SPUR REGIONAL STRATEGY

SPUR REPORT
TRANSPORTATION

Freeways of the Future

Delivering a fast and reliable regional bus network on existing freeway lanes

JANUARY 2021

This report is a component of the SPUR Regional Strategy, a vision for the future of the San Francisco Bay Area

spur.org/regionalstrategy

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Acknowledgements

Authors:
Jonathon Kass and Arielle Fleisher

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SPUR Task Force:
Charles Anderson, Helena Culic-Caro Robert Del Rosario, Austin Denmeier, Lauren Dong, Ron Downing, Michelle Go, Ian Griffiths, Chris Lepe, Linda Morris, Sean Nozzari, Aaron Quigley, Toshi Tosh Shephard-Ohta, Dave Vautin

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Designed by Shawn Hazen
Copy Edited by Becky Ohlsen
Cover photo by Sergio Ruiz

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Executive Summary

Imagine a Bay Area where your school, your job and your friend in the next county are no more than 30 minutes away via convenient, reliable and enjoyable buses zipping along uncongested freeway express lanes throughout the day. In this future, a fast, reliable and coordinated regional express bus network operating on a system of freeway express lanes connects transportation hubs throughout the region and beyond. All-electric buses serve freeway stations and freeway-adjacent stations that are accessible via walking, bicycling, local transit and evolving neighborhood transportation options. Stations in the freeway median create destinations that help bring more people and energy to otherwise desolate freeway underpasses and overpasses, reducing the freeway's impact as a barrier between surrounding communities. Direct access ramps make it easy for vehicles to get into and out of freeway express lanes from the local street network, allowing the express lane network to support shorter distance transit connections and promoting a rich mix of other high-occupancy travel modes, including local bus operators, private shuttles and vanpools. The netw ork delivers high-quality regional transit options to portions of the Bay Area that have historically been underserved, connects new destinations along corridors that already have some regional transit, and provides an alternative where existing regional rail has been filled to capacity. Meanwhile, this fast and sustainable transit option reduces solo driving, improves air quality and helps the region meet its greenhouse gas emissions-reduction targets.

This report considers benefits of a coordinated regional express bus network operating on freeway express lanes and proposes strategic policies, processes and regulatory reforms needed to deliver such a network. This report does not propose specific express bus routes or operating details.

Historically, policymakers have looked to rail service to deliver fast, high-capacity regional-scale transit. But achieving regional goals for increased transit use and reduced greenhouse gas emissions demands improvements that can be delivered more quickly and affordably by bus than by rail. The Bay Area already has extensive high-occupancy vehicle (HOV) lanes and express lanes and an ambitious plan for expanding that network throughout the region. The region also has express buses, though they are not operated as a coordinated network nor are they supported with targeted infrastructure, such as efficient access to express lanes and accessible, high-quality stops. The region's commitment to creating a comprehensive and continuous express lane network creates an opportunity for regional express buses to deliver faster and more reliable transit options. Designed properly, with ramps and bus stops that are easy to access, the express lane network could support buses, vanpools, private shuttles and high-occupancy vehicles.

The effort is not without major challenges, both in the development of an express lane network, and in the design and implementation of express bus service. Challenges include the following:

- → Efficient development of a freeway express lanes will require conversion of existing general-purpose lanes, which has been politically challenging in the past.
- → Fragmented authority for both express lanes and regional bus operation threatens efforts to deliver efficient and coordinated regional services.
- → Delays in delivering express lane projects, sometimes due to slow and complex approval processes, hamper the region's ability to create an efficient express bus network.
- → Express bus services attract disproportionately white and higher income riders. Ensuring equitable access will require explicit service design and pricing strategies to serve more diverse communities.

To address these opportunities and challenges, SPUR makes the following recommendations:

Recommendation 1:

Establish a "conversion first" policy to deliver the region's express lane network.

A continuous express lane network is essential for fast and reliable express bus service. It must be developed primarily through conversion of existing freeway lanes so that the network can be delivered quickly, affordably and in line with greenhouse gas emissions reduction goals.

Recommendation 2:

Accelerate at least three regional express bus pilot routes within the next five years.

The process of establishing a more efficient regional express bus network will be iterative. Pilots to deliver uncongested regional express bus routes should begin immediately and incorporate near-term strategies where continuous freeway express lanes cannot be put quickly into place. These strategies may include some combination of intensive HOV enforcement, conversion of freeway shoulders to part-time transit lanes and increased restrictions on which vehicles may access HOV lanes as necessary to maintain speed targets.

Recommendation 3:

Seek legislative and administrative policy changes to expedite implementation of express lanes.

Creating express lanes that adequately support a regional express bus network will require a new state law authorizing the conversion of general-purpose traffic lanes to express lanes. It will also require more flexible Caltrans guidelines to accommodate express bus infrastructure such as stations and direct access ramps. In addition, the process will be accelerated if Caltrans and the Metropolitan Transportation Commission (MTC) establish "corridor managers," who are jointly accountable to Caltrans and the MTC, and who take ownership of completing express lane projects.

Recommendation 4:

Rationalize governance.

Creating coherent regional policies that prioritize fast reliable regional express bus operation will require a stronger regional governance model — one that ensures coordinated pricing (including low-income discounts), fines, enforcement methods and lane-access policies. These policies should include criteria for the use of express lane revenues to support a regional express bus network and a regional authority that can assign bus-operating responsibilities for regional express bus routes.

Recommendation 5:

Develop a comprehensive regional express bus network plan.

MTC should lead development of an integrated express bus network plan that includes performance metrics and equity strategies. This initiative should also establish a process to coordinate planned and future freeway rehabilitation projects to incorporate express bus infrastructure.

Recommendation 6:

Establish equity targets and design the network and operations to meet the targets.

A growing regional express bus network must deliver service equitably, particularly for those who have not been well served by regional buses in the past, including nonwhite people and people with low incomes. This requires that MTC develop explicit equity principles, performance metrics, market analysis, discount fares, off-peak service and strategies to connect neighborhoods to the express bus network.

Introduction

The Need for a Regional Express Bus Network

The San Francisco Bay Area needs more reliable regional transit to meet its equity, sustainability, economic and livability goals. These goals are enumerated in Plan Bay Area 2040,[1] the region's long-range plan for sustainable growth. Plan Bay Area 2040, the most recently adopted regional transportation plan, shows that even with the proposed $194 billion[2] invested in transit construction and operations, the region is not expected to meet performance targets for equitable access, transit speed, job accessibility, and the share of trips that do not use a car.[3] We need new transit strategies that connect Bay Area residents with jobs via fast, convenient and reliable means. A regional express lane and express bus network is an indispensable part of meeting this goal. It is a cost-effective complement to rail service, maximizes existing transportation infrastructure, is flexible and scalable and can be an important part of ensuring transit equity.

Major rail investment will continue to be an important component of the regional transit network. However, changing demographics, including growth of both poverty and jobs in the suburbs, has increased the need for regional transit outside the urban core. We must now connect a broader geography than rail can cost-effectively reach. A new network of fast and reliable bus service and other high-occupancy modes will need to play a larger role in the region's future. A regional express bus network can coordinate with rail in three ways, as illustrated in Figure 1 below:

- → **It** *extends* **beyond rail** to serve more of the region and the mega-region (e.g., buses operating on express lanes were found to be a high-performing alternative to the costly BART extension to Livermore).
- → **It** *complements* **rail service** in existing corridors by offering different stops and expanding access (e.g., express bus service contemplated by MTC on I-880 express lanes would run parallel to BART but serve different communities and destinations).
- → **It** *relieves* **congestion and** *provides* **helpful redundancy** along rail lines where capacity constraints are acute (e.g., extensive transbay bus service is a convenient alternative where BART is over capacity).

Relative to new rail investments, a regional express bus network operating on a system of managed freeway lanes is affordable and can be delivered in a reasonable timeframe, because it relies primarily on existing infrastructure – the expansive regional freeway network. The Bay Area has more than 4,000 lane-miles of freeways serving primarily single-occupant vehicles. While policymakers have sought to improve freeway efficiency and sustainability with high-occupancy vehicle (HOV) lanes, this has failed to deliver reliable travel times, especially for buses. This is due to poor enforcement and the fact that HOV occupancy is too crude a tool to effectively manage congestion (see "Why Can't Buses Rely on HOV Lanes?" on page 17). An express lane network, created by converting existing freeway HOV lanes and general-purpose lanes, can deliver rapid, reliable and sustainable travel.

1 Plan Bay Area 2040 is the most recently published Regional Transportation Plan and Sustainable Communities Strategy for the San Francisco Metropolitan Region. The updated Plan Bay Area 2050 is under development and will be published in 2021.

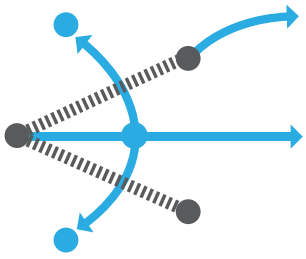
2 Plan Bay Area 2040, Investment Strategy Final Supplement Report, July 2017 (pp 13).

3 PBA2040

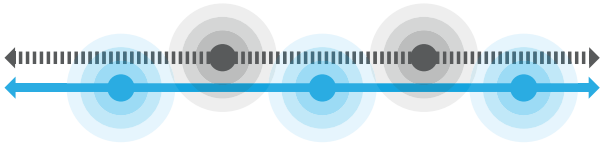
FIGURE 1

Express Bus Complements Regional Rail

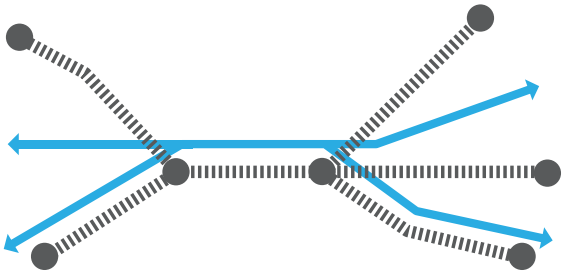
A regional express bus network can complement regional rail service by extending beyond regional rail corridors, serving communities on existing rail corridors that are far from rail stations, and providing redundancy and congestion relief along regional rail segments that cannot meet travel demand.



Areas regional rail cannot reach
e.g. from Dublin Pleasanton to Livermore



Communities along regional rail corridors with poor access to rail.
e.g. I-880 BART corridor from Oakland to San Jose



Corridors where regional rail is over capacity
e.g. Transbay Tube / Bay Bridge

A network of express buses operating on freeway express lanes is a flexible and scalable solution, enabling responsiveness to uncertain and evolving transportation needs in a time of great transition. Shifting pandemic and post-pandemic travel patterns are the most recent and extraordinary examples of why we need flexible solutions. But we also need a network that is adaptable to an uncertain technological future. A well-designed network of express lanes, stations and passenger access points would serve multiple potential future scenarios, including:

- → Mega-regional bus service networks (e.g., to destinations such as Sacramento, Santa Cruz, Tracy and other locations outside of the nine-county Bay Area).
- → Real-time adaptive jitney services.
- → Autonomous shuttle services.

These future services may serve as efficient connectors to the express bus network or use the infrastructure created for express buses to efficiently access and travel on the express lane network.

Changing demographics also call for new transit solutions to address equity. While poverty in the United States has historically been concentrated in urban areas, suburbs in the country's largest metro areas saw the

Source: SPUR

number of residents living below the poverty line grow by 57 percent between 2000 and 2015, accounting for nearly half of the total national increase in the poor population in that period.[4] The Bay Area is no exception. This suburbanization of poverty means that equity in transit access requires reaching deeper into the suburbs that have historically relied on car travel. A regional express bus network is part of the solution to connecting communities to employment centers.

For these reasons, a regional express bus network is essential to improve equity, sustainability and livability for the Bay Area. SPUR's recommendations draw upon TransForm's *Regional Express (ReX) Transit Network*[5] report (see sidebar on page 9), which lays out a bold and detailed scenario for a Bay Area regional express bus network.

As a complement to the *ReX* report, SPUR argues that now is the time—politically and practically—for a major push on a regional express bus network.

The Limits of Supply Side Transportation Solutions

Transportation decision-makers have a mixed record when it comes to efficient new transit systems that promise to lure travelers out of their cars, and thereby improve travel efficiency, equity, the environment and the economy. This report calls for repurposing a portion of our existing freeway infrastructure, which is being used inefficiently either as unreliable general-purpose lanes or unreliable HOV lanes. SPUR's proposed system is explicitly designed to work for diverse styles of bus travel as the concept evolves. Most importantly, this proposal comes as part of a 50-year regional vision that presumes substantial growth in areas that are not currently served by good regional transit, providing an efficient, affordable and sustainable way to better connect these evolving communities to jobs and services around the region. This is not "build it and they will come." Rather, it is "build a foundation that permits our transit network to better adapt as they come."

4 Elizabeth Kneebone, "Poverty Crosses Party Line" (Washington: Brookings Institution, 2016), https://www.brookings.edu/research/poverty-crosses-party-lines/#AL.

5 https://www.transformca.org/ReX

TransForm's Regional Express (ReX) Transit Network Report

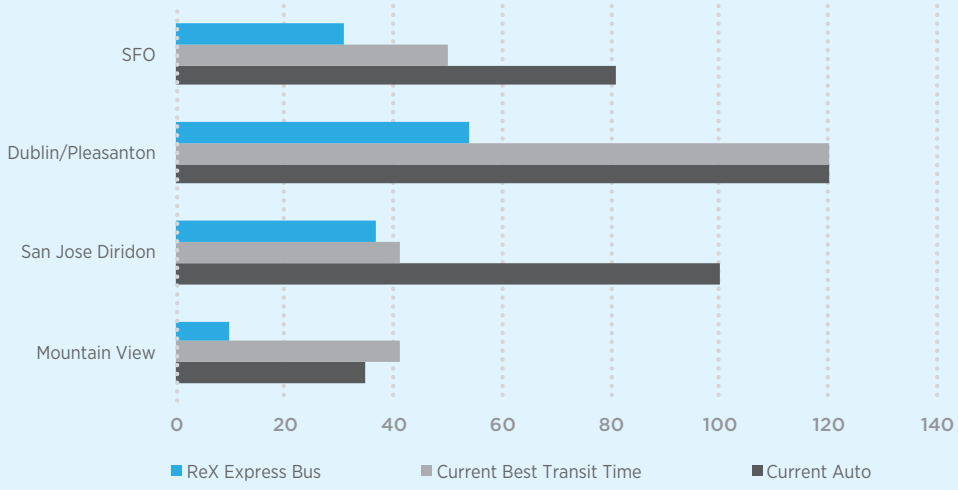
TransForm, an organization that advocates for transportation and planning reforms that advance equity and sustainability, published its *Regional Express (ReX) Transit Network* report in October 2019, laying out a bold scenario for a Bay Area express bus network.[6] The *ReX Network Report* provides an ambitious and detailed vision for a potential Bay Area express bus network with estimated costs, projected performance, and discussions of how the network should function.

The proposed ReX network includes 17 freeway-based express bus routes throughout the region, 68 feeder routes and multiple major transportation hubs and stations that serve as efficient and convenient transfer locations. The vision assumes a complete express lane network as well as key tunnels, bus flyover ramps and other direct connectors to ensure that buses can travel from freeways to stations and major destinations without congestion or delay. The *ReX* report found that the proposed network would dramatically reduce transit travel times during both peak and off-peak hours and deliver regional bus connections as quickly as private automobiles.

FIGURE 2

How Much Would Express Buses on Express Lanes Improve Travel Times?

Regional express buses operating on freeway-based express lanes with freeway-based stations could dramatically improve travel times relative to current bus options and relative to peak period car travel times. This chart shows TransForm's estimates of travel time comparisons on the proposed ReX network for trips to and from the proposed East Palo Alto Hub.



ReX was chosen for deeper analysis under the Metropolitan Transportation Commission (MTC) Horizon Initiative—intended to evaluate potential projects for the next update to the regional transportation plan known as Plan Bay Area 2050.[7] MTC's initial analysis found compelling reasons to pursue the regional express bus concept but also highlighted challenges. On the positive side, MTC found that the top 25 proposed bus routes could carry more passengers per day than BART (pre-pandemic). The modeling analysis also found that the express bus network reduced congestion on both the freeway network and the rail network in areas where capacity constraints might otherwise demand major capital investments.

6 TransForm's ReX Network Report can be found at https://www.transformca.org/ReX.

7 SPUR and TransForm were jointly selected by MTC's Transformative Transportation Projects competition based on their proposal to run an express bus network on an optimized system of express lanes. This MTC award meant that the express bus concept would be analyzed as part of the regional transportation system modeling to evaluate potential projects for the 30-year regional transportation plan. TransForm's *ReX Network Report* formed the basis for this express bus network modeling.

Source: ReX Network Report, https://www.transformca.org/ReX

MTC's model identified two primary challenges:

1. Poor benefit/cost performance under all three Plan Bay Area scenarios: This was due to two things: First, costly tunnels, ramps, and stations were included to ensure uninterrupted bus travel. Second, it proposed all-day high-frequency service throughout the entire network. As modeled, many of the lines did not have the ridership to justify such infrastructure and service frequencies.

2. Equity challenges because the ridership was disproportionately higher-income: This was likely because the network model served major regional job hubs, where jobs are disproportionately white-collar, and because long-distance express service is generally used more by higher-income riders.[8]

Following this initial modeling analysis, MTC determined that a more targeted selection of routes could avoid the costliest infrastructure while delivering high ridership, congestion relief, equity and strong benefit/cost ratios. MTC worked with SPUR and TransForm to include a set of three initial regional routes in the preliminary Plan Bay Area 2050 draft, along with proposed fare and schedule polices designed to maximize accessibility to low-income riders and serve a diverse range of communities.

8 Hiroyuki Iseki and Brian D Taylor, "The Demographics of Public Transit Subsidies: A Case Study of Los Angeles," September 1, 2010, https://escholarship.org/uc/item/9ng526f1

Chapter 1

What Are Managed Lanes, Express Buses and Express Lanes?

A system of managed lanes consists of:

- → Interconnected and uncongested high occupancy vehicle travel lanes.
- → Predominantly express lanes, but potentially including segments of bus-on-shoulder, transit-only lanes and high-performing HOV lanes.[9]
- → Coordinated policies regarding hours, tolls, access and enforcement.
- → Supportive additional infrastructure, including bus stops and direct access ramps.

Regional express buses primarily serve regional-scale trips with limited stops. Such services often extend beyond the boundaries of a single transit district. Express bus service can take a variety of forms, but there are two primary categories:

1. Multiple stops near the beginning and end of the route with few or no stops in between.
2. Limited stops at significant hubs along a major corridor.

To achieve travel times that are competitive with private cars, express bus service strives for direct routes and efficient stops that do not stray from the primary corridor. Customers may need to travel farther to reach express bus stops, as discussed in Chapter 4, but they are rewarded with faster and more consistent travel times.

Operating an efficient regional express bus network requires a system of managed lanes delivering uncongested travel. Managed lanes are lanes where specific strategies are used to actively respond to changing conditions, typically traffic.[10] This requires prioritizing the types of vehicles allowed to access the lane during periods of high demand. There are two main ways to manage lane access:

1. Through blanket restrictions—for example, by creating transit-only lanes, HOV lanes or truck-only lanes.
2. Through fees—for example, by increasing toll prices during congested periods to a price that will limit the number of drivers choosing to enter the lane to a level that avoids congestion.

Express lanes (also referred to as high-occupancy toll lanes or HOT lanes) use a combination of these two strategies. They restrict vehicle access — typically based on vehicle occupancy requirements — to ensure uncongested travel. However, vehicle occupancy is a crude congestion management tool: A 2+ carpool requirement might yield congested travel while a 3+ carpool requirement might eliminate congestion but also leave too much road capacity unused in an otherwise congested corridor. The system can be fine-tuned, for example, by allowing single- or double-occupant vehicles to access the lane for a fee, where the fee is set to

9 Bus-on-shoulder lanes are a type of transit-only lane. Designated portions of freeway shoulders, adapted as necessary to accommodate the weight and width of buses, allow buses to travel on freeways, with speeds often limited to no more than 35 miles per hour, and with access sometimes limited to peak periods when freeway lanes are congested.

10 https://ops.fhwa.dot.gov/freewaymgmt/mngd_lns_hov.htm

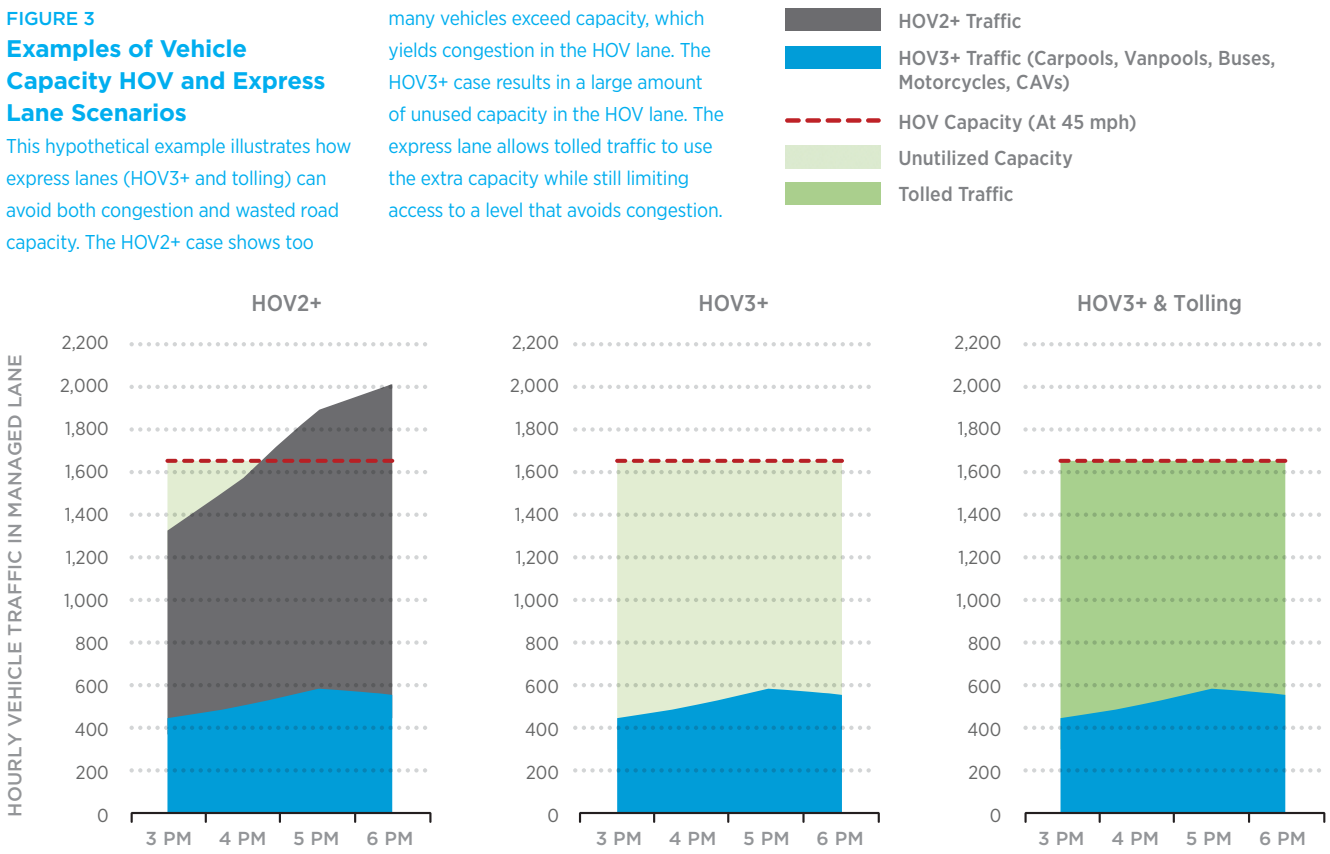
limit access to only the number of vehicles that can be accommodated without generating congestion (see Figure 3). This allows a lane to deliver uncongested travel, without leaving excessive unused road capacity. This is important because unused road capacity during peak travel times can be both inefficient and infuriating to adjacent travelers in severely congested travel lanes. A system of managed express lanes makes better use of existing infrastructure and reduces public frustration. Also, the fees have the potential to generate revenue that supports installation of equipment, enforcement, maintenance and corridor transit services.

A regional express bus network refers to express service with coordinated customer information, wayfinding, fares and schedules. Many regional express lanes and express buses exist in the region today, but, as discussed in Chapter 2, these services do not yet form a coordinated network.

FIGURE 3

Examples of Vehicle Capacity HOV and Express Lane Scenarios

This hypothetical example illustrates how express lanes (HOV3+ and tolling) can avoid both congestion and wasted road capacity. The HOV2+ case shows too many vehicles exceed capacity, which yields congestion in the HOV lane. The HOV3+ case results in a large amount of unused capacity in the HOV lane. The express lane allows tolled traffic to use the extra capacity while still limiting access to a level that avoids congestion.



All-Lane Management as an Alternative Approach

Express lanes are one strategy to manage vehicle access and congestion for a portion of the freeway. Many argue that it would be better to manage congestion on *all* lanes of the freeway, not just a few express lanes. This is a much bigger endeavor, requiring some combination of tolls and restricted access for every lane on the freeway. This would require federal regulatory changes, evaluation of impacts on equity and investments to mitigate them, and overcoming complex political hurdles. However, if all-lane management were accomplished, it would minimize the need for express bus infrastructure within the freeway right-of-way, because buses could enter and exit the freeway more easily, traveling in the right lane with limited congestion. This would significantly reduce the infrastructure cost of delivering express bus service.

Source: Managed Lane Implementation Plan, MTC, November 2019.

Chapter 2

Current Bay Area Managed Lanes and Express Buses Fall Short

The Bay Area already has an extensive managed lane network and numerous freeway-based express bus services. The region thus has components of a regional express bus network, but the pieces do not operate efficiently, and certainly not as a network.

Managed Lanes and Authorities

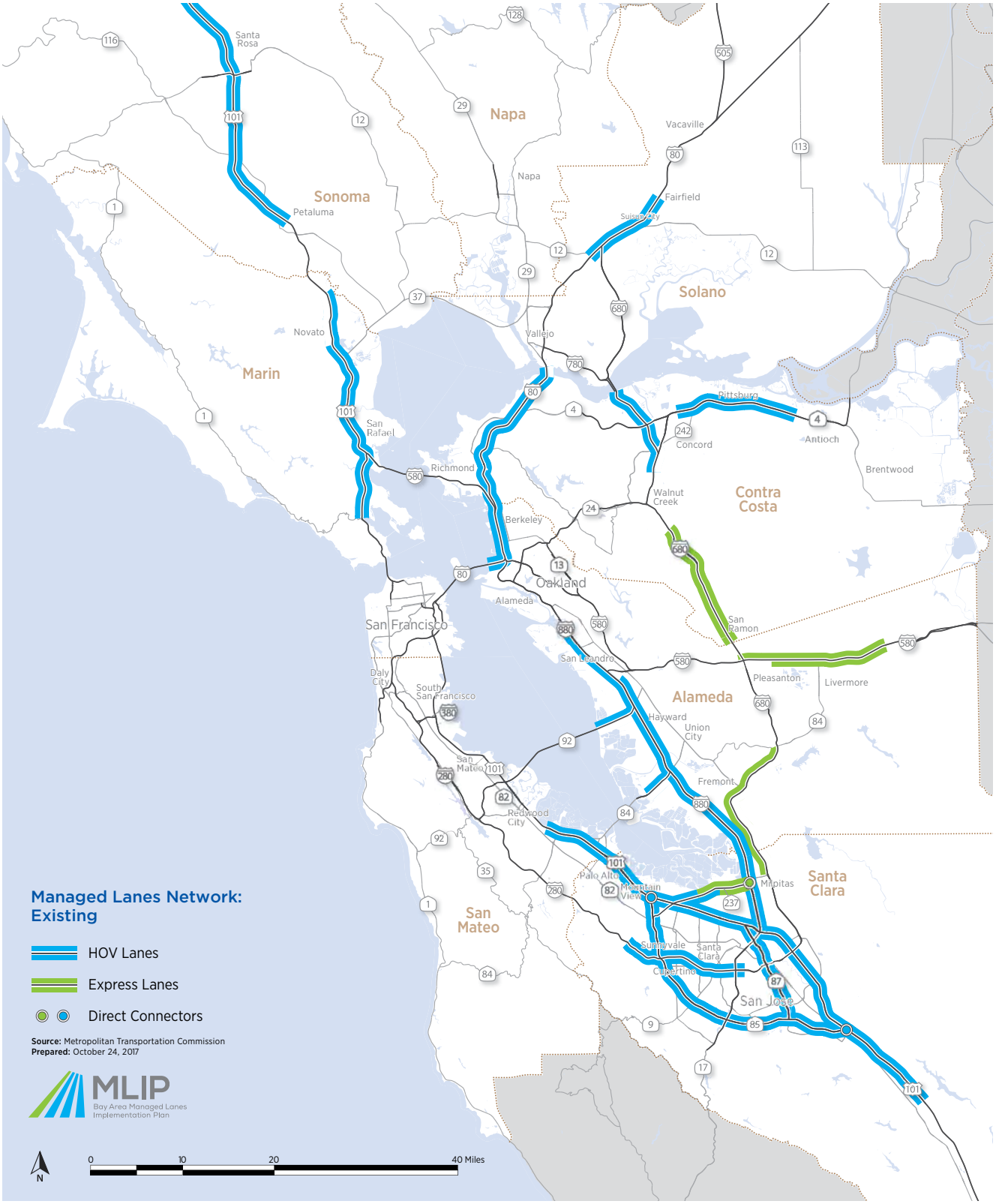
There are roughly 450 lane-miles of HOV lanes and 72 miles of express lanes in the 9-county Bay Area (see Figure 4). The express lanes will more than double by 2022, with the opening of an additional 74 miles on I-880 from Oakland to Milpitas and I-680 north of Walnut Creek.[11] MTC envisions a 600-mile network over the next several decades (see Figure 5). Authority to operate express lanes is scattered across five different authorities (see Figure 6).

11 MTC Express Lanes Quarterly Report, 4th Quarter October – December 2019, https://mtc.ca.gov/sites/default/files/BAIFA%20EL%202019%20Q4%20Report.pdf

FIGURE 4

Existing Managed Lanes (HOV Lanes + Express Lanes)

The existing network of managed lanes (as of October 2017) covers many heavily used freeway segments, though many segments remain disconnected. The network is predominantly made up of HOV lanes, which are frequently congested during peak periods.

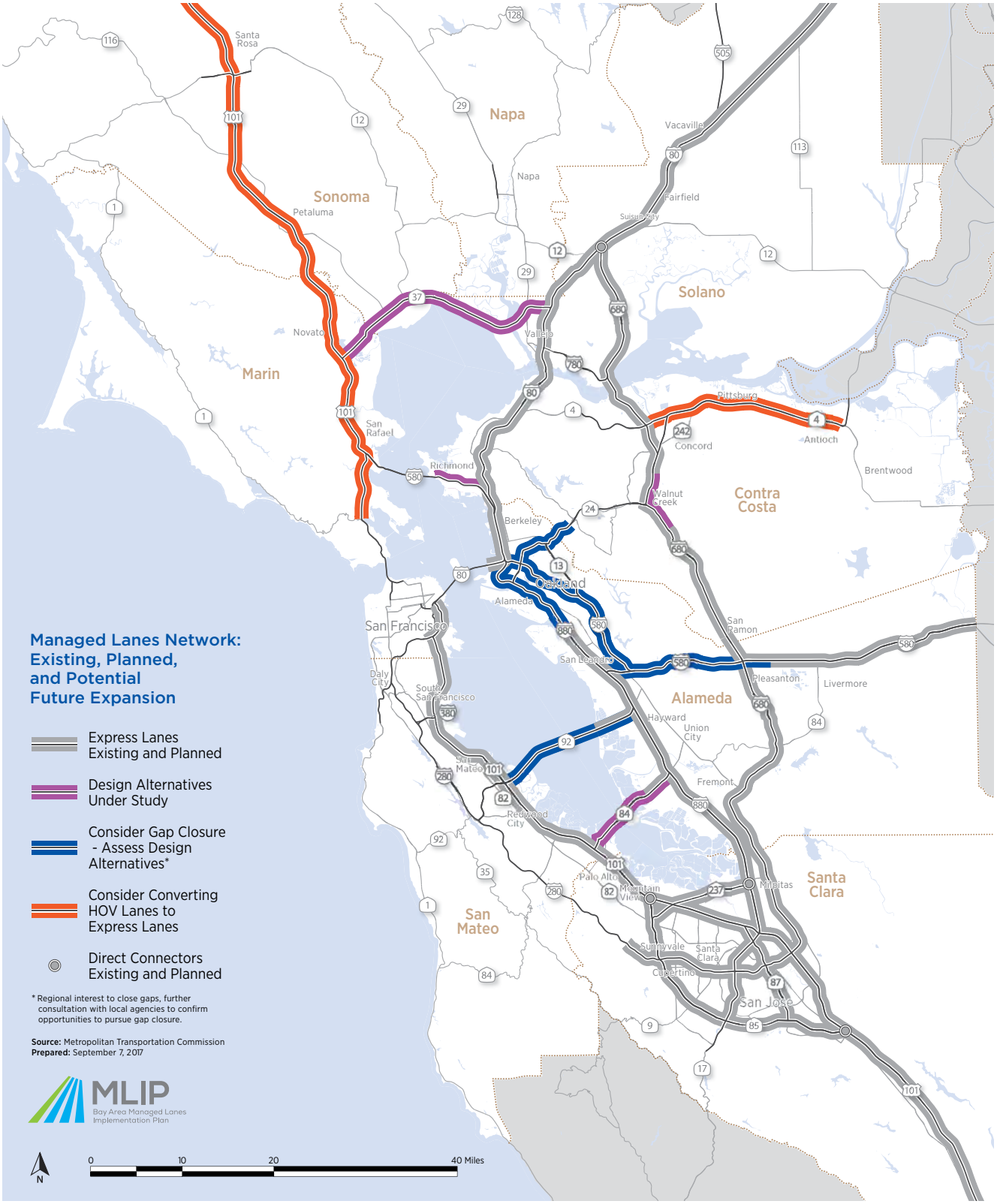


Source: MTC Managed Lane Implementation Plan, November 2019.

FIGURE 5

An Expansive Express Lane Network in 2035 and Beyond

MTC envisions a 600-mile network of express lanes, developed through a combination of adding new lanes to existing freeways and converting HOV lanes into express lanes.



Source: MTC Managed Lane Implementation Plan, November 2019.

FIGURE 6

Fragmented Authority Over Express Lanes Within the Region

Authority for express lane implementation is distributed among five different entities, each of which partners with Caltrans, which has authority over what can be implemented on the freeway network.

Source: MTC Express Lanes Quarterly Report, Q3 2019.

Why Can't Buses Rely on HOV Lanes?

HOV lanes do not deliver reliable travel speeds, particularly for buses. Of the region's roughly 450 miles of HOV lanes, more than 50% are "very degraded," meaning that the average speed is below 45 mph for more than half of the operating hours. In many cases, HOV lanes routinely slow to a near standstill during peak hours.

Lack of adequate enforcement is a key reason for this. MTC vehicle occupancy data shows that a high percentage of HOV lane users are violating vehicle-occupancy rules. On average, violators make up 19% of traffic in the morning peak and 25% in the afternoon peak, with violation rates as high as 39% in the worst segments.[12] As general-purpose lanes get more congested, cheating is increasingly tempting. HOV lane enforcement is challenging, because it is difficult to identify how many passengers are in a vehicle, particularly at night and for vehicles without a clear view of passengers. Conducting enforcement on the freeway is potentially hazardous, so pulling vehicles over to check occupancy requires reasonable confidence that there is a violation.

While technology is improving the likelihood of automated HOV enforcement, tech alone will not solve the challenges. First, it will be extremely costly to install and to monitor. While express lanes have several types of equipment to support enforcement — such as license place readers, vehicle sensors and video surveillance cameras — most of the region's extensive HOV network lacks such monitoring and communications equipment.

Second, even with perfect enforcement, tools for managing HOV lanes are limited, which makes it challenging to ensure reliable travel speeds. As illustrated in Figure 3, setting the HOV threshold too low (e.g., 2+ occupants) results in congestion. But the next option of 3+ occupants is likely to leave excessive unused capacity in the lane, resulting in reduced freeway capacity and the political challenge of an underutilized lane adjacent to lanes with more severe congestion.

For buses, accessing HOV lanes presents the same challenges as accessing express lanes. In most cases, buses must merge across multiple lanes of congested traffic. While this can be addressed by building direct access ramps, as is proposed for the express lane network, this infrastructure investment is not justified unless it delivers access to a high-performing and reliable lane—which HOV lanes don't reliably deliver.

These challenges mean that we cannot rely on existing or new HOV lanes to support a regional express bus network.

Regional Express Bus Service

Dozens of express bus routes operate throughout the Bay Area. They are heavily commute-oriented, usually providing non-stop service from a transit center or residential area to a major job hub. (Golden Gate Transit in the North Bay is an exception in that it serves job centers dispersed along the US-101 corridor.) Many express bus services connect to BART or Caltrain stations, but there has been little effort to coordinate them as an integrated network.

12 MTC, *Managed Lane Implementation Plan: Moving More People in Buses and Carpools Through HOV Operational Strategies*, November 2019.

Express bus services can be costly to operate. Buses frequently operate in heavy traffic, resulting in slow travel times and the need for operators to build a lengthy time buffer into their schedules due to inconsistent travel times. Also, commute services are often nearly empty on the return trip, so buses travel long distances with little or no fare revenue. Finally, fare collection is often lower than local service because passengers travel longer distances for the same fare. Even where express buses charge a premium fare, it rarely makes up for customers' longer average travel distance and the frequent long-distance return trips with few paying passengers.

Also, current express bus routes do not operate solely in express lanes, although many make use of HOV lanes where possible. Since accessing HOV lanes requires merging across multiple, often-congested freeway lanes, express buses use HOV lanes only when justified based on the length of freeway travel and the speed of the HOV lane.

While current express bus routes frequently operate non-stop once they enter the freeway, making stops typically requires exiting the freeway completely and traveling on surface streets to a nearby transit center or to park-and-ride lots adjacent to the freeway. Golden Gate Transit often stops at bus stops located on freeway off-ramps, avoiding the need to travel on surface streets. However, these freeway-adjacent bus stops are unfriendly to passengers, with loud, high-speed adjacent traffic, wide streets, poor landscaping and limited services. This counterbalances their efficiency benefits. Meanwhile, frequent freeway-adjacent and on-/off-ramp bus stops require buses to move to the right lane, which makes using HOV lanes or express lanes impractical, since buses would have to cross multiple lanes of often congested traffic to reach stops.

Public Express Bus Operators

Currently, 80 express bus routes operate on Bay Area freeways and highways under 12 separate transit authorities (see Appendix A for a more detailed description).

FIGURE 7

Bay Area Freeway-Based Express Bus Routes

At last 80 express routes operate today. Most of these travel the majority of their route on freeways. Only a few include express lanes, and even then, buses may be unable to access the express lane across congested travel lanes.

OPERATOR	# OF ROUTES
AC Transit	29
County Connection (CCCTA)	8
Dumbarton Express	2
Fairfield and Suisun Transit (FAST)	2
Golden Gate Transit	17
LAVTA (Wheels)	3
SamTrans	1
SolTrans	3
Tri Delta Transit	3
VINE	2
Valley Transportation Authority (VTA)	6
WestCAT	4

Source: ARUP Research on behalf of SPUR

These 80 routes operate on nine different freeways and highways. Figure 8 shows the existing regional network, and Appendix B includes a table of routes for each freeway corridor.

FIGURE 8
Regional Express Bus Routes on Highways
Express bus routes run in many of the region's freeway corridors. They operate as distinct lines, some only during peak periods. They do not function as an integrated express bus network, but they do provide important transit connections to major job centers and to the regional rail network.

Private Shuttles

In addition to the public network, there is a rich array of freeway-based private express bus services. In 2018, more than 1,600 shuttles served the region's largest employers, carrying tens of thousands of employees.[13] Large companies like Google, Apple and Genentech charter private buses to run from designated pick-up areas to company campuses. Companies often rent parking from private owners as park-and-ride pick-up locations but also serve a variety of neighborhood locations in cities, and in some cases use park-and-ride facilities that are shared by public express bus operators, such as freeway-adjacent facilities owned by Caltrans. These shuttles travel predominantly on the region's freeways, often using HOV lanes for some long-haul segments. In some cases, private shuttles operate on routes that are poorly served by existing express bus services. In other cases, they provide redundant service, either to deliver a higher quality experience for employees or to ensure that the route provides service directly to the company's campus.

The Region's Existing Express Bus Services Fall Short of Their Potential

Today's express bus services are extensive and vital for many commuters but cannot take full advantage of regional efforts to prioritize travel for high-occupancy vehicles. Poor performance and poor coverage of the region's HOV and express lane network, along with limited dedicated access for buses, leave many express buses stuck in traffic. This means slower speeds, less reliability and higher operating expenses than would be possible with a more supportive freeway infrastructure.

In addition, services are oriented around peak period commuting to and from job hubs, which means inbound and outbound passenger loads are very imbalanced, resulting in higher operating subsidies. Today's express bus services leave out many areas with poor regional transit alternatives and do not fully leverage the region's freeway assets.

13 https://www.protocol.com/silicon-valley-tech-shuttles

Source: Managed Lane Implementation Plan, November 2019.

Chapter 3

Cause for Optimism

Regional, state and national policy priorities are creating an unprecedented opportunity to advance both express lane networks and express bus services. The necessity for improved regional transit options, a new tangible vision for regional express bus networks, technological advances and an increasing number of examples from around the country all support strong, near-term action.

Regional Momentum

Motivated by concerns over equity, emissions reductions and cost-effectiveness, MTC is taking action and demonstrating regional leadership on express lane expansion, related policy coordination and regional express bus implementation. As MTC commissioners increasingly acknowledge the cost of delivering regional rail projects and the imperative to make access to express lanes more equitable, they are recognizing that for certain corridors regional express bus service is the only hope for effective new regional transit connections.[14]

MTC staff is currently developing the Bay Area Express Lanes Strategic Plan, a document that defines near-term expansion of the express lane network and ensures that investments are prioritized in service of the region's greenhouse gas (GHG) emissions reduction, equity and mobility goals. While this strategic plan has not yet come to the commission for approval at the time of this report's publication, commissioners have already expressed a sense of urgency regarding express lane implementation. Also, the commission has recently endorsed several express lane expansion projects that appear in the strategic plan, including San Mateo US-101, Santa Clara US-101 and Solano I-80.[15]

As part of Plan Bay Area 2050, MTC is proposing to expand the managed lane network through several strategies, including the construction of new lanes, conversion of existing HOV lanes and conversion of current general-purpose lanes to express lanes. Also, in collaboration with SPUR and TransForm, MTC proposed sponsoring a three-corridor pilot of regional express buses on managed lanes, derived from TransForm's *ReX Network Report* (see page 9). Although the inclusion of these express bus pilots in Plan Bay Area 2050 has not been finalized as of October 2020, MTC's sponsorship signals the agency's recognition that regional leadership is essential, even though bus transit projects are traditionally sponsored by transit operating agencies.

In addition to these steps toward regional leadership, several organizations have put forth visions to help the public and policymakers better understand what a regional express network could look like and how it might perform. The most detailed of these visions is the previously described *ReX Network Report*, but there is also MTC's Managed Lane Implementation Plan[16] and AC Transit's vision for regional express bus service.[17] All three move the region toward a shared vision of the regional express bus concept.

Finally, leadership at the subregional level is driving initiatives to link disparate transit agencies to coordinate express service within certain corridors. For example, AC Transit and WestCAT recently collaborated on a plan

14 Comment from Commissioner Jim Spering at the March 2020 MTC Operations Committee meeting.

15 MTC endorsed SM 101 in 2018 for an SB 1 application. In May 2020, MTC endorsed funding for SOL 80 (for RM3 and SB1 funding), ALA 680 (for RM3 funding) and SCL 101 (for SB1 funding).

16 MTC, *Managed Lane Implementation Plan: Moving More People in Buses and Carpools Through HOV Operational Strategies*, November 2019.

17 AC Transit prepared an unpublished vision for regional express bus service as part of scenarios developed for a potential regional transportation funding measure in 2019.

for express bus improvements along the I-80 corridor across Contra Costa and Alameda counties. The Contra Costa Transportation Authority is coordinating seven transit agencies, neighboring counties, and business organizations to provide express services in the I-680 corridor. Likewise, the Dumbarton Express provides express bus service between the East Bay and the Peninsula through a partnership among AC Transit, BART, Caltrain, SamTrans, Union City Transit and Valley Transportation Authority. These subregional initiatives show the growing acknowledgment that greater coordination is both necessary and possible.

Growing State and National Policy Support

At the state level, Governor Newsom's 2019 executive order on climate change[18] empowers efforts to retrofit our freeways to meet the state's emissions reduction targets and deliver climate solutions. As a result, there is new openness among the California State Transportation Agency (CalSTA) and Caltrans leadership to create greater flexibility in freeway design standards for express lanes, including through narrowing lane width standards, loosening constraints on converting general purpose lanes, and possibly streamlining express lane conversion projects. There is also an increased willingness to consider bus-on-shoulder solutions to make regional bus travel more attractive.

Federal interest in using pricing more broadly has opened opportunities to convert existing traffic lanes to express lanes—a practice that has been historically discouraged.[19] Potential federal support for the conversion of general-purpose lanes to express lanes, coupled with state-level support, would ease this historic constraint to optimizing the use of freeways.[20]

Broad Benefits of Express Lanes

A system of express lanes supporting a regional express bus network would benefit a wide range of users. These broad benefits are the basis for the growing support described above among regional leaders and offer hope for increasing support as express lanes become better understood by leaders and the public.

With 10% of Bay Area residents traveling by carpool,[21] faster and more reliable travel for qualifying HOVs would benefit tens of thousands of travelers. As currently planned, express lanes on corridors with the highest carpool volumes (I-880, US 101 and State Route 237) will continue to deliver free access to 3+ carpools and a 50% toll discount to 2+ carpools. Also, direct access ramps constructed for express buses to enter and exit express lanes can also be used by other HOVs, eliminating the time and frustration of crossing multiple lanes of congested traffic. This also makes express lanes functional for HOVs that are taking shorter trips, potentially alleviating arterial traffic.

An express lane network with direct access ramps can also reduce costs and improve service for local transit operators. Transit agencies would likely rely on freeway segments for their local routes if they could assume reliable travel times and efficient access to express lanes.

Private shuttles and vanpools, which travel primarily by freeway, would also benefit significantly. Faster travel and opportunities to make efficient stops along a freeway route would permit these private services to serve more travelers.

Express lanes can also offer solo vehicle drivers the option to bypass congestion on days when the driver

18 Executive Order N-19-19 (https://www.gov.ca.gov/wp-content/uploads/2019/09/9.20.19-Climate-EO-N-19-19.pdf)

19 23 U.S.C. §129(a)(1)(B)

20 These trends on pricing are discussed further in *Value Driven,* SPUR's recent report on transportation pricing, https://www.spur.org/publications/spur-report/2020-10-29/value-driven.

21 See MTC Vital Signs, https://www.vitalsigns.mtc.ca.gov/commute-mode-choice (accessed June 13, 2020)

determines that it is worth paying a toll for the time savings. Tolls for express lanes are set to limit single-occupant vehicle access to a level that maintains uncongested flow, but on days when a solo driver prioritizes a faster trip, express lanes create that option. As MTC examines means-based tolls for express lanes, this can be done in an equitable manner.[22]

Technological Innovations

Technological advances will make express lanes and express bus networks more effective. Each of the following innovations will improve performance and broaden the range of benefits:

- **Viable electric bus technologies.** Transit agencies are rapidly expanding their electric bus fleets as electric buses demonstrate increased travel range, better power options and competitive prices.[23] The California Air Resources Board requires all buses purchased after 2029 to be battery-electric or fuel cell vehicles.[24]
- **First/last mile innovation.** Growing mid-range travel modes such as bike share, electric-assist bikes and on-demand transit make getting to/from freeway transit stations more realistic. This is critical for balancing efficiency and access, as described in Chapter 4.
- **Lane changing technology.** Budding onboard technology can help buses operate on freeways, including by making lane changing more efficient and safer. Sensors on buses can improve their ability to merge in crowded freeway conditions and to navigate through narrower lanes such as may be required for certain bus-on-shoulder segments.
- **Automated enforcement.** Improved automated enforcement will keep noncompliant vehicles from congesting the lanes. These technologies include advanced detection equipment that can determine how many passengers are in a vehicle, even at night or when windows are visually obstructed, and phone app-based technologies that can confirm valid carpool participants.
- **Autonomous vehicles.** Automated vehicles and connected vehicles — vehicles that rely on signal communication with other vehicles and roadside equipment to navigate — will find an early home on express lanes, and other information technology could dramatically reduce implementation costs and timeframes (see text box below).
- **Real-time in-vehicle toll information.** Managed lanes rely on dynamic tolling, adjusting toll rates based on peak/off-peak travel times and levels of congestion. This, in turn, relies on communicating real-time fares to drivers, often via expensive infrastructure like large overhead electronic freeway signs. Information technology innovations could enable real-time communication with drivers much more efficiently, in terms of both time and cost.[25]

While not all of these innovation examples are ready for real-world use, express lane planning should take these evolving technologies into account.

22 The purpose of the toll is to filter out drivers who don't value faster travel as much. Means-based tolls simply adjust the fee scale appropriately for lower-income drivers. A low-income discount would give drivers who meet the criteria more ability to choose to use the lane when it would benefit them – similar to the way higher-income drivers can make that choice today.

23 https://uspirg.org/feature/usp/electric-buses-america (accessed on Aug 7, 2020)

24 https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040 (accessed on Aug 7, 2020)

25 This technology and associated policy implications is discussed further in SPUR's transportation pricing report, *Value Driven,* https://www.spur.org/publications/spur-report/2020-10-29/value-driven. .

Opportunity for Autonomous and Connected HOVs

Express lanes offer an opportunity for early adoption of autonomous and connected vehicles, including buses and shuttles. Express lanes are more segregated and controlled environments than other freeway lanes and surface streets, so they have the potential to serve as a safe operating space for autonomous buses and shuttles far before other parts of the road network. Also, connected vehicle technology, autonomous buses and jitneys offer the potential to serve a far greater area with freeway-based transit.

Chapter 4

Delivering a Comprehensive Regional Express Bus Network: Challenging but Worthwhile

Now is the time to grapple more seriously with the challenges of building and operating a transformational regional express bus network. This chapter describes the challenges that must—and can—be overcome to deliver the comprehensive and high-performing express bus network that the Bay Area region needs.

Delivering a Regional Express Lane Network Through Lane Conversion

Wherever feasible, the region's express lane network should be created by converting existing freeway lanes. This reduces cost, speeds delivery times, minimizes community impacts and avoids the GHG emissions, air quality and land use impacts associated with freeway expansion.[26] Where present, HOV lanes can be converted to express lanes; otherwise, existing general-purpose lanes will need to be converted.

Delivering express lanes through lane conversion is the approach that is most consistent with our regional objectives, but this strategy comes with interrelated policy and political challenges.

Policy and Regulatory Challenges

State law does not address whether general-purpose lanes may be converted directly to express lanes. Such conversions are neither explicitly prohibited nor authorized.[27] Federal law appears to permit such conversions through a Federal Highway Administration (FHWA) program known as the Value Pricing Pilot Program.[28] It also permits a two-step process where lanes are converted first from general-purpose to HOV lanes, and then to express lanes.[29] Both processes are somewhat administratively cumbersome and leave substantial discretion to FHWA regarding whether there is sufficient local support. Federal legislation to explicitly authorize the conversion of general purpose lanes to express lanes would be more efficient and would give greater confidence to regions considering this approach.

Political Challenges

When a general-purpose lane is converted to an express lane, congestion in the remaining general lanes is likely to get worse, at least until drivers adjust their choice of travel mode and route. Thus, despite the sustainability

26 June 12, 2020, MTC Operations Committee presentation notes that express lanes delivered through freeway expansion result in significantly more VMT and GHG emissions than those created by conversion of existing freeway lanes.

27 Streets & Highways Code 149.7(m) states, "Nothing in this section shall authorize or prohibit the conversion of any existing nontoll or nonuser-fee lanes into tolled or user-fee lanes, except that a high-occupancy vehicle lane may be converted into a high-occupancy toll lane. Streets & Highways Code 143(q) states: «Nothing in this section shall be construed to allow the conversion of any existing non-toll or nonuser-fee lanes into tolled or user fee lanes with the exception of a high-occupancy vehicle lane that may be operated as a high-occupancy toll lane for vehicles not otherwise meeting the requirements for use of that lane."

28 Based on interview with Angela Fogle and Neil Spiller of the FHWA, June 17, 2020. Also see https://ops.fhwa.dot.gov/congestionpricing/value_pricing/index.htm

29 See 23 CFR 810.108(b), 23 CFR 810.102 , and 23 U.S.C. 166 (b).

benefits, cost savings and faster project completion, such lane conversion projects generate political opposition. Although qualifying carpools (including buses and vanpools) and those who choose to pay the toll will experience less congestion as a result of the conversion, at least initially the majority of drivers will experience some worsening congestion. These political challenges are visible in ongoing debates at MTC, where some commissioners favor freeway expansion as a means to deliver certain express lanes, even where lane conversion may be a viable option.[30]

New freeway tolls also face political challenges. Public and political opposition to road pricing has been the predominant challenge confronting express lane development for decades. Two basic arguments are waged against congestion-based tolling:

1. It is unfair that those who can afford to pay tolls can avoid congestion while those who cannot afford the tolls are stuck in traffic – thus the "Lexus Lanes" moniker.
2. Motorists have already paid for roads through gas taxes and other user fees, so it is unfair to charge them to use the roads.

Certainly, the equity concerns are real and must be mitigated with a robust equity strategy including discounts for low-income drivers, but mitigation alone will not fully address public concerns.

The congestion pricing debate is long and rich, and there are many counter-arguments to the concepts above, many of which are addressed in SPUR's recent work on pricing, *Value Driven*.[31] The sensitivity around tolling heightens the need for a transparent process for setting express lane tolls driven by well-defined community goals. Where tolls are perceived as simply a new way to raise revenue, pricing efforts will fail. These political and public perception challenges also highlight the reality that political capacity to implement express lanes is intertwined with the use of any net revenue they generate.

Lack of a Regional Authority and Planning

The Bay Area's complex governance landscape presents challenges for implementing a coordinated regional transit network. SPUR has discussed the challenges associated with our fragmented transit authorities, including in the reports *Seamless Transit,*[32] *Solving the Bay Area's Fare Policy Problem*[33] and *A Regional Transit Coordinator for the Bay Area.*[34]

Fragmented Managed Lane Authorities

Unfortunately, the pattern of fragmented governance of transit agencies is being replicated for express lane governance. There are currently five authorities involved in the development and management of managed lanes (see Figure 6.) This is an exceptional level of institutional complexity, which makes it difficult to develop express lanes that are reliable for trips that cut across counties and express lane management authorities. This fragmented governance also makes it harder to ensure consistent policies to support express bus operations on express lanes that cross through multiple authorities.

In most states, the state department of transportation (DOT) is the lead entity in developing and operating express lanes. This is logical since the state DOT owns and operates the freeway network. In California, however,

30 See MTC Operations Committee meeting, June 12, 2020, Item 6b discussion. https://mtc.ca.gov/whats-happening/meetings/meetings-archive/operations-committee-2020-jun-12

31 https://www.spur.org/publications/spur-report/2020-10-29/value-driven

32 https://www.spur.org/publications/spur-report/2015-03-31/seamless-transit

33 https://www.spur.org/publications/white-paper/2019-05-23/solving-bay-area-s-fare-policy-problem

34 https://www.spur.org/publications/spur-report/2020-12-01/regional-transit-coordinator-bay-area

Caltrans is not the lead entity. Without Caltrans playing a leadership role, both the Bay Area and the Los Angeles region have ended up with fragmented express lane governance. Leadership is often spread across some combination of metropolitan planning organizations (MTC is the MPO for the nine-county Bay Area), county transportation commissions and special entities authorized through state legislation for a particular corridor or county.

Having a variety of authorities involved is not without benefits. For example, having multiple agencies work through the design, development, permitting and construction process might mean projects get finished faster. In some cases, county agencies — such as Santa Clara County's Valley Transportation Authority — have significant capacity, stakeholder leverage and integration of highway and transit functions that may help deliver express lanes. Steps to centralize policymaking authority should draw on the strengths of the current system. An efficient express lane network for the nine-county Bay Area, however, requires policies that optimize regional performance over narrower county-level needs.

Recently, the region has seen leadership and collaboration from the Bay Area Infrastructure Finance Authority (BAIFA), the Valley Transportation Authority (VTA) and the Alameda County Transportation Commission (ACTC) to enhance coordination for managed lane operating policies and standards. For example, in January 2020, BAIFA updated its toll ordinance to create common hours of operation, HOV threshold and toll discounts for clean air vehicles. VTA recently set 50% toll discounts for clean air vehicles to match bridge toll policies, and ACTC is working to do the same. Toll pricing is not coordinated, although algorithms for each operating authority generally seek to maximize throughput, so for now the pricing approach is similar across authorities.

Regarding the delivery of express bus service, the array of transit agencies also presents a challenge, though not necessarily a barrier. Sound Transit in Seattle, for example, contracts with individual public transit operators around the region to deliver coordinated and centrally planned regional express bus service. Although there are reasonable methods to advance a coordinated network with multiple operators, the current situation in the Bay Area has no lead regional bus transit coordinator. A new type of regional institutional structure will be required to deliver an optimal regional network.

Lack of Regional Bus Planning

Because the Bay Area has no primary regional bus operator, there has been limited regional vision around bus planning. Several subregional operators, such as Golden Gate Transit and AC Transit, have worked to deliver express bus service on specific corridors, but it has been challenging for them to deliver reliable service without associated roadway policies that support regional bus performance. The Valley Transportation Authority plays the dual role of bus operator and county transportation authority. VTA has placed less emphasis on cross-county bus services, and with the extension of BART to Santa Clara County has recently reduced its express bus operations.

Where agencies have delivered regional express bus service, they have typically focused on subregional or individual transit district goals, delivering service that is commute-oriented and relatively inefficient. For example, a service may provide two inbound morning commute trips while returning nearly empty.

Despite fragmented governance, recent partnerships have delivered more coordinated service within specific corridors and subregions. These efforts are ad hoc but demonstrate the demand for more regional coordination. Examples include:

- → Innovate 680 in the I-680 corridor[35]
- → The West Contra Costa Express Bus study,[36] a collaboration of AC Transit and WestCAT
- → The Dumbarton Express, a contract bus service across the Dumbarton Bridge, developed through a partnership of six agencies (AC Transit, BART, Caltrain, SamTrans, Union City Transit, VTA)[37]

While corridor and subregional efforts continue to grow, no entity is responsible for a coordinated regional express bus vision and implementation plan. For transit, MTC's role as the regional transportation planning body includes dispersing funds, setting targets and prioritizing among projects that are proposed by agencies and jurisdictions. However, transit operators have often expressed discomfort with MTC showing stronger leadership in defining transit projects. Operators are concerned that MTC will not be objective in its funding allocation decisions, and that because MTC does not run transit services, it thus lacks operations expertise.

Lengthy Project Delivery Times

Delivering express lanes takes too long. Recent projects have taken from five to eight years to simply convert HOV to express lanes (e.g., I-880 and I-680). Where there are no HOV lanes, the process is far more complex. The direct conversion of general-purpose freeway lanes to express lanes is not specifically authorized by state law, so segments without existing HOV must generally take one of two paths, both of which generate additional delay, expense and political controversy:[38]

1. Construct a new lane to serve as an express lane. This not only increases costs, it also generates additional freeway capacity for vehicle travel, which conflicts with environmental goals such as GHG emissions reduction obligations.
2. Follow a two-step process that first converts a general-purpose to an HOV lane, and then converts the HOV to an express lane (see Policy and Regulatory Challenges on page 24).

Separate from the complexities of lane conversions, project ownership is another major factor in considering delays. Express lanes and other express bus infrastructure, such as direct access ramps and bus stations, involve complex partnerships between Caltrans, regional agencies and counties, and are very likely to encounter delays. Freeway projects are complex, and Caltrans has competing multibillion-dollar programs for which it is 100% accountable (e.g., the State Highway Operations and Protection Program). Given the challenges that any freeway project will confront, Caltrans will need to have a strong sense of ownership and accountability to overcome those challenges swiftly and creatively. To do this, Caltrans must be more integral to the early project design and held accountable for performance. A model used in San Diego, where Caltrans assigns a corridor manager who is accountable to the MPO, is an approach to consider for the Bay Area.

Balancing Bus Efficiency and Customer Access

Delivering good customer access to the express bus network requires funding to address specific challenges of freeway environments, and the broader challenges of providing sustainable access in lower-density environments (i.e., in places that do not support adequate local transit connections and where few residents or jobs are within

35 https://ccta.net/projects/innovate-680/ (accessed June 2, 2020)

36 https://www.wcctac.org/app_pages/view/672#:~:text=There%20currently%20is%20no%20direct,trip%E2%80%9D%20using%20multiple%20transit%20providers. (accessed June 2, 2020)

37 https://dumbartonexpress.com/ (accessed June 2, 2020)

38 This is now subject to SB 743 requirements. These are new and will likely take some time to work out. These requirements will require mitigations for the VMT/GHG impacts. Projects will be required to have fewer environmental impacts or mitigate those impacts, though this will take more time and increase direct costs.

biking and walking distance from express lane stations).

Station Design in Freeway Environments

Efficiency is paramount for express buses. Delivering reliability and travel times that are equal to or better than single-occupant vehicles is essential for competitive service. Fast and reliable travel is achieved by deviating as little as possible from the freeway express lanes where travel conditions are predictable. The challenge is that these freeway-adjacent environments can be inhospitable for bus riders. Bus stations along the freeway can be loud and isolated, and the auto-oriented design characteristic of freeway access zones is often unpleasant for walking and biking. These areas are often far from job concentrations or walkable commercial services. As a result, there may be access benefits for riders when the bus can leave the immediate freeway environment and travel to more hospitable areas, even though this may reduce efficiency.

Connecting riders with freeway-based buses traveling in express lanes requires at least one of two actions:

1. Get passengers to freeway median stations to board the bus, or
2. Get buses efficiently in and out of the freeway median to pick up passengers at more people-friendly locations.

Both strategies are likely needed along a typical express bus corridor, and the specific approach for each station will need to be appropriate to the surrounding context in terms of land use and travel behavior, as well as existing and potential roadway and public space design.

Appendix C describes station types that balance customer access and bus efficiency in different ways.

These stations and direct access ramps will have costs beyond the current initial funding proposed in initial drafts of Plan Bay Area 2050. Their funding will require some combination of express lane toll revenue and funds that would otherwise be spent on freeway widenings and more costly forms of transit expansion such as rail extensions. Costs could be reduced if coordinated with required freeway rehabilitation projects.

Bus-on-Shoulder: An Alternative to Freeway Median Access

Bus-on-shoulder lanes convert a freeway shoulder to a transit-only lane, typically during congested periods.[39] This may require widening the shoulder, redesigning some drainage infrastructure or even strengthening the roadbed where it was not designed to carry consistent traffic. Minneapolis-St. Paul has fully implemented this approach, having installed 290 miles of bus-on-shoulder service.

Bus-on-shoulder should be deployed where appropriate as a complementary strategy to express lanes. This follows the approach in Minneapolis, where there are major investments in both bus-on-shoulder and express lanes, sometimes both operating on the same segment of a freeway.

There are benefits and challenges to bus-on-shoulder lanes relative to express lanes.

Benefits

- → Buses can access an uncongested travel lane without merging across congested travel lanes. This creates faster and cheaper implementation of efficient freeway routes and great flexibility for access to the lanes. Bus-on-shoulder lanes can thus be used for short segments as well as longer distances.
- → Freeway-based buses can easily access freeway-adjacent facilities such as bus transfer stations, park-and-ride lots or major employment centers, rather than requiring passengers to make their way to freeway median stations.

Challenges

- → State authorities typically limit bus speeds on shoulders to 35 miles per hour or 10 miles per hour faster than adjacent traffic, whichever is slower.
- → Many states require specific training and certification for bus operators to use shoulders to ensure drivers are familiar with safety requirements.
- → Bus-on-shoulder operations raise freeway management concerns. For example, buses would use space on the shoulder that is currently used for highway speed enforcement activities and would preclude the use of shoulders as a place to quickly get dangerous freeway debris out of the way.
- → Although there have been few safety problems with bus-on-shoulder lanes, both authorities and other motorists often perceive these lanes as a safety risk because they are typically narrower than typical freeway lanes.
- → If a shoulder is being used for other urgent functions (e.g., as a vehicle breakdown lane, a law-enforcement stop zone or a temporary freeway debris depository), buses must merge back into a congested travel lane. Although far better than being stuck in the congested traffic lane for the entire trip, these disruptions create fundamental reliability problems if bus service and customers come to depend upon bus-on-shoulder lane travel times.
- → Converting a shoulder lane for bus use adds vehicle capacity to the freeway, which may be undesirable from the perspective of managing vehicle miles traveled. Although this new capacity is specifically for buses, which may be a suitable policy priority, it indirectly increases single-occupant vehicle capacity by relocating existing buses from travel lanes to shoulder lanes.

39 A recent Federal Highway Administration Guide details bus-on-shoulder implementation. Jenior, P., Dowling, R., Nevers, B. (Kittelson & Associates, Inc.); Neudorff, L. (CH2M), Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy, FHWA-HOP-15-023, January 2016.

Though daunting, many of the challenges can be mitigated with technology and strategic implementation. Overall, bus-on-shoulder can serve as an important component of a regional freeway-based express bus network. For example, where direct access ramps to an express lane have not yet been constructed, or cannot be constructed due to geographic constraints, buses can travel on a bus-on-shoulder lane until they reach a point where express lane direct access ramps have been built. Also, if there are areas where politics or traffic conditions prohibit conversion of a general-purpose lane to an express lane, a bus-on-shoulder lane can be used to afford continuous uncongested travel for buses.

Bus-on-shoulder is under consideration in several Bay Area locations, including segments of US 101 in Marin County, I-680 near San Ramon, and in the Dumbarton Bridge corridor.

First/Last-Mile Access

In freeway and auto-oriented environments, special consideration must be given to riders' access to bus stops. Investment in surface street enhancements will be necessary for acceptable access by pedestrians and bicyclists. Also, the local bus network is sparse in lower-density suburban areas. Newer mobility options (e.g. bike share, electric-assist bikes and TNCs) are likely to be important elements as well.

Park-and-ride facilities are the predominant access strategy for express bus services at the present, and are likely to remain an important part of customer access to the Bay Area express bus network. However, a focus on park-and-ride presents efficiency and sustainability challenges. These facilities can lead express bus service to focus on peak commute service because, without strong alternative access, riders cannot easily get to the bus after the park-and-ride parking lot is full. Moreover, rather than expanding the diversity of modes around the bus station, park-and-ride lots can make the immediate environment more auto-oriented and less walkable. In many cases, there are opportunities to repurpose underutilized parking near bus stations. On I-880 and I-80, MTC is pursuing private lots that incorporate bike/pedestrian access, e-bike lockers and paid parking to make these facilities more sustainable and broaden first/last mile access.

Meeting Equity Priorities

A regional express bus network must be intentionally designed to meet the needs of low-income and nonwhite communities that have long been underserved by transit investment. Traditionally, express bus service has been designed to mitigate highway congestion and has focused on peak-period travel to major job centers. This has resulted in operations that disproportionately serve higher-income white-collar workers. This was evident in MTC's travel demand model evaluation of the proposed Regional Express (ReX) Transit Network (see page 9). Low-income and nonwhite communities are typically more reliant on transit due to lower car ownership rates, so prioritizing investment in these communities is essential to achieve equitable access to jobs and services.

As with all transportation investments, there is a tension between serving the largest number of riders and serving those riders with the most intense need. For example, providing service outside of commute hours is critical for people who cannot afford or are unable to drive, but this service can be more expensive to provide on a per-rider basis.

Express bus service can better serve those with the most intense need through:

- → Means-based fares.
- → Bus rapid transit routes that either connect with regional express routes or enter the freeway to become regional express bus routes.
- → First/last mile investments that link to communities of concern.

Equity also requires policies to rectify the unequal burden of express lane tolls. Tolls are meant to manage the number of vehicles in an express lane at a level that maintains uncongested flow for buses and carpools. Since people's price sensitivity goes up as their income goes down, means-based tolls can be fair for people of all income levels while still maintaining the goal of managing congestion.

Overall, regional express bus service can improve transit to suburban areas that are increasingly low-income. Turning that potential into reality will require deliberate action and ongoing performance monitoring.

Balancing Express Bus Costs

MTC's evaluation of the ambitious ReX Network (see page 9) showed that the costs exceeded the benefits. This evaluation makes clear that the express bus network must be designed with routes that have higher average performance and less costly infrastructure than what was included in the complete ReX Network. This section highlights key considerations and complexities when evaluating the benefits and costs of express bus service on managed lanes.

Constructing and operating the express lane system is one component of cost. Express lanes can generate sufficient net revenue through tolling to offset both construction and operating costs.[40] Operating policies make a big difference in how much toll income is produced. For example, revenue would increase dramatically with the following actions:

- → Automate enforcement to reduce carpool violations.
- → Eliminate or reduce free access for clean air vehicles.
- → Increase free carpool access to 3+ carpools.
- → Build more direct access ramps to broaden the utility of express lanes.

As shown in Figure 9, express lanes around the country show a range of experience regarding operating revenue, with some requiring ongoing subsidy and others producing significant net revenue.[41]

FIGURE 9

Annual Revenues and Operating Costs for Express Lane Facilities

Express lane corridors around the country show a wide range of revenues relative to operating cost. Some have net costs while others produce net revenue that can be used for transit investment—though in some cases the revenue is used for additional highway infrastructure expansion.[42]

EXPRESS LANE FACILITY	REGION	STATE	EXPRESS LANE ANNUAL REVENUES	EXPRESS LANE ANNUAL OPERATING COSTS
I-15	Salt Lake City	UT	$500,000	$500,000
SR-167	Seattle	WA	$743,000	$843,000
I-35W	Minneapolis	MN	$751,000	$1,690,000
I-394	Minneapolis	MN	$1,600,000	$961,000
I-25	Denver	CO	$2,400,000	$1,500,000
I-15	San Diego	CA	$4,400,000	$4,400,000
I-10	Houston	TX	$8,000,000	$2,370,000
I-95	Miami	FL	$14,790,000	$7,630,000
SR-91	Orange County	CA	$41,246,000	$22,380,000

Source: FHWA

There may be capital costs beyond the express lanes themselves, including direct access ramps, bus stations and expanded bus storage and maintenance facilities. For example, a set of on/off ramps can cost from $30 million to more than $100 million.[43] With good coordination, however, costs could be reduced, since many

40 Get citation from Lisa Klein.

41 This figure should not be taken as a clear statement of relative amounts of net revenue between systems. Robust comparisons across systems is difficult because different systems account for tolling back office costs differently (e.g., some have debt and include debt service, others don't)

42 FHWA Priced Managed Lane Guide, 2013, Publication Number: FHWA-HOP-13-007

43 See *San Diego SR-15 Mid-City BRT Options*, https://www.ibigroup.com/ibi-projects/state-route-15-mid-city-brt-stations/

sections of the region's freeway network require rehabilitation and modernization. In many locations, express bus infrastructure can be coordinated with planned freeway interchange upgrades. For example, in the I-80 corridor through Alameda and Contra Costa Counties, the Ashby Avenue, University Avenue, Gilman Avenue and San Pablo Dam Road interchanges all need major infrastructure work. These required rehabilitation projects should consider regional express bus plans and incorporate express bus access and bus stop designs. While infrastructure needs are substantial, the benefits that extend to HOV users, local transit operators and private shuttle and vanpool services justify a higher level of capital investment than if this infrastructure were for express buses alone.

In addition to capital infrastructure, operating costs can be significant. For the Bay Area, the average cost for major public bus operators is $175 per hour that a bus is in service. By operating in express lanes without congestion and focusing service on main regional corridors with high-ridership demand, operating subsidies can be far less than other regional transit alternatives. Figure 10 present a very approximate scenario as an illustration.

FIGURE 10

Pinole to San Francisco Hypothetical Round Trip Express Bus Costs

Express buses traveling in uncongested lanes have the potential to operate at low operating subsidies because fast travel times improve not only customer experience but also efficiency.

ITEM	AMOUNT
Operating cost per hour that a bus is in service	$175
Round-trip travel time	1 hour
Round-trip operating cost	$175
Fare per passenger	$3
Capacity	60 seats
Round-trip revenue (assuming 50% occupancy each way)	$180
Net subsidy required	$0

Source: SPUR analysis

Although this is a crude estimate, it illustrates that in uncongested travel with high demand trunk-line service, an express bus line can be operated without great subsidy.

At least initially, operating strategies to increase equity—such as longer spans of service and more frequent off-peak service—may increase operating costs. Over time, however, the system should be designed to attract strong ridership throughout the service period, both by incorporating stops at a diverse range of hubs along the route and through coordinated land-use policies.

Chapter 5

Recommendations: How to Create a Robust Express Bus Network

Despite significant challenges, opportunity and momentum exist now to overcome obstacles to delivering an efficient freeway-based express bus network. To achieve the vision of a connected Bay Area, SPUR developed five recommendations for an accessible, equitable network of buses throughout the region.

Recommendation 1

Establish a "conversions first" policy to deliver the region's express lane network.

Who's responsible: *MTC, Caltrans District 4, County Transportation Authorities*

MTC, in consultation with county transportation authorities and Caltrans District 4, should commit to converting existing freeway lanes rather than constructing new freeway lanes as the priority method for delivering express lanes.[44] This policy will reduce VMT and GHG emissions by eliminating the induced demand associated with freeway expansion. It will also minimize the time and capital funding necessary to deliver the express lane network.

A conversion-first policy means that where there are options to deliver a particular express lane either through expansion or through conversion, conversion should be prioritized. A conversion-first policy can also mean that among express lane projects around the region, with other factors being similar, a project that can be delivered through lane conversion should be prioritized over one that requires lane expansion.

In some circumstances, it's not possible or practical to convert an existing travel lane. MTC should work with Caltrans District 4 to establish clear criteria to define where lane expansion is necessary for a continuous express lane network. These criteria should require the evaluation of bus-on-shoulder options before considering freeway expansion. Where not already required by law, MTC should require concurrent VMT and air pollution mitigations for any lane expansions.[45] Additional mitigations should be required for lane expansions in communities of concern, since they are already overexposed to air pollution and collisions from vehicles traveling through their community.

44 At present, there is no explicit state authorization to convert general-purpose lanes directly to express lanes. This policy recommendation is therefore directly tied to legislative action to clarify such authority discussed in Recommendation 3.

45 SB 743, in effect as of July 1, 2020, requires mitigations for VMT increases through CEQA. Experience with the effectiveness of this law will inform what supportive actions are justified by MTC.

Recommendation 2

Accelerate at least three pilots to demonstrate express bus operations in express lanes in the next five years.

Who's responsible: *MTC, existing express bus operators, transit agencies, Caltrans*

The region needs to begin experimenting with express bus service in express lanes, and the riding public must become acquainted with the experience of uncongested bus travel. It will take many years to design, approve and deliver freeway lane designs that support the most efficient and reliable bus travel, even if our region puts in place a more efficient project delivery approach. It is therefore valuable for MTC and transit agencies to gather lessons quickly so that operating lessons can inform ongoing express lane designs.

Implement Changes on Existing Express Routes to Deliver Immediate Benefits

Existing express bus services have an established customer base and experienced transit operators. MTC should expand its work with current express bus operators to identify locations where express lanes or other lane management strategies will deliver immediate benefits. This process should also examine where existing routes might be connected to provide longer regional connections that serve a broader array of trips. Delivering faster, more reliable and more accessible service in these existing corridors will demonstrate the value of proposed new investments.

Consider Interim Solutions to Avoid Freeway Congestion

MTC, Caltrans and transit operators should implement a variety of solutions to deliver immediate bus congestion relief and get good comparisons of cost and benefit, such as:

- → Deploying intensive HOV enforcement strategies.
- → Trying HOV policy adjustments (e.g., adjustments to clean air vehicle access).
- → Implementing bus-on-shoulder lanes.

Incorporate Bus Rapid Transit Segments Into at Least One Early Pilot

If feasible, include one pilot route incorporates an arterial bus rapid transit (BRT) route that feeds directly into a freeway express lane segment. Ideally, this pilot would include a single express bus route that serves two arterial BRT segments in different parts of the region as well as the connecting express lane segment. Potential examples of this BRT approach include:

- → Geary BRT (San Francisco) to International Blvd. BRT (Oakland).
- → International Blvd. BRT (Oakland) to El Camino Real BRT (multiple Peninsula cities) or Santa Clara Alum Rock BRT (San Jose).
- → San Pablo Ave. BRT (multiple East Bay cities) to El Camino Real BRT (multiple Peninsula cities) or to Santa Clara Alum Rock BRT (San Jose).

Recommendation 3

Seek legislative and administrative policy changes to expedite implementation of express lanes.

Who's responsible: *MTC, CalSTA, state legislature, Caltrans headquarters, Caltrans District 4*

The following actions are needed to deliver express lanes in a reasonable timeframe.

Seek Clear Legislative Authority on Lane Conversions

MTC should pursue legislative changes to establish clear legal authority for the direct conversion of general-purpose lanes to express lanes. If necessary, MTC should consider pursuing such legislative authority as a pilot for the nine-county region, or potentially an even more limited pilot for several corridors within the region. Other regions, such as the Los Angeles metropolitan region, may also be interested in participating in such pilots. MTC and CalSTA should partner to pursue greater lane conversion flexibility at the federal level through the Federal Highway Administration.

Provide Statewide Managed Lane and Express Bus Implementation Guidance

CalSTA and Caltrans headquarters should prepare stronger guidance on how Caltrans districts can support and prioritize managed lane and express bus implementation. Caltrans districts are inherently conservative when evaluating changes to freeway infrastructure. Specific safety risk from any departure from typical freeway design often outweighs any more general safety benefit from reducing dependence on private automobiles. Districts are worried about changing norms and accelerating projects without extensive data collection, modeling and analysis. Such guidance should apply not only to current efforts to convert existing HOV lanes to express lanes and install the infrastructure required to retrofit freeways for express buses, but also to Caltrans's role in evaluating future general-purpose lane conversions. CalSTA guidance is necessary to help Caltrans district offices in considering the benefits of more flexible designs and streamlined administrative review. Guidance should include:

- → Flexibility on geometric standards such as lane widths to accommodate conversion of existing lanes to express lanes, direct access ramps and express bus stations.
- → Flexibility for implementing bus-on-shoulder segments.
- → Updated measures of effectiveness for traffic analysis (e.g., evaluate whether a particular solution increases the number of people that can be accommodated rather than the number of vehicles, or whether it increases congestion in adjacent general-purpose lanes).
- → District-level performance targets for implementing regional managed lanes and other infrastructure that supports express bus service.

Implement Caltrans Corridor Manager Approach for Express Lanes

MTC, county transportation agencies and Caltrans District 4 should implement a Corridor Manager program akin to the approach used in San Diego, mentioned previously. A Caltrans corridor manager is responsible for the coordination and delivery of a suite of projects in a given freeway corridor. The MPO pays a portion of the corridor manager's salary, and the corridor manager is accountable not only to the Caltrans district leadership but also to the MPO board. This level of consistent accountability is essential to maintain schedules on complex

freeway projects. It elevates Caltrans staff to feel more ownership. The corridor manager position also tends to attract staff who are eager to work on cutting-edge, complex projects and are more apt to take some risks in exploring new infrastructure solutions and new delivery approaches.

Streamline CEQA Exemptions

MTC should seek CEQA streamlining for projects that support bus and HOV travel and do not expand the right-of-way or increase VMT, like express lane conversion projects and express bus facilities, including stations, stops and maintenance/storage facilities. Streamlining should include exemptions similar to those available for rail extension and station modernization programs, as well as reduced time for judicial review.[46]

Recommendation 4

Rationalize governance.

Who's responsible: *MTC, state legislature, Bay Area Infrastructure Finance Authority (BAIFA), transit agencies*

Successful express bus and express lane networks depend on policies and services that deliver seamless regional service and optimize for the greatest regional benefits. This requires regionally consistent policies, management of revenues and assignment of operating responsibilities.

Regional Express Lane Management

MTC should work with state legislators to centralize express lane planning, policymaking, revenue management and implementation for managed lanes into one regional entity. This entity could be the Bay Area Infrastructure Finance Authority (BAIFA), expanded to include representation from across the region, or it could be assigned to an existing entity with full regional representation such as MTC or the Bay Area Toll Authority (BATA).

This entity should have the authority to set all aspects of pricing, fines, enforcement methods and lane access policies (e.g., criteria for establishing the HOV threshold for accessing lanes, what types of vehicles may access express lanes for free or for a discount, low-income driver discounts). This level of coordination will require funding support from region-wide express lane revenues.

Criteria for Use of Express Lane Revenue

MTC should establish criteria for the use of net express lane revenues. The criteria should recognize that the continuousness and operational performance of the full express lane network will impact the value and revenue stream for individual corridors. The criteria should include a percentage of revenue that must be available to support express bus operations and capital investments required to deliver efficient infrastructure such as stations, stops, maintenance facilities, buses and storage facilities. This new MTC authority need not alter the geographic distribution of revenues between counties. (Express bus implementation and operations would likely consume any net revenue from any express lane corridor, so there is no reason for revenues to be geographically redistributed.) Rather, the criteria would establish uses within each county that support regional connections and are directly related to improving mobility with the corridor where revenue is generated.

Clear and transparent regional criteria for revenue expenditures are essential for political reasons as much as

46 A law taking effect just prior to publication, SB 288 (Wiener), provides some of this proposed CEQA streamlining but does not offer streamlining for the conversion of general purpose lanes to HOV or express lanes.

for policy priorities. The perception that tolls are set primarily to generate revenue creates political pushback in an already challenging situation. Designating net revenue to support mobility within express lane corridors is an important way to diminish political sensitivities associated with transportation user fees.

A Process for Assigning Bus Operating Responsibility

The state should authorize MTC to assign operating responsibilities to the most appropriate transit agency. Today, many transit agencies operate express bus routes that traverse multiple transit districts because it is clear which geography has the primary interest in the route. Future express bus routes that are planned to optimize regional network performance may not fall clearly under one particular transit agency. Since MTC is not a transit operator, it will need to assign operating responsibilities and establish funding and performance criteria to properly align incentives for the selected operating agency.

Recommendation 5

Develop a comprehensive regional express bus network plan.

Who's responsible: *MTC, California Legislature*

A comprehensive planning document is vital to inform express lane implementation priorities and policies and related regional transportation decisions. For example, express bus network planning and prioritization must be coordinated with ongoing planning for rail investment, transit governance, first/last-mile access planning and policies governing private transportation services.

MTC should lead the regional express bus network plan in collaboration with Caltrans, regional transit operators and county transportation authorities. While the plan should directly inform investment priorities, its preparation should not delay the implementation of near-term express bus investments, such as pilots discussed in Recommendation 2.

The planning effort should include the following:

- → Establish principles to guide the region's express bus priorities, driven by Plan Bay Area 2050 principles (affordable, connected, diverse, healthy and vibrant).
- → Identify performance targets and objectives that will govern capital and operating investment priorities as well as express lane access policies.
- → Include an equity strategy that establishes equity performance targets and identifies design, access investments and operating policies necessary to deliver a network that performs well for low-income and nonwhite communities (see Recommendation 6).
- → Identify all freeway rehabilitation and modernization projects that are planned on proposed express bus routes. Identify which design adaptations should be implemented into existing planned freeway work to ensure that projects can easily accommodate future express bus infrastructure requirements (e.g., stations and direct access ramps).
- → Explicitly design the bus network and policies to maximize flexibility for future operations, including:
  - Direct access ramps to the express lane network that allow a diversity of transit and other high-occupancy vehicle services to access the network.
  - Policies to manage and facilitate the use of express bus stops by privately operated buses, local transit agencies and other very high-occupancy vehicles.
  - Consideration of future automated and connected vehicle technologies and how express lanes can

serve as a guideway for such technologies.

- → Engage diverse stakeholders – including local, state and county government partners, advocates, the business community, private transportation operators and mega-region partners. Broad public engagement and messaging must function to develop a collective regional understanding of how express buses on managed lanes will deliver broad regional mobility enhancements.

This level of regional bus planning will be a new role for MTC and will require new dedicated funding as well as the development of new expertise.

Recommendation 6

Establish equity targets and design the network and operations to meet the targets.

Who's responsible: MTC

Equitable planning must be central to the regional express bus network plan described in Recommendation 5. A new regional network must improve access to jobs and services for historically disadvantaged groups. As demonstrated by MTC's analysis of the ReX regional express bus proposal, achieving equitable benefits from such a network requires explicit attention to service patterns and fares. Delivering on equity targets will require routine performance tracking reports that trigger investment and operations plans to correct for any equity gaps. Specific strategies should include the following:

- → **Establish ridership floors for low-income and nonwhite riders**. Within the constraints dictated by express lane network implementation, prioritize network investments that would increase nonwhite and low-income ridership so that it exceeds a proportionate share of systemwide ridership.
- → **Conduct market analyses for nonwhite and low-income riders**. Developing the express bus network in a manner that prioritizes historically underserved riders will require both public outreach and technical analysis to assess travel needs and priority service characteristics. This should be done in conjunction with the regional express bus network plan.
- → **Prioritize services that support long span and high off-peak frequency**. Long service spans and off-peak frequencies boost nonwhite and low-income ridership because they support travel outside the typical commute periods.
- → **Prioritize extensions in an equitable manner**. Until nonwhite and low-income ridership exceed the target proportion of total express bus ridership, MTC should fund route extensions in such a manner that the collective projected nonwhite/low-income ridership share increases for each tranche of extensions.
- → **Establish discount fares**. Establish a discount fare structure for low-income riders, including free or low-cost transfers to other transit and transit adjacent services (such as bike share).
- → **Establish discount tolls**. Establish a toll discount program for low-income drivers.
- → **Prioritize last-mile services to/from communities of concern**. A diverse range of first/last-mile investments will be necessary as discussed in Chapter 3. These and other potential last-mile connections should be considered to enhance the utility and ridership benefits of the network.
- → **Regularly conduct user research**. Assess if, how and why (or why not) the routes are meeting the needs, wants and expectations of riders in communities of concern.

Appendix A

Bay Area Freeway-Based Express Bus Routes

OPERATOR	NUMBER OF ROUTES	DESCRIPTION
AC Transit	29	Primarily serves downtown San Francisco via the Bay Bridge, as well as Foster City and San Mateo via the San Mateo Bridge and Stanford and Palo Alto via the Dumbarton Bridge.
County Connection (CCCTA)	8	Mostly along the I-680 corridor as well as Martinez and Pittsburg/Bay Point. Most routes serve at least one regional transit center, with minimal local service compared to the AC Transit Transbay routes.
Dumbarton Express	2	The DB line provides service between Union City BART and Stanford University, and DB 1 provides service between Union City BART and Stanford Research Park.
Fairfield and Suisun Transit (FAST)	2	The Blue Line operates between Pleasant Hill BART and Sacramento, and the Green Line operates between Suisun City/Fairfield and El Cerrito del Norte BART.
Golden Gate Transit	17	Weekday commute bus routes between San Francisco, Marin and Sonoma counties.
LAVTA (Wheels)	3	Wheels provides three express bus routes to East Dublin/Pleasanton BART Station on Routes 20X, 70X and 580X. Route 70X also connects to Pleasant Hill and Walnut Creek BART stations.
SamTrans	1	Route FX operates weekday service between Foster City and downtown San Francisco.
SolTrans	3	Routes 82, Y and R provide service between Vallejo and Walnut Creek BART, Fairfield and San Francisco.
Tri Delta Transit	3	Routes 200, 201 and 300 provide service between Martinez–Pittsburg/Bay Point BART Station, Pittsburg/Bay Point BART Station–Concord BART Station, and Brentwood Park & Ride–Antioch BART Station.
VINE	2	Routes: 10X and 11X provide service between Napa–Calistoga and Napa–Vallejo.
Valley Transportation Authority (VTA)	6	Routes 101, 102, 103, 104, 121 and 168 provide weekday service across Santa Clara County. .
WestCAT	4	Routes JX, JPX, JR and JL provide service to BART, in addition to the Lynx Express route that operates between Hercules and San Francisco.

Appendix B

Interstates and Highways Carrying Current Express Bus Routes

FREEWAY	EXPRESS BUS ROUTES
Interstate 80	Berkeley/Oakland to San Francisco Vallejo/Pinole/Hercules to San Francisco Fairfield to Pleasant Hill Fairfield to Richmond
Interstate 580	San Rafael to Richmond Oakland/San Leandro/Castro Valley to San Francisco
Interstate 680	Fremont/Milpitas to San Jose Concord/Walnut Creek to San Ramon Concord/Walnut Creek to Pleasanton/Dublin
Interstate 880	Fremont/Hayward/Oakland to San Francisco Fremont to Milpitas
Highway 4	Brentwood – Antioch Pittsburg - Martinez
Highway 37	Napa to Calistoga Napa to Vallejo
Highway 84	Union City to Palo Alto
Highway 92	Hayward to San Mateo
Highway 101	Santa Rosa/Petaluma/Novato to San Francisco Foster City to San Francisco

Appendix C

Options for Freeway Transit Stations and Stops

The design of express bus stations and stops for freeway-based transit is a balance between bus efficiency and customer access. There are three primary station types – online, inline and offline – that range from a greater emphasis on efficiency to a greater emphasis on customer access. This section also considers hybrid approaches and the completely different alternative of bus-on-shoulder stops.

Online Stations

Online stations are located within the freeway. They prioritize efficiency by allowing the bus to remain within the express lane environment. Buses move left from the express lane into the median station to pick-up passengers. The bus then merges from the left back into the express lane. The time required for the stop is simply the time required for passengers to leave and enter the bus plus the time to decelerate and accelerate for the stop.

Passengers can access online stations from below or above.

Access from below freeway: J-Line, LA Metro, showing elevated freeway median station (left) accessed from the local roadway below the freeway (right).

Source: Steve Hymon, LA Metro (left) and Metro96 (right)

Access from above: San Diego MTS Rapid 235 line at City Heights Station, showing the freeway median station underneath the local roadway used for passenger access.

While extremely efficient, online stations have several disadvantages for transit customers:

1. Passengers must wait in the freeway median, which can be noisy and visually unpleasant and may feel unsafe.
2. They require space within the freeway median, including at least a bus stopping area and a passenger waiting area in each direction. In some locations, this requires realigning freeway travel lanes to create a wider median. Elevator and stair access from the street level to the freeway elevation must be created.
3. Accessing the station from an underpass or an overpass may be unpleasant for customers. There are sometimes broader community benefits in that the activity generated by these stations can improve safety and minimize a freeway's barrier effect (e.g., Berkeley's Rockridge BART station is a train station analog of this effect), but during periods of low activity these underpass and overpass environments are likely to be problematic.

An additional challenge is that only passengers can access at these points. There is no option for vehicles to enter or exit the express lane. This limits flexibility for other buses, shuttles or qualifying high-occupancy vehicles that might otherwise use the station as an access point for express lane travel.

Source: San Diego Metropolitan Transit Systema

Inline Stations

Inline stations are located within or adjacent to the freeway right-of-way but require the bus to leave the express lane environment. These stations provide small customer access improvements relative to online stations, but at some small efficiency cost.

With inline stations, the bus must exit the express lane to the left, then travel up a ramp to a freeway overpass or down a ramp to a freeway underpass. The online station is located at the intersecting roadway. By removing the station from the freeway level, there is an opportunity to create quieter and somewhat less isolated station environment. The time required for an inline station stop is the same as for an online station, except that there may be additional time required to wait for cross traffic at the intersecting roadway.

The photo here shows an inline station on a freeway overpass, with bus pads on the shoulder of the off-ramp, allowing buses to stop at the overpass and then immediately continue back onto the freeway via a direct access onramp.

East Gate Park & Ride Station, Sound Transit, Seattle, WA.

Inline stations may require less space than online stations because some portion of the total area (the station, plus the bus stopping area and potentially a separate through lane) can be located over or under the existing freeway. They do not require elevators or stairs since buses are meeting passengers at surface streets.

The great benefit is that they provide direct access to the express lane network for other users. These access points can be open to all who qualify or can be more restrictive such as only HOV access (thus excluding toll-paying single-occupant vehicles) or restricted to some higher occupancy threshold (i.e., permitting only buses and vanpools). The great value is the flexibility to accommodate future solutions for sustainable mobility, whether it is adaptive jitney services, tech shuttles or local public bus services wishing to design routes that make more use of freeway links.

Source: Washington State Department of Transportation Source: Washington State Department of Transportation

Offline Stations

Offline stations are located away from the freeway environment. They prioritize meeting customers at an activity center or simply an environment that is more accessible and pleasant than the freeway. Although they prioritize access over efficiency, offline stations can be quite efficient if they are close to the freeway and connected by an exclusive, direct roadway connection.

To reach an offline station, a bus exits the freeway via a direct access ramp and travels through mixed traffic or via an exclusive freeway connector. The time required for the stop depends on the travel time to the offline station but will be several times that required for online or inline stations. Offline stations may be necessary where there are unsafe, inconvenient or unpleasant options for customers to access a station that is close or adjacent to the freeway, or where there are or will be major destinations at the offline station site.

The Salesforce Transit Center in San Francisco can be thought of as a particularly grand offline station, though it is not at this time associated with freeway express lanes. Another example is the Santa Rosa Transit Mall, a major intermodal bus hub served by Golden Gate Transit regional express service, located several blocks from US-101 in Sonoma County.

Hybrid Approaches

Not all stations fit cleanly into one of these categories. Depending on the particular geometry of the freeway and the access priorities at that particular site, hybrid approaches may be developed. For example, at Sound Transit's Mountlake Terrace Transit Center in Seattle, a primary station area sits outside of the immediate freeway environment with a direct pedestrian causeway to an inline median freeway stop.

Mountlake Terrace Transit Center, showing causeway to freeway median (top) and freeway median station (bottom).

Source: Google Maps (left) and Wikimedia Commons user SounderBruce (right)

Bus-on-Shoulder Stops

Bus-on-shoulder travel is less efficient due to speed constraints and interactions with freeway on and off-ramps. However, stops can be highly efficient and more affordable. Because buses do not need to cross congested traffic lanes to get in and out of shoulder lanes, these stops can be located directly on access ramps in a manner that allows the bus never to fully exit the freeway. This environment can be inhospitable for passengers, as shown in the image below, an on/off ramp stop for Golden Gate Transit. While the quality of the stop can be improved from this example, customer access is often quite challenging and requires strong safety protections.

Bus-on-shoulder stops can also work efficiently on streets adjacent to the freeway. When there is an off-ramp to adjacent streets followed immediately by an onramp back onto the freeway, buses can efficiently exit the freeway to access a stop or station that is more accessible to passengers. With signal priority and/or exclusive transit lanes, this approach can maintain reasonable efficiency while improving customer access.

Smith Ranch Road Bus Stop, Northbound US 101, Marin County, California.

Source: Google Streetview

San Francisco | San Jose | Oakland

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