockers are more secure but may be priced per hour or day. Although the guarded parking is logistically preferable for longer HSR trips, the price can be a drawback to its use (Cervero et al., 2013). Free bicycle parking near the station is a potential strategy to encourage bicycling and HSR ridership (Puello and Geurs, 2016; van der Spek and Scheltema, 2015).

In the SF Bay Area, BART and Caltrain have installed extensive secure lockers, bicycle stations, and cages that reduce the number of passengers that carry bicycles on board, which at times of high ridership causes further crowding and may increase rider stress. This parking has been crucial as biking to transit trips have more than tripled between 1990 and 2009 (Cervero et al., 2013; Pucher and Buehler, 2009). Additionally, BART and Caltrain have increased space onboard for riders who do prefer to take their bicycles onboard. Coordinated road improvements and urban planning have also increased bicycle mode choice in municipalities throughout the region (Pucher and Buehler, 2009).

Vehicle Parking

Parking is space intensive and can encourage use of single-occupancy vehicles (SOVs); however, some studies have shown that there is a positive correlation between parking spaces and station boardings (Baum-Snow and Kahn, 2000; Cervero, 2006; Chakour and Eluru, 2014; Kuby et al., 2004; Merriman, 1998). Merriman (1998), in a study of Chicago commuter rail, found that 0.6 to 2.2 additional riders were the result of an added parking spot.

Parking lots in the form of multi-level structures are typically more efficient than surface lots (Priemus, 2008). Martin Hurrell (2012) found that when considering the price of City and County of San Francisco land, it is cheaper to provide a multi-level parking structure with paid parking rather than surface lots if the land value is over $2 million dollars per acre. The land value threshold was determined by dividing the land cost per space then comparing surface and multi-level parking, with the cost-efficient option being the lowest per space total. Loukaitou-Sideris et al. (2017) emphasized distributing parking facilities to surrouding neighborhoods to dilute the spatial impact of one large parking lot while perserving land on the station. The pullout to the right summarizes parking lot design suggestions from multiple studies.

Suggestions for Parking Design

- Minimize parking footprint and barrier
- Build compact parking structures
- Provide easy access to vehicle routes
- Price parking structure, matching private costs to social costs
- Reserve spots for commuters in vehicle-dependent regions
- Create satellite lots with shuttles

Sources: Deakin et al. (2008), Loukaitou-Sideris et al. (2012), Wilson (2015)

In the SF Bay Area, BART planners conducted a study to see if park-and-ride users would be more willing to have (1) free unreserved parking, (2) paid daily reserved parking (reserved spot at station until 10am), or (3) a paid monthly reserved spot. With reserved spots, travelers — mainly commuters — spread out their arrival times instead of traveling during the peak period. The added costs of reserved parking ($5 a day) did not significantly push travelers to find an alternative access mode or drive to their destination entirely (Syed et al., 2009).

For curbside pick-up and drop-off points, there is limited research on the subject, so it is difficult to recommend best practices. Based on the physical dilemma stated earlier in the report (stations need to be small and walkable to help encourage multimodality and commercial activity), curbside pick-up and drop-off space should be limited to allow flexible movement of other modes.

Physical Integration for Shared Mobility

In addition to parking for personal bicycles and vehicles, station planners will also need to include characteristics that encourage physical integration with shared mobility. Suggestions for features that encourage shared mobility include bikesharing stations, electric carsharing stations, ridesharing (carpooling and vanpooling areas), and TNC loading zones. Table 5 includes key characteristics that can encourage multimodal integration with shared mobility and potential actions public agencies can take to implement these characteristics (Broward Metropolitan Planning Organization, 2009; SANDAG, 2017). The table was initially developed for mobility hubs, but the characteristics are also applicable to HSR station design.

Table 5: Mobility Hub Key Features and Potential Actions for Physical Integration

	Characteristic	Description	Potential Action
Station Design	**Art and Architecture**	Creates sense of place through art and architectural elements	Collaborate with community organizations to develop unique art and architecture
	Waiting Areas	Offers well-lit, partially enclosed waiting areas	Use community input to design waiting areas that feel safe and comfortable
	Mobile Retail	Provides mobile retailers or delivery services to enhance station	Partner with businesses who already offer, or are interested in offering, these services
	Aesthetic Fit	Fits with the surrounding environment	Partner with local businesses and property owners to increase development around transit hubs
Station Access	**Activity Access**	Provides access to housing, jobs, entertainment, and other activities	Partner with local institutions to promote transit use
	Accessibility	Accessible and navigable for people with a wide range of capabilities	Work with accessibility-focused organizations to ensure accessibility
	Walkability	Provides crosswalks and walkways for pedestrian safety	Prioritize pedestrian safety and use of space, rather than vehicle use
	Rideability	Allows for station access via electric powered micromobility devices (e.g., hoverboards, electric scooters, etc.)	Ensure that walkways are wide enough to safely accommodate rideable devices
	Bikeability	Offers biking infrastructure (e.g., bike storage, pathways)	Promote the use of biking through the provision of biking infrastructure
	Flexible Curb Management	Allows for variety of uses of curbspace from multiple modes (e.g., freight, public transit, and TNCs)	Design curbs with flexible use in mind, prioritizing safety for all users
	Smart Parking	Uses technology to provide real-time parking information	Implement technology-based systems to monitor parking capacity
Shared Mobility	**Shared Micromobility**	Access to station-based or dockless modes (e.g., shared scooters)	Supplement existing transportation options with bikesharing and scooter sharing options
	Charging	Offers charging stations for micromobility and electric vehicles	Partner with local programs for flexiblydesigned charging stations

	Characteristic	Description	Potential Action
	Carsharing	Alleviates vehicle ownership responsibilities by sharing vehicles	Implement permitting process that delineates carsharing parking areas and practices
	Carpooling	Divides vehicle ownership costs between riders	Offer carpooling incentives, such as carpool-only parking
	For-Hire Services	Offers curbspace for TNCs and Taxis	Partner with TNCs to provide on-demand ridesharing services
	Microtransit	Vehicles that accommodate five to 12 people for local service provision	Partner with local microtransit providers to enhance service coverage
	Neighborhood Electric Vehicles	Provides low-speed, low emission transportation mode for local areas	Accommodate neighborhood vehicle design needs in station design
Service Provision	**Public Transportation**	Serves local and regional public transportation routes and lines	Co-locate services together to increase accessibility
Service Provision	**Service Frequency**	Offers frequent service and timed transfers	Locate stations at multi-route intersections to increase connectivity
Service Provision	**Real-Time Information**	Broadcasts real-time route information	Use telecommunication technology to provide updated information to riders
Service Provision	**Integrated Fare Payment**	Offers single fare payment for multiple modes	Integrate fare payment system between all modes of transportation

Sources: Shaheen et al. (forthcoming), created with information from Broward Metropolitan Planning Organization (2009) and SANDAG (2017)

Station Area (Within a Quarter-Mile to One-Mile Radius)

A station's success is heavily dependent on its connection to the surrounding transportation network, especially in cities with heavy decentralization and sprawl. Multiple literature reviews conducted by the Authority all emphasize that California cities, especially low density cities in the Central Valley, need to support the stations with policies that encourage dense, mixed-use development around the stations while also keeping public transit convenient and easy to use and providing walkable streets (Deakin, 2008; Loukaitou-Sideris et al., 2012; Loukaitou-Sideris et al., 2015; Nuworsoo and Deakin, 2009) .

The area surrounding the station can contribute to the station's role as a node and place. To increase travel demand and activities in the station area, some studies suggest encouraging higher density development and a diverse mix of land uses (Cervero, 2002; Nuworsoo and Deakin, 2009). Additionally, studies suggest encouraging active transportation and mass transit over SOVs because of they are often more efficient spatially (Cervero, 2002; Crane, 2000).

Street Structure

In general, adjusting the structure of street networks to rectangular blocks (as opposed to circuitous shapes), smaller block sizes, and a higher density of street intersections allow more direct routes to public transit stations. Re-aligning streets can extremely difficult for existing infrastructure but can be considered for greenfield (i.e., undeveloped) sites. By cutting down on unnecessary travel time and distance, planners can expand the station's catchment area for active modes (Ton et al., 2019) and allow more direct routes – for example, shrinking the distance traveled of bus routes (Cervero and Kockelman, 1997). The pullout to the right highlights suggestions for local zoning and street design to achieve a walkable, efficient, and dense station area. As mentioned earlier, the area outside the station is not within the governance power of station planners, necessitating collaboration with nearby local governments to coordinate changes to the surrounding area or new developments (Bertolini and Spit, 1998).

Insights on Street Design from the Literature

Local Zoning Recommendations:

- Increase density around stations
- Incentivize infill developments
- Provide density bonuses (SB 35)
- Streamline project review process
- Lower parking requirements

Characteristics of Pedestrian- and Active Transit-Friendly Streets:

- Direct routes to destinations and public transit
- Small block sizes
- Rectangular blocks (not circuitous)
- High intersection rate (dense grid)
- Wide sidewalks
- Mid-block crossings
- Traffic calming (physical design to provide safety to pedestrians, cyclists, and motorists)

Sources: Cervero and Kockelman (1997), Crane (2002), Deakin et al. (2008), Eidlin (2015), Ewing and Cervero (2001, 2010), Loukaitou-Sideris et al. (2012), Park (2008)

Walking, as a modal choice, is primarily determined by the traveler's travel time and the density of attractions in their catchment area (Ton et al., 2019). Because of walking's limited range, it has the most to lose from unnecessary, indirect routes in the form of long, circuitous cul-de-sac street networks (Hickman et al., 2010). Numerous studies on HSR and/or multimodal connections highlight that dense street grids encourage a walkable environment (Cervero, 2002; Dill et al., 2013; Loukaitou-Sideris et al., 2015; Park, 2008).

This discussion highlights the concept that the station is a node in the surrounding transportation network. Although a well-designed station can encourage multimodal trips by minimizing transfer time and heightening travelers' experiences, there is a ceiling to its influence if the surrounding infrastructure and transportation network are poorly structured (e.g., roads and transit lines with indirect paths) or do not provide enough service (i.e., infrequent headways).

Anastasia Loukaitou-Sideris et al. (2012), after reviewing Authority's *Urban Design Guidelines* (California High-Speed Rail Authority, and PB PlaceMaking Group, 2011), was concerned that the 'boilerplate' TOD recommendations are not guaranteed to translate to suburban cities, exurban cities, and bedroom communities. After surveying the case study cities with stations, Loukaitou-Sideris et al. (2012) found that larger cities (San Francisco, Fresno, Anaheim) had been adequately preparing station areas with TODs and network improvements; however, the lower density cities, with the most to gain from development generated by HSR, have not prepared scenarios or the cities prepared standard TOD suggestions without targeted investment plans.

In addition to providing direct routes and encouraging TOD, cities can attempt to reduce personal vehicle use by providing street infrastructure that support active modes and micromobility. Users of active transit often feel most secure on dedicated or protected lanes, and they often cannot use sidewalks (or it is not feasible for pedestrian safety). The next subsection discusses infrastructure for micromobility and active transportation around station areas.

Infrastructure for Micromobility and Active Transportation

In keeping with the notion of HSR as the backbone of a larger comprehensive transportation plan, it is important to consider greater city-wide bicycle planning and infrastructure when designing HSR stations (Martens, 2004; Van der Spek and Scheltema, 2015). The proportion of HSR riders who arrive by bicycle will directly reflect the cyclability of the surrounding community and relative preference for bicycling as a form of transit, especially within the typical three-mile willingness-to-bike radius of the station (Eidlin, 2015). Bicycling is an option if the bicycle infrastructure at the station, at the destination/origin, and on the route between those locations is consistently available (Martens, 2004; Pucher and Buehler, 2009; van der Spek and Scheltema, 2015).

Optimal infrastructure planning for bicycling in station vicinities takes note of two key frameworks: Robert Geller's (2009) cyclist typology and the Level of Traffic Stress (LTS) Analysis (Mekuria et al., 2012). Cyclist typology divides cyclists into four categories: "strong and fearless," "enthusiastic and confident," "interested but concerned," and "no way no how" (Geller, 2009). Eight out of 10 urban cyclists in the U.S. fall under the "interested but concerned" category of cyclist who are averse to sharing the road with cars on major streets, even with a dedicated bicycle lane (City of Berkeley, 2017; Dill and McNeil, 2013; Geller, 2009). Geller describes this overwhelming majority of the public as: "They would ride if they felt safer on the roadways—if cars were slower and less frequent, and if there were more quiet streets with few cars and paths without any cars at all" (Geller, 2009).

Because stress and fear are the largest barriers to urban cycling, LTS can be used as a framework to determine how to best reduce sources of rider stress (Mekuria et al., 2012). LTS maps the level of stress experienced by cyclists in a given area, allowing planners to evaluate bicycle routes and gaps in the urban infrastructure. LTS, combined with cyclist typology (perhaps better thought of in economic terms as willingness to cycle), can be used as a quality-of-service measure to assess road conditions for cycling and augment bicycle mode choice (Mingus, 2015). Intersections are most often the weakest points in low-stress network connectivity, and intimidating intersections often serve as the largest barrier for cyclists (Mekuria et al., 2012).

Caltrans' current classifications of bicycle facilities can be used to rank priority for bicycle infrastructure (Caltrans, 2017). Caltrans has designated four types of bicycle facilities:

- **Class I** bicycle facilities consist of off-road paths and trails.
- **Class II** bicycle facilities designate an on-road bicycle lane, typically five to six feet wide. They may also include a painted "buffer" of two to four feet.
- **Class III** bicycle facilities include bicycle routes. These are shared facilities with vehicles and other road users, often marked by signs.
- **Class IV** bicycle facilities are protected bike lanes that are physically separated from vehicle lanes by grade separation, flexible bollards, or other permanent barriers.

However, it must also be noted that "higher" classes may not always be preferable over "lower" classes, and that the main deciding factor must be the highest reduction of LTS.

The next section of the literature review explores three types of rail station and airport integration. While the HSR is not planned for airport-rail connections, these stations still offer relevant experience on designing stations for mode integration, as well as insights into passenger behavior and willingness to use connecting modes.

Airport-HSR Integration

Airports can offer lessons for multimodal integration at stations, especially since they are almost always dependent on feeder services (e.g., shuttles, rail, taxis, etc.) and must strategize around constrained space for parking and curbside pick-ups and drop-offs. Airports are sometimes even at the forefront of integration with innovative modes. For example, in Portland, Oregon, the airport is serving as a testing ground for an Uber app feature that uses a PIN verification feature in an effort to create more efficient pickups (Uber, 2019). In this section, the researchers present lessons learned from air/rail integration in Europe. The discussion is organized by three types of spatial relationships, described below.

The Airport Cooperative Research Program (ACRP) defines three types of spatial relationships between rail stations and airports (Airport Cooperative Research Program, 2015). The relationships are based on distance:

- **Type One** stations are within walking distance of the airport terminal;
- **Type Two** stations are primarily used to access the airport, but are not within walking distance; and
- **Type Three** stations are not primarily for airport access but are in the same city or region.

These relationship types are explored in further detail below. Subsequently, an example of air/rail relationships in Lyon, France and Paris and a discussion of what makes for a successful multimodal station are presented in the pull out.

Type One (Station within walking distance of Terminal)

Type One stations allow a seamless transfer between rail and the airport, as travelers do not rely on another mode to bring them between two locations. Type One stations exist at the airports in

Oslo, Norway, Lyon, Zurich, Geneva, Amsterdam, and Frankfurt. Type One is viewed most efficient option for transfers between rail stations and airports. To collect airline passengers, the station sacrifices the flexibility of rail alignment and the station's use. If the station is not constructed at the same time as the terminal, placement can be expensive because it requires vital airport land and rail alignment. At the same time, dedicating an entire HSR stop to the airport is risky because it would be difficult to capture non-airline ridership, thereby relying on airlines to supply sufficient ridership (Airport Cooperative Research Program, 2015).

Type Two (Station exclusive to Airport usage but not within walking distance)

Type Two stations are near the airport terminal — meaning their primary use is still for air/rail integration — while remaining on the rail alignment. Type Two stations are too far from the terminal to walk, requiring a method of transferring people to and from the rail station (i.e., a "people mover"). Although Type Two stations are not as closely connected to the nearby airport, this type may allow more space for other modes (e.g., bus, regional rail, rideshare) that may access the airport, and possibly reduces the cost and difficulty of reorganizing the rail alignment or airport terminal (in comparison to Type One). An exclusive, ongoing people mover may reduce transport friction for travelers making connections. This option provides air/rail integration without sacrificing cost effectiveness. Dusseldorf and Paris Orly airports have Type Two stations (Airport Cooperative Research Program, 2015).

Type Three (Station non-exclusive to Airport usage)

Type Three stations are located without much consideration of the local airport's location. For this type of rail station, the distance between the station and air terminal requires intracity connections by modes such as bus, regional rail, rideshare, or shuttle. Unlike Type One and Two, Type Three allows the rail station to collect travelers from an area of higher demand (i.e., an urban center). At the same time, travelers looking to make the air/rail connections must add another mode to their trip. With an exclusive, high-quality shuttle service, a Type Three station can provide more convenient connections to airport travelers; however, it comes at the risk of permanently alienating travelers who miss a flight because of an ineffective, unreliable connection. If the gap between the airport and Type Three station is consistently minimized, this option could lead to higher levels of system connectivity because the station can serve the airport without needing to compromise on location or using the limited land in the immediate airport area. Airports with Type Three stations include London Heathrow, Madrid, Barcelona, Vienna, Munich, Hamburg, Paris CDG (Airport Cooperative Research Program, 2015).

Case Study of Air/Rail Connections in France

Paris' HSR station at Charles de Gaulle (CDG) airport has approximately 2.6 million air/rail travelers each year, making it a clear success story in France and outpacing other air/rail stations (Airport Cooperative Research Program, 2015). However, the CDG airport is nearly two miles from the Type Three HSR station, requiring travelers to take taxis, buses, or unreliable regional trains to get to Gare du Nord HSR station. Only recently has Paris announced a dedicated HSR link from the CDG airport to the HSR station (The Local, 2019).

At the same time, the Saint Exupéry airport's HSR station in Lyon has been an example of exceptional site planning to maximize air integration. The airport terminal is only a 400-foot walk from the HSR station. However, as of 2011, HSR represents only one percent of the airport's feeder modes, while CDG had HSR serve as six percent. Ninety-two percent of the travelers at the HSR station were not coming from the air terminal and instead used it as a regular HSR station. Based on surveys with Lyon airport managers and travelers, ACRP found that Lyon airport functioned as a secondary airport rather than an international hub. For travelers in the Southern France region, it was more efficient to take a train or local feeder airport to an international airport, rather than to take a train to Lyon, which would likely result in another airport connection (Airport Cooperative Research Program, 2015).

ACRP interviews with European station planners were critical of the 'if you build it, they will come' transportation planning philosophy. In their opinion, HSR could not take the place of the feeder air system based solely on integrated service times and physical infrastructure. The Frankfurt HSR intermodal system mastermind, Hans Fakiner, commented that "a successful intermodal system only occurs when it is in the business interest of the airport, the airlines, and managers of the rail system" (Airport Cooperative Research Program, 2015). Frankfurt and Paris CDG saw high rates of air/rail transfers because of their market share penetration — even if they have lower-quality connections.

Recommendations for Further Research

There is a plethora of literature dedicated to studying the "place" aspect (i.e., the station is the destination of the trip) of stations with topics such as TOD, community planning, and general development trends. Fewer studies examine how a station's layout, mode accessibility (Puello and Geurs, 2016), modal choice (Haas, 2017), and pedestrian network can fulfill the role of the "node" (i.e., a connection point). Bertolini's node-place framework provided a good theoretical overview of the role of rail stations in the transportation network (Bertolini, 1996; Bertolini and Spit, 1998). There are also a few studies that detail mode choice for access and egress to stations, but the literature is limited.

More research is needed on the traveler behavior at HSR stations. One aspect of the inconsistency is the interdisciplinary approach needed to properly address station access and the many components of an HSR door-to-door journey (Coxon et al., 2018). Relevant disciplines include transportation planning, land-use planning, architecture, civil engineering, behavioral economics, psychology, political science, and public policy. This multidisciplinary approach makes it difficult for researchers to form a universal framework of analysis and add other contributions to this discussion. Boarnet and Crane (2001) and Cervero (2002) both discuss the absence of a universal, systematic analytical framework on the influence of urban structure on travel behavior. Van Hagen's station behavioral framework, which repurposed concepts from the psychology discipline, gives a logical understanding of traveler's expectations when at a rail station; however, it has not been thoroughly studied and tested (Peek and van Hagen, 2002; van Hagen, 2011). Silva (2013) goes into further depth of the literature available and unavailable for this general area of built environment affecting mobility.

Literature exists on topics related to specific modes, such as parking for vehicles and bikes, park-and-ride, and walking; however, they are not necessarily tied to HSR nor are they studied as in combination with each other. There are many studies on airport connections to HSR (Haas, 2017). Loukaitou-Sideris et al. (2015) and Eidlin (2015) collected case studies of many European HSR stations; however, there are limited examples of HSR stations in low density and rural areas for future California HSR stations to draw lessons from.

In the HSR literature and station layout recommendations reviewed for this report, the researchers found a recurring suggestion that stations — and all transportation projects — be planned and developed by cooperative governance, with multiple agencies at the table to represent a variety of viewpoints, solutions, and consistent communication (Bertolini and Spit, 1998; Eidlin, 2015; Loukaitou-Sideris, 2013; Loukaitou-Sideris et al., 2015). Future research or case studies can investigate best practices for planning for HSR stations as a collaborative effort by many agencies. Future research should also study whether and how HSR station layouts can reduce the distance and barriers between modes and transfers in order to maximize walkability, traveler utility, network connections, and flexibility. This study seeks to fill these gaps by considering multimodal integration between stations and other modes, including those yet to be deployed (i.e., urban air mobility, autonomous vehicles), while also investigating traveler decision-making for trips that involve HSR.

Expert Interviews

To gain an understanding of the unique characteristics in and around each of the three future HSR station sites (Fresno, Kings/Tulare, and San José), the researchers used semi-structured expert interviews. See Appendix B for the list of questions designed to interview strategic site experts and Appendix C for the list of questions designed to interview domestic or international experts.

In the spring of 2018, researchers conducted nine expert interviews with seven public agencies in the SF Bay Area and the Central Valley. Interviewees represented the following agencies:

- The City of San José
- The Central Valley Community Foundation
- The City of Visalia
- The City of Hanford
- The Tulare County Association of Governments (TCAG)
- The Altamont Commuter Express (ACE)
- The Fresno Economic Development Corporation

The following section summarize discussions with these nine experts.

Knowledge of Shared Mobility

All of the participants were knowledgeable about shared mobility. However, the level of knowledge and usage of shared mobility varied among each community's members, according to the expert interviewees. In San José, interviewees discussed the recent launch of multiple shared scooter platforms, station-based bikesharing, and transportation network companies (TNCs, also known as ridesourcing) in the city. In Fresno, interviewees were familiar with all modes; however, they explained that bikesharing has not been successful yet in Fresno and that TNC providers may have limited service availability throughout the city. In Kings and Tulare Counties, the interviewees unanimously agreed that the most common shared service was vanpooling, followed by carpooling. They indicated that many San Joaquin Valley residents may not have any experience using TNCs, even though they are familiar with the services Uber and Lyft provide. Additionally, in some cities in Kings and Tulare Counties, the interviewees mentioned that data-enabled smartphone use might be lower than elsewhere in the state. They also talked about the recent installation of internet kiosks in downtown areas. This information proved valuable for localized survey formulation.

HSR and Economic Development

When participants were asked about the potential for HSR to support economic development, responses varied. There was consensus that HSR is a valuable economic development tool in a broader sense. Interviewees from Fresno and San José were hopeful that HSR would generate jobs locally. One planner from San José described the city as not feeling like the largest city in the Bay Area, despite it being so, and was optimistic that HSR would change that image. In Kings and Tulare Counties, while the direct employment benefits were not discussed at length, interviewees talked about the economic development potential around the immediate station vicinity and its synergy with the Cross Valley Corridor to link many cities in Kings and Tulare Counties to HSR. In San José, the Downtown Station Area Plan, which is currently being updated, includes plans for development around the current station area, such as a large employment center for Google. However, interviewees noted that Google may be more motivated by BART's San José extension than the planned HSR station. In Fresno, respondents were able to provide more concrete examples of HSR's direct economic impact. Bitwise, a technology company, has already established a location in Fresno and there are three to four other businesses currently in negotiations to either 1) establish locations in Fresno and Silicon Valley or 2) establish a location in Fresno for access to Silicon Valley. Additionally, the city of Fresno has been actively involved in its station area planning efforts by facilitating dense, walkable projects.

Enticing businesses to relocate prior to the system's opening will help boost not only HSR ridership but also downtown revitalization. In San José, the participants viewed HSR as a complement to existing transportation modes and discussed the possibility of increased multi-modal ridership if HSR were competitive with the costs of intrastate air travel. Many interviewees were eager to know the pricing structure in order to better understand the implications HSR could have on economic development.

HSR and Connections to Local Planning

As mentioned earlier, HSR is integrated into current local and regional planning processes at the three station locations. The City of San José is conducting six studies that are directly or indirectly related to HSR. Fresno has completed a Station Area Master Plan and is working to keep it up to date, particularly as Transform Fresno (also known as the Fresno Transformative Climate Communities Collaborative) projects begin to be implemented. In Kings and Tulare Counties, the proposed Cross Valley Corridor will serve as a feeder service to the future rail station.

Although housing was not included in the expert interview questions, interviewees discussed potential HSR impacts on housing at each location. In San José, respondents anticipate that a potential impact of HSR is the flattening of housing prices, followed by a relative rise in home value as the system gets closer opening. This impact was mostly viewed in a positive light in San José, although some respondents brought up the lack of affordable housing in the Bay Area and expressed concerns that HSR could exacerbate this shortage by raising downtown home prices. Interviewees in Fresno expressed similar concerns about rising housing costs. Much of the attractiveness for business relocation to the Central Valley is driven by cost of living and if HSR increases land values in the Central Valley, the cost of living could rise to a point where the county loses its attractive value proposition. Other interviewees expressed optimism that the city would support high density development around the station, potentially mitigating rising housing costs. In contrast, the interviewees from Kings and Tulare Counties noted the lack of existing market-rate housing in their communities. Two respondents noted that in the counties' long-range plans there are multiple sites approved for market-rate, single-family home developments, but no developers are pulling permits for the sites. The shortening of travel time by HSR to major jobs centers might make housing developments in their counties more attractive if there is a demand among workers for a more rural lifestyle.

HSR Benefits and Drawbacks

Participants were asked what they perceived to be the largest benefits and drawbacks of HSR stations in their counties. Although many of the responses have already been touched upon, they are summarized here as well.

Regarding benefits and opportunities, respondents in San José and Fresno saw the potential for the creation of large jobs centers. In Fresno, respondents commented that HSR would have the ability to encourage downtown revitalization, as both an employment center and a destination. One respondent cited interest in using the HSR station as an anchor, similar to how stations operate in cities in Spain. An "anchor" HSR station is used by many people for a variety of purposes, with less than half of users being ticketed passengers. In Kings and Tulare Counties, interviewees were excited for the development of market rate housing.

When probed about drawbacks, one respondent thought a potential drawback was the risk of not realizing the full system from Los Angeles to San Francisco. Many respondents also discussed the challenge of convincing residents to reduce their dependency on private vehicle ownership. In the words of one interviewee:

"To get the general population to both understand that [the private car is not space efficient] and be willing themselves to change their travel behavior [so that we can make the most of HSR] is the biggest challenge. I think it's [the project] going to happen one way or the other, but as a planner I hope that we can be proactive about it, rather than reactive. And by that, I mean we'll try to steer travel behavior…So that's the biggest challenge, is to really help people understand the role of train stations and HSR in the city. And then to be willing to make tradeoffs now […] for really rational planning to occur for that less car-dependent future."

The addition of HSR without corresponding densification of urban form was a concern for some interviewees. They emphasized the importance for planners to champion TOD. In Kings and Tulare counties, the participants were concerned about creating effective feeder public transit routes to the station and adjacent downtown areas. There were also concerns that HSR may not directly serve today's local economy, which relies on a highway-based logistics industry, and that HSR could divert funding from other public works' needs.

Even given these potential challenges, interviewees were generally optimistic about the project moving forward. Understanding the specific opportunities and challenges related to each location gave the researchers a sense of how urban form and local cultures may influence station use. This in turn helped inform the decision to pursue focus groups in Kings and Tulare counties rather than surveys, as focus groups would allow for a more in-depth discussion about the local context and needs in the region. A summary of the focus group findings is available in a later section of this report.

HSR Station Access

The following subsections provide the interviewees' descriptions of station access (e.g., other modes that can be used to connect to and from the station) at each of the three locations, as well as plans to improve station access.

San José

In the City of San José, Diridon Station is already a high-functioning transit hub. It is currently served by three commuter train services (Caltrain, Capitol Corridor, and ACE, VTA light rail and buses, and many regional and intercity buses. Additionally, there are private corporate shuttles that provide first- and last-mile service to commuters. The city is interested in regulating corporate shuttle use at their park-and-ride lots in the future. TNCs also serve the station; however, there is not a dedicated pick-up and drop-off zone at the transit hub. There is a large Bay Wheels (formerly Ford GoBike) bikesharing station at the transit hub, and Lime Bike has introduced a fleet of dockless e-bikes and scooters. Bird scooters are also present in the downtown area, where the station is located. The location provides open walking connections to the SAP Center (a large sports arena) and is less than a ten-minute walk from San José City Hall.

Participants from the City of San José say that the city is dedicated to promoting pedestrian and bicycle access to the station as it develops in the future. While the city is abreast of future modes (such as AVs, both privately and publicly operated), the respondents did not see these modes fundamentally changing the way the station would function. Users arriving in AVs would likely still require the curb space, similar to the needs of TNCs. One respondent did mention UAM but commented that it is mostly a theoretical discussion at the moment, as opposed to a practical one.

Fresno

The City of Fresno's discussions were focused primarily on the future HSR station's location. One respondent noted an "across the tracks" mentality regarding the existing rail line that has colored current station access. The future station area will served by buses and one Bus Rapid Transit (BRT) line. Some participants expect Fresno Area Express, the transit agency, will provide more feeder service closer to the HSR Station. The Greyhound terminal is not located very close (roughly a mile away) to the site for the future HSR station. There are Central Valley specific ridesharing and vanpooling services, such as Green Raiteros, that serve downtown Fresno, and one respondent noted that these vans might see more use during the day in the downtown area once HSR is running and users need transportation to and from the station. Another respondent mentioned a Transform Fresno project that will establish sustainable mobility centers around the city. Although the exact locations have not been settled upon, there is hope of establishing one near the HSR station and one on the "other side of the tracks" in Chinatown to encourage more connection. While there are no bikesharing services currently operating in Fresno, the participants said that the future station area is in a dense, walkable neighborhood that is conducive to active modes.

Kings/Tulare

The station in the Kings/Tulare region is located five miles or more from the nearest downtown, which is in the city of Hanford. Thus, access to the station by a mode other than a private vehicle is unlikely. The Tulare County Area Transit agency is currently considering providing bus service as part of an early phase of the Cross Valley Corridor project site do. The site does not present much potential for connections with active modes, given its distance from destinations. Participants discussed the Cross Valley Corridor being the dominant feeder to the site, with auto-oriented access in the mix as well.

The Link Between HSR and Local Demographics

When asked about future demographic shifts, interviewees in San José were hopeful that auto ownership rates would decline. They also expressed concern that HSR could widen the income inequality gap already present, both through wealth generation related to home prices and the addition of more high-paying jobs, as opposed to service-sector employment. One respondent noted that the opposite of this was possible too, if high-quality, low-cost transit was realized in tandem with HSR. Thus, participants were uncertain if HSR would change the shifts already currently underway in the Bay Area. In Fresno, one respondent did not see HSR shifting demographics, as demographics were more driven by birth rates than by migration, and did not see HSR bringing that enough new residents to surpass this trend. Another respondent did comment, however, that HSR has already helped to attract the technology-sector, and the respondent anticipated this trend continuing through HSR's opening. Respondents said Silicon Valley to Central Valley (commonly referred to as Valley-to-Valley) commuters could become more prevalent. In Kings and Tulare Counties, interviewees did not see HSR contributing to demographic shifts. This perception was partly due to HSR's physical distance from geographic centers and also partly due to a perception that today's local economy is not supported by HSR. Another respondent noted that demographic shifts were primarily tied to the agricultural economy, and even more specifically by water policy. Overall, understanding perceptions of HSR and station users at each site provided a reference point for potential demographic groups to survey; the concept of super-commuters from the north Central Valley into the Bay Area presented itself as an informative proxy for future HSR users.

Focus Groups

Between September 2017 and May 2019, the PAC provided recommendations on the methodological design of the study. The PAC recommended conducting a focus group in the greater Hanford area due to the difficulty of surveying in Kings and Tulare Counties, where the planned HSR station will be built on existing farmland. The focus group findings are also intended to supplement the stated preference survey and further understanding of how local stakeholders may access and egress from their HSR station. The research team conducted three primary forms of recruitment for the focus group: 1) distributing flyers in downtown Hanford, directly to community members and local businesses; 2) posting flyers in community facilities, such as the library and town square; and 3) posting event announcements online on websites such as craigslist and Facebook.

The focus group was conducted in two sessions: an in-person focus group of seven participants in the Hanford City Hall on September 27, 2018, and a phone interview of one participant (who could not attend the original group) on October 12, 2018. Although the two sessions were held separately, they received the same questions using a standard protocol and, as a result, the two sessions' responses were merged into this summary. Focus group participants were asked to complete a brief survey to collect basic demographic and travel behavior information prior to starting. A copy of the focus group protocol is attached in Appendix D, and a copy of the focus group questionnaire is attached in Appendix E.

This section presents findings from a focus group with participants from the Kings and Tulare Counties. The focus group was conducted to better understand the area's travel patterns and mode choice. The focus group results are split into five categories based on mode and travel.

Questionnaire Results

The participants' questionnaire answers reflect the area's preference for private vehicles as a travel mode. When asked what their primary mode of transportation was, all the respondents chose vehicles, and there was only one respondent who took public transit at least once a month. When asked what shared services they used, half the participants chose TNCs. The remaining participants used vanpooling or did not use a shared service. In addition, the participants infrequently used shared services: the respondents who had the highest usage rate used shared services at most once or twice a month.

The participants' demographics were fairly representative of the area's two counties, Kings and Tulare.

Table 6 compares the focus group's demographics against each county's demographic information.

Table 6: Demographic Distributions of the Focus Group and Counties

Demographic Attribute	Focus Group (N = 8)	Kings County (%)*	Tulare County (%)*
Household Size			
Average	4	—	—
One or two residents	3	47.1	43.5
Three or more residents	5	52.9	56.5
Vehicles per Household			
Average	2.6	—	—
Zero vehicles	0	6.8	6.3
One or two vehicles	4	69.9	69.4
Three or more vehicles	4	23.2	24.3
Gender			
Female	4	44.7	50
Male	4	55.3	50
Marital Status			
Married	7	51	52.5
Single	1	49	47.5
Age **			
below - 29	0	48.2**	50.5**
30 - 39	4	15.3**	13**
40 - 49	2	14.1**	12.2**
50 - 59	0	10.9**	10.6**
60 - over	2	11.6**	13.6**
Number of Children			
Zero	1	—	—
One	2	—	—
Two to Three	3	—	—
Four and up	2	—	—
Average	2.5	—	—
Children's Age			
Having children below 18	3	46	46.3
Having children above 18	5	—	—
Average children's age	16	—	—
Homeownership			
Homeowner	7	51.8	56.2
Renter	1	48.2	43.8
Highest Level of Education (25 years and over)			
Graduated high school or equivalent	2	25.5	25.8

Some college	1	26.1	21.7
Bachelor's degree	3	9.3	9.3
Master's degree	2	3.8	4.6
Employment Status			
Employed	6	46.9	52.6
Unemployed	0	5	5.9
Not in labor force	2	44.4	41.4
Ethnicity			
White/Caucasian	3	54.3	60.1
Black/African-American	1	7.2	1.6
Asian	0	3.7	3.4
Hispanic or Latino	2	50.9	60.6
Two or more races	0	4.9	4.2
Decline to answer	2	—	—
2017 Household, pre-tax income			
Under $24.9K	0	22.6	25.5
$25K to $34.9K	1	11.1	11.7
$35K to $49.9K	0	16.5	15
$50K to $74.9K	2	17.4	17.7
$75K to $99.9K	0	13.5	10.7
$100K to $149.9K	2	11.9	11.7
$150K to $199.9K	2	4	4.1
$200K and above	0	3	3.6
Decline to answer	1	—	—
2017 Monthly rent or mortgage payment			
No payment	1	2.8	2.4
Less than $500	1	15.8	16.6
$500 to $999	2	33.8	35.1
$1,000 to $1,499	1	27	26.6
$1,500 to $1,999	2	12.7	11.2
$2,000 or more	0	7.9	8.1
Decline to Answer	1	—	—

*County data sourced from the 2017 American Community Survey (ACS)
**County age data sourced from the 2010 U.S. Census

Current Travel Patterns

Following the introductory questionnaire, participants were asked what attributes they found to be the most important when selecting a travel mode. Half of the participants (N=4 of 8) said that convenience was the most important consideration when selecting a travel mode. The focus group participants who were parents of minor children unanimously agreed that private vehicles are almost a necessity while raising a family. Three of the eight participants said cost was the most important consideration when selecting a travel mode. The remaining participant, who said time was the most important consideration, was a young professional with a varying commute pattern. One of the retirees empathized with the young professional, saying that they would favor time over convenience if they still worked.

All of the working participants preferred to drive a personal vehicle to get to work. The participants felt that it was not practical to use alternative commute modes when private vehicles are faster and more convenient in rural-suburban Kings-Tulare area. For leisure travel in the area, participants were still comfortable with exclusively driving around town. Participants did not consider low-speed and active transportation modes an option because of the area's high temperatures from May to September and sprawling blocks, as well as the perception of streets being autocentric.

Regarding inter-city and intrastate travel, many group participants highlighted that they still rely on private vehicles but would ideally ride rail (Amtrak). However, many said they ride rail infrequently. Participants reported enjoying riding the train because of its spacious nature and the convenience of not having to drive long distances. At the same time, participants expressed that the logistics of transferring between modes (e.g., first- and last-mile connections, changing trains, and thruway connections) was the biggest barrier to frequent rail use. Focus group participants indicated that inconvenient connections (primarily southbound to Southern California) required a high-level of travel planning to understand the connections and multiple fare payment systems.

Focus group participants indicated a greater number of first- and last-mile challenges at the destination rail station than their origin (Hanford). When traveling to the origin station, participants favored parking their private vehicles at the station for day trips or get dropped off by a friend or family for an extended trip. Even if the station had free parking, participants preferred not to park overnight because of security concerns (e.g., perceived lack of gated parking, cameras, and security guards) and the presence of the homeless in public areas.

For participants, a lot of apprehension toward rail travel was associated with the last-mile connection at their destination station. Participants' personal preferences limited their modal options once they arrived at the destination station. A few participants highlighted their reliance on family or friends to pick them up at the destination station. Participants expressed discomfort with public mass transit (e.g., bus, rail) because of the numerous transfers, the added length to the trip, the perception of uncleanliness, and the perceived safety concerns of other riders. A few participants were very supportive of using TNCs to bridge the last-mile gap while other participants distrusted TNCs because of various concerns related to safety, surge pricing, and other issues.

Shared Mobility

Focus group participants were not readily familiar with the term "shared mobility," but they did recognize common shared modes such as TNCs and scooter sharing. Half of the participants had direct experiences with TNCs, while two participants had used scooter sharing. Focus group participants were generally enthusiastic about scooter sharing, but there was a consensus that scooters—along with other active transportation modes such as cycling and walking—may not be compatible with Hanford's residents, weather, and its built environment. When discussing a scenario of shading streets to negate the sun's high temperatures, participants were skeptical of the ability to provide the amount of shade needed to comfortably use these modes. Participants frequently discussed the built environment (i.e., sprawling blocks, auto-oriented streets, and the overall lack of active transportation infrastructure) when considering modes. Although a few participants conceded that the city could designate parts of the street for bike and scooter infrastructure, they still preferred grade-separated facilities or residential streets to minimize potential interactions with aggressive drivers. One participant commented that the Hanford community has a negative perception of cyclists, suggesting that they are lower income and/or "transient." Although participants appreciated the benefits that these modes offer, they were concerned about the accessibility of scooters — specifically, for older adults and people with disabilities.

When the discussion evolved to the use of TNCs, the group was split almost evenly between participants supportive and skeptical of TNCs. Out of the eight participants, the three youngest participants (late-20s to mid-30s) were largely supportive of the mode itself—although this was not without criticism. Each of these participants expressed concerns about multiple experiences with TNCs in larger cities. These concerns included cancellations, the inability to find drivers, and other service-related issues. Supportive participants found TNCs an inexpensive, flexible option compared to public transportation when visiting a larger city. When discussing criticisms, supportive participants were worried about the usage rate of TNCs in the local area and the added time of waiting for a pooled ride. No participant had used TNCs in the local area because of limited availability and the long wait times associated with the service. Participants also discussed their willingness to use pooled TNCs (e.g., UberPool, Lyft Line), but only if the benefit of a lower price outweighed the added time inconvenience.

Participants who were skeptical did not necessarily have experience using TNCs and often referred to the experiences of relatives and stories from the media. When asked about the barriers that limit their use of TNCs, participants cited personal safety, the lack of situational comfort, a potential lack of control, no cultural precedent, and preference for taxi cabs. Regarding the perceived threat of personal safety, participants expressed concern that TNCs drivers are not properly screened as well as concerns about sharing rides with strangers.

The participants who had concerns with using TNCs preferred taxi cabs because of a perception of taxi cabs having a trustworthy brand and certified drivers. There were notable divisions between focus group participants over whether TNCs or taxi services were cleaner or safer and the effectiveness of app-based rating systems (e.g., whether the ratings are trustworthy and effective). One skeptical participant said that there is an immediate discomfort with the idea of using a mode that requires giving up control in an enclosed setting, especially when the alternative is driving a personal vehicle that allows the traveler to retain personal control.

Automated Vehicles (AVs)

Participants were familiar with and interested in AVs. Most participants said they would use a private AV; however, there were participants who did not trust AVs because of safety concerns. With respect to shared automated vehicle (SAVs), participants said they would only use SAVs if they were sure that both the vehicle and sharing a ride with a stranger was safe. One participant emphasized that they did not want to be in an uncontrolled, confined space with a stranger. One participant suggested that they would prefer AVs over HSR, even for long journeys. Participants were uncertain about whether AVs would impact traffic congestion, and if this impact would influence their willingness to use driverless vehicles.

Urban Air Mobility (UAM)

UAM is an emerging concept envisioning air transportation for passenger mobility, cargo delivery, and emergency management within or traversing metropolitan areas (Shaheen et al., 2018). In recent years, innovations in on-demand aviation, automation, and electrification are contributing to a variety of concepts using aircraft and helicopters to provide aerial mobility. Although there are numerous challenges that must be addressed for UAM to be market viable, due to the potential for these services to be available when California's high-speed rail commences service, the researchers included some questions about UAM as a potential access mode to HSR. None of the focus group participants were familiar with UAM, but they were intrigued by the concept. Although there was some interest in the technology, one participant was annoyed that there was a focus on future modes (i.e. AVs, UAM) while leapfrogging improvements to existing transportation infrastructure.

High-Speed Rail Station Access

When asked if the future HSR system would change travel patterns, all participants anticipated that they would travel more. One parent said that HSR trips could bring their children more exposure to different experiences across the state. When asked about the potential of HSR to change participants' employment or housing decisions, most did not think it would impact these decisions. One participant suggested that his spouse's contract-based employment could benefit from the wider reach of day trips. Many participants projected that there will be a higher demand for houses in the Central Valley because people could easily travel for work and leisure.

Participants were confident that their travel pattern to rail stations would largely remain the same with the addition of HSR; in other words, they would still park their vehicle in the lot for day trips and be dropped off by friends or family for extended trips. Participants predicted that they would have the same safety concerns about their vehicles and personal safety at an HSR station (i.e. theft, personal harm, people loitering at stations, the homeless, health hazards of pigeons).

When presented with unfamiliar modes, participants were open to using the modes if they were efficient and comfortable, particularly with higher-occupancy modes such as shuttles, light rail, and microtransit. One participant expressed some concern that an HSR shuttle or bus service may require you to travel to a bus stop before you get to the train. When presented with a luggage service, the focus group quickly rejected the concept because of their concern about lost luggage. One participant saw potential in the service if it was able to connect to airport luggage and provided a seamless connection between rail and air travel.

Using HSR to access distant airports (e.g., San Francisco or Burbank) was an attractive option for all focus group participants because they could take advantage of lower cost flights without driving and parking or transferring through the Fresno airport. When asked what the leading factor was for choosing air travel over HSR, participants said cost. However, focus group participants did acknowledge that HSR could serve the same trips at a lower cost with time savings and increased convenience.

When asked about final thoughts on HSR in general, participants were generally optimistic about HSR as a mode, but a few were disappointed with the project's management. Multiple parents highlighted that a faster train could allow younger people to have new experiences and share them with their community. A few of the participants were concerned that Senate Bill 1 would be redirected toward HSR funding and that external costs from HSR would be introduced to the local area (e.g., higher property taxes, new residents). They were also concerned about the impacts of HSR on agriculture lands and the increasing project costs and poor oversight. Overall, participants were very adept at separating their personal opinions of the project from how they may use the service in the future.

User Surveys and Discrete Choice Models

To provide a quantitative view of traveler decision-making to and from HSR stations, the research team designed and implemented a stated preference survey (N = 2,256), hosted via the Qualtrics survey platform. This section consists of five parts. First, the section discusses the goals of the survey and its design. Next, the section details data collection, processing, and cleaning. The third section provides an overview of sample characteristics, such as demographic information. The following subsection describes the modeling approach the researchers used. Finally, the researchers present and discuss the results of the multinomial logit (MNL) discrete choice model.

Survey Design

In line with the goals of the project, the research team designed the stated preference survey to ask respondents about future mode choices to and from HSR stations. Respondents were asked to choose from a set of possible modes to travel to and from HSR stations. The use of the HSR system or station area was presented as a given. The researchers chose the year 2030 to represent when the IOS would be operational (an estimate) and allow respondents to firmly anchor their decisions in the future. To account for technological change in the transportation options available to travelers, two potential future scenarios were designed: 1) a status-quo case and 2) a high-innovation case. The status-quo case assumed that only modes currently available today would be available in 2030. Those modes included:

- Walking
- Biking (personal, shared, and shared e-bicycles)
- Shared scooters
- Private vehicles (alone, driving a carpool, riding in a carpool)
- Transportation Network Company vehicles (alone and pooled)
- Taxis
- Public transit (bus and rail, where applicable)
- Microtransit

The high-innovation case included three additional modes that are either being currently piloted, tested, or discussed for use in the state of California:

- Private AVs (using alone)
- Automated shuttles (described as driverless microtransit)
- UAM (described as a passenger aerial taxi)

In this way, the survey was able to capture respondent preferences for currently available and potentially available modes. These preferences can help inform future station design needs.

The survey also included two trip-purpose categories:

- Leisure travel (i.e., shopping trips, long-duration vacation trips, and nightlife/outing trips) and
- Business travel (i.e., commute trips, meeting trips [described as off-site meetings separate from normal commute travel], and long-duration business travel trips.

Respondents had an equal chance of seeing a question asking about access to a station or egress from a station within each of those six trip types. The modes available to choose from varied by 1) the future scenario, 2) the trip length (i.e., distance to or from the HSR station), 3) the station area (i.e., the built environment context), and 4) the access or egress scenario. Trip purpose did not affect mode availability.

Each respondent was shown a maximum of four stated-preference scenarios, with an equal likelihood of seeing each possible variation. Each scenario came with accompanying text to explain the choice situation to the respondent, and each mode was described by the six possible characteristics (as applicable):

- Walking time,
- Access time (to the mode from the trip origin),
- Egress time (from the mode to the station),
- Waiting time (to be picked up by hailed and transit modes),
- Travel cost, and
- Parking cost.

Not all modes were associated with each characteristic; for example, while a transit mode might have had access, egress, and wait times, it did not have an associated parking cost.
Each characteristic had at most five levels of values that it could take. Sample characteristics and explanatory text are shown below in Table 7 provides an example of one of the possible scenarios a respondent would have been shown.

It is the year 2030, and you are on your way to go clothes shopping at Fresno's High Speed Rail station. Among the following options which would you select? Please choose only one option. Access time is the time it takes to reach the mode (e.g., walking to the bus stop, or your car); wait time is time spent waiting (e.g., for your Uber/Lyft pickup, the bus, etc.); travel time is the time spent in transit; egress time is the time it takes to reach the station from the mode's end point (e.g., walking transfer, walking from a parking lot).

Table 7: Sample Characteristics

Alternative	Access time [min.]	Wait Time [min.]	Travel Time [min.]	Egress time [min.]	Cost [$]	Parking cost [$]
Bike	0	0	32	0	0	0
Bikesharing	3	0	32	1	2	0
e-Bikesharing	3	0	28	1	3	0
Scooter Sharing	3	0	30	1	3	0
Drive alone	0	0	15	1	7	5
Private Automated Vehicle	0	0	15	0	15	0
Drive in a carpool	0	0	18	1	6	5
Ride in a carpool	0	3	18	1	1	0
TNC (Uber/Lyft)	0	3	21	0	12	0
Pooled TNC (uberPOOL, Lyft Shared rides)	0	5	24	1	7	0
Taxi	0	5	21	0	10	0
Bus	0	7	30	3	2.25	0
Train	0	10	28	5	2.25	0
Microtransit	0	4	26	2	5	0
Automated Shuttle	0	3	26	2	5	0
Urban Air Mobility (e.g., air taxi)	1	2	6	1	20	0

This survey design enabled the estimate of an MNL model that accounted for many different travel scenarios and preferences.

Data Collection and Sampling

Following the decision to pursue a focus group in Hanford/Visalia area (Kings/Tulare), the PAC and research team agreed to pursue an intercept sample via postcard surveys on trains, at train platforms, and public locations (i.e., grocery stores, outside city halls, etc.) in San José, Fresno, and Madera. The teams hoped to yield a non-random but useful sample to represent current and potential future HSR users. Madera was chosen as a proxy site to reach current ACE users, whose travel patterns potentially provide a basis for future HSR use cases.

After procuring the proper consent from transit providers to survey on train platforms and on trains, the research team, with support from additional staff at TSRC, conducted an initial field test during the Fall of 2018. Field surveyors were dispatched on southbound morning commute trains, evenly divided between the Capitol Corridor and Caltrain. Surveyors on Capitol Corridor trains (boarding at Emeryville or Jack London stations) distributed survey solicitation postcards to riders after explaining the study purpose. The solicitation postcards contained a link to the online survey as well as further explanation of the study purpose and available incentives for completing the study.[1] The survey was available for completion by both computer and mobile devices, and it was available in both English and Spanish.

The surveyors then distributed postcards to arriving passengers at San José Diridon station until the end of the morning commute, at high foot traffic locations throughout downtown San José during the day (e.g., near City Hall, outside grocery stores), and then again at the Diridon station to northbound commuters during the evening commute. One surveyor boarded and distributed postcards on an outbound ACE train and then continued on to Fresno via Amtrak. On the morning of the next day, the surveyor distributed postcards on a San José-bound ACE train and conducted postcard distribution in San José during the daytime and during the evening commute. The response rate from this field test was lower than anticipated and indicated that the initial sampling plan would not yield enough responses from which to estimate a model.

At this point, the PAC and the research team agreed to pursue an alternative approach: using Qualtrics survey panels to collect a representative general population sample in similar geographic areas to the station areas. Qualtrics survey panels are based upon Designated Market Area (DMAs)[2] and are collections of census-defined county geographies, often used by marketing companies for market studies. For the purposes of this study, three DMAs were chosen: 1) The SF Bay Area, 2) Fresno, and 3) Sacramento. The Sacramento DMA was included to provide a sample of respondents who reside in regions near commuter rail services (i.e., ACE and Amtrak services [Capitol Corridor and San Joaquin]).

To collect as representative a sample as possible, respondents were screened based upon four demographic questions: 1) age, 2) county of residence, 3) gender identity, and 4) race/ethnicity. The collection team at Qualtrics set quota targets based upon American Community Survey (ACS) data available for age, gender identity, and race/ethnicity and segmented by DMAs. The survey was originally distributed for a three-week period beginning September 10, 2019; however, data collection lasted for an extra two weeks (ending on October 20, 2019) because of issues hitting survey quota targets, particularly in the Fresno DMA. During the extension, the demographic quotas were removed as the research team and PAC decided to prioritize collecting as many responses as possible.

The main advantage of the Qualtrics panel-based approach were that participant recruitment and incentivization were taken care of by Qualtrics, which eased the data collection burden. As the original survey was available only for online or mobile completion, utilizing an online

---

[1] Respondents who fully completed the survey and provided a contact address were eligible to receive small virtual gift cards ($10) to online retailers.
[2] A DMA region is a group of counties that form an exclusive geographic area in which the home market television stations hold a dominance of total hours viewed.

solicitation approach did structurally limit the sample further with respect to internet or mobile-data availability. Disadvantages of this Qualtrics approach included a limited ability to target current rail commuters. Instead, the researchers had to adjust the collection goal to a representative sample of the DMAs. Other disadvantages, as described in the next section, included response duplication and difficulty collecting the desired sample sizes within each DMA. This resulted in the research team choosing between the competing goals of sample representativeness and sample size during data collection stage with Qualtrics. Removing the quotas allowed for collection of a large enough sample to estimate a model, but the sample population is not guaranteed to be representative of the general population of the region or of current or future HSR users. However, compared with the initial field test, Qualtrics enabled the survey team to collect a large enough sample to estimate a model.

Data Processing and Cleaning

Qualtrics provided in-house data cleaning that eliminated obviously unusable responses. These responses were not counted toward the desired quotas. Once the Qualtrics-cleaned data was delivered, the research team completed an extensive review of the data to determine the final sample. The research team identified 245 duplicate responses in the Qualtrics-provided data, and another 17 responses were dropped from the sample because the respondents did not complete any of the stated preference questions.

The final cleaned sample population is provided below in Table 8. These sample sizes exceeded the original goal of 2,000 responses even after removal of the duplicates and dropped responses.

Table 8: Cleaned Sample Population

DMA	Requested Quotas	Cleaned Sample Size
San Francisco Bay Area	1,000	1,030
Fresno	700	856
Sacramento	300	370
Total	**2,000**	**2,256**

Sample Characteristics

As it was only feasible to screen respondents based upon their age, gender identity, and race/ethnicity; the research team expected the sample to differ from each region's demographics slightly. Comparison population data for the three regions comes from the most recent ACS five-year estimates. Some demographic categories are not directly comparable, but where possible, matched categories between the sample and the population are presented here.

As shown in the following demographic tables, the sample in both the SF Bay Area and Sacramento regions tracked closely with the population for gender identity (see Table 9). The Fresno sample skewed more female, likely as a result of survey quota issues. Regarding race and ethnicity, although the categories are not matched, it is clear that the sample is not representative of the population in any of the three regions (see Table 10). For this reason, race and ethnicity were not included during the modeling procedures. While the samples skewed younger than the population in every region (see Table 11), age was initially included in the model to account for comfortability with shared mobility services and other demographic indicators that are related to age (i.e., marriage and family status, employment, etc.).

Table 9: Gender identity (n = 1994)[3]

Demographic category (survey)	SF Bay Area sample (%)	Sacramento sample (%)	Fresno sample (%)	Total sample percent (n = 1994)	**Demographic category (census)**	SF Bay Area population (%)	Sacramento population (%)	Fresno population (%)
Female	50.39	51.50	59.37	50.39	**Female**	50.32	50.60	49.90
Male	49.61	48.50	40.63	49.61	**Male**	49.68	49.40	50.10

[3] Due to lack of available comparison data for categories other than male and female, the survey team was restricted from implementing a survey quota that included other gender identities. In future studies, researchers should be aware of this and look proactively for available data on all gender identities.

Table 10: Race and ethnicity (n = 1994)

Demographic category (survey)	SF Bay Area sample (%)	Sacramento sample (%)	Fresno sample (%)	Total sample percent (n = 1994)	**Demographic category (census)**	SF Bay Area population (%)	Sacramento population (%)	Fresno population (%)
Caucasian/non -Hispanic	44.82	53.41	43.78	44.82	**White**	62.27	79.57	68.50
Hispanic or Latino	13.96	10.63	34.33	13.96	**Hispanic or Latino (any race)**	24.18	23.78	53.50
Asian	25.10	17.17	5.64	25.10	**Asian**	23.52	13.22	12.00
Black/African American	8.01	12.53	7.30	8.01	**Black or African American**	6.82	5.22	6.00
Mixed (2 or more)	4.30	3.81	3.32	4.30	**Mixed (2 or more)**	6.99	2.75	4.60
Other	3.81	2.45	5.64	3.81	**American Indian and Alaska Native**	1.60	1.42	2.80
					Native Hawaiian and Other PI	1.13	4.77	0.50
					Some other race	10.15	6.18	15.10

Table 11: Age (n = 1994)

Demographic category (survey)	SF Bay Area sample (%)	Sacramento sample (%)	Fresno sample (%)	Total sample percent (n = 1994)	**Demographic category (census)**	SF Bay Area population (%)	Sacramento population (%)	Fresno population (%)
					15 to 19 years	5.70	7.10	7.20
18-24	17.19	17.17	20.73	18.25	**20 to 24 years**	5.72	7.28	7.10
25-34	27.93	22.34	32.67	28.34	**25 to 34 years**	14.67	13.25	15.40
35-44	22.17	21.25	21.74	21.87	**35 to 44 years**	13.57	12.32	12.80
45-54	13.67	14.71	9.78	12.69	**45 to 54 years**	13.61	12.02	11.00
55-64	10.84	15.80	9.45	11.33	**55 to 59 years**	6.64	6.25	5.60
					60 to 64 years	6.50	6.78	4.90
65-74	6.25	7.36	4.64	5.97	**65 to 74 years**	9.86	9.20	7.10
75-84	1.95	1.09	1.00	1.50	**75 to 84 years**	4.91	4.60	3.40
85 or older		0.27		0.05	**85 years and over**	2.12	1.93	1.70

Income and commute mode to work were not included in the quotas provided to Qualtrics, and thus were not expected to be representative of the populations, as shown in Table 12 and Table 13. The sample skewed toward the lower end of the income spectrum in all regions, which is potentially due to the characteristics of the panels used by Qualtrics to recruit participants. Regarding commute mode share, the drive alone mode share of the samples in the SF Bay Area and Fresno regions tracked closely to those of the actual populations, while the Sacramento sample had a lower drive alone mode share than the actual population. Although TNC mode share figures were not available for the populations, TNCs were included during the modeling exercise because it was available in all scenarios and because it is the form of shared mobility that most respondents were likely to be familiar with.

Table 12: Income (n = 1945)

Demographic category (survey)	SF Bay Area sample (%)	Sacramento sample (%)	Fresno sample (%)	Total sample percent (n = 1945)	**Demographic category (census)**	SF Bay Area population (%)	Sacramento population (%)	Fresno population (%)
Less than $10,000	12.65	14.09	22.86	15.99	**Less than $10,000**	3.73	5.37	6.70
$10,000 to $14,999	5.16	4.97	9.58	6.48	**$10,000 to $14,999**	2.74	4.25	5.60
$15,000 to $24,999	8.91	8.84	11.93	9.82	**$15,000 to $24,999**	5.20	7.82	11.60
$25,000 to $34,999	8.81	10.77	15.63	11.26	**$25,000 to $34,999**	5.02	8.77	10.30
$35,000 to $49,999	12.04	14.92	13.78	13.11	**$35,000 to $49,999**	7.73	11.78	13.40
$50,000 to $74,999	16.50	19.06	12.61	15.78	**$50,000 to $74,999**	12.98	15.57	17.40
$75,000 to $99,999	13.46	11.05	6.89	11.00	**$75,000 to $99,999**	11.54	13.4	11.70
$100,000 to $149,999	12.25	9.39	4.54	9.36	**$100,000 to $149,999**	17.92	16.43	13.50
$150,000 to $199,999	5.67	4.42	1.18	4.06	**$150,000 to $199,999**	11.79	8.15	5.20
$200,000 or more	4.55	2.49	1.01	3.08	**$200,000 or more**	21.30	8.52	4.50

Table 13: Commute mode to work (n = 1973)

Demographic category (survey)	SF Bay Area sample (%)	Sacramento sample (%)	Fresno sample percent (%)	Total sample percent (n = 1973)	Demographic category (census)	SF Bay Area population (%)	Sacramento population (%)	Fresno population (%)
Bicycle	1.47	3.07	0.67	1.52	**Bicycle**	1.43	1.77	0.50
Bikesharing	0.20	0.28		0.15				
Bus	9.14	5.59	3.35	6.74	**Public Transportation**	10.10	1.77	1.10
Rail	7.56	3.91	0.17	4.66				
Carpool	7.37	8.10	7.54	7.55	**Carpool**	9.69	9.75	12.40
Drive Alone	66.31	72.07	81.57	71.97	**Drive Alone**	66.48	75.28	79.00
Scooter sharing			0.17	0.05				
Taxi	0.49		0.17	0.20	**Taxi, motorcycle, or other means**	1.94	1.43	1.30
Shared TNC	0.29	0.28		0.30				
Transportation Network Company	1.96	1.68	0.34	1.42				
Walk	5.21	5.03	6.03	5.42	**Walk**	3.38	1.75	1.80
					Work from Home	7.17	8.27	4.00

Discrete Choice Modeling Approach

After data cleaning, the survey yielded answers to 7,507 choice experiments (an average of 3.33 experiments seen per respondent). As discussed previously, the number of modes available to choose from varied by the experiment type; respondents saw an average of 12.8 modes per choice experiment.

The research team chose to pursue an MNL modeling approach to account for variability between modes and between individuals. An MNL model is a type of discrete choice model,[4] which is a branch of economics that pertains to the understanding of choices between discrete (i.e., generally mutually exclusive) alternatives. Discrete choice modeling is based upon random utility theory, which suggests that when presented with complete information, individuals make decisions to maximize their utility, subject to knowledge constraints, which are often represented as errors. In transportation, discrete choice models are often used to describe individual or collective traveler behavior, such as the decision to take public transit or a private car or the decision to work from home. In this study, the respondents were asked to choose from amongst a

[4] For further reading on discrete choice modeling as applied to transportation, please refer to Train and McFadden (1978) or Ben-Akiva and Lerman (1985) in the References.

set of alternatives, each with varying characteristics. An MNL model can help explain the variation in preferences between modes as well as the relative importance of certain characteristics of each mode. For example, MNL can help researchers understand how travel cost influences a decision if someone is choosing between transit or a TNC.

For the purposes of this project, mode-specific and individual-specific characteristics were included in the model as they were helpful in drawing conclusions regarding station design. Additionally, specific interaction variables were included in the model to investigate the importance of station design-related policy levers available to the Authority as well as to account for regional differences between respondents. The policy levers were:

- Parking cost, which was assigned to drive alone and carpool modes, and
- Egress time (i.e., the duration of time between exiting a mode until entering the station).

Based on current station configurations, the researchers assumed that TNCs would have negligible egress time, as riders are typically dropped off directly in front of stations. Public transit, microtransit, shared micromobility, and UAM modes were all assumed to have non-negligible egress times. Parking cost applied only to driving alone and carpooling, with uniform parking costs per vehicle for both.

Respondents' regional differences were accounted for in two primary ways:

- Grouping respondents by their region and
- Grouping choice experiments by the station area.

Respondents from the Fresno and Sacramento DMAs were grouped to represent Central Valley residents. Although Sacramento isn't always considered to be part of the Central Valley for regional or state planning purposes, the researchers decided to group them together because respondents from both Fresno and Sacramento regions would likely use HSR to commute toward the SF Bay Area. Station areas were grouped according to Central Valley (i.e., Fresno and Kings/Tulare) and SF Bay Area (i.e., San José Diridon). The research team was interested in understanding how individuals approached questions regarding station areas with which they were more likely to be familiar. For example, how did SF Bay Area residents interact with experiments related to San José, or how did Central Valley residents interact with experiments related to Kings/Tulare or Fresno?

For the rest of this section, results are presented by grouping similar modes and comparing results within groups (and between groups where appropriate). The results are available in Table 15 through Table 18 in the next section. The mode groups are as follows:

- **Active modes**, which include walking, personal bike, bikesharing, and e-bikesharing and scooter sharing;
- **Private vehicle-based modes**, which include driving alone, private automated vehicles, carpooling (riding and driving), TNCs, pooled TNCs, and taxis;
- **Public transit and microtransit modes**, which include public transit (bus and rail) and microtransit (current microtransit and automated shuttles); and
- **UAM**, described to respondents as air taxis.

Discrete Choice Modeling Results

As discussed previously, discrete choice models are often used to compare decisions between mutually exclusive alternatives. Results are often presented in contrast to the decision to choose a “default” or comparison choice. For this project, the use of a TNC was chosen as the comparison trip because respondents were able to choose the TNC option in all of the stated preference scenarios, whereas driving alone (which is often used as a comparison choice) was only available for access (not egress) scenarios. All interaction and individual specific variables in the model are binary (i.e., 0/1) indicator variables, which means that the non-included category was used for comparison; for example, the leisure trip purpose indicator variable can be used to compare leisure trip choices when compared with business trips, and the car commuter indicator variable can be used to estimate car commuter choices compared to commuters using all other commute modes.

The example specification shown below represents the full utility function for the comparison TNC mode (e.g., Uber, Lyft, or Via) trip. This utility function is the same for all other modes. If a variable was mode-specific and would therefore be null in the utility function for another mode, it is represented by dash in the table.

$U_{i,TNC} =$

Mode specific (and interaction) variables:

$$ASC_{TNC} +$$
$$+ \beta_{wait\ time_{TNC}} Wait\ Time_{TNC} * \left(\frac{1hr}{60mins}\right)$$
$$+ \beta_{travel\ time,\ TNC} * Travel\ Time_{TNC} * \left(\frac{1hr}{60mins}\right)$$
$$+ \beta_{egress\ time,\ TNC,\ Central\ Valley} * Egress\ Time_{TNC}(= 0) * \left(\frac{1hr}{60mins}\right) * Central\ Valley^{5}$$
$$+ \beta_{egress\ time,\ TNC,\ SF\ Bay\ Area} * Egress\ Time_{TNC}(= 0) * \left(\frac{1hr}{60mins}\right) * SF\ Bay\ Area$$
$$+ \beta_{travel\ cost,TNC} * Travel\ Cost_{TNC} * \left(\$\frac{1}{100}\right)$$
$$+ \beta_{parking\ cost,\ TNC,\ Central\ Valley} * Parking\ Cost_{TNC}(= 0) * \left(\$\frac{1}{100}\right) * Central\ Valley$$
$$+ \beta_{parking\ cost,\ TNC,\ SF\ Bay\ Area} * Parking\ Cost_{TNC}(= 0) * \left(\$\frac{1}{100}\right) * SF\ Bay\ Area$$

Individual specific (and interaction) variables[6]

$$+ \beta_{leisure} * (Trip\ purpose = leisure)$$
$$+ \beta_{leisure,\ Central\ Valley} * (Trip\ purpose = leisure) * Central\ Valley$$
$$+ \beta_{car\ commuter} * Car\ Commuter$$
$$+ \varepsilon_{i,TNC}$$

Equation 1: Utility specification for the TNC mode

Each beta value in the equation is shown as a parameter in Table 15 through Table 18. When reading the tables, the sign of a parameter indicates in which direction it is pushing a respondent's choice: a negative parameter value indicates that the variable influences respondents toward the comparison mode (i.e., toward choosing a TNC) whereas a positive parameter value indicates that the variable influences respondents towards choosing the alternate mode. The magnitude of the parameter (and its statistical significance) indicates the relative importance of that directional influence.

The mode-specific variables chosen for inclusion in the model represent factors unique to each built environment context, level of urbanization, or factors that would be within the control of a station planning entity, such as egress time from a specific mode to the train platform and parking cost. The individual-specific variables chosen for inclusion in the model also account for

[5] For modeling purposes, the region indicator variables are combinations of respondent and station location. For example, the Central Valley indicator included only experiments where all of the following was true: the respondent lived in either the Sacramento or Fresno DMA and the station area in the experiment was Kings/Tulare or Fresno.

[6] Other variables tested but not included in the final model included: income, age, sex, use of other commute modes, access time, and choice scenario type (future vs. status quo).

regional differences, via the regional-indicator variables. Age and income differences, along with whether a respondent commutes primarily via an automotive mode (in this case, a private vehicle, carpooling, a TNC, or taxi), are also accounted for.

Due to the size of the dataset, estimating an MNL with all observations included required more computing power than was readily available to the research team. To overcome this issue, the model was bootstrapped, which involved taking repeated draws from all observations with replacement and averaging the results. In this case, the researchers used a bootstrap sample of 70,000 observations (from the 96,099 total) with 10 draws. Table 14 presents the sample characteristics after bootstrapping.

Table 14: Bootstrap Results

Bootstrap Results	
Fitted Log-Likelihood	-11155
Null Log-Likelihood	-12288
Number of Observations	7502
Number of Parameters	81
Rho-Bar-Squared	0.09
Rho-Squared	0.09

The results presented in Table 15 through Table 18 are the averages across all 10 draws. The model explained roughly nine percent of the total variation observed across the choice experiments, which suggests that there are behaviors or interactions that were not captured by the experimental design. The chosen model outperformed other tested models, although other model forms (e.g., nested logit, mixed logit, hybrid discrete choice and machine learning models) might produce better results.

In regard to active modes, as shown below in Table 15, the walk and personal bike modes did not yield statistically significant results across all variables. This suggests that respondents did not actively consider these modes when answering the choice experiments. When compared with taking a TNC, respondents were less likely to choose electric shared micromobility modes (e-bikesharing and scooter sharing) than they were to choose traditional bikesharing. This may be due to the relatively limited familiarity with or use of electric shared micromobility amongst respondents, particularly in the Central Valley. That relationship is enforced by the strong and negative influence of auto ownership on choosing any active shared mode. Regionally, there were no statistically significant differences with respect to active modes, possibly because of the familiarity issue. Finally, egress time for each of the shared modes was not statistically significant. This indicates that the egress time did not a significant influence on a respondent's decision to choose a mode, comparing between active transit and TNCs.

Table 15: Model Results for Active Modes

	Walk		Personal Bike		Bikesharing		e-Bikesharing and Scooter Sharing	
	Parameter	P-value	Parameter	P-value	Parameter	P-value	Parameter	P-value
Alternative Specific Constant	-0.06	0.831	-0.08	0.702	-0.3883*	0.085	-0.60***	0.003
Travel Time [hrs]	-0.05	0.845	-0.04	0.890	-0.13	0.728	-0.19	0.552
Travel Cost [$0.01]	-	-	-	-	-0.01	0.998	-0.02	0.991
Parking Cost - Central Valley [$0.01]	-	-	-	-	-	-	-	-
Parking Cost - SF/Bay Area [$0.01]	-	-	-	-	-	-	-	-
Egress time - Central Valley [hrs]	-	-	-	-	0.00	1.000	0.00	1.000
Egress time - SF/Bay Area [hrs]	-	-	-	-	0.00	1.000	0.00	1.000
Trip purpose is leisure	-0.02	0.895	-0.05	0.788	-0.22	0.185	-0.34**	0.025
Trip purpose is leisure - Central Valley	-0.01	0.978	-0.02	0.921	-0.06	0.833	-0.08	0.742
Auto commuter	-0.06	0.762	-0.09	0.652	-0.3224*	0.081	-0.474**	0.005

***, **, * denote significance at 99%, 95%, and 90% confidence levels, respectively

When comparing private vehicle modes against the TNC baseline (see Table 16), the model suggests that respondents preferred driving alone when all else was held equal; this was the single strongest parameter in the entire model. This result is not surprising, as the sample population had a much higher rate of commuting by automotive modes than the overall population across all DMAs. As with active modes, the differences between the regional groups were not statistically significant.

None of the parameters associated with private AVs were statistically significant, suggesting that respondents did not actively considering the mode when making their decisions. This could be due to a few factors: unfamiliarity with or skepticism of AVs, their relative characteristic similarity to private vehicles, or other effects that the model did not capture. Compared to TNCs, the model suggests a distaste for time spent carpooling and carpooling for leisure purposes. These results are consistent with prior assumptions.

Interestingly, respondents were insensitive to parking cost, which suggests that the maximum presented parking cost of $11 was not high enough to influence respondent decision-making. This suggests that parking costs could be raised, or other pricing structures pursued, if station planners wanted to encourage the use of non-private vehicle modes. Alternatively, discounts could be explored for carpooled modes, as this was not explored in the current project.

Contrary to the researchers' expectations, the estimated model showed a relative preference for taxis over pooled TNCs when the two are compared against choosing a TNC. This may be due to: 1) the assumption that taxis are private and pooled TNCs are shared, 2) pooled TNC use and familiarity may be low throughout the sample population, or 3) factors not captured in the model (e.g., taxi commute share or use). No regional differences were significant.

Table 16: Model Results for Vehicle Modes

	Driving alone		Private automated vehicle		Carpooling		Pooled TNCs		Taxi	
	Parameter	**P-value**	**Parameter**	**P-value**	**Parameter**	**P-value**	**Parameter**	**P-value**	**Parameter**	**P-value**
Alternative Specific Constant	0.75***	0.001	-0.20	0.410	-0.21	0.180	-0.44**	0.012	-0.36**	0.030
Travel Time [hrs]	0.12	0.813	-0.05	0.965	-0.22*	0.093	-0.29***	0.007	-0.28***	0.007
Travel Cost [$0.01]	-	-	-	-	-	-	-0.11	0.721	-0.11	0.633
Parking Cost - Central Valley [$0.01]	0.01	0.996	-	-	-0.01	0.998	-	-	-	-
Parking Cost - SF/Bay Area [$0.01]	0.00	0.999	-	-	0.00	1.000	-	-	-	-
Egress time - Central Valley [hrs]	-	-	-	-	-	-	-	-	-	-
Egress time - SF/Bay Area [hrs]	-	-	-	-	-	-	-	-	-	-
Trip purpose is leisure	0.32**	0.049	-0.10	0.686	-0.28*	0.068	-0.18	0.220	-0.15	0.265
Trip purpose is leisure - Central Valley	0.16	0.508	-0.05	0.822	-0.15	0.433	-0.05	0.805	-0.07	0.744
Auto commuter	0.71***	0.001	-0.15	0.466	-0.16	0.259	-0.35**	0.036	-0.29*	0.070

***, **, * denote significance at 99%, 95%, and 90% confidence levels, respectively

Results for public transit modes (i.e., bus and rail) and microtransit (includes both microtransit and automated shuttles), displayed in Table 17, demonstrate somewhat counterintuitive relationships. When both are compared with the baseline TNC choice, the model suggests a slight preference for public transit over microtransit. This relationship is reinforced when looking at auto commuters as well. The model suggests that spent on a public transit vehicle is preferable to time spent in a TNC, which is inconsistent with prior work on this topic; the only other mode in the model to demonstrate this relationship is driving alone. As the estimated model did not reveal a statistically significant relationship to travel cost for any mode, the influence of cost on time cannot be investigated. More research on these variables might reveal the source of variation.

The relative preference for public transit over microtransit suggested by the model indicates that station planners should work with local area planners to ensure that public transit modes are prioritized at the station, and that existing public transit links serve the station area. New, flexible route service models could be pursued, but the model results suggest that individual familiarity may play a role in adoption.

Table 17: Model Results for Public Transit and Microtransit

	Public Transit		**Microtransit**	
	Parameter	**P-value**	**Parameter**	**P-value**
Alternative Specific Constant	-0.30**	0.015	-0.52***	0.005
Travel Time [hrs]	0.12*	0.094	-0.30***	0.005
Travel Cost [$0.01]	-0.04	0.870	-0.14	0.575
Parking Cost - Central Valley [$0.01]	-	-	-	-
Parking Cost - SF/Bay Area [$0.01]	-	-	-	-
Egress time - Central Valley [hrs]	0.00	0.999	0.00	1.000
Egress time - SF/Bay Area [hrs]	0.00	1.000	0.00	1.000
Trip purpose is leisure	-0.02	0.775	-0.21	0.155
Trip purpose is leisure - Central Valley	0.01	0.920	-0.06	0.866
Auto commuter	-0.37***	0.004	-0.42**	0.017

***, **, * denote significance at 99%, 95%, and 90% confidence levels, respectively

While the estimated model did not produce any significant results for ground-based AV modes, results for UAM, shown in Table 18, suggest that all respondents were sensitive to the costs for UAM trips. UAM was the only mode for which the travel cost parameter was significant, which is in line with expectations as costs associated with UAM were outliers (i.e., nearly double in magnitude) compared to costs for other modes. Taken together, the results for future modes indicate that further research is needed to understand respondent preferences for more familiar modes.

Table 18: Model Results for Urban Air Mobility

	Urban air mobility (UAM)	
	Parameter	**P-value**
Alternative Specific Constant	-0.53***	0.005
Travel Time [hrs]	-0.21	0.201
Travel Cost [$0.01]	-0.37**	0.017
Parking Cost - Central Valley [$0.01]	-	-
Parking Cost - SF/Bay Area [$0.01]	-	-
Egress time - Central Valley [hrs]	0.00	1.000
Egress time - SF/Bay Area [hrs]	0.00	1.000
Trip purpose is leisure	-0.24	0.129
Trip purpose is leisure - Central Valley	-0.06	0.824
Auto commuter	-0.41**	0.021

***, **, * denote significance at 99%, 95%, and 90% confidence levels, respectively

Overall, the modeling exercise produced some interesting results and created more questions worth considering for HSR station planners. For ground-based modes, the model did not produce any conclusive results regarding commute sheds (i.e, the distances that people commute to employment), the built environment, or street networks near the stations (i.e., based upon travel time or travel cost). The dominance of automotive-based commutes, and the model results indicate that the commute mode has a strong influence HSR station access or egress mode.

Station planners could work with local and regional planners on joint efforts to reduce auto commute rates or vehicle ownership, such as offering parking discounts to shared modes (carpool, pooled TNC, or carsharing), or by de-prioritizing parking lots in station area design. Additionally, given the insignificance of parking cost in the estimated model, station planners may wish to consider raising parking costs or testing variable parking cost structures (e.g., time-based fees) with goal-oriented discounts. Egress time, the added walking time to the train platform or final destination in the station, was not significant in the model. Further modeling including longer egress times could shed light on whether off-site parking facilities encourage or discourage the use of certain modes. Regarding active modes, station planners may wish to use the HSR station design guidelines to facilitate ease of access for active modes.

Regionally, there were no statistically different results when comparing respondents from the Central Valley against respondents from the SF Bay Area. The researchers estimated multiple different models – for example, estimating models that did not include the interactions between respondent DMA and station area – in an attempt to tease out any differences. However, this did not produce statistically significant results. One possible explanation for this lack of regional variation is if the sample population had similar exposure to reporting on the topic, such as if their knowledge was derived from large circulation news outlets. Further investigation into the relationship between sentiment toward the HSR project and mode choices might reveal variations that regional differences did not.

The introduction of a fundamentally new form of travel can result in unexpected changes in travel behavior, and station planners would do well to consider the long-term effects of station area design on regional travel patterns. Follow-up investigation using the data collected during this study could target: 1) the estimation of mode shares by station areas, 2) the effect of granular trip purpose (i.e., shopping vs. nightlife, commute vs. business trip) or trip duration on mode choice, or 3) dive into the relationships between other potential demographic variables of interest (e.g., respondent housing tenure, life decisions) and mode choice. Additionally, a similar modeling approach could be applied to other potential station areas along the IOS, and it could incorporate any of the above factors.

To help inform station design as the IOS moves toward completion, future work studies might investigate full trip patterns. For example, researchers could examine the directional commute from the Central Valley to San José or further north in the SF Bay Area, asking sequenced mode choice questions that investigate joint choices between HSR and other modes compared to alternative means of transportation. Instead of asking respondents to assume that they had already chosen to use HSR, future studies could ask respondents to choose a bundle of transportation options for specific trip purposes. Such results could be used to inform regional or state-level partnerships between the Authority and other agencies. It could also help identify promising use cases for HSR, such as a link to airports for out-of-state travel. Investigating the influence of HSR on car ownership patterns and structures might help to inform how the IOS, and eventually the full HSR system, can steer the state on its path to long-term environmental and sustainability goals.

Conclusion

Throughout the span of this research project, the current status of HSR in California has become more uncertain. As such, the results of this report can be used to help develop an understanding of how the project might benefit different types of users, particularly along the currently planned IOS.

The experts interviewed during this research process were generally familiar with shared mobility and revealed that as knowledge of shared mobility grows, the inclination to us it likewise increases. This results in the HSR rail stations potentially acting as mobility hubs that integrate a variety of shared mobility services. Similar to the findings from the literature review, the expert interviews demonstrated the opportunity for HSR stations to serve more than a transportation purpose. HSR stations can act as anchor points that draw people to new, mixed-use areas. In addition, HSR can encourage businesses to relocate to areas surrounding the station to bring in more jobs and employment opportunities for local residents. HSR stations may also be able to support the revitalization of areas, such as downtowns, to help with economic development.

According to the expert interviews, HSR stations can potentially support local planning practices and goals, particularly in regard to housing. Housing surrounding current and future HSR stations can help increase density to support TODs and residents may benefit from increased housing values. The expert interviews also offered insight on the potential opportunities and benefits of the HSR. Experts reiterated previous statements about the opportunities HSR stations may provide for economic development, downtown revitalization, and support for local planning practices. However, experts also voiced concerns over transitioning people from a private vehicle-based society to a rail-based one.

The experts also provided information on station access based on the three example stations: San José, Fresno, and Kings/Tulare. The Diridon Station in San José is currently functioning as a transit hub accessible by a variety of modes. As the station continues to grow, the city is looking at ways to increase bicycle and pedestrian access. The existing Fresno rail station currently has a limited number of modes that access the station and is predominantly accessed by local services and private vehicles. However, when the HSR station is completed, it will be located in a dense, walkable area, supporting a greater variety of ways to access the station. The Kings/Tulare station is located five miles from downtown Hanford and as a result station access is almost exclusively limited to private vehicles. Tulare County Transit agency is considering operating a bus line to access the station during the initial operations of the HSR to increase station access.

The potential demographic shifts as a result of the HSR also vary by station. It is unclear whether the HSR will widen the existing income inequality gap in San José or if it will offer residents a low-cost, high-quality transit system. In Fresno, experts felt as though demographic shifts were more a result of birth rates and migration patterns, so HSR is unlikely to cause any major changes. At the Kings/Tulare station, experts do not predict a large demographic shift as a result of the HSR, mostly because of the station's distance from other developments.

The focus groups offered insight on a variety of topics including on current travel patterns, shared mobility, AVs, UAM, and HSR station access. Generally, the focus groups helped identify specific regional needs in less densely developed areas. Most of the participants have relied on private vehicles their entire lives in the Kings-Tulare region, and as a result, participants were inclined to use a mode they were comfortable with rather than trying a new service to travel. This lack of drive does not mean that users are not open to try a new mode for intra and inter-city travel. Rail services offer the convenience of not having to drive, although participants voiced concerns regarding first- and last-mile connections, particularly at destination stations. A modal shift will likely require a coordinated effort to get community support.

Participants also offered insight on how they perceived shared modes and alternative modes in general. An ongoing theme was that participants relied on perception as much as experience. Some participants were generally optimistic about using these modes, although they did voice some concerns. Regarding active modes, such as bikesharing and scooter sharing, participants were concerned about the lack of supportive infrastructure (e.g., protected bike lanes) and weather conditions (e.g., high temperatures). With shared vehicle modes, such as TNCs, participants were more concerned with the availability of drivers and ride cancellations and the participants preferred taxis because of perceptions of greater trustworthiness. When asked about emerging modes, including AVs and UAM, participants were not familiar with these modes and had limited concerns.

With respect to HSR, participants were generally optimistic about its potential to increase access to surrounding destinations and potentially offer employment opportunities. The focus group was more willing to try convenient, established modes to access HSR stations. Participants were confident using personal automobiles — whether that be parking at the station for day trips or being dropped off for extended trips – in accessing the Kings/Tulare HSR station. Aside from the potential time and cost savings the HSR may offer, participants were concerned with the project management and other resulting local impacts, such as higher taxes in the areas surrounding HSR stations. Overall, the results of this focus group highlight that the process of integrating a new mode into this community is not as simple as physically launching a mobility service. Educational and outreach are critical components as well.

In addition to the expert interviews and focus groups, the user surveys and modeled results provided valuable insight. Survey respondents were generally unfamiliar with the HSR and future modes (e.g., bikesharing and scooter sharing) which may result in inconclusive modeling results. However, the model did show that respondents have a tendency to choose auto-based modes, which is consistent with high driving commute rates. This finding presents the opportunity for the Authority to work with local governments to incentivize alternative modes (e.g., carpooling, active modes). Additionally, the Authority can design HSR stations to support alternative modes rather than private vehicles. The survey and model also offered information on parking, a critical aspect of station design. Respondents were generally insensitive to parking prices, possibly because of their dependence on personally owned vehicles or because of the flat rate parking prices in the choice experiments. These findings present the opportunity for station planners to offset the cost of station development and operations by exploring revenue-generating strategies, such as variably priced and off-site parking.

In addition to parking considerations, the estimated model also suggested few regional differences in travel behavior. The survey and model illustrated that the HSR stations have the opportunities to support different modal options and to explore innovative ways to address parking availability and costs and to support different modal options.

This research presented a variety of findings on how users may access HSR stations and about HSR in general in California. However, there are still many areas of research that need to be addressed. To begin, further research can be conducted to identify the cause of demographic shifts. It is currently unclear as to what causes these shifts, whether it is a result of residents electing to move elsewhere or are they being priced out of their current location. Residents potentially being priced out of their location is supported by commute patterns, such as those from Fresno to the Silicon Valley. Exploring how rail-base alternatives can improve this commute is a logical next step in research. This research could be completed through a survey of the commuting population.

References

Airport Cooperative Research Program. (2015). Integrating Aviation and Passenger Rail Planning. https://doi.org/10.17226/22173

Apter, M. (2007). Reversal Theory: The Dynamics of Motivation, Emotion and Personality (2nd ed. edition). Oxford: Oneworld Publications.

Baum-Snow, N., and Kahn, M. E. (2000). The effects of new public projects to expand urban rail transit. Journal of Public Economics, 77(2), 241–263. https://doi.org/10.1016/S0047-2727(99)00085-7

Ben-Akiva, M., and Lerman, S. (1985). Discrete Choice Analysis: Theory and Application to Travel Demand. MIT Press.

Berkeley Law, and UCLA Law. (2013). A High Speed Foundation: How to Build a Better California Around High Speed Rail (p. 34). University of California, Berkeley and Los Angeles.

Bertolini, L. (1996). Nodes and places: Complexities of railway station redevelopment. European Planning Studies, 4(3), 331–345. https://doi.org/10.1080/09654319608720349

Bertolini, L., and Spit, T. (1998). Cities on Rails: The Redevelopment of Railway Stations and their Surroundings. Taylor and Francis.

Boarnet, M. G., and Crane, R. (2001). Travel by Design: The Influence of Urban Form on Travel. Oxford University Press.

Brons, M., Givoni, M., and Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. Transportation Research Part A: Policy and Practice, 43(2), 136–149. https://doi.org/10.1016/j.tra.2008.08.002

Broward Metropolitan Planning Organization. (2009). 2035 Broward Transformation Long Range Transportation Plan. http://www.browardmpo.org/images/WhatWeDo/LRTP/2035_Broward_Transformation_Long%20Range_Transportation_Plan_-_Amended_reduced.pdf

California High-Speed Rail Authority, and PB PlaceMaking Group. (2011). Urban Design Guidelines: California High-Speed Train Project (p. 95). Retrieved from California High-Speed Rail Authority website: https://www.hsr.ca.gov/docs/programs/green_practices/sustainability/Urban%20Design%20Guidelines.pdf

California High-Speed Rail Authority. (2016). Station Communities. Retrieved from California High-Speed Rail Authority website: https://www.hsr.ca.gov/high_speed_rail/station_communities/

Caltrans. (2017). A Guide to Bikeway Classification. Retrieved from Caltrans website: http://www.dot.ca.gov/d4/bikeplan/docs/caltrans-d4-bike-plan_bikeway-classification-brochure_072517.pdf

Caltrans. (2018). California State Rail Plan. Retrieved from Caltrans website: https://dot.ca.gov/programs/rail-and-mass-transportation/california-state-rail-plan

Cervero, R. (2002). Built environments and mode choice: Toward a normative framework. Transportation Research Part D: Transport and Environment, 7(4), 265–284. https://doi.org/10.1016/S1361-9209(01)00024-4

Cervero, R. (2006). Alternative Approaches to Modeling the Travel-Demand Impacts of Smart Growth. Journal of the American Planning Association, 72(3), 285–295. https://doi.org/10.1080/01944360608976751

Cervero, R., Caldwell, B., and Cuellar, J. (2013). Bike-and-Ride: Build It and They Will Come. Journal of Public Transportation, 16(4). https://doi.org/10.5038/2375-0901.16.4.5

Cervero, R., and Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. Transportation Research Part D: Transport and Environment, 2(3), 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6

Chakour, V., and Eluru, N. (2014). Analyzing commuter train user behavior: A decision framework for access mode and station choice. Transportation, 41(1), 211–228. https://doi.org/10.1007/s11116-013-9509-y

Cheng, Y. H. (2010). High-speed rail in Taiwan: New experience and issues for future development. Transport policy, 17(2), 51-63.

City of Berkeley. (2017). Berkeley Bicycle Plan. Retrieved from City of Berkeley, Transportation Division website: https://www.cityofberkeley.info/berkeleybikeplan/

Coxon, S., Napper, R., and Richardson, M. (2018). Urban Mobility Design. Elsevier.

Crane, R. (2000). The influence of urban form on travel: An interpretive review. Journal of Planning Literature, 15(1), 3–23.

Daamen, W. (2004). Modelling passenger flows in public transport facilities. Retrieved from http://resolver.tudelft.nl/uuid:e65fb66c-1e55-4e63-8c49-5199d40f60e1

Deakin, E. (2008). Transit Oriented Development for High Speed Rail (HSR) in the Central Valley, California: Design Concepts for Stockton and Merced. (p. 136). Retrieved from The Center for Global Metropolitan Studies, University of California, Berkeley website: http://www.hsr.ca.gov/docs/programs/green_practices/sustainability/Sustainability%20Design%20Concepts%20for%20Stockton%20and%20Merced-1.pdf

Dill, J., and McNeil, N. (2013). Four Types of Cyclists? Transportation Research Record: Journal of the Transportation Research Board, 2387, 129–138. https://doi.org/10.3141/2387-15

Dill, J., Schlossberg, M. A., Ma, L., and Meyer, C. (2013). Predicting Transit Ridership at Stop Level: Role of Service and Urban Form. Presented at the Transportation Research Board 92nd Annual MeetingTransportation Research Board. Retrieved from https://trid.trb.org/view/1242765

Eidlin, E. (2015). Making the Most of High-Speed Rail in California: Lessons from France and Germany (p. 82). The German Marshall Fund of the United States.

Ewing, R., and Cervero, R. (2001). Travel and the built environment: a synthesis. Transportation research record, 1780(1), 87-114.

Ewing, R., and Cervero, R. (2010). Travel and the Built Environment: A Meta-Analysis. Journal of the American Planning Association, 76(3), 265–294. https://doi.org/10.1080/01944361003766766

Fan, Y., Guthrie, A., and Levinson, D. (2016). Waiting time perceptions at transit stops and stations: Effects of basic amenities, gender, and security. Transportation Research Part A: Policy and Practice, 88, 251–264. https://doi.org/10.1016/j.tra.2016.04.012

Frank, L. D., and Engelke, P. (2005). Multiple impacts of the built environment on public health: walkable places and the exposure to air pollution. International regional science review, 28(2), 193-216.

Friman, M., and Fellesson, M. (2009). Service Supply and Customer Satisfaction in Public Transportation: The Quality Paradox. Journal of Public Transportation, 12(4). https://doi.org/10.5038/2375-0901.12.4.4

Garmendia, M., de Ureña, J. M., Ribalaygua, C., Leal, J., and Coronado, J. M. (2008). Urban Residential Development in Isolated Small Cities That Are Partially Integrated in Metropolitan Areas By High Speed Train. European Urban and Regional Studies, 15(3), 249–264. https://doi.org/10.1177/0969776408090415

Gasparini, G. (1995). On Waiting. Time and Society, 4(1), 29–45. https://doi.org/10.1177/0961463X95004001002

Geller, R. (2009). Four Types of Cyclists. Retrieved from Portland Office of Transportation website: https://www.portlandoregon.gov/transportation/article/264746

Givoni, M., and Rietveld, P. (2007). The access journey to the railway station and its role in passengers' satisfaction with rail travel. Transport Policy, 14(5), 357–365. https://doi.org/10.1016/j.tranpol.2007.04.004

Grotenhuis, J.-W., Wiegmans, B., and Rietveld, P. (2007). The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. Transport Policy, 14, 27–38. https://doi.org/10.1016/j.tranpol.2006.07.001

Haas, P. (2017). Modal Shift and High-Speed Rail: A Review of the Current Literature (p. 64). Retrieved from Mineta Transportation Institute website: https://transweb.sjsu.edu/research/modal-shift-and-high-speed-rail-review-current-literature

Handy, S., Paterson, R. G., and Butler, K. S. (2003). Planning for street connectivity: getting from here to there. Apa Planning Advisory Service Reports, (515), 1-75.

Hernandez, S., Monzón, A., and De Oña, R. (2014, June 11). Urban transport interchanges: Importance-Performance analysis for evaluating perceived quality.

Hess, D. B. (2012). Walking to the bus: Perceived versus actual walking distance to bus stops for older adults. Transportation, 39(2), 247–266. https://doi.org/10.1007/s11116-011-9341-1

Hickman, R., Ashiru, O., and Banister, D. (2010). Transport and climate change: Simulating the options for carbon reduction in London. Transport Policy, 17, 110–125. https://doi.org/10.1016/j.tranpol.2009.12.002

Hine, J., and Scott, J. (2000). Seamless, accessible travel: Users' views of the public transport journey and interchange. Transport Policy, 7(3), 217–226. https://doi.org/10.1016/S0967-070X(00)00022-6

Iseki, H., and D. Taylor, B. (2010). Style versus Service? An Analysis of User Perceptions of Transit Stops and Stations. Journal of Public Transportation, 13. https://doi.org/10.5038/2375-0901.13.3.2

Kettner, C., Kletzan-Slamanig, D., and Köppl, A. (2015). Climate policy integration: evidence on coherence in EU policies. In Environmental Pricing. Edward Elgar Publishing.

Koohsari, M. J., Sugiyama, T., Lamb, K.E., Villanueva, K., and Owen, N. (2014). Street connectivity and walking for transport: Role of neighborhood destinations. Preventive Medicine, 66, 118-122. https://doi.org/10.1016/j.ypmed.2014.06.019.

Kuby, M., Barranda, A., and Upchurch, C. (2004). Factors influencing light-rail station boardings in the United States. Transportation Research Part A: Policy and Practice, 38(3), 223–247. https://doi.org/10.1016/j.tra.2003.10.006

Loukaitou-Sideris, A. (2013). New Rail Hubs along High-Speed Rail Corridor in California: Urban Design Challenges. Transportation Research Record, 2350(1), 1–8. https://doi.org/10.3141/2350-01

Loukaitou-Sideris, A., Cuff, D., Higgins, T., and Linovski, O. (2012). Impact of High Speed Rail Stations on Local Development: A Delphi Survey. Built Environment (1978-), 38(1), 51–70. Retrieved from JSTOR.

Loukaitou-Sideris, A., Peters, D., Colton, P., and Eidlin, E. (2017). A Comparative Analysis of High-Speed Rail Station Development into Destination and Multi-Use Facilities: The Case of San Jose Diridon (No. CA-MTI-16-1502; p. 169). Mineta Transportation Institute.

Loukaitou-Sideris, A., Peters, D., and Wei, W. (2015). Promoting Intermodal Connectivity at California's High Speed Rail Stations. Mineta Transportation Institute Publications. Retrieved from http://scholarworks.sjsu.edu/mti_publications/194

Martens, K. (2004). The bicycle as a feedering mode: Experiences from three European countries. Transportation Research Part D: Transport and Environment, 9(4), 281–294. https://doi.org/10.1016/j.trd.2004.02.005

Martens, K. (2007). Promoting bike-and-ride: The Dutch experience. Transportation Research Part A: Policy and Practice, 41(4), 326–338. https://doi.org/10.1016/j.tra.2006.09.010

Martin, P. C., and Hurrell, W. E. (2012). Station Parking and Transit-Oriented Design: Transit Perspective. Transportation Research Record, 2276(1), 110–115. https://doi.org/10.3141/2276-13

Mbatta, G., Sando, T., and Moses, R. (2008). Developing Transit Station Design Criteria with a Focus on Intermodal Connectivity. Journal of the Transportation Research Forum, 47(3). https://doi.org/10.5399/osu/jtrf.47.3.2121

McFadden, D. (1981). Econometric models of probabilistic choice. Structural Analysis of Discrete Data with Econometric Applications, 198272.

Mekuria, M., Furth, P., and Nixon, H. (2012). Low-Stress Bicycling and Network Connectivity (No. CA-MTI-12-1005; p. 68). Retrieved from Mineta Transportation Institute website: https://transweb.sjsu.edu/sites/default/files/1005-low-stress-bicycling-network-connectivity.pdf

Merriman, D. (1998). How many parking spaces does it take to create one additional transit passenger? Regional Science and Urban Economics, 28(5), 565–584. https://doi.org/10.1016/S0166-0462(98)00018-0

Mingus, C. D. (2015). Bicyclist perceived level of traffic stress: A quality of service measure (Thesis, Georgia Institute of Technology). Retrieved from https://smartech.gatech.edu/handle/1853/53605

Mishalani, R., McCord, M., and Wirtz, J. (2006). Passenger Wait Time Perceptions at Bus Stops: Empirical Results and Impact on Evaluating Real - Time Bus Arrival Information. Journal of Public Transportation, 9(2). https://doi.org/10.5038/2375-0901.9.2.5

Mohino, I., Loukaitou-Sideris, A., & Urena, J. M. (2014). Impacts of high-speed rail on metropolitan integration: An examination of London, Madrid and Paris. International planning studies, 19(3-4), 306-334.

Monzón, A., Ortega, E., and López, E. (2016). Influence of the first and last mile on HSR accessibility levels. In Chapters (pp. 125–143). Retrieved from https://ideas.repec.org/h/elg/eechap/16534_7.html

Murakami, J., and Cervero, R. (2012). High-Speed Rail and Economic Development: Business Agglomerations and Policy Implications. Retrieved from University of California Transportation Center (UCTC) website: https://trid.trb.org/view/1249019

Nes, R. (2002). Design of Multimodal Transport Networks: A Hierarchical Approach. DUP Science.

Nickelsburg, J., Ahluwalia, S., and Yang, Y. (2018). High-Speed Rail Economics, Urbanization and Housing Affordability Revisited: Evidence from the Shinkansen System. UCLA Anderson School of Management, 24.

Nuworsoo, C., and Deakin, E. (2009). Transforming High-speed Rail Stations to Major Activity Hubs: Lessons for California. Proceedings of the 2009 Transportation Research Board 88th Annual Meeting: Washington, D.C. Retrieved from https://digitalcommons.calpoly.edu/crp_fac/44

Olszewski, P., and Wibowo, S. S. (2005). Using Equivalent Walking Distance to Assess Pedestrian Accessibility to Transit Stations in Singapore. Transportation Research Record: Journal of the Transportation Research Board, 1927(1), 38–45. https://doi.org/10.1177/0361198105192700105

Palmer, D., James, C., and Jones, M. (2011). Door to Door Journeys. Transport Research Laboratory.

Park, S. (2008). Defining, Measuring, and Evaluating Path Walkability, and Testing Its Impacts on Transit Users' Mode Choice and Walking Distance to the Station. Retrieved from https://escholarship.org/uc/item/0ct7c30p

Peek, G. J., and van Hagen, M. (2002). Creating synergy in and around stations: Three strategies for adding value. Transportation Research Record, 1793(1), 1-6.

Pol, P. (2008). HST stations and urban dynamics: Experiences from four European cities. In F. Bruinsma, E. Pels, P. Rietveld, H. Priemus, and B. van Wee (Eds.), Railway

Development: Impacts on Urban Dynamics (pp. 59–77). https://doi.org/10.1007/978-3-7908-1972-4_4

Priemus, H. (2008). Urban dynamics and transport infrastructure: Towards greater synergy. In F. Bruinsma, E. Pels, P. Rietveld, H. Priemus, and B. van Wee (Eds.), Railway Development: Impacts on Urban Dynamics (pp. 15–33). https://doi.org/10.1007/978-3-7908-1972-4_2

Pucher, J., and Buehler, R. (2009). Integrating Bicycling and Public Transport in North America. Journal of Public Transportation, 12(3). https://doi.org/10.5038/2375-0901.12.3.5

Puello, L. C. L. P., and Geurs, K. T. (2016). Train station access and train use: A joint stated and revealed preference choice modelling study. Accessibility, Equity and Efficiency. Challenges for Transport and Public Services, 144–166. https://doi.org/10.4337/9781784717896.00017

Rosenbloom, S. (2007). Transportation Patterns and Problems of People with Disabilities. In M. J. Field, A. M. Jette, and I. of M. (US) C. on D. in America, The Future of Disability in America. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK11420/

SANDAG. (2017). Mobility Hub Features Catalog. Retrieved from https://www.sdforward.com/fwddoc/mobipdfs/mobilityhubcatalog-features.pdf

Schakenbos, R., Paix, L. L., Nijenstein, S., and Geurs, K. T. (2016). Valuation of a transfer in a multimodal public transport trip. Transport Policy, 46, 72–81. https://doi.org/10.1016/j.tranpol.2015.11.008

Shaheen, S., Cohen, A., Broader, J., Davis, R., Brown, L., Neelakantan, R., and Gopalakrishna, D. (forthcoming). Mobility on Demand Planning and Implementation: Current Practices, Innovations, and Emerging Mobility Futures. U.S. Department of Transportation.

Shaheen, S., Cohen, A., and Farrar, E. (2018). The Potential Societal Barriers of Urban Air Mobility (UAM). UC Berkeley: Transportation Sustainability Research Center. Retrieved from https://escholarship.org/uc/item/7p69d2bg

Silva, C. (2013). Structural accessibility for mobility management. Progress in Planning, 81, 1–49. https://doi.org/10.1016/j.progress.2012.07.001

Syed, S., Golub, A., and Deakin, E. (2009). Response of Regional Rail Park-and-Ride Users to Parking Price Changes: Systemwide Results and a Detailed Study of Two Stations. Transportation Research Record, 2110(1), 155–162. https://doi.org/10.3141/2110-19

The Local. (2019, February 6). Paris: High-speed rail link to CDG airport WILL be built, government insists. Retrieved May 29, 2019, from The Local website: https://www.thelocal.fr/20190206/paris-high-speed-rail-link-to-cdg-airport-will-go-ahead-government-insists

Ton, D., Duives, D. C., Cats, O., Hoogendoorn-Lanser, S., and Hoogendoorn, S. P. (2019). Cycling or walking? Determinants of mode choice in the Netherlands. Transportation Research Part A: Policy and Practice, 123, 7–23. https://doi.org/10.1016/j.tra.2018.08.023

Train, K., and McFadden, D. (1978). The goods/leisure tradeoff and disaggregate work trip mode choice models. Transportation Research, 12(5), 349–353.

Uber. (2019). Enabling seamless airport pickups. Retrieved April 20, 2020, from Uber Blog: https://www.uber.com/blog/seamless-airport-pickups/

Ureña, J. M., Menerault, P., and Garmendia, M. (2009). The high-speed rail challenge for big intermediate cities: A national, regional and local perspective. Cities, 26(5), 266–279. https://doi.org/10.1016/j.cities.2009.07.001

Van den Berg, L., and Pol, P. M. J. (1998). The Urban Implications of the Developing European High-Speed-Train Network. Environment and Planning C: Government and Policy, 16(4), 483–497. https://doi.org/10.1068/c160483

Van der Spek, S. C., and Scheltema, N. (2015). The importance of bicycle parking management. Research in Transportation Business and Management, 15, 39–49. https://doi.org/10.1016/j.rtbm.2015.03.001

Van Hagen, M. (2011). Waiting experience at train stations. Retrieved from https://research.utwente.nl/en/publications/waiting-experience-at-train-stations

Van Hagen, M., Galetzka, M., and Pruyn, A. T. H. (2014). Waiting experience in railway environments. Journal of Motivation, Emotion, and Personality, 2(2), 41–55. https://doi.org/10.12689/jmep.2014.305

Vickerman, R. (2015). High-speed rail and regional development: the case of intermediate stations. Journal of Transport Geography, 42, 157-165.

Watkins, K., Ferris, B., Borning, A., Rutherford, G., and Layton, D. (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. Transportation Research Part A: Policy and Practice, 45, 839–848. https://doi.org/10.1016/j.tra.2011.06.010

Wegener, M., and Fürst, F. (2004). Land-Use Transport Interaction: State of the Art (SSRN Scholarly Paper No. ID 1434678). Retrieved from Social Science Research Network website: https://papers.ssrn.com/abstract=1434678

Weinstein Agrawal, A., Schlossberg, M., and Irvin, K. (2008). How Far, by Which Route and Why? A Spatial Analysis of Pedestrian Preference. Journal of Urban Design, 13(1), 81–98. https://doi.org/10.1080/13574800701804074

Zhen, F., Cao, X., and Tang, J. (2018). The role of access and egress in passenger overall satisfaction with high speed rail. Transportation. https://doi.org/10.1007/s11116-018-9918-z

Živković J. (2019) Urban Form and Function. In: Leal Filho W., Azeiteiro U., Azul A., Brandli L., Özuyar P., Wall T. (eds) Climate Action. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham

Appendix A: Station Area Maps

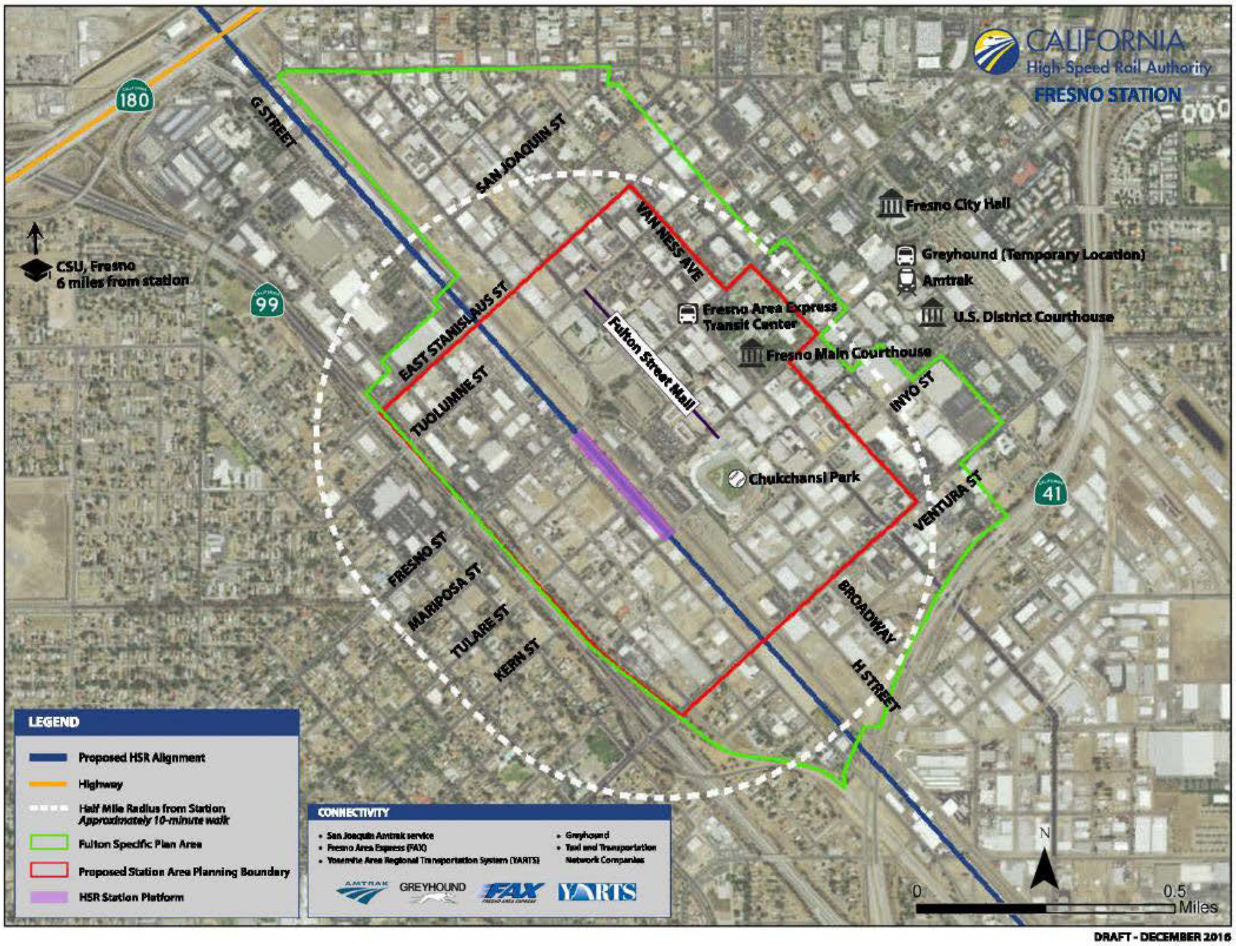

Figure 6: Fresno Station Area Map
Source: California High-Speed Rail Authority (2016)

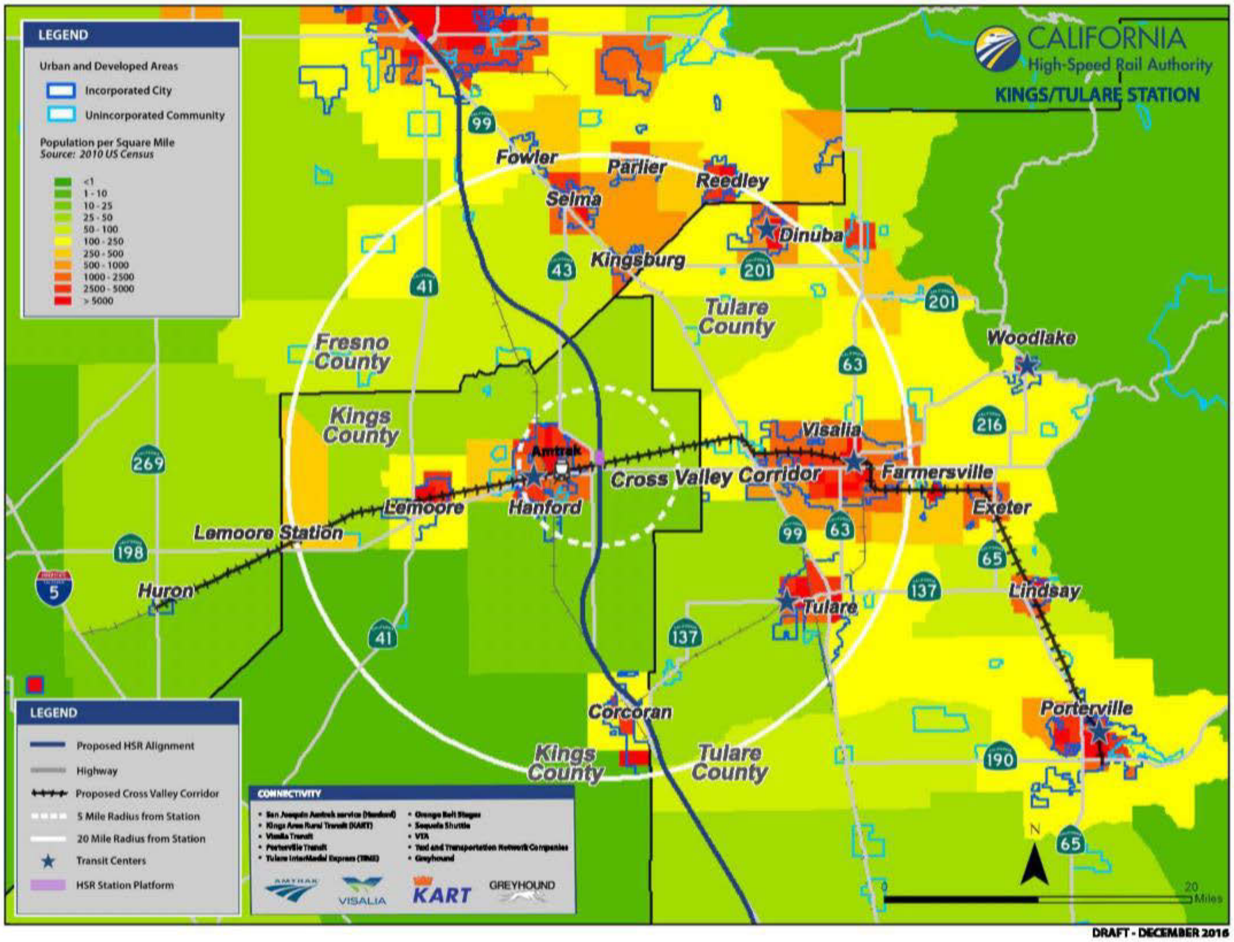

Figure 7: Kings/Tulare *Area* Station Map
Source: California High-Speed Rail Authority (2016)

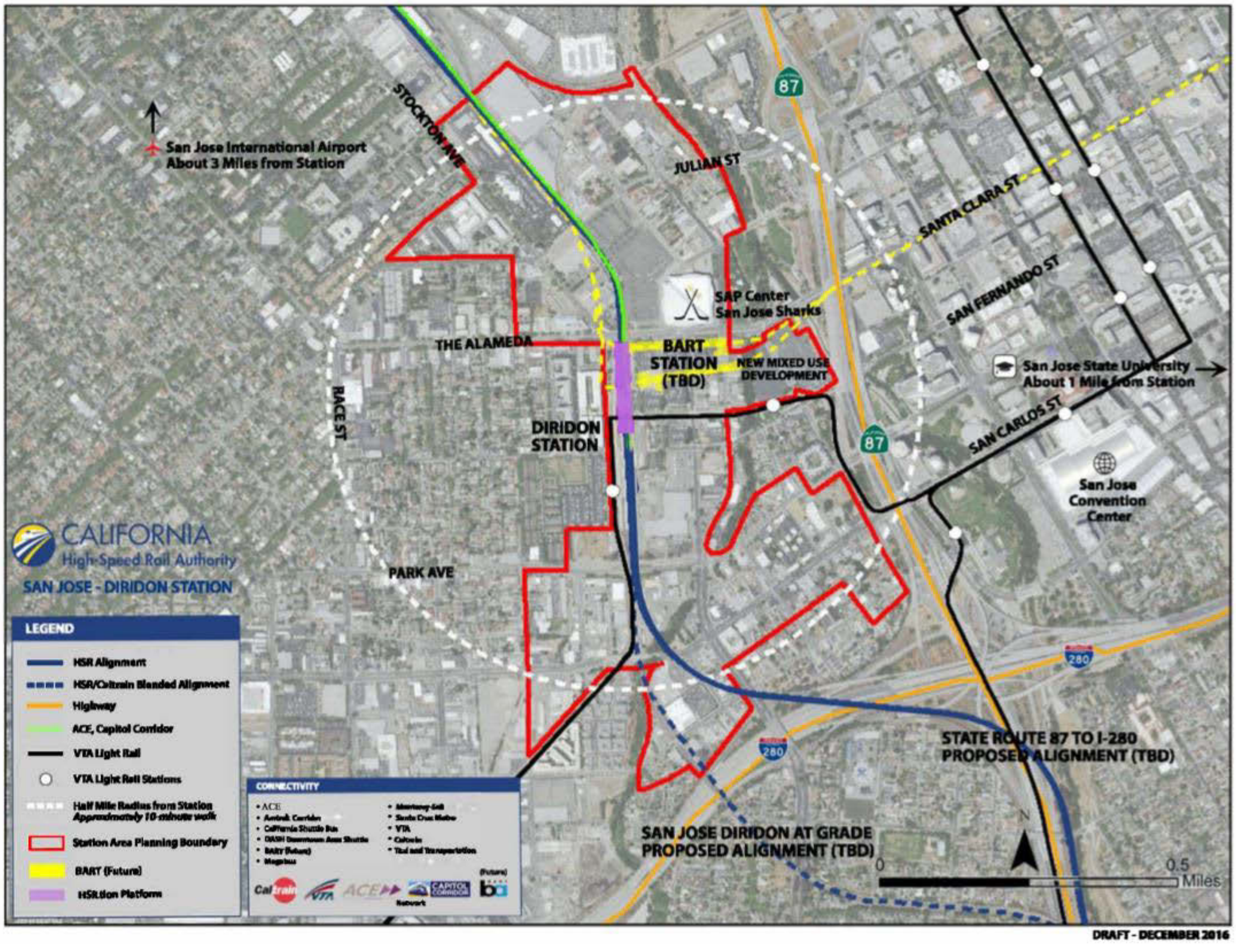

Figure 8: San José Area Station Map
Source: California High-Speed Rail Authority (2016)

Appendix B: Expert Interview Questions For Strategic Site Respondents

Interview Questionnaire

(strategic site respondents)

Review consent form and CPHS protocol and request oral consent before beginning.
Request consent to record and keep recording on secure server.

General/Background Information

- How long have you been at your current organization? In your current role?
- How long have you been working in rail, HSR, or your field?
- Are you involved in California HSR?
    - If so, are you involved in planning for station access, transit/bike/ped planning, or development around the station?

For the purposes of the rest of this interview, we have divided our questions into two timeframes, roughly delineated by: the present (or station/system development) and the future (roughly 2040, to capture system/station growth periods and system/station maturity).

Shared Mobility

- Do you think local residents/employees in your community are familiar with shared mobility?
    - If so, with what shared modes (e.g., bikesharing, carsharing, ridesourcing/TNCs, ridesharing, etc.) are they most familiar?
    - Who uses shared mobility in your community? Are there any local studies documenting modal use?
- What is the general level of knowledge in your community regarding app-based mobility offerings? What percentage of the population do you estimate has access to a smartphone and bank account?

The station area and your local economy

The Present

I'd like you to think for a moment about your jurisdiction or community at present and activities related to HSR system and station development.

- What types of land use/zoning changes are happening in and around the station area?
    - Do you think HSR will change the nature or intensity of land use/zoning in and around the station area?
- Is the development and construction of the HSR system, or your local station, being used as a tool for economic development? How?
- Can you please describe the current connections to the station area (e.g., on-platform transfer, terminal, walking, bikesharing), at present?
- What do you see as the biggest opportunities for the new station area (e.g. shifting land uses, creating new jobs and housing centers, etc.)?
        - What would you most like to see happening surrounding your station?
- What do you see as the biggest perceived local challenges regarding HSR and the station (e.g., impacts on agriculture, wildlife, etc.)?
- Regarding your local HSR station, can you please describe the current planning processes underway and linkages to other/local regional plans (e.g., local public transit plans, bike/ped plans)?

The future (system opening, growth, and maturity)

- How do you see HSR fitting into [your jurisdiction]'s economy in the next 30 years?
- What types of modes is [your jurisdiction] considering when thinking about station access? Which modes will be the most popular and why?
- Considering a 20-year planning horizon, are there any future modes you are considering (e.g., automated shuttles, etc.) or that should be considered?
- Given current connections with local public transit today, do you expect they will change when the HSR system opens in up to 20 years? If so, why?
- How important do you feel that fare coordination (i.e., using an HSR ticket to board a local bus) is to the future operation of the system?
- What do you see as the role, if any, of automated vehicles (ground- or air-based) regarding station access for passengers and the delivery of goods when the system opens?

Demographics

The present

- In your community, are there any changes in socio-demographics or auto ownership occurring (e.g., tech workers moving in, growing elderly population, etc.)?
    - What types of user groups do you anticipate using the HSR station (remember this may not occur until 2040 timeline)?

The future (system opening, growth, and maturity)

- Given your thoughts regarding shifts in socio-demographics prior to opening, how do you see the introduction of HSR affecting these?
    - If respondent indicated that HSR would attract people to their jurisdiction (i.e., new residents, employees, travelers) … How do you think these shifts may affect the longer-term socio-demographics of your jurisdiction?
- Are there populations or groups of riders that you anticipate being attracted to your jurisdiction by HSR?

Survey design

This next set of questions focuses on how best to reach populations that you anticipate being users of the HSR network, or frequenting the station area.

- Given your thoughts regarding shifts in socio-demographics, are there specific populations that you anticipate being regular users of the HSR network, or the station area?
    - If so, what would be the best way to reach them to conduct a survey (e.g., clipboard at train stations, DMV, shopping centers, online link, etc.)?

Concluding remarks

- Do you have any additional comments on topics we have not covered?

Other Experts in the Field

- Who would be on your list of leading experts regarding, regional or high speed rail station access?
    - [Name, Title, Organization]

Thank you very much for your time, and for sharing your thoughts on this topic.

Appendix C: Expert Interview Questions for Domestic/International Respondents

Interview Questionnaire

(Domestic/international experts)

Review consent form and CPHS protocol and request oral consent before beginning.
Request consent to record and keep recording on secure server.

General/Background Information

- How long have you been at your current organization? In your current role?
- Can you describe your duties and tasks related to rail, high-speed rail (HSR), or your field?

Your background in the rail industry, and specifically HSR

- Given your own experience, what do you believe are the best practices and lessons learned for HSR station access planning?
    - o Are you familiar with the planned HSR project in California?
    - o If yes, what would be your recommendations for station access planning for the California HSR system?

HSR, development, and governance

The following questions will only be asked to experts with relevant experience in station area development and station area land use regulation.

- What are HSR best practices regarding long-term economic development around station areas?
- What are best practices regarding using HSR as a tool for urban redevelopment?
- What are some types of governance structures that might be best suited to overseeing HSR network development?
- Are there any best practices for managing the development of regional or HSR networks and stations? (Examples include regional consolidation surrounding the Grand Paris plan)
- In your opinion, what are some good best practices for capturing future value near station areas? (examples could include Infrastructure Financing Districts, and Tax Increment Financing, among others).

HSR station area development

The following questions will only be asked to experts with relevant experience in station area development and transit, airport, or HSR oriented development (TOD, AOD, and HSROD, respectively).

- How does existing land use influence surrounding station modal access?
- For new and existing systems, what percentage of riders do you estimate live within the immediate station vicinity [defined as within ½ mile (~1km)]; in the intermediate vicinity [defined as ½ mile (~1km) to 5 miles (~8km)]; beyond 5 miles (~8km)?
    - What are some good case studies that encourage multimodal access to stations?
- What best practices come to mind with respect to access/egress modes in limiting or eliminating the need to dedicate large amounts of rights-of-way to parking?
- In your opinion, what are the biggest opportunities for new stations (e.g., shifting land uses, creating new jobs and housing centers, etc.)?
    - Similarly, what are the biggest perceived challenges to the strategies you mentioned (e.g., from the public, local government, etc.)?
- Generally, can you comment on safety/security considerations regarding station design and access (e.g., security protocols and access similar to airports)?

HSR, shared mobility, and MOD/MaaS

The following questions will only be asked to experts with relevant experience incorporating shared mobility/MOD/MaaS into station access/egress planning.

- Given the growth in on-demand and app-based services, how has station design and access/egress changed?
    - What examples can you point us to of stations changing their designs to accommodate MOD or MaaS or other transformative transportation technologies (e.g., retrofitting of changing new stations)?

HSR and first- and last-mile access

- How important is integrated fare payment in supporting feeder rail and local transit service to HSR?
    - Are you familiar with any studies on this topic?
- Have there been any studies regarding the evolution of station access over time (e.g., 6 months, 1 year, 2 years, 5-10 years, 20+ years after opening)?
- What do you see as the role, if any, of automated vehicles (ground- or air-based) regarding station access for passengers and the delivery of goods over the next 10 years?

HSR and demographics

I'd like you to think for a moment about the rapidly evolving transportation ecosystem and the current shifts in socio-demographics (e.g., aging population, gentrification, language barriers, etc.). How might this affect HSR or regional rail stations?

- Are there any good examples of before/after studies (e.g., 6 mos, 1 year, 2 years) regarding shifts in socio-demographics in areas near new or re-designed regional or HSR stations?

The future of HSR and station access

As regional rail and HSR networks mature, they can become less adaptable to future changes in transportation and demographics, foreseen or otherwise. Questions in this section focus on how mature systems have adapted to such changes.

- Given the long planning horizons (10-20 years, or more) for many HSR networks, are there any future modes (e.g., automated shuttles, automated vertical takeoff and landing vehicles, etc.) that should be considered?

Concluding remarks

- Do you have any additional comments on topics we have not covered?

Other experts in the field

- Who would be on your list of leading experts regarding high speed rail station access?
    - [Name, Title, Organization]

Thank you very much for your time, and for sharing your thoughts on this topic.

Appendix D: Focus Group Protocol

HIGH-SPEED RAIL (HSR) STATION ACCESS AND EGRESS STUDY
Focus Group Protocol

Introduction: 10 mins

- Moderator introduction and focus group purpose/overview
- Participant introductions: Please introduce yourself and tell the group your experience with shared mobility services, and your experience with California HSR

Current Travel Patterns: 10 mins.

- How often do you ride Amtrak?
    - How do you typically get to Amtrak?
    - How do you feel about using a Thruway coach to connect to Amtrak?
- What are your thoughts on a light-rail connection to Amtrak?

Experience with Shared Mobility: 15 mins.

- Are you familiar with shared mobility?
    - By this, we mean the use of transportation assets and/or infrastructure in a shared manner including: carsharing (either person to person, or provided by a fleet); bikesharing in all forms; carpooling; vanpooling; scooter sharing; transportation network companies, or ridesourcing/transportation network companies (TNCs), such as Uber, Lyft, and others; e-hail for taxis; and mictrotransit shuttles (such as Chariot, Via, and others). This may also include aerial modes that are not currently in commercial operation, such as urban air mobility or light rotary aircraft designed to transport a few passengers point to point.
- How did you first hear about shared mobility?
- In an average week, how many times do you use shared mobility services?
- What were some of the key concerns you had before using shared mobility services (rank top 3)?
    - How do you think these fears can be addressed (e.g., more information)?
    - Have those concerns persisted using the services? Do you have new concerns?
    - How do you think these concerns (after usage) can be addressed (e.g., control of who rents your vehicle, user rating systems, etc.)?
- What do you consider the greatest personal benefit of shared mobility services?
- What do you consider the greatest disadvantage of shared mobility services?

Automated Vehicles: 10 mins.

- Are you familiar with automated vehicles?
    - By this, we mean ground- or air-based vehicles that operate safely without the need for human supervision. This does not necessarily mean that humans cannot assume control of the vehicles or direct them regarding how to reach destinations, only that human supervision is not required for operation. Such vehicles may take

forms similar to those being discussed today or they may take different forms yet to be envisioned.

- How comfortable would you be taking a ride in an automated vehicle?
    - For instance, would you be willing to replace your private car for a privately-owned, automated vehicle?
    - Alternatively, would you be willing to share a ride in an autonomous vehicle that operated similarly to an Uber or a Lyft?
    - Alternatively, would you be willing to take a ride on an automated public bus?
- What do you consider the greatest personal benefit of automated vehicles?
- What do you consider the greatest disadvantage of automated vehicles?
- Are you familiar with urban air mobility?

High-Speed Rail: 10 mins.

- Please describe your thoughts and feelings about California HSR
- In your opinion, is there anything the state could be doing to make HSR better?
- What do you consider the greatest personal benefit of HSR?
- What do you consider the greatest disadvantage of HSR?

HSR Future Station Access: 20 mins.

- 10-15 years into the future, do you anticipate any changes to your travel patterns or preferences?
    - For instance, are might you have moved or switched jobs in that timeframe?
    - Are there any changes to transportation overall that would affect your travel patterns or preferences??

- 10-15 years in the future, if HSR were part of your daily commute, what would be the most convenient way for you to access the station? Give a list of options (Bike, Bikesharing, e-Bikesharing, Scooter Sharing, Drive alone, Drive carpool, Ride carpool, TNC (Uber/Lyft), Shared TNC, Taxi, Bus, Train, Microtransit)
- What would be the most convenient way for you to get to your office from the station?
- What if the following modes were available as well? (Automated vehicles, Automated shuttles)
- What if urban air mobility were also available?
- 10-15 years in the future, if you were using HSR as part of business travel (for meetings or longer-term business trips) what would be the most convenient way for you to access the station?

- 10-15 years in the future, if you were going on vacation within the state, what would influence your decision about whether or not to take HSR?
- 10-15 years in the future, if you were going on vacation outside the state, what would influence your decision about whether or not to take HSR to get to the airport?
- What would be the most convenient way for you to get to the HSR station, if you were going to use it?

Closing: 5 mins.

- Is there anything else you would like to tell us?

Incentives

Appendix E: Focus Group Questionnaire

FOCUS GROUP QUESTIONNAIRE

Thank you for completing this questionnaire. All answers are completely confidential.

Survey Number________________

First, we have some vehicle-related questions.

1. How many **people** (including yourself) live in your household? __________
2. How many of them (including yourself) drive (or have the ability to drive)? _____
3. How many vehicles do you currently own?.____________
4. If you own a vehicle, are you planning on selling it, or have you sold a vehicle in the last year?
    a. If so, why?
5. If you do not own a vehicle, do you plan to purchase one in the next year?
    a. If so why?

    b. If not, are you purposefully postponing a purchase, and why?

Next, we have some questions about your travel patterns.

6. If you own or have access to a vehicle, what types of trips do you typically make using it? (Select all that apply)

    - ☐ Shopping within city limits (short distance travel)
    - ☐ Shopping outside of city limits (long distance travel)
    - ☐ Work (as part of daily commute)
    - ☐ Sporting Events
    - ☐ Restaurants/bars (where drinking may be involved)
    - ☐ Errands (medical appts., picking up or dropping off kids or relatives, etc.)
    - ☐ Other, please specify: ________________________

7. If you do not own or have access to a vehicle, what types of trips do you typically make? (Select all that apply)

- ☐ Shopping within city limits (short distance travel)
- ☐ Shopping outside of city limits (long distance travel)
- ☐ Work (as part of daily commute)
- ☐ Sporting Events
- ☐ Restaurants/bars (where drinking may be involved)
- ☐ Errands (medical appts., picking up or dropping off kids or relatives, etc.)
- ☐ Other, please specify: _________________________

8. When you make these trips, what modes do you typically use?
    a. Modes for shopping within the city limits________________
    b. Modes for shopping outside the city limits________________
    c. Modes for work (as part of daily commute)_______________
    d. Modes for sporting events_____________
    e. Modes for restaurants/bars (where drinking may be involved)_________
    f. Modes for errands_______________
    g. Modes for other (please specify)__________ Modes____________

9. During a typical week, how many times do you **take public transit (e.g., bus, commuter rail, etc.)**? (**If you do not public transit, please skip to question 14)**

- ☐ Once a week
- ☐ Two times per week
- ☐ Three times per week
- ☐ Four times per week
- ☐ Over four times per week, please specify how many times: _____ per week
- ☐ I do not take public transit on a weekly basis

10. Please select all modes of **public transit** you take **at least once a month:**

- ☐ Bus
- ☐ Commuter Rail
- ☐ Light Rail
- ☐ Other, please specify: ___________
- ☐ I do not take transit

11. What types of trips do you typically make using public transit? (Select all that apply.)

- ☐ Shopping within city limits (short distance travel)
- ☐ Shopping outside of city limits (long distance travel)
- ☐ Work (as part of daily commute)
- ☐ Sporting Events
- ☐ Restaurants/bars (where drinking may be involved)
- ☐ Errands (medical appts., picking up or dropping off kids or relatives, etc.)
- ☐ Other, please specify:_________________________

12. When you take public transit, how do you access the stations (e.g., by walking, driving, etc.)?

a. Walking
b. Bike
c. Driving your own car
d. Driving a carpool
e. Riding in a carpool
f. A Transportation network company (e.g., Lyft, Uber)
g. Vanpooling
h. Other_________________

13. Are you familiar with the term 'sharing economy?"

- ☐ Yes
- ☐ No

14. Which modes are you familiar with?

- ☐ Transportation Network Companies (e.g., Lyft, Uber)
- ☐ Carsharing (e.g., Zipcar, car2go)
- ☐ Bikesharing
- ☐ Vanpooling
- ☐ Microtransit (e.g., Chariot)
- ☐ Urban Air Mobility

15. Are you familiar with the term 'automated or autonomous vehicle?"

- ☐ Yes
- ☐ No

Now, we have a few questions about the sharing economy.

16. What shared services outside do you use? (Please select all that apply.)

- ☐ Transportation Network Companies (e.g., Lyft, Uber)
- ☐ Carsharing (e.g., Zipcar, car2go)
- ☐ Bikesharing
- ☐ Vanpooling
- ☐ Microtransit (e.g., Chariot)
- ☐ Urban Air Mobility
- ☐ Other, please specify: __________________________________
- ☐ I do not use shared services

17. How frequently do you use shared mobility services?

- ☐ Rarely (a few times a year)
- ☐ Sometimes (once or twice a month)
- ☐ Regularly (once or twice a week)
- ☐ Often (three to four times a week)
- ☐ Never

18. For what trip purposes do you typically use shared mobility? (select all that apply)

- ☐ Shopping within city limits (short distance travel)
- ☐ Shopping outside of city limits (long distance travel)
- ☐ Work (as part of daily commute)
- ☐ Sporting Events
- ☐ Restaurants/bars (where drinking may be involved)
- ☐ Errands (medical appts., picking up or dropping off kids or relatives, etc.)
- ☐ Other, please specify:_________________________

Now, we have a few questions that will help us categorize the results of this questionnaire.

19. Are you… ☐ Female ☐ Male ☐ Other______

20. What is your current marital status?

☐ Single ☐ Married ☐ Separated ☐ Divorced ☐ Widowed

21. What is your age? ______________ years

22. Do you have children? If so, please state the number of children and their ages.

- ☐ Child 1, age _______
- ☐ Child 2, age _______
- ☐ Child 3, age _______
- ☐ Child 4, age _______
- ☐ Child 5, age _______
- ☐ I do not have any children
- ☐ Decline to answer

23. Do you own or rent your home?

- ☐ Own
- ☐ Rent

24. Are you currently seeking a new place to live?
    a. Yes

i. If yes, within what timeframe are you thinking about moving?
1. Reasons (fill in)

b. No
    i. If no, in the next 10-15 years, might you be considering moving?
        1. Reasons (fill in

25. What is the last level of school that you completed?

- ☐ Grade school
- ☐ Some high school
- ☐ Graduated high school or equivalent (GED)
- ☐ Associate's degree
- ☐ Some college
- ☐ Bachelor's degree
- ☐ Some graduate school
- ☐ Master's degree
- ☐ Ph.D. or higher
- ☐ Other, specify: ________

26. What is your current level of employment?
    c. Single job, fully employed
    d. Single job, partially employed
    e. Multiple jobs, fully employed
    f. Multiple jobs, partially employed
    g. Unemployed, searching
    h. Unemployed, not searching

27. What is your ethnicity? (Please choose one)

- ☐ White/Caucasian
- ☐ Black/African-American
- ☐ American Indian/Alaska Native
- ☐ Asian
- ☐ Hispanic or Latino
- ☐ Native Hawaiian/Pacific Islander
- ☐ Two or more races
- ☐ Other, please specify: ___________
- ☐ Decline to answer

28. What was your household's 2017, pre-tax income?

- ☐ Under $15K
- ☐ $15K to $24.9K
- ☐ $25K to $34.9K
- ☐ $35K to $49.9K
- ☐ $50K to $74.9K
- ☐ $75K to $99.9K
- ☐ $100K to $149.9K
- ☐ $150K to $199.9K
- ☐ $200K and above

☐ Decline to answer

29. What was your average monthly rent or mortgage payment in 2017?
    i. Less than $500
    j. $500 to $749
    k. $750 to $999
    l. $1,000 to $1,249
    m. $1,250 to $1,499
    n. $1,500 to $1,749
    o. $1,750 to $1,999
    p. $2,000 to $2,499
    q. $2,500 to $2,999
    r. $3,000 or more
    s. Decline to Answer

Thank you very much for completing this questionnaire!

Appendix F: User Survey

Current Travel Behavior

2. How many vehicles do you currently own or lease? [choice 0-5+]
3. How many vehicles does your household currently own or lease? [choice 0-5+]
4. During a typical work week, what are your work hours?
5. During a typical work week, how many days do you spend in your place of employment?
6. What is your typical daily commute? [travel time (fill in), distance (fill in), modes used (drop-down), cost estimate (fill in)]
7. When thinking about your commute, what factors influence your decision most? (Please select all that apply) [Travel time, wait time, cost, convenience, family responsibilities, other (fill in), etc.]
8. As part of your work responsibilities, do you attend meetings offsite from your office?
    b. If yes, please describe frequency
    c. If yes, please describe last or typical business trip journey
    d. If no, please describe any business trip journeys, if any.
9. As part of your work responsibilities, do you take business trips with an overnight stay inside California?
    e. If yes, please describe frequency
    f. If yes, please describe last or typical business trip journey
    g. If no, please describe any business trip journeys, if any.
10. As part of your work responsibilities, do you take business trips with an overnight stay outside California?
    h. If yes, please describe frequency
    i. If yes, please describe last or typical business trip journey
    j. If no, please describe any business trip journeys, if any.
11. During a typical week, about how often do you personally partake in the following kinds of activities?
    k. Shopping trips (clothing, furniture, etc.)
    l. Eating at restaurants, other nightlife
    m. Sporting events
    n. Weekend travel
12. When thinking about long-distance and/or weekend travel, what factors influence your decision most? (Please select all that apply) [Travel time, wait time, cost, convenience, family responsibilities, other (fill in), etc.]
13. Describe one or more of the above (If one, the one with most frequency, or randomized)
14. About how often do you take longer vacation trips?
15. Describe the most recent, or a typical longer vacation trip.

Mobile Phones and Internet Access

16. Select the option that best describes your mobile phone status [Do not own a mobile phone; own a non-smartphone; own a smartphone]
17. Selection the option that best describes your mobile phone [Do not own a mobile phone; only call and text capabilities; call, text, and internet/data access but does not have a data plan; call, text, and Internet access with a data plan]
18. Do you have access to an Internet connection in your home (wifi or broadband)?

19. Do you use an in-vehicle or Internet-based applications on your mobile device to navigate (e.g., Google Maps, Waze, Apple Maps, etc.)

Sharing Economy Platforms

20. How familiar are you with the following modes? Please rank from 1 to 9 with 1 being most familiar [carsharing (either person to person, or provided by a fleet); bikesharing in all forms; carpooling; vanpooling; scooter sharing; transportation network companies, or ridesourcing/transportation network companies (TNCs), such as Uber, Lyft, and others; e-hail for taxis; mictrotransit shuttles (such as Chariot, Via, and others); Aerial modes such as urban air mobility]
21. Have you ever used a ridesourcing/TNC or ridesharing (carpooling platform)? This may include Uber, Lyft, Gett, Chariot, Via, or other. [Never; rarely; sometimes (several times a month); often (about once a week); regularly (several times a week); I don't know what this is]
    a. Does your employer or someone else pay your fare for the use of these services?
22. Have you ever used a microtransit platform? Chariot, Via, or others. [same set as above]
    a. Does your employer or someone else pay your fare for the use of these services?
23. Have you ever used a carsharing platform? This may include Zipcar, Car2Go, Getaround, Turo, or other. [same set as above]
    a. Does your employer or someone else pay your fare for the use of these services?
24. Have you ever used a bikeshare platform? This may include Ford GoBike, Lime Bike, JUMP, or other. [same set as above]
    a. Does your employer or someone else pay your fare for the use of these services?
25. Have you ever used a vanpool or employer-based ridesharing service? This may include Enterprise, Green Raiteros, or other. [same set as above]
    a. Does your employer or someone else pay your fare for the use of these services?
26. Have you ever used a casual carpool? This may include online-based platforms or 511. [same set as above]
    a. Does your employer or someone else pay your fare for the use of these services?

Automated or Autonomous Vehicles

27. How familiar are you with automated or autonomous vehicles? [not sure how to specify these levels]
28. How comfortable are you being driven by a vehicle in which your supervision is not required? [very comfortable → no wouldn't do this]

Mode Choice Questions
For the next section of the survey, we will ask you questions about your preferred travel mode of choice for certain types of trips in the future. You will be presented with a scenario and a list of options and their attributes. Please consider these options as exhaustive and refrain from making further assumptions in these cases. If you feel that further assumptions are necessary, please record them and inform us in the open response section at the end.

Business 1
Access [33% chance commute, meeting, long-duration travel]
Status Quo Commute, Walkable Access

It is the year 2030, and you are accessing [Insert Station Name Here] as part of your daily commute travel. Among the following options which would you select? Please choose only one option. Access time, is the time it takes to reach the mode (e.g., walking to the bus stop, or your car); wait time is time spent waiting (e.g., for your Uber/Lyft pickup, the bus, etc.); travel time is the time spent in transit; egress time is the time it takes to reach the station from the mode's end point (e.g., walking transfer, walking from a parking lot).

Alternative	**Access time [min.]**	**Wait Time [min.]**	**Travel Time [min.]**	**Egress time [min.]**	**Cost [$]**	**Parking cost [$]**	**Decision**
Walk	0	0	25	0	0	0	
Bike	0	0	15	0	0	0	
Bikesharing	5	0	15	1	2	0	
e-Bikesharing	5	0	10	1	3	0	
Scooter Sharing	5	0	12	1	3	0	
Drive alone	0	0	7	3	4.5	7.5	
Drive carpool	0	0	12	3	3.5	7.5	
Ride carpool	0	5	12	3	1	0	
TNC (Uber/Lyft)	0	3	8	0	12	0	
Shared TNC	2	5	12	0	7	0	
Taxi	0	5	8	0	10	0	
Bus	5	7	15	1	2.25	0	
Train	7	10	10	2	2.25	0	

Microtransit (Via, Chariot)	3	4	11	0	5	0	

Business 2
Egress [33% chance commute, meeting, long-duration travel]
High/High Long-duration travel, Driving-range Egress

It is the year 2030, and you have just arrived at [Insert Station Name Here] as part of a three-day business trip. To get to your final destination, among the following options which would you select? Please choose only one option. Access time, is the time it takes to reach the mode (e.g., walking to the bus stop, or your car); wait time is time spent waiting (e.g., for your Uber/Lyft pickup, the bus, etc.); travel time is the time spent in transit; egress time is the time it takes to reach the station from the mode's end point (e.g., walking transfer, walking from a parking lot).

Alternative	Access time [min.]	Wait Time [min.]	Travel Time [min.]	Egress time [min.]	Cost [$]	Parking cost [$]	Decision
Private Automated Vehicle	0	1	17	0	15	0	
Ride Carpool	0	3	17	0	1	0	
TNC (Uber/Lyft)	0	3	19	0	12	0	
Shared TNC	0	5	22	1	7	0	
Taxi	0	5	19	0	10	0	
Bus	0	7	32	3	2.25	0	
Train	0	10	25	5	2.25	0	
Microtransit	0	4	24	2	5	0	
Automated Shuttle	0	3	24	2	5	0	
Urban Air Mobility	1	2	8	1	25	0	

Leisure 1
Access [33% chance shopping, nightlife/sports, long-duration travel]
High/High Shopping, bikeable access

It is the year 2030, and you are on your way to go clothes shopping at [Insert Station Name Here]. Among the following options which would you select? Please choose only one option. Access time, is the time it takes to reach the mode (e.g., walking to the bus stop, or your car); wait time is time spent waiting (e.g., for your Uber/Lyft pickup, the bus, etc.); travel time is the time spent in transit; egress time is the time it takes to reach the station from the mode's end point (e.g., walking transfer, walking from a parking lot).

Alternative	Access time [min.]	Wait Time [min.]	Travel Time [min.]	Egress time [min.]	Cost [$]	Parking cost [$]	Decision
Bike	0	0	32	0	0	0	
Bikesharing	3	0	32	1	2	0	
e-Bikesharing	3	0	28	1	3	0	
Scooter Sharing	3	0	30	1	3	0	
Drive alone	0	0	15	1	7	5	
Private Automated Vehicle	0	0	15	0	15	0	
Drive carpool	0	0	18	1	6	5	
Ride carpool	0	3	18	1	1	0	
TNC (Uber/Lyft)	0	3	21	0	12	0	
Shared TNC	0	5	24	1	7	0	
Taxi	0	5	21	0	10	0	
Bus	0	7	30	3	2.25	0	
Train	0	10	28	5	2.25	0	
Microtransit	0	4	26	2	5	0	
Automated Shuttle	0	3	26	2	5	0	

Urban Air Mobility	1	2	6	1	20	0	

Leisure 2
Egress [33% chance shopping, nightlife/sports, long-duration travel]
Status Quo Longer-duration travel, Driving-range egress

It is the year 2030, and you have just arrived at [Insert Station Name Here] as part of a week-long vacation. To reach your destination, among the following options which would you select? Please choose only one option. Access time, is the time it takes to reach the mode (e.g., walking to the bus stop, or your car); wait time is time spent waiting (e.g., for your Uber/Lyft pickup, the bus, etc.); travel time is the time spent in transit; egress time is the time it takes to reach the station from the mode's end point (e.g., walking transfer, walking from a parking lot).

Alternative	**Access time [min.]**	**Wait Time [min.]**	**Travel Time [min.]**	**Egress time [min.]**	**Cost [$]**	**Parking cost [$]**	**Decision**
Ride carpool	0	5	45	3	10	0	
TNC (Uber/Lyft)	0	3	45	0	30	0	
Shared TNC	0	5	56	0	22.5	0	
Taxi	0	5	45	0	25	0	
Bus	0	7	85	3	2.25	0	
Train	0	10	65	10	2.25	0	
Microtransit	0	4	60	0	15	0	

Opinions about California High-Speed Rail

29. Please select the option that best describes your opinion about HSR [strongly support → strongly against]
    a. Please provide reasons [give a list, and an other]
30. Please select the option that best describes your opinion about gasoline taxes [strongly support increases → strongly against)
31. Please select the option that best describes your political views [democrat, independent, republican, other, unregistered]

Demographics

32. In what year were you born? [dropdown list]
33. With what gender do you identify? [Male, Female, Other (Fill-in), prefer not to answer]
34. With what race/ethnicity do you identify? (select all that apply) [Black/African American/Caribbean, American Indian or Alaskan Native, Asian, Caucasian/White, Hispanic or Latino, Middle-Eastern, Native Hawaiian or Pacific Islander, South Asian (e.g., Indian, Pakistani, etc.), Southeast Asian, Other (please specify), Prefer not to answer]
35. What is the highest level of education you have completed? [Less than high school, Currently in high school, High School GED, Currently in 2-year college, 2-year college degree, Currently in 4-year college, 4-year college degree, Currently in post-graduate degree, Post-graduate degree (MA, MS, PhD, MD, JD, etc.), Prefer not to answer]
36. What kind of housing do you currently live in? [Detached single-family home, Attached single family home, Building/house with fewer than 10 units, Building with between 10 and 100 units, Building with more than 100 units, Mobile home/RV/Trailer, Other, please specify]
37. Including yourself, how many people live in your current household? [choice 0-5+]
38. What best describes your relation to the other people in your current household? (select all that apply) [roommates, spouse, children, family, boarders/renters]
39. How long have you been living in your current household? [choice 0-10+ years]
40. Is your household owned or rented (Ownership can either be by your or another household member)?
    a. If owned, are you one of the primary owners?
41. Are you currently seeking a new place to live?
    a. If yes, within what timeframe are you thinking about moving?
        i. Reasons
    b. If no, in the next 10-15 years, might you be considering moving?
        i. Reasons
42. What is the address of your current household? Please list the closest cross streets and/or the zip code.
43. Do you plan to buy a new vehicle in the next three years?
    a. If yes, why?
    b. If no, why?
44. If vehicle owner, do you plan to sell a vehicle in the next three years?
    a. If yes, do you plan on replacing that vehicle?
        i. If yes, why?

ii. If no, why?

b. If no, why?

45. What is your current level of employment? [Single job, fully employed; single job, partially employed; multiple jobs, fully employed; multiple jobs, partially employed; unemployed, searching; unemployed, not searching]
46. What is the address of your place of employment? Please list the closest cross streets and/or the zip code.
47. What was your personal gross (pre-tax) income in 2017? [Less than $10,000; $10,000 to $14,999; $15,000 to $24,999; $25,000 to $34,999; $35,000 to $49,999; $50,000 to $74,999; $75,000 to $99,999; $100,000 to $149,999; $150,000 to $199,999; $200,000 or more]
48. What was your household income in 2017? [Less than $10,000; $10,000 to $14,999; $15,000 to $24,999; $25,000 to $34,999; $35,000 to $49,999; $50,000 to $74,999; $75,000 to $99,999; $100,000 to $149,999; $150,000 to $199,999; $200,000 or more]
49. What was your average monthly rent or mortgage payment in 2017? [Less than $500; $500 to $749; $750 to $999; $1,000 to $1,249; $1,250 to $1,499; $1,500 to $1,749; $1,750 to $1,999; $2,000 to $2,499; $2,500 to $2,999; $3,000 or more]
50. Through what means did you access this survey?

Drawing Eligibility

As described in the consent form, only participants who opt to include their email address are eligible for the drawing.

Email Address:

This survey has asked a lot of questions about your travel behavior and mode choices. If you would like, please feel free to elaborate here on anything else related to your travel behavior and mode choice that you feel would be helpful for researchers to understand.
[open response]

Thanks very much for your participation!