HORIZON

TOWARD A SHARED FUTURE: STRATEGIES TO MANAGE TRAVEL DEMAND

APPENDIX A - BEST PRACTICE REVIEW OF STRATEGIES TO REDUCE VEHICLE TRIPS

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MTC and ABAG compiled a set of 42 transportation strategies, based on a review of the available literature and evidence from the application of these strategies from around the world. The strategies are generally new in that they have not previously been implemented in the Bay Area or have been implemented to a lesser extent than presented here. Some of the strategies in this review would require significant technological advancement or would necessitate overcoming major implementation barriers. Given the exploratory nature of this review, all potential strategies were included, including some that are often considered impractical or politically difficult by today's standards.

Strategies are organized under the following five categories that work together to achieve vehicle trip reduction and a potential future where travel is mainly in shared services:

1. Seamless, ubiquitous and affordable travel alternatives to single-occupant vehicles (SOVs)
2. Driving reflects true social costs
3. More efficient distribution of goods
4. Plan places and mobility together
5. Major traffic generators reduce solo trips through requirements and incentives

Each strategy is briefly described, in some cases including examples of implementation of the strategy elsewhere. A preliminary assessment of each strategy's ability to reduce vehicle miles of travel (VMT)[1] is indicated as High, Medium, or Low. The rating for VMT reduction potential is simply a comparison of a given strategy relative to others in this section, since quantitative estimation of VMT reduction was not performed for this screening level assessment. An indication of the time frame for implementation is also provide as Short-term (5-10 years), Mid-term (10-20 years), or Long-term (20+ years).

This screening assessment was used to select eight strategies that appear to have the greatest potential to reduce vehicle travel, specifically single occupancy vehicle travel, and their alignment with Horizon's Guiding Principles (Affordable, Connected, Diverse, Healthy and Vibrant). TDM strategies considered for adoption must be subject to a more thorough analysis that considers cost effectiveness and effects on vulnerable communities and other equity impacts. Appendix B provides further assessment on the eight strategies.

1. Seamless, Ubiquitous and Affordable Travel Alternatives To SOVs

These strategies focus on increasing the utility, convenience and/or affordability of travel options other than single occupant vehicles. Improving these modes and services has the potential to reduce personal vehicle ownership.

1.1. Free feeder services to high capacity transit

Description: Feeder services to high-capacity bus and rail services could be free for all users. These feeder vehicles could use autonomous vehicle technology to provide on-demand or frequent service particularly in suburban and rural communities. Residents and visitors could obtain free passes, paid for by the government, that would enable access to publicly owned systems. Alternatively, transit systems could eliminate fare collection mechanisms altogether, which would help improve efficiency of bus service. In order to remain effective, this strategy would need to be accompanied by major expansion of transit system capacity in select corridors that already face overcrowding, such as peak-period BART service and many Muni routes.

VMT reduction potential: Medium. Several international cities have implemented this strategy, as has the city of Chapel Hill, NC, which saw its system ridership more than double[2] in the few years following the switch to a free system. An interesting example of free transit at a larger scale is provided by the city of Tallinn, the capital of Estonia, which implemented free transit for all residents in 2012. In Tallinn, transit ridership mode shares rose from 55 percent to 63 percent after implementing free transit for the 400,000 residents, but VMT rose simultaneously.[3] The growth in VMT despite free transit is attributed to several factors:

- Despite car modal shares falling slightly (-3 percent), VMT rose due to large increases in total trip generation and average trip length related to increased development and economic opportunities.
- Transit already had high market share (40 percent of all trips), was already subsidized or free for 50 percent of residents due to various exemptions.
- Prior to the program, 30 percent of trips in Tallinn were conducted entirely on foot, and average trip lengths on transit shrunk as free transit began to replace many walking trips. Overall walking trips decreased 4 times as much as automotive ones.

A free transit program in the Bay Area might be more successful at reducing VMT than in Tallinn; transit market share is at a lower starting point and without such a high share of free passes, walking has a lower starting mode share (3.6 percent of commuting trips), and the Bay Area has a developed economy unlikely to experience such rapid changes in trip length and frequency. Despite all of these disadvantages of Tallinn in creating shifts away from autos, this program still did create a decrease in automobile mode share, indicating that it likely did reduce VMT relative to the hypothetical scenario of not implementing the program.

The impact of free transit on travel behavior and VMT would need to be studied extensively prior to any policy decisions. Free transit would certainly benefit individuals who are unable to drive alone, due to disability, income, age or other reasons; the strategy would not reduce VMT among these populations. For the majority of residents who have a choice of driving vs. transit, the ability of free transit to cause mode shift would depend heavily on issues like transit service frequency, convenience, travel time, and perceived safety. For most current SOV drivers, it is unlikely that the cost of transit is the major impediment to transit use. If free transit causes further overcrowding or degrades transit service in other ways, it could create disincentives to mode shift away from SOVs for some travelers.

Implementation: Short-term. This policy could be implemented relatively quickly with agreement from transit agencies operating in the Bay Area and identification of alternative funding sources. Alternatively, public agencies could purchase transit passes and provide them free to residents, as was done in Tallinn.

1.2. Inclusion of fare payments in trip planning apps

Description: Integrating fare payment into trip planning apps reduces the complexity in multi-modal trip planning, thereby enabling car-free lifestyles. Ideally, all modes could be paid for using a single app, in which payment information is entered only once upon signup. The inclusion of payment options in planning apps reduces the number of steps needed to book trips.

VMT reduction potential: Low. The potential for mobility as a service (MaaS) systems to reduce VMT is potentially large, though this singular strategy is only a small component of a MaaS-style change in the system. It is unclear to what extent this will spur mode shift away from private car usage, but VMT reduction potential is likely low.

Implementation: Short-term. This would require cooperation from trip planning app developers (likely private sector), as well as all of the participating transit providers. MTC's role could be to create a structure or formal incentive for standardizing and linking various modes and services, similar to their role coordinating fare collection via the Clipper Card.

1.3. Linked/seamless transportation accounts

Description: This proposal expands the Clipper® card concept, which uses a singular payment card for many transit agencies, to also include additional options. Clipper currently covers 22 Bay Area transit agencies, including all major providers. Clipper could provide a singular payment account for the full suite of transportation options in the Bay Area, including various private bikeshare and shuttle options.

VMT reduction potential: Medium. The potential for MaaS systems to reduce VMT is potentially large, though this singular development is only a small component of a MaaS-style change in the system. Given that nearly all Bay Area transit systems already accept Clipper, the effects of adding bikeshare, shuttles and possibly other services is likely to be small.

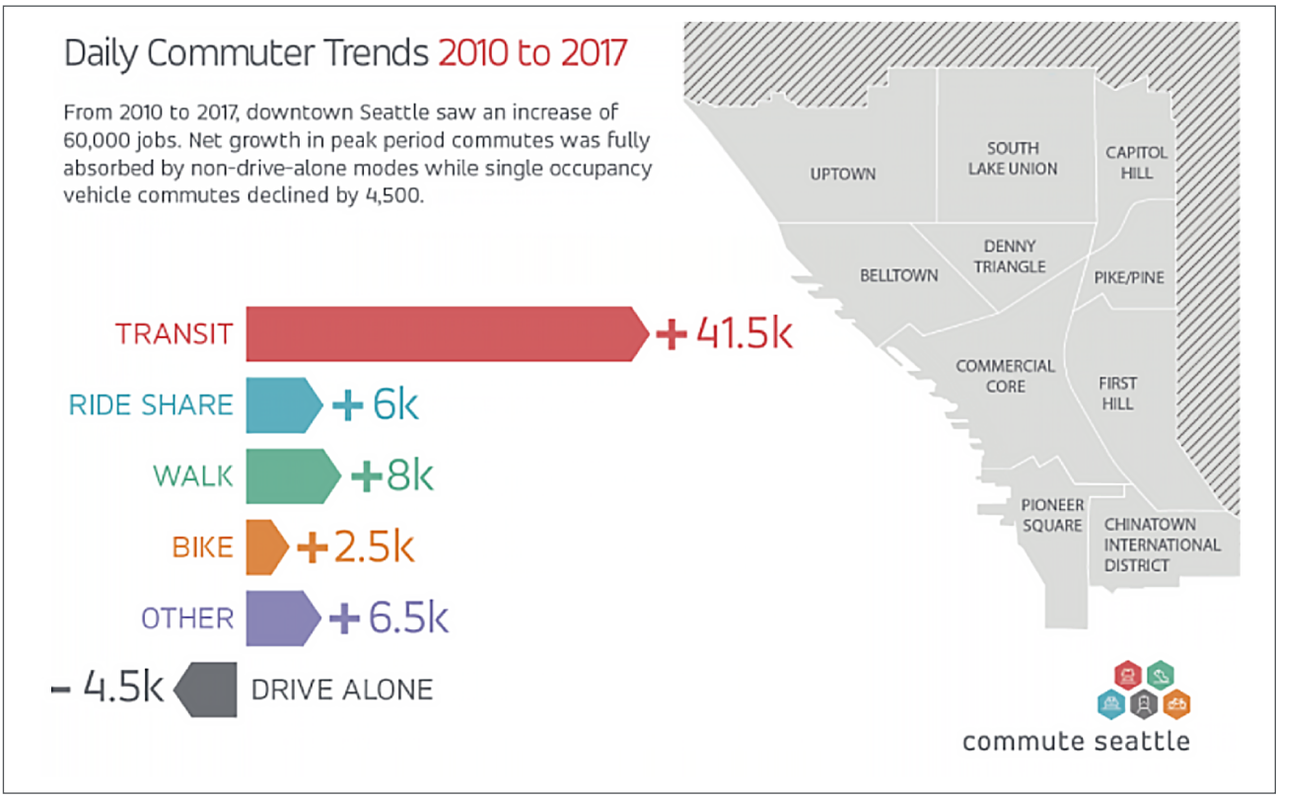
Implementation: Short-term. MTC would have to work out details with additional transportation providers to expand the integrated payment concept.

1.4. Offer flat-rate transportation packages

Description: This strategy involves offering carefully crafted transportation packages to residents to allow them to get bulk discounts, and also have a more seamless multimodal trip selection experience, as the trips could be pre-paid on several modes with one purchase. These packages could include traditional transit as well as bikeshare, shuttles or transportation network companies (TNCs), such as Uber and Lyft. The available packages could be monthly or annual, and could be specific to only certain modes. Since the goal of these flat-rate packages would be to reduce car ownership, they would need to have a compelling value proposition and an ability to handle all types of trips.

Prior examples include Seattle, which has had success with bulk transit passes. The region has experienced an acceleration in its shift toward transit and away from driving alone,[4] and it credits that largely to a large scale employer-based transit bulk package program (**Figure 1**).[5]

Figure 1. Commuter trends as reported by Commute Seattle



Other demonstrations have also started to provide bulk passes for a variety of modes, such as the Whim app in Finland.[6]

VMT reduction potential: Medium. VMT reductions would depend on the popularity of the available offerings. The convenience and bulk-scale could make transit and other non-SOV modes more popular, thereby having a large impact.

Implementation: Short-term. Flat-rate packages could be developed and implemented quickly, but they could take a long time to catch on. The packages would likely be offered through private third-party service such as Whim, or could potentially be offered by public agencies.

1.5. Shared, electric, connected, automated vehicle fleets

Description: Transportation agencies could invest in the provision of Shared, Electric, Connected, Automated Vehicle (SECAV) fleets. While automation is not necessary for these fleets, it would make the strategy more cost-effective. These fleets could be targeted to serve communities currently without transportation options, providing coordinated, on-demand transportation. These vehicles would not need to be parked conveniently next to highly valued land and would require less parking overall than personally owned vehicles. For maximum efficiency in linking passengers, one provider would be ideal. Further, these vehicles could be built smaller and lighter since they could operate exclusively on lower-speed roads as localized services or links to high-capacity transit. These vehicles would potentially be cheaper to design and produce, and their classification as "Urban Speed Vehicles" means that they are not required to have extensive crash testing.[7]

VMT reduction potential: Low. By transitioning VMT to electric vehicles and lighter-built vehicles with higher efficiency, emissions reductions could be significant, but VMT reductions would likely be modest at best. These services would potentially reduce the need for car ownership in certain areas and could consolidate trips on certain corridors. However, they might also induce new demand for vehicle travel. While the potential for linking trips promises some efficiency improvements, empty miles and route deviations for picking up passengers could mitigate those gains.

Implementation: Mid-term. These fleets could be commissioned now, although optimal efficiency would require new vehicle designs and automation, which are still some years away. Similar pilots are already underway in West Sacramento, CA,[8] and in Arlington, TX, with Via.[9] Operationally, these current pilots are very similar to this SECAV concept, with coordinated fleets proving affordable flex transit to a geofenced area, although they are not yet using all-electric or automated vehicles. The West Sacramento and Arlington examples, while potentially valuable experiments, lack the scale necessary to have substantial system-wide impacts.

1.6. Enforced vehicle occupancy rates

Description: New policies could be adopted to directly target the issue of inefficient vehicle rides by mandating vehicle occupancy levels, either as averages (for services) or as a hard rule. This strategy essentially takes the concept of a high-occupancy vehicle (HOV) lane and applies it to a broader network. For shared services, this strategy might mean mandating that transportation network companies (TNCs) demonstrate that they meet a certain threshold of average ridership, or that they have less than a minimum percentage of empty miles. For regular drivers, pricing or mandating occupancy levels in a similar fashion would require a mechanism to detect and record occupancy levels. In some locations, vehicles with solo drivers could be banned. Occupancy requirements for vehicles on urban roads were implemented in Jakarta, Indonesia, in 2003; however, this policy was revoked in 2016 after concerns about passengers for hire (including children).[10] [11]

VMT reduction potential: Medium. Especially if/when shared-use services gain more substantial market share, this strategy could have a large impact on VMT. However, mandating certain occupancy levels could create a variety of consequences, such as further exacerbating the monopolistic nature of the TNC market, since new services take time to reach scale needed to have high match rates and improve occupancy. This strategy could also potentially incentivize TNCs to route vehicles further out of their way to pick up other passengers, thereby increasing VMT.

Implementation: Short-term for fleet vehicles, long-term for personal vehicles. This strategy could be enacted soon for fleet vehicles by local governments. For personal vehicles, however, identifying a technological system for collecting data from all travelers would be a substantial task, and the strategy is likely a long-term prospect.

1.7. Mobility hubs

Description: The Bay Area can invest in the creation of mobility hubs, which provide a variety of transportation services and seamless integration of multi-modal connections at transit stations. Mobility hubs can help increase the share of travel, particularly at peak times, on existing high-capacity rail and bus rapid transit (BRT) systems, and provide improved options for first/last mile connections and off-peak travel. Each mobility hub should be tailored to address the needs of its users and the surrounding neighborhood. Elements of mobility hubs can include bikeshare, carshare, passenger loading areas, bicycle parking and bus connections. Additionally, mobility hubs can include real-time transit information to assist passengers making connections and infrastructure to support active transportation (bicycle facilities, sidewalks, comfortable waiting areas, etc.). Amenities in mobility hubs support passenger comfort and ease of navigation. Although mobility hubs are important for addressing first/last mile connections to transit, they are also valuable in their ability to provide mode options for a point-to-point trip types.[12]

Although all of the individual elements exist today, the concept of coordinating and promoting mobility hubs is relatively new in North America. The Toronto area regional planning and transit agency, Metrolinx, was one of the first to define a mobility hubs strategy when it released its regional transportation plan.[13] More recently, SANDAG has launched a regional mobility hubs implementation strategy as part of the implementation of its regional plan.[14]

VMT reduction potential: Medium. With extensive implementation, mobility hubs have the potential to significantly improve connections to transit and provide low-carbon travel options at activity nodes throughout the region. A modest and inconsistent implementation of mobility hubs would have far less VMT reduction benefit.

Implementation: Mid-term. Many transit stations already include some multi-modal connections and passenger amenities and this strategy could build off existing treatment concepts and lessons learned to create new mobility hubs. MTC can also help coordinate data sharing and payment systems that can be used to pay for rides with transit and private systems, including bike share and car services.

1.8. Rationalization and integration of transit

Description: There are approximately 25 transit agencies operating in the Bay Area, each with different fare and transfer systems, wayfinding and trip planning tools, equipment types and organizational structures.

Consolidation of transit agencies could help to ensure consistent policies, platforms, schedules and other functions. Consolidated agencies can then rationalize service – improving connections, addressing gaps and eliminating duplicative service. Efficiencies from agency consolidation, joint procurement and maintenance, and service rationalization could result in cost savings that can be used to improve service and further fill gaps in the system. Consolidated agencies will also provide better service through coordinated branding and marketing.

VMT reduction potential: Low. Integration and rationalization of transit could improve service and attract new riders in some locations – most likely in those areas that are currently served by multiple bus providers. However, the overall impact across the region would likely be small, since most of the densest core areas are already served by a one primary agency for bus transit, and bus connections to major rail transit hubs are already coordinated.

Implementation: Mid-term. In theory, there are no major barriers to the integration of transit organizations and rationalization of service. But substantial consolidation would likely take 10 years or more due to the large number of agencies and the long history of independent operation. Transit agencies can coordinate certain functions of service (such as data for trip planning) as a first step in consolidation.

1.9. Ridesharing

Description: This strategy uses technology, incentives and operational improvements to achieve a reduction in travel demand through more efficient use of the Bay Area's transportation network. Reducing travel demand by 3 to 5 percent can yield a 50 percent drop in congestion-related delays. This is the percent reduction observed on holidays, such as on Indigenous Peoples/Columbus Day, when some residents do not travel to work.[15]

Ridesharing consists of two to 15 passengers who share a ride, generally using a participant's own vehicle in the case of carpooling, or a company-provided or leased van in the case of vanpooling.

Currently an estimated 16,000 empty seats cross the Bay Bridge on a daily basis, as most vehicle trips crossing the Bay Bridge are made by solo drivers.[16] Filling these seats could allow more people to travel without having to add road capacity to the transportation network. As automobiles transition to connected and autonomous vehicles, pricing and incentives to increase pooling will be critical to preventing a significant increase in congestion.

VMT reduction potential: Medium. This strategy has the potential to fill empty seats without adding capacity in the Bay Area's most congested corridors. The Metropolitan Transportation Commission (MTC) offered a "First Trip Credit" to carpool riders and drivers who downloaded the Scoop carpool app and took a first trip. Over 9,000 riders and drivers used the credit and took 267,000 one-way person trips as members of a carpool during the six-month time period. These trips include the first subsidized trip and subsequent trips made during the survey period. About 75 percent of the participants were riders (thereby reducing vehicle trips) and of those, 60 percent they would have otherwise driven alone (or been driven by a TNC) if they had not used the carpool service. The estimated cost per vehicle trip reduced was $1.85.

Increasing efficiency and flow in carpool/ high-occupancy vehicle lanes could be accomplished through operational improvements, enforcement and occupancy policy changes. Operational improvements on highways and arterials, including transit signal priority, bus queue jump lanes or bus-on-shoulder lanes can give time savings advantages to high-occupancy vehicles and can be highly impactful in reducing travel demand.

Implementation: Short-term. With the number of apps and other ridematching services currently available, this strategy could be implemented to a larger extent over the next few years.

2. Driving Reflects True Social Costs

Strategies in this section support a philosophy of reducing current subsidies and incentives that encourage private vehicle ownership, such as free parking, taxation and fees that are lower than needed to support a multimodal transportation system. Personal ownership of vehicles continues in this scenario, though personal use of vehicles would decline. These strategies typically include pricing elements.

2.1. Parking tax

Description: This strategy levies an additional tax for parking owners and users. There are multiple ways this strategy could be applied. For example, a tax based on the size of the parking facility could be charged to a commercial parking provider, or a tax in the form of a flat fee or percentage of parking cost could be charged to the vehicle driver. Charges levied on owners based on facility size rather than on use can disincentivize developers from building facilities. Alternatively, facility owners could pass charges on to the drivers to recover the additional cost. Costs applied to the driver, whether as a direct tax or costs passed from the parking provider, would increase the total trip cost and consequently would reduce parking and SOV travel demand.

VMT reduction potential: High. The impact of this strategy on VMT would depend on the level of pricing, method of implementation and other factors. A review of parking pricing studies found that elasticities for parking demand range "from -0.1 to -0.6, with -0.3 being the most frequently cited value."[17] This suggests that a doubling of price (i.e., a 100 percent increase) would lead to a 30 percent reduction in parking demand. Impacts on driving will also depend on local context, including access to other parking options and alternative modes.

Implementation: Short-term. Local jurisdictions can implement and levy a tax. A direct tax to parking facility users would have an immediate impact on driving behaviors. Alternatively, the Bay Area Air Quality Management District could establish an Indirect Source Rule (ISR) that would require developers to mitigate emissions associated with vehicle trips that would be generated by a development, like a parking facility, or pay a mitigation fee. In a future of zero-emission vehicles, ISR would not be an effective tool to reduce VMT.

2.2. Dynamic parking pricing

Description: Municipalities and private parking providers can vary the price and maximum duration of parking to reduce demand. San Francisco is rolling out citywide implementation of its dynamic parking pricing system, SFpark, after a successful pilot period. In this system, the price of a parking space varies by the occupancy rate of a street. Drivers can identify available parking spaces on mobile devices and select spaces based on price and location.

VMT reduction potential: Low. The SFpark Pilot saw a 30 percent decrease in VMT in the affected areas between 2011 and 2013, in part due to a decrease in the amount of time drivers spent circling in search of parking. Control areas saw a 6 percent decrease in VMT during the same time period.[18] While this pilot appears to have successfully led to a reduction in VMT in locations with high parking occupancy, dynamic parking would have less of an impact in areas with excessive parking supply. According to a 2015 Metropolitan Transportation Commission (MTC) study of 25 Bay Area downtown and major transit areas, only five of the study locations have on-street peak-period occupancy rates over 75 percent, indicating an oversupply of parking in many of the region's downtowns and transit hubs.

Implementation: Short-term. MTC can help coordinate dynamic parking pricing systems in municipalities by providing technical assistance or coordinating shared systems to reduce costs and help create seamless parking systems on municipal boundaries.

2.3. VMT pricing

Description: VMT pricing is the practice of charging fees based on the distances vehicles travel. The concept has been proposed as an alternative to a flat gas tax, which has lost purchasing power as a revenue source for infrastructure as vehicles have become more fuel-efficient and governments have been reluctant to increase the gas tax.

VMT pricing may be a flat rate per mile or depending on the technology used, may include variable rates for peak periods, vehicle occupancy, vehicle type, etc. Miles may be tracked by in-vehicle GPS units, which can be tracked periodically. Location data can be stored privately in the unit.

In the United States, Oregon DOT has been developing a VMT program (OReGO) and has conducted a series of pilot tests. As of the writing of this report, the Oregon State Legislature has not decided to implement the system statewide. Caltrans conducted a VMT pilot project for passenger and freight vehicles in 2017, testing reporting systems and recoding methods. The agency issued an initial report and will continue to test the feasibility of this program. The Oregon DOT and Caltrans pilot programs deliberately set the VMT fees at a level similar to what the owner would pay in fuel taxes, so a typical driver would see little net change in cost. European countries, including Germany, Switzerland and the Netherlands, have charged freight trucks per mile.[19]

VMT reduction potential: High. Pilot projects in Seattle and Atlanta have shown VMT reductions of 12 and 3 percent respectively, although the pilot project in Seattle was combined with a peak period congestion charge. Sacramento; Portland, OR; and Washington D.C., have also shown VMT reductions of approximately 10 percent with VMT fees in modeling simulations.[20] [21]

Implementation: Long-term. Although Caltrans is currently studying the feasibility of a VMT tax, additional pilot tests could be conducted in the Bay Area.

2.4. Central business district cordon pricing

Description: Cordon pricing refers to the practice of charging a fee for vehicles entering a specified geographic area, usually a downtown or central city. Cordon pricing can be static or vary by time of day, vehicle type, or current traffic conditions.

Several large cities impose cordon pricing in their downtowns, including London, Singapore, Stockholm, and Milan. In London, vehicles are charged once per day if they enter the downtown area, no matter how often they travel in and out. In contrast, other systems such as Singapore and Stockholm charge each time the vehicle passes the cordon.

Singapore and Stockholm have dynamic cordon pricing. In Stockholm, pricing is higher at peak travel periods. The Singapore Land Transport Authority is currently developing a new system that will integrate parking, VMT and cordon payments. Each car will have an in-unit device that will track the vehicle as it passes payment points as well as miles traveled. The device will show real-time traffic and expected payments to the driver to help the driver plan their trip.

New York City has proposed collecting fees for vehicles entering the southern part of Manhattan but has not yet had sufficient public support to pass a measure. The most recent proposal calls for a phased roll-out with entrance fees for private vehicles, surcharges for freight vehicles and car service vehicles, caps on the amount of time car service vehicles can operate in the central district without passengers, and discounts for low-income persons. All revenue from this system would fund transit.[22]

VMT reduction potential: Medium. Cordon pricing has shown to reduce traffic in cordoned areas if priced appropriately. London initially saw a decrease in traffic in its cordoned central business district, however, in recent years, an increase in delivery and car service vehicles has contributed to a rise in traffic congestion in this area.[23] Because vehicles in London are only charged once per day, delivery and car service vehicles may be less sensitive to the fee.

Between its implementation in 2006 and 2012, traffic in Stockholm's cordoned central city decreased by about 29 percent across the cordon. Studies have shown that vehicle traffic in Stockholm was not transferred to other areas of the city after cordon pricing was established.[24] [25]

Implementation: Mid-term. Municipalities can develop cordons in congested areas using existing technology. As the Bay Area has multiple major urban centers, a multi-zone approach may be needed to avoid out-migration from car-free zones. Establishing systems to charge vehicles entering the cordoned area will require significant investment. San Francisco County Transportation Authority previously studied possible cordon areas in the city of San Francisco.[26]

2.5. Express lanes

Description: High-Occupancy Toll (HOT) lanes (sometimes called Express Lanes) are price managed lanes reserved for vehicles meeting specific occupancy levels (such as two or more passengers) or for those willing to pay an additional fee. Fees may be fixed or dynamic. State DOTs around the country are converting high-occupancy vehicle (HOV) or carpool lanes to HOT lanes, amid national decreasing carpool rates leading to excess capacity on HOV lanes. This strategy would involve converting some existing mixed-flow lanes to HOT/express lanes; it would not involve highway capacity expansion.

In the Bay Area, four locations currently have express lanes: Interstate 580 in Alameda County, Interstate 680 in Contra Costa County, Interstate 680 in Alameda County (Sunol Grade), and state Route 237 in Santa Clara County. Other California express lanes can be found on Interstate 15 in San Diego and SR 91 in Riverside and Orange counties. Tolls on the I-15 express lanes vary depending on congestion levels; the SR 91 express lanes use a variable pricing system based on the time of day. Some facilities allow low-emission vehicles to use HOT lanes for free, however, caps on these vehicles are in place as they become more popular.

VMT reduction potential: Low. This strategy c ould reduce SOV travel to the extent that it encourages carpooling. In some circumstances, replacing a mixed-flow lane with an HOV lane or HOT lane can increase ridesharing and reduce total VMT. However, some studies show that converting HOV lanes to HOT lanes can result in a decrease in carpooling, as added capacity becomes available for SOVs.[27] This strategy is not likely to cause a significant reduction in VMT, but could provide a revenue stream to support transit or other vehicle trip reduction strategies.

Implementation: Mid-term. Implementation of this strategy throughout the Bay Area would require many years of planning and coordination with Caltrans. The Bay Area Toll Authority is currently working with Caltrans to convert some existing lanes to express lanes and construct new lanes to create a seamless regional network of express lanes in the region.[28]

2.6. Major increase in Bay Area bridge tolls

Description: Tolls could be significantly increased on Bay Area bridges. Currently eight Bay Area bridges have tolls, most with toll rates of $5 for a SOV and $2.50 for a carpool (the Golden Gate Bridge has higher tolls). Raising tolls would reduce demand by single occupant vehicles and raise additional revenue that can be used to improve transit and other alternatives to SOV travel. Toll rates could be fixed throughout the day or could vary with time of day or congestion levels. Currently the Bay Bridge has a higher SOV toll rate ($6) during peak hours; the other bridges do not have variable toll rates.

A recent poll indicated that toll increases on Bay Area bridges could be a method to raise funding for transit.[29] This likely indicates that current bridge pricing is too low and Bay Area residents/workers expect that higher tolls could reduce travel times and/or improve transit options. Compared to the Bay Area, tolls for tunnels between New York and New Jersey are significantly higher: $12 and $10.50 for peak and off-peak hours, respectively, with carpool vehicles charged $6.50 during peak periods.

VMT reduction potential: High. The impact of this strategy on VMT would depend on the magnitude of the toll increase and the availability of alternatives to driving in the bridge corridors. An assessment of increased charges during peak periods on the San Francisco-Oakland Bay Bridge in 2010 suggests that "every dollar increase in average toll during the time series (approximately one year before and after the fare increase took place) was associated with a loss of 103,600 motorized vehicles crossing the bridge each month." The study also showed a high reduction in carpool vehicles once carpool rates changes from free to a discounted rate.[30] If the bridge toll increases are coupled with significant transit improvements as well as carpool options, particularly in the Golden Gate, Bay Bridge, and San Mateo/Dumbarton bridge corridors, the potential for VMT reduction is high.

Implementation: Short-term. The increase in revenue from this strategy could help pay for transit improvements, which will be needed to absorb additional passengers who may choose not to drive on the bridges.

2.7. Fee/subsidy schemes for shared-use rides

Description: This strategy involves creating fees and subsidies for various transportation services based upon a mixture of the following:

- GHG emissions per passenger mile of the service
- Average occupancy (including deadhead miles)
- Current traffic levels (higher fees on peak times)
- Personal factors (lower fees for low-income or disabled residents)

In summary, this strategy puts fees on low-occupancy, high emissions services and subsidizes the cleanest services. As envisioned, it would be applied to shared use vehicles operated by transportation network companies (TNCs).

VMT reduction potential: Medium. The VMT impacts of this approach would depend on the extent of shared use vehicles and the magnitude of the fees and subsidies. Some reports suggest that 95 percent of VMT will come from shared fleet vehicles by 2030.[31] If so, this approach could cover essentially all of road transportation and could be highly effective. Even in 2017, there are estimates that TNCs already accounted for 20 percent of VMT in San Francisco,[32] so this approach would likely have broad applicability even with more modest growth of shared used vehicles.

A fee/subsidy structure could be coupled with parking fees, which would disproportionately add costs to personally owned vehicles, for which parking is a much larger share of overall cost. With enough scale, pooled services could be highly efficient, and pushing the market toward them could drastically increase light-duty vehicle average ridership. High fees on empty miles and single-occupancy rides will also reduce VMT. With the advent of AVs, especially high fees on empty mileage would also serve as a valuable means to reduce that travel.

The subsidized cost of (already cheap) pooled TNC services would make them highly competitive with rail, thereby potentially increasing VMT, as is already reportedly underway in NYC and other mature ridesharing markets.[33] To combat this effect, this fee/subsidy scheme could be expanded to other modes such as rail and bikeshare.

Implementation: Mid-term. Since TNCs account for a significant and growing share of VMT, this policy could be impactful in the short term. Full implementation of this strategy, with fees and subsidies optimized to minimize inefficient travel, would take longer to establish. New local or regional policies would need to be established to implement this strategy, possibly requiring state authorization.

2.8. Car-free zones

Description: Municipalities can designate streets or specific neighborhoods as car-free zones. Car-free zones are a mechanism to encourage safe and comfortable travel by walking, cycling or use of other non-motorized vehicles.

Several cities in Europe have implemented car-free zones, with varying restrictions. A street or zone may be restricted for private automobiles but may allow taxis or delivery vehicles. Streets may also be restricted for private vehicles during certain hours of the day, which is a common practice in school zones. Municipalities will need to coordinate with emergency and law enforcement services to determine access needs for those functions. Many well-known car-free zones are historic districts with high levels of tourism, such as in Venice, Copenhagen, New Orleans' French Quarter, Kyoto and many others. Recently, cities have begun to restrict cars in an effort to promote livability and reduce VMT. Freiburg, Germany, has an extensive car-free zone in the city center.

Oslo, Norway, is preparing is eliminate vehicles from its downtown by 2019, with the exception of transit vehicles, delivery vehicles and accommodations for people with disabilities. To achieve this goal, the city is investing heavily in bicycle infrastructure and eliminating parking spaces. (Norway also plans to ban all gasoline-fueled cars in the country by 2025.) Other cities planning car-free zones include Madrid, Singapore, Chengdu (China) and Hamburg, among others.

VMT reduction potential: Medium. The reduction of VMT resulting from car-free zones would be high in the implementation area, assuming there are adequate transportation options in place to retain the accessibility and desirability of the car-free zone. Downtown San Francisco is the most obviously candidate for a car-free zone. It is unclear if other car-free zones would be viable in other Bay Area locations, but could be considered to avoid out-migration from car-free zones. Because car-free zones would affect only trips entering that geographic area, VMT reduction region-wide would likely be limited.

2.9. Emission-free zones

Description: Municipalities can designate specific streets or neighborhoods as "emission-free zones." In designated areas, access is provided for non-motorized or electric vehicles. Similar to other types of restrictions, exceptions may be made for people with disabilities, emergency and law enforcement vehicles, and other exceptions as appropriate. Additionally, emission-free zones may be held in effect during certain times or may be blanket bans. Cities around the world are planning low-emission and emission-free zones, with some planning to expand emission-free zones to entire cities. In 2017, 12 mayors signed a Fossil-Free Streets Declaration, indicating their commitment to establishing an emission-free zone in their city by 2030.[34] Los Angeles and Seattle are among the signatories.

VMT reduction potential: Medium. Like car-free zones, it is unclear how many locations in the Bay Area could impose an emission-free zone. Currently, because low-emission/electric vehicles make up only a small fraction of the vehicle fleet, an emission-free zone would have a similar effect as a car-free zone, and would significantly reduce VMT in the zone. If, in the future, the majority of vehicles are electric, this strategy would have little or no impact on VMT. Emission-free zones could be considered as an interim strategy prior to implementing car-free zones.

Implementation: Mid-term. Municipalities could identify areas appropriate for low-emission or emission-free zones. An increase in transportation services would be needed to complement the strategy.

2.10. Pay-as-you-drive insurance

Description: Pay-As-You-Drive (PAYD) Insurance, or usage-based insurance, charges vehicle owners by usage parameters, including mileage traveled. PAYD insurance is offered in a handful of states, including California, as well as in Europe and Asia. However, most major insurers to not offer this option or do not widely advertise the option.

VMT reduction potential: Low. According to studies, user-based insurance could reduce driving rates among users by between 3 and 8 percent.[35] [36]

Implementation: Short-term. Insurance regulations are controlled by state governments. Local government agencies have limited opportunity to implement this strategy, aside from encouragement strategies.

2.11. Gasoline tax increase

Description: California could increase the excise tax on gasoline. Like other states, California levies taxes on gasoline and diesel fuel to pay for transportation infrastructure. The current state gasoline tax is 41.7 cents per gallon; the federal gasoline tax is an additional 18.4 cents per gallon. California's gasoline tax is the fifth highest in the nation.

VMT reduction potential: Medium, possibly short-term effects. Higher gasoline prices have been linked to reductions in driving, although some of the reductions in driving may be a temporary effect, where drivers may acclimate to higher prices and return to pre-increase driving levels after a period of time. Higher gas prices may also encourage purchases of fuel-efficient vehicles, which will reduce GHG emissions. Gas taxes have not been used in the United States as a strategy to reduce VMT.[37]

Implementation: Mid-term. Given the narrow passage of a gasoline tax increase as part of SB1 in 2017 and the subsequent call for repeal, passage of another gasoline tax increase in California in the near future is highly unlikely.

2.12. Variable sales tax for new vehicles

Description: This strategy involves a mileage-based sales tax imposed on new vehicles, spread out over three years, as opposed to a flat sales tax, paid at the time of purchase. This concept was studied in a recent report submitted to the Transportation Research Board by Allen Greenberg of the US DOT, which outlines possible price-shifting strategies to reduce greenhouse gas emissions. A mileage-based sales tax could incentivize consumers both to purchase new fuel-efficient vehicles by lowering the tax rate and encourage owners to drive less.[38]

VMT reduction potential: Low. Further study is needed to assess the potential impacts on VMT. New vehicles make up about 6.5 percent of all registered vehicles in the United States, so VMT impacts across the entire fleet would be limited.[39]

Implementation: Short-term. Further studies into the impacts and feasibility of this concept would have to be conducted. If simulations or tests appear promising, this strategy could be promoted to state legislators as an alternative to a flat sales tax for vehicles.

2.13. Toll all highways and bridges

Description: This strategy involves collecting tolls on all highways and bridges in the Bay Area. Tolls could be fixed per roadway segment or charged based on distance traveled. Toll rates could be increased at peak periods or other highly congested periods to reduce congestion and encourage use of carpooling or transit. Charging drivers for use of the road network will reduce the demand for driving single-occupancy vehicles (SOVs) and raise additional revenue that can be used to improve transit and other alternatives to SOV travel, assuming prices are set appropriately.

VMT reduction potential: High. The potential of this strategy to reduce VMT depends on the magnitude of the tolls. As the price of driving increases, VMT will decrease as drivers shift to other modes, shorten trips or forego discretionary trips altogether. Research on fuel price elasticity can provide a starting point for estimating VMT effects. A report published by the Federal Highway Administration synthesized several prominent studies on travel demand relative to fuel cost, finding a wide range in elasticities, ranging from -0.1 to -0.63.[40] These values imply that doubling the cost of driving would reduce driving by 10 to 63 percent.

Implementation: Long-term. The Bay Area Toll Authority (BATA) would likely implement a regional tolling strategy, in cooperation with Caltrans and local governments. New tolls and increases to existing tolls will require legislation from the State and approval from local voters. Implementation of this strategy throughout the Bay Area would be challenging and require many years of planning and coordination. The current plan to develop a regional HOT network could be expanded to include all lanes of all freeways. Tolls would be placed on all freeways, charged by distance/segments of freeway, as measured by entry/exit points. Another option would be to consider using satellite connected in-unit transponders to collect tolls based on distance traveled on the freeways. All vehicles would have in-unit transponders connected to satellite systems that track vehicle miles on tolled roads.

3. More Efficient Distribution of Goods

These strategies focus on reducing VMT associated with freight movement. While freight has not traditionally been considered as part of TDM, it will need to be addressed as part of any long-term effort to significant reduce VMT and GHG emissions. Freight trucks already contributes disproportionately to congestion and emissions in urban areas, and this is likely to get worse. E-commerce sales are growing 15 to 20 percent per year, or doubling in 5 years. In addition to online retail sales (e.g., Amazon), numerous smaller start-up companies are offering home delivery of specialty items (Blue Apron, Doordash, etc.) Disadvantaged communities are disproportionately affected by freight movement.

In the MTC region, heavy-duty trucks account for just under 5 percent of VMT.[41] Heavy trucks are responsible for a larger share of congestion and emissions. It is estimated that while trucks contribute 7 percent of VMT in American cities overall, they can be attributed to 18 percent of congestion.[42] Strategies in this section address opportunities to increase freight efficiency or shift freight miles to non-motorized or low-emission modes. Note that that strategies in this section would not contribute toward the GHG reductions required under SB 375, since the targets established under that regulation apply only to light-duty vehicle GHG emissions.

3.1. Urban consolidation centers

Description: Urban Consolidation Centers (UCC) are locations, typically on the edges of cities, where shipments can be brought and resorted prior to being sent to their final destinations. This allows goods from various suppliers to be re-packaged into singular shipments based on final destinations, thereby reducing the number of vehicles and trips necessary to transport the goods.

VMT reduction potential: Medium. Research and analysis of the potential benefits of UCCs has been largely theoretical. One study estimated that freight VMT reductions from UCCs in the densest cities, such as New York, could be as high as 45 percent.[43] However, actual reductions would likely be much lower due to implementation challenges as noted below.

Implementation: Long-term. The major challenge with this strategy is finding an appropriate role for the public sector. In theory, UCCs could be developed and managed by public entities (e.g. port authorities or local governments), private companies, or through public-private partnerships. Companies involved in freight shipping, warehousing and transport are highly competitive and unlikely to cooperate without financial incentives to do so. Even if public agencies were able play a role, the process of selecting and developing freight centers is difficult and could require significant analysis and stakeholder outreach, as well as land use changes in building the facilities. The role of the public sector could potentially be in the development of UCCs by providing funds for their development, or by assisting in the research supporting their placement and operations.

3.2. Parcel lockers/neighborhood delivery pods

Description: Parcel lockers are drop boxes situated at locations such as apartment buildings, supermarkets, office buildings and shopping malls where people can pick up packages using individual access codes sent to their mobile devices. Customers can select which location they prefer for each delivery and can collect the parcel at any time that is convenient. Parcel delivery companies benefit because they have fewer delivery locations and fewer failed delivery attempts, saving time and mileage and reducing vehicle emissions.

In addition to stationary parcel lockers, companies have already begun real-world use of small automated ground vehicles (AGV) that function essentially as self-navigating lockers.[44] These vehicles are electric-powered, small enough to navigate on sidewalks and efficient, thereby not necessarily counting as VMT in the traditional sense. AGVs would be loaded at warehouses and sent out to customers, while customers would be able to see delivery location and updated arrival time estimates.

VMT reduction potential: Medium. Stationary parcel lockers are feasible in the densest portions of the Bay Area. Because the concept is relatively new in the U.S., the VMT reduction potential is highly uncertain. A recent McKinsey report estimated that parcel lockers could cut delivery vehicle emissions by up to 70 percent in the densest cities.[45] Higher density means that locations can be chosen with high foot traffic, meaning more pickups can be made without additional trips to/from the lockers.

AGVs are a more futuristic strategy, and their potential for VMT reduction is even more uncertain. AGVs have two factors limiting their contributions to VMT and GHG reduction. First, the energy used to power AGVs vehicles, while much less than a traditional car, is not zero, and their small size means that 200 percent more total AGV mileage is necessary to complete the same deliveries as done with traditional vehicles.[46] Further, they are likely to only be viable in dense neighborhoods. Still, assuming they run purely on electricity, which seems likely based on industry developments, they could potentially reduce emissions and traditional on-road VMT.

Implementation: Short-term. Parcel lockers require little additional infrastructure, and are already being deployed extensively at retail stores. Amazon is beta testing the Amazon Hub delivery locker for apartment lobbies; the delivery locker accepts packages from all carriers. Local governments can encourage UCCs and micro-consolidation centers (MCCs) through preferential zoning or property tax relief or identify unconventional spaces for MCC temporary operations.[47] The public sector can encourage UCCs, MCCs and parcel lockers by creating partnerships for lockers to be located in public spaces, such as libraries.

3.3. Electric-assist delivery bicycles

Description: Electric-assist bicycles enable emission-free freight delivery in dense urban areas. They have become a favorite tool by some delivery workers in cities such as New York, despite regulations prohibiting them in certain areas due to concerns over safety.[48] The bikes include typically-built electric bicycles, along with delivery-focused bikes that are attached to cargo containers. UPS introduced e-bike delivery last year, starting a pilot program in Portland, Oregon. Some concept designs allow for loads of over 260 pounds, and in some European cities, these bikes have gained significant traction, reportedly replacing up to 60 percent of inner-city vehicle delivery routes.[49]

VMT reduction potential: Low. Cargo e-bike company, The City Hub, claims that each of its bikes can replace two standard delivery vehicles, yielding a high reward per vehicle, since they can often bypass traffic and get places faster.[50] But since the total share of regional VMT from small-scale deliveries is currently small (a fraction of the 5 to 7 percent of VMT caused by all kinds of urban freight movement), the greatest potential for VMT reduction is still low. This strategy could have more significant impacts if combined with other strategies, such as UCCs, that would allow an increasing share of shipments to be delivered with these bikes.

Implementation: Short-term. Electric-assist delivery bikes are already deployed at scale in European cities and are a proven concept. The most important thing for public agencies to do would be to clarify regulations on these bicycles (regulations in New York City preclude them from operating.) Bay Area local and regional agencies could also develop programs to encourage their use, such as subsidizing their purchase and incentivizing their use by major businesses.

3.4. Shift to off-peak/night delivery

Description: Delivery of freight in urban areas during off-peak times (including night delivery) avoids congestion, thereby allowing trucks to operate more efficiently and reducing emissions. Night deliveries are often limited by noise concerns and practical issues of delivering without a person to receive packages. In some cases, noise concerns have been reduced by training "people to work more quietly and to requiring shippers to attach noise-canceling equipment to delivery vehicles, as Barcelona did in a pilot project that has gone national."[51] Further, by using EVs for delivery vehicles, noise, costs and emissions can be cut further.

VMT reduction potential: Low. As a strategy to combat congestion, this has high potential without creating significant costs. However, VMT will likely be largely unchanged. Still, if combined with UCCs to accommodate EV delivery vehicles, there could be significant emissions impacts. Further, while noise may be a concern, night deliveries could actually allow larger vehicle sizes to enter urban cores, thereby consolidating shipments and reducing VMT. Among the trips being shifted to nighttime, total urban freight VMT could fall by 70 percent due to vehicle consolidation and more efficient routing due to lower restrictions on where large trucks can travel.[52]

Implementation: Short-term. Several cities have already begun experimenting with nighttime deliveries, such as New York City and Barcelona. As was done in New York City, public agencies could initiate a campaign to incentivize major suppliers and receivers to switch to nighttime deliveries. The campaign could be entirely informational or could include formal incentives or regulations.

3.5. Drones

Description: In this context, "drones" refers to small, automated, flying vehicles used for package delivery. Drones are undergoing testing and even commercial use for a variety of applications (e.g., wildlife observation, bridge inspection). The extent to which they can be a viable solution for scaled deliveries remains unclear due to a variety of technological and regulatory hurdles. Issues of safety, noise, weather restrictions, landing space availability and aesthetics are likely barriers to adoption.

VMT reduction potential: Low. Drones could potentially supply package deliveries of lighter items, thereby eliminating some vehicle miles. However, their potential to absorb significant market share for the reasons listed above will likely limit any impact.

Implementation: Long-term. Drone technology is being actively advanced by many major companies, including Amazon, but is still many years off from scaled delivery operations.

3.6. Autonomous urban freight delivery vehicles

Description: Light-duty urban freight delivery vehicles would likely be built with standardized interchangeable components, allowing them to be networked and serve a variety of different applications.[53] The advantages of these vehicles over their traditional counterparts are mostly that they could have increased logistical potential for route optimization and load-pooling, and that they could deliver at all times of day. Further, their short distances could more easily enable electrification than in longer-range freight vehicles.

VMT reduction potential: Low. Multiple sources agree that there is potential for these vehicles to provide emissions benefits through both VMT reduction and electrification.[54] Load pooling has been estimated to reduce urban freight VMT by 30 percent,[55] automated delivery vehicle systems could significantly tap into that potential. However, without UCCs, the ability to actually gain significant market share and network effects, which is fundamental to harnessing VMT reduction potential, total impact will probably be low.

Implementation: Long-term. To deploy these kinds of vehicles at scale is effectively the ultimate AV challenge; it requires that they be usable on all streets in the network, capable of navigating mixed fleets and have network communication with a wide variety of stakeholders.

4. Plan Places and Mobility Together

Various regulations and incentives associated with land development can discourage SOV travel and support transit and non-motorized modes. Local governments can leverage their planning and permitting authority to ensure that new development maximizes TDM potential. The strategies in this section address ways to physically plan cities to encourage and incentivize shared and active mobility.

4.1. Adjust parking requirements for new developments

Description: Historically, local governments have set parking minimums for new developments to ensure enough parking supply for the site during periods of maximum demand. Many local governments are re-thinking these policies because they can result in excessive land area devoted to parking, drive up cost for infill development and discourage access by non-SOV modes. There are numerous efforts to eliminate or reduce parking minimums and establish maximums. In early 2017, Buffalo, New York, became the first city in the U.S. to eliminate parking minimums citywide when it adopted a new zoning ordinance ("The Green Code"). In an assessment of 25 Bay Area locations for MTC's VPP Parking Regional Analysis,[56] researchers found that many areas had more parking supply than demand, which mirrors findings in parking supply studies of other areas. San Francisco has already seen progress in removing parking minimums, reducing maximums and easing requirements on the areas still subject to the minimum requirements.

Local jurisdictions can also incentivize developers to meet other policy goals in exchange for reduced parking minimums or other incentives. For example, a city could allow developers to install carpool or electric vehicle parking spots to reduce the amount of required parking or allow developers to pay a fee in lieu of meeting the parking minimum.

VMT reduction potential: Medium. Multiple studies have found that reduced parking supply is associated with lower vehicle trip rates and higher shares of transit riders.[57] The California Air Pollution Control Officers Association (CAPCOA) estimates that limiting parking supply can reduce VMT by 5 to 12.5 percent in the project area.[58] Reductions will depend on types of parking requirements and incentives, such as those targeting shared vehicles or prioritizing transit-rich areas.

Implementation: Short-term. Local jurisdictions would need to enact ordinances or change zoning and building codes to change parking supply requirements. While these ordinances and codes could be enacted within a few years, the impact of these changes would be over a longer term; the overall parking supply would change at the pace of new or redevelopment.

4.2. Shared parking

Description: This strategy includes measures to encourage dynamic, shared parking that allows for improved utilization of existing infrastructure. Essentially, this means an expansion of strategies already tested as part of SFpark pilot projects, such as using demand-response variable parking pricing and providing real-time parking information. Shared parking strategies could also include zoning or regulatory changes to encourage more parking to be designated for multiple uses, rather than mandatory parking minimums for each specific land-use type.

VMT reduction potential: Low. Shared parking can reduce parking requirements by 20 to 40 percent.[59] This improved utilization can reduce parking demand and allow for denser cities, which can potentially have the negative effect of inducing VMT.[60] However, in cities like San Francisco that have limited parking supply, limiting the circling and searching for spaces can have VMT benefits. Results from the SFpark pilot projects in 2011 showed that VMT declined by 30 percent in pilot areas as compared to 6 percent in control areas between 2011 and 2013.[61] While promising, the impacts of programs like SFpark would likely be much less impactful in Bay Area neighborhoods that are less dense and not as limited in terms of parking supply. Further, it should be noted that as shared-use services gain a greater share of VMT, the impact of this kind of policy will wane.

Implementation: Short-term. Shared parking policies could be coordinated by agencies such as MTC, SFMTA and other local jurisdictions in the near future.

4.3. Incentives for unbundling parking in new developments

Description: Unbundling parking is the practice of charging unit rentals and parking spaces separately. This strategy is used to incentivize residents to choose not to drive and shifts public perception to understand market value of parking spaces. This strategy can also improve housing affordability (at least for residents without vehicles). Unbundled parking has been used in TOD projects in addition to municipal codes and incentives.[62]

VMT reduction potential: Low. According to a CAPCOA study, unbundled parking can reduce VMT up to 13 percent.[63] A 2010 study in San Francisco found that a combined strategy of carsharing and unbundled parking reduced vehicle ownership rates from 1.04 vehicles per unit to 0.76 vehicles per unit.[64] This strategy would apply only to new development, so would have limited region-wide impact in the near term.

Implementation: Short-term. MTC can encourage municipalities to offer incentives for unbundling parking in new developments. MTC can also provide technical assistance.

4.4. Enforced TDM plans and strategies for new developments

Description: Local governments could require TDM plans and strategies for new developments and enforce these through fees or other financial mechanisms. Cambridge, Massachusetts, passed an ordinance requiring all non-residential buildings adding parking to create a Parking and Travel Demand Management plan. Large projects were monitored over time to assess the building's mode share goals. In 2012, the city reported that the majority of buildings met their mode share commitments and showed single-occupancy vehicle rates less than projected. Buildings that did not meet targets were typically located farther from transit.[65] Buffalo, New York, requires most new developments and major renovations in the city to create plans with TDM strategies that reduce vehicle trips by 10 to 20 percent over two years. The City of San Francisco recently passed a robust and flexible TDM ordinance for new development, called SHIFT. A number of other cities have TDM ordinances, including Buffalo, NY; Fairfax, VA; and Arlington, VA, ranging from a required practice for developments meeting specific thresholds to voluntary activities linked to incentives such as density bonuses.[66]

VMT reduction potential: Medium. The effectiveness of TDM plans at reducing VMT will depend greatly on the travel options available at a given development site and the success of enforcement. In transit-rich areas with priced parking, TDM plans could reduce VMT at new developments to 20 percent or more. However, assuming TDM plans are required only for new developments, the net impact of this strategy for the entire region would be limited, since existing land uses are not affected.

Implementation: Short-term. Technical assistance in monitoring and enforcement activities can be provided to municipalities to encourage adoption of TDM ordinances.

4.5. Required TDM strategies for corridor plans or other community plans

Description: A TDM plan could be a required component of a corridor plan or study. Incorporating TDM strategies into a corridor plan can help relieve a busy corridor of traffic congestion and help planners and engineers move away from a capacity-expansion approach. In the U.S., municipalities and state DOTs are beginning to incorporate TDM strategies into corridor planning process.[67] TDM approaches to mitigate congestion resulting in construction activities can be designed as permanent strategies rather than temporary ones.

VMT reduction potential: Low. As with development-focused TDM plans, the potential for this strategy to reduce VMT can vary greatly depending on available travel options and the selected strategies for corridors. Monitoring and enforcement of a TDM plan at a corridor or community scale would be more difficult than at the project scale, likely limiting the VMT reduction potential.

Implementation: Short-term. MTC and county transportation agencies could require a TDM component for corridor plans. MTC and county agencies can also provide technical assistance to municipalities to include TDM strategies into plans to update locally owned streets. MTC can also work with Caltrans District 4 to encourage TDM plans on state-owned roads in the Bay Area during corridor studies/plans.

4.6. Replace parking minimums with mobility subsidies

Description: Mandatory parking minimums could continue to be removed throughout the region (as many have already been removed),[68] and ordinances could be made to encourage or mandate that residencies provide stipends for mixtures of transportation services instead. This means that an increasing share of Bay Area residents are guaranteed to have options available to them facilitating a car-free lifestyle. It also encourages new developments to be transit-oriented. This model is already being tested by Parkmerced, a collection of 8,900 apartments in San Francisco that partnered with Uber to offer tenants a $100 transportation monthly stipend, which can be put toward Clipper cards, Uber or Getaround.[69]

VMT reduction potential: Medium. In San Francisco, 37 percent of residents live in multifamily buildings.[70] Assuming this strategy applies to new development, the reduction potential is limited by the amount of new housing built in the region. The degree of VMT change per user depends on what modes are subsidized – options include small TNC vehicles, bicycling or transit. VMT reduction will also depend on what percentage of trips from these residents would have otherwise been taken in personal vehicles.

Implementation: Short-term. Individual cities and counties would implement this strategy through zoning and permitting regulations. Some building owners may also voluntarily implement mobility packages, as one already has done, but a mandate would likely need to come from a city ordinance to be effective.

4.7. Require developers to include coworking spaces in new developments

Description: Local governments could require developers to include workspace in multi-unit residential buildings to encourage teleworking. Developers are beginning to include co-working spaces in residential buildings as desirable amenities in response to an increase in teleworking rates.[71] [72]

VMT reduction potential: Low. Teleworking can reduce congestion rates at peak periods and potentially reduce VMT. It is unclear if teleworking can reduce overall VMT, as people teleworking may drive more during the day or may choose to live in more remote areas, resulting in longer commutes on non-telework days. According to a recent report by Global Workplace Analytics, 50 percent of jobs in the United States may be appropriate for full or partial teleworking, and this number is likely higher in the Bay Area. Over 80 percent of working adults have expressed an interest in at least part time teleworking.[73]

Implementation: Short-term. Municipalities could include a requirement or incentive for developers to include co-working spaces in new residential buildings.

5. Major Traffic Generators Reduce Solo Trips Through Requirements and Incentives

Strategies in this section focus on incentives or requirements for the private sector to reduce VMT among employees, customers and residents at locations that are major generators of vehicle trips. Most of the strategies focus on employer programs, with the exception of one, which targets retail and event venues. These strategies align with rising rates of telecommuting and online shopping.

5.1. Commute trip reduction–employers (aggressive/enforced)

Description: Employer trip reduction ordinances have been implemented around the country for decades. The specific requirements for achieving the reductions vary, but ultimately there is a goal for the employer to meet – either a trip reduction goal, a trip cap goal or a mode share goal – and if the employer does not meet their goal, they incur a fine or are required to implement further action. Examples of existing policies include:

- **Rule 2202, South Coast Air Quality Management District, Southern California:** The rule provides employers with a menu of options to reduce emissions (primarily from employee commutes but also has options for earning credits by reducing emissions through other efforts). It applies to companies with 250 or more employees, which are required to register annually with the Air District to implement a TDM program. The rule establishes a worksite-specific emission reduction target and requires employers to meet that target annually.
- **Fairfax County, Virginia:** Among other requirements, Fairfax County's TDM ordinance requires annual traffic counts and employer surveys to establish mode share and determine whether employers are meeting their non-drive-alone mode share goals. If, in a given year, the non-drive-alone mode share goals are not met, the employer is required to work with the County to develop remedies.
- **Santa Monica, California:** Santa Monica TDM Ordinance requires employers with 10 or more employees to submit an annual worksite transportation plan. The plan is required to include specific strategies that will be implemented to encourage employee commute trip reductions.

VMT reduction potential: Medium. The existing Bay Area Commuter Benefits Ordinance requires employers to choose from a menu of worksite transportation options, aimed at reducing employee commute trips, but does not assign a target or goal for employers. This ordinance could be modified to add goals and targets for individual employers, and require that they increase existing worksite transportation programs in place. The ordinance could also be modified to add penalties for not meeting goals and targets, and these funds could then be used for incentives or site-specific remedies.

Implementation: Short-term. This strategy could be implemented within 5 to 10 years by enhancing the existing Bay Area Commuter Benefits Ordinance.

5.2. Discretionary trip reduction–retail and event venues

Description: Trip reduction aimed at employers have been widely implemented, targeting commute trips and peak-period congestion. However, work trips account for only 20 to 30 percent of total trips, and this share has been declining. A trip reduction program could be implemented to target discretionary trips, such as shopping and entertainment, where trips could be eliminated or shifted to more sustainable modes. Beyond TDM for new development requirements, these requirements would encourage the continued use of sustainable modes by customers when traveling to such sites, through discounts on purchases or tickets, free shipping, valet bicycle parking and other ongoing incentives.

Santa Monica's TDM Ordinance mentioned above requires strategies for employee commute trip reductions and also strategies for incentivizing customers and visitors to "walk, bike, ride transit, and/or carpool." The City/County of San Francisco requires valet bicycle parking for events requiring a street closure and with an anticipated number of participants greater than 2,000.

VMT Reduction: Medium. This strategy could potentially influence a large number of trips, but it would be challenging to implement and its effectiveness at changing behavior is uncertain. Shoppers often have limited ability to avoid driving. Retailers are highly competitive and many may be unwilling to offer additional discounts to incentivize sustainable travel. There is likely greater potential to limit SOV travel associated with entertainment and other special events, but these trips account for a smaller share of regional travel. Event venues or organizers could be encouraged or required to offer discounts on tickets for those taking public transportation or carpooling, be required to offer rideshare matching and preferential carpool parking, and/or valet bicycle parking.

Implementation: Short-term. Implementation of this strategy would depend on MTC, BART and other regional agencies for outreach and coordination, in partnership with local governments.

5.3. Telework tax credit

Description: A tax credit could be offered to employers who implement telework policies, which would reimburse employers for telework-related expenses such as computers, hardware, software, phone systems, remote connections to company servers and broadband internet services.

Virginia provides an example of the type of tax incentive legislation that could be implemented. The Virginia Telework Tax Credit provides individual employers up to $50,000 in tax credits each year for telework-related expenses. The tax credit applies to employers who incur eligible telework expenses (such as expenses for computer hardware and software, data processing equipment, telecommunications equipment and high-speed Internet connectivity equipment) up to $1,200 for each new participating employee in telework. In addition, the credit can be used for up to $20,000 to conduct a telework assessment (to assess equipment and training needs, barriers/issues, and develop telework policies and procedures, etc.). The credit is subject to specific requirements, such as requiring the employer to have a signed telework agreement with each new teleworking employee and to file an application to reserve a portion of the credit, which is limited statewide to $1 million per year.[74]

VMT reduction potential: Medium. Teleworking can reduce congestion at peak periods by eliminating trips entirely. It is unclear how many employers in the Bay Area are able to implement teleworking and of those how many have not yet done so. According to the Society for Human Resource Management, results from a 2014 survey reveal that 48 percent of employers offer one or more flexible work arrangements to employees.[75] (Flexible work arrangements include telework, flex time, compressed work weeks, and more.) The Virginia Telework program conducted an evaluation of their program through surveys of participating employers and found that five percent of participating employees had never teleworked previously. Of the 15 participating employers who responded to the survey, they estimated a daily VMT reduction of approximately 9,000 miles.

Implementation: Mid-term. The State of California could offer state tax credits to employers who implement telework policies and incur operational expenses. Employers could be required to submit documentation for the number of days each employee worked from home per year, as well as their approximate commute distance, for purposes of estimating emissions and congestion savings. This program could also be administered as an incentive program, with a fund source that is administered by a local or regional agency.

5.4. Compressed work week/flex-time tax credit

Description: Similar to the telework tax credit, a tax credit could be offered to employers who offer other flexible work arrangements, such as compressed work week or flex-time schedules. Employers are most likely to experience cost savings, associated with reduced office space, in either of these strategies. However, employers could incur marginal expenses related to peripheral operating costs, especially as staggered work schedules ultimately result in longer hours of operation and more total hours of operation for the main building (e.g., additional hours for security or administration staffing, additional hours for lights and heating/air conditioning, etc.). Some employers could choose to close entirely one day a week or one day every other week, if their business could accommodate it.

VMT reduction potential: Low. Compressed work week programs can reduce congestion at peak periods by eliminating trips entirely. Flex-time programs do not eliminate trips/VMT, but have the potential for reducing congestion at peak periods by shifting trips outside the peak periods. The net effect of these strategies on VMT has not been carefully studied and is therefore uncertain. Some have suggested that participants in compressed work week programs perform more non-work trips on their "off day," thereby negating any VMT reduction benefits.

Implementation: Mid-term. The State of California could offer state tax credits to employers who implement either of these flexible work arrangement policies. Since additional expenses incurred would be arduous to measure and demonstrate, a flat rate may be considered, based on number of employees, up to a specific dollar limit per company. Companies could be required to document the number of employees participating in the program(s), the number of days per year those employees avoided a trip to work entirely, approximate commute distance, and/or (for flex-time programs) number of days per year employees worked a shift outside the peak periods. This program could also be administered as an incentive program, with a fund source that is administered by a local or regional agency.

5.5. Eliminate free/subsidized employee parking

Description: A large share of employers offer subsidized parking to employees as a fringe benefit even though there is a cost for the parking. Providing free parking helps to encourage SOV commute trips. Without free parking, commuters who drive would face increased operational trip costs; a 2012 Colliers' parking survey found that median parking rates in the central business districts of San Francisco and San Jose are $29 and $15 per day, respectively. Considering the operating costs for a typical driving trip in the Bay Area is less than $4 per day (assuming operating costs for a medium sedan is approximately $0.17 per mile, excluding vehicle ownership costs, and the typical driving trip length in the Bay Area in 2015 was 23 miles per day), adding the full cost of parking is a significant increase to commuter driving costs.[76] [77] This strategy has the potential to significantly reduce vehicle trips. A case study of five areas by Willson and Shoup in 1990 found that eliminating parking would reduce the number of commute automobiles by 15 percent to 38 percent.

VMT reduction potential: Medium. Drivers with employer-paid parking would face a new parking cost and would respond similar to parking pricing strategies (for example, see Parking Tax). The scale of the impact on VMT will depend on the share of commuters with free parking and local context. For example, only 28 percent of car trips in San Francisco have subsidized parking; in SFCTA's Parking Supply study, which examined various parking scenarios, the modeling team found that eliminating employer-paid parking in portions of San Francisco would only reduce the SOV mode share by 0.2 to 0.7 percentage points. Impacts would also depend on the rate and availability of parking in the targeted areas, including possible spillover parking in adjacent areas with cheap or free parking.

Implementation: Short-term. This strategy would require local jurisdiction action to change ordinances and zoning codes. This strategy would be most feasible for properties with unbundled parking and should be considered in conjunction with unbundling policies.

5.6. Regional network of telework/co-work centers

Description: This program could offer a network of offices/work spaces, either on a membership/fee basis, or free to any member of the public, who could work remotely but is unable or would prefer not to work from home. These telework centers would include individual work stations as well as group meeting spaces, access to broadband internet, phone services, printers and photocopy machines, and more. Traditional telework centers offer amenities typically offered in office environments, but these telework centers could also offer maker-spaces with 3-D printers, sewing machines, wood-working and metal working tools, kitchen/catering spaces, and more.

Washington, D.C.'s Commuter Connections program offers a network of telework/co-work centers, with thirteen locations around the region. Telework/co-work locations are offered through the subsidy of shared-workspace companies who also rent space to individuals and companies directly.

VMT Reduction: Medium. Telework or co-work centers have the potential for reducing VMT by reducing commute distances. For the traditional office-environment, congestion would be reduced especially during peak hours, but if the concept of these telework/co-work centers could be broadened to accommodate other types of industries and professions, there is potential for reducing VMT throughout the day. Beyond reducing VMT, these spaces could spur economic development through the encouragement and support for small business start-ups, or even augmented tools and services for established companies.

Implementation: Mid-term. Regional agencies could subsidize existing co-work spaces to offer spaces for any member of the public who wishes to work remotely. Regional agencies or states could also consider additional funding for public libraries to establish co-working spaces, maker-spaces, etc. Public libraries may also consider ongoing revenue streams, such as fee-based or membership-based usage of these spaces to fund operations beyond the initial construction and establishment.

5.7. Parking cash out

Description: As noted in the Eliminate Free/Subsidized Parking strategy, subsidized parking shields commuters from the full cost of driving, and a significant share of employees would shift to other modes if faced with the true cost of driving. However, rather than eliminate employer-subsidized parking, cash out allows the commuter to decide whether to continue parking with a perceived opportunity cost. This strategy does not burden the employer or employee with additional costs, except for minor administrative costs to the employer, and does not proscribe any particular mode, allowing the employee to make the choice in his or her best interests. While California already has a law requiring employers with 50 or more employees in non-attainment-designated air basins to offer parking cash out, many employers are not aware of the requirement and there is little-to-no enforcement of the law.

VMT reduction potential: Low. Similar to parking pricing strategies, there will be a reduction in driving relative to the opportunity cost of cash out. The cash out amount will depend on the value of parking in each area and whether or not there is any potential spillover parking in adjacent areas (or efforts to prevent spillover parking). The impact will also depend on how many employees fall under the law's criteria (i.e., companies with over 50 employees and parking that is not owned or can be reduced without penalty), although local agencies could choose to expand the scope of the mandate. According to the TDM manager for the City of Santa Monica, parking cash out is the most effective TDM strategy the City has implemented.

Implementation: Short-term. Because the policy mechanism to implement this already exists, local and regional agencies can focus on education and enforcement to implement this strategy. However, this strategy is limited to employers with unbundled parking and therefore should be considered in conjunction with unbundling policy efforts. The timeline for realizing the full VMT reduction benefits of this strategy will partly depend on the turnover of offices with bundled or owned parking.

Table 1. Strategies to Manage Travel Demand

	STRATEGY	VEHICLE TRIP REDUCTION POTENTIAL	SHORT-, MID-, LONG-TERM*	IMPLEMENTING AGENCY (STATE, REGIONAL, LOCAL)
TRAVEL OPTIONS	1.1 Free transit	Medium	Short-term	Regional / Local
	1.2 Inclusion of fare payments in trip planning apps	Low	Short-term	Regional
	1.3 Linked / seamless transportation accounts	Medium	Short-term	Regional
	1.4 Flat-rate transportation packages	Medium	Short-term	Regional
	1.5 Shared, electric, connected, and autonomous vehicle fleets	Low	Mid-term	Local
	1.6 Enforced vehicle occupancy rates	Medium	Short-term	Regional
	1.7 Mobility hubs	Medium	Mid-term	Regional
	1.8 Rationalization and integration of transit	Low	Mid-term	Regional
	1.9 Ridesharing	Medium	Short-term	Regional / Local
PRICING	2.1 Parking tax	High	Short-term	Regional / Local
	2.2 Dynamic parking pricing	Low	Short-term	Regional / Local
	2.3 VMT pricing	High	Long-term	State / Regional
	2.4 CBD cordon pricing	Medium	Mid-term	Regional
	2.5 HOT/Express lanes	Low	Mid-term	State / Regional
	2.6 Major increase in bridge tolls	High	Short-term	Regional
	2.7 Fee/subsidy schemes for shared-use rides	Medium	Mid-term	Regional
	2.8 Car free zones	Medium	Long-term	Regional
	2.9 Emission-free zones	Medium	Mid-term	Regional
	2.10 Pay-as-you-drive insurance	Low	Short-term	State / Local
	2.11 Gas tax increase	Medium	Mid-term	State
	2.12 Variable sales tax for new vehicles	Low	Short-term	State / Regional
	2.13 Toll all freeways and bridges	High	Long-term	Regional
GOODS DELIVERY	3.1 Urban consolidation centers	Medium	Long-term	Regional
	3.2 Parcel lockers/neighborhood delivery pods	Medium	Short-term	Local
	3.3 Electric-assist delivery bicycles	Low	Short-term	Local
	3.4 Shift to move off-peak/night delivery	Low	Short-term	Local
	3.5 Drones	Low	Long-term	Regional / Local
	3.6 Autonomous urban freight delivery vehicles	Low	Long-term	Regional
DEVELOPMENT AND MOBILITY PLANNED TOGETHER	4.1 Adjust parking requirements	Medium	Short-term	Local
	4.2 Shared parking	Low	Short-term	Regional / Local
	4.3 Incentives for unbundling parking in new developments	Low	Short-term	Regional / Local
	4.4 Vehicle trip reduction requirements on developments	Medium	Short-term	Regional / Local
	4.5 Required vehicle trip reduction strategies for corridor plans or other community plans	Low	Short-term	State / Local
	4.6 Replace parking minimums with mobility subsidies	Medium	Short-term	Regional / Local
	4.7 Requirement for developers to include workspace in multi-unit residential developments	Low	Short-term	Regional / Local
SOLO DRIVING COMMUTE REDUCTION	5.1 Commute trip reduction – employers (aggressive/enforced)	Medium	Short-term	Regional / Local
	5.2 Discretionary trip reduction – retail and event venues	Medium	Short-term	Regional / Local
	5.3 Telework tax credit	Medium	Mid-term	Regional / Local
	5.4 Compressed work week / Flex-time tax credit	Low	Mid-term	Regional / Local
	5.5 Eliminate free/subsidized employee parking	Medium	Short-term	Local
	5.6 Regional network of telework/co-work centers	Low/Medium	Long-term	Regional
	5.7 Parking cash-out	Medium	Short-term	Local

*Short-term = 5-10 years. Mid-term = 10-20 years. Long-term = 20+ years

ENDNOTES

1. VMT is a basic measure of the amount of vehicle travel generated in a specified geographic area. One vehicle traveling one mile constitutes one vehicle mile, regardless of its size or the number of passengers. VMT refers to the number of vehicle miles traveled within the region during a typical weekday. VMT is a common measure of roadway use and economic activity and has a strong correlation with congestion.

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HORIZON

TOWARD A SHARED FUTURE: STRATEGIES TO MANAGE TRAVEL DEMAND

APPENDIX B - HIGH-IMPACT STRATEGIES TO REDUCE VEHICLE TRIPS

STUDY PARTNERS

ASSOCIATION OF BAY AREA GOVERNMENTS
METROPOLITAN TRANSPORTATION COMMISSION

ICF

The eight strategies described in Appendix B emerged from the original list of approximately 40 strategies **(listed in Appendix A)**, based on discussions with MTC staff regarding Bay Area priorities, vehicle miles traveled (VMT) reduction potential, and equity. Each strategy described considers the Horizon's Guiding Principles. The descriptions here serve as a starting point for identifying the best strategies for the Bay Area to reduce VMT. Each strategy requires additional detailed analysis for analysis during the Futures phase of Horizon.

The Perspective Papers are the beginning of a conversation about strategies to solve regional challenges. Following the release of the Perspective Papers, MTC and ABAG staff will engage stakeholders in identifying which of the strategies from the Perspective Papers can overcome the various challenges that the region could face across a series of divergent futures, or "what if" planning scenarios that have varying assumptions on the economy, technology and the environment. Following the Futures analysis and stakeholder engagement, a short list of strategies that are most effective in overcoming regional challenges will be recommended.

1. Free Transit

Description

All public transit service or select routes within the Bay Area could be free for all users. Transit agencies could eliminate fare collection mechanisms and procedures, which could offset a portion of operational costs. However, in order to remain effective and reduce VMT, this strategy would need to be accompanied by an expansion in transit service, including additional capacity in select corridors that already face overcrowding, and additional routes/services and frequency to increase access in suburban areas.

Examples

Several cities have elected to eliminate fares on select routes, districts or services, including Seattle, Washington (buses in the downtown district); Kansas City, Missouri (KC Streetcar in the downtown district); Miami, Florida (elevated driverless people mover in the downtown district); Jacksonville, Florida (Skyway route in the downtown district); and Baltimore, Maryland (four fare-free routes in the downtown). Other cities have elected to eliminate fares for the entire transit system, including Chapel Hill, North Carolina; Corvalis, Oregon; and Tallinn, Estonia. Several motivations factored into the decisions for offering free transit, including the need to reduce or curb operational costs, the desire to improve mobility options to individuals with lower-incomes, desire to enhance economic development and viability, and the desire to reduce traffic congestion. The examples show that a major factor in whether fare-free transit is feasible lies within the extent to which transit is already being subsidized.

- **Chapel Hill, NC.** Chapel Hill Transit (CHT) is the second largest transit system in North Carolina, providing over 7 million rides per year. CHT serves the communities of Chapel Hill, Carrboro and the University of North Carolina at Chapel Hill (UNC). The two towns and the university share annual operating and capital costs associated with CHT on a contractual basis. Part of the decision to eliminate fares was based on the fact that Chapel Hill already had a very low fare-box recovery ratio (10 percent), so eliminating the services related to fare collection was a cost-savings measure[1] . Since eliminating fares in 2002, Chapel Hill Transit has seen ridership increase from around 3 million rides a year to over 7 million rides per year.[2] Chapel Hill Transit has also increased transit service by about 20 percent.[3]

- **Tallinn, Estonia.** In January 2013, Tallinn, Estonia, made transit free to all residents. Researchers at the Royal Institute of Sweden, who are monitoring the results, estimated a 1.2 percent increase in ridership that can be attributed to the free fares. The balance of the estimated 3 percent increase in ridership can be attributed to service improvements and new priority lanes for buses. The researchers also found that the most significant mode-shift was among pedestrians choosing to ride transit more often than walking, as opposed to reducing SOV travel. However, the researchers did find evidence of improved access to the city. The most significant increase in transit ridership (10 percent) occurred in Lasnamäe, a densely populated area with high unemployment and a large ethnic-minority population of Russians. In the case of Tallinn, the number of car users decreased, although VMT rose due to increases in trip lengths, possibly due to new development and further distances between residences and

employment, shopping, and other destinations.[4] [5]

- **Seattle/King County.** From 1973 to 2012, Seattle/King County operated free transit within a designated area in the downtown district. By 2012, more than 10 million rides per year were logged inside the free-fare area.[6] In 2012, Seattle/King County ended the free-ride zone due to the inability to generate revenues to cover rising operational costs. Despite the ceased free-ride area, ridership increased by 3 percent between 2016 and 2017. Only three other metropolitan areas (Phoenix-Mesa, AZ; Houston, TX; and New Orleans, LA) experienced an increase in transit ridership in the same year, and Seattle's increase was the largest. Some of the reasons credited for the increase in ridership are attributed to an expansion in service, and holistic improvements to the entire system (as opposed to one route or area). Since 2014, Seattle/King County has increased transit service by 13 percent. Specifically, Seattle/King County implemented substantial bus service while also planning longer-term investments in light rail.[7] Commute Seattle's 2017 Commute Mode Survey reported that three new light rail stations had been added, "…dramatically increasing the share of residents within a 10-minute walk to a station with 10-minute frequencies in service."

VMT Reduction Potential

For most individuals who drive alone, it is unlikely that the cost of transit is the major impediment to transit use. Increased and improved transit service would likely have a greater impact on mode shift than eliminating costs. Seattle's recent investments in transit have increased transit service by 13 percent (so far) and ridership has increased by 3 percent in just the last year.

Although VMT increased after free transit was implemented in Tallinn, factors contributing to the increase in VMT and minimal increases in transit ridership may be specific to the Tallinn context and not applicable to the Bay Area. In the Bay Area, the walking mode share is low, creating less opportunity to shift modes from walking to transit; subsidized transit is also significantly lower, which means there are cost savings opportunities for a higher percentage of people; and the Bay Area has a developed economy unlikely to experience the changes in trip length and frequency that were seen in Tallinn. Despite the aforementioned issues with Tallin's free transit program, there was a decrease in automobile mode share, indicating that free transit may have been successful, at least compared to a scenario of not implementing free transit.

Past research on transit fare elasticity presents a wide range of values, from -.009 to -1.32, with a mean value of -0.38. Some studies have estimated different transit fare elasticities for bus versus rail transit.[8] Elasticities tend to be higher when the starting transit fare is high (i.e., if fares are already low, a fare reduction will have less impact). The Simpson-Curtain rule suggests a simple rule-of-thumb elasticity of -0.33 (if transit fares double, ridership will decline 33 percent). The Moving Cooler study estimated the impacts of several transit fare reduction scenarios, the largest of which assumed a 50 percent reduction in transit fares, which was estimated to create a 15 percent increase in transit ridership (elasticity of -0.3).[9]

Some researchers have concluded that fare elasticity is strongly asymmetric—passenger demand falls in response to an increase in price, but the ridership effect associated with a price reduction is smaller. Research also suggests that the long-run fare elasticity is significantly higher (in absolute terms) than the static or short-run elasticity. This suggests that travelers gradually adjust their travel behavior to

price changes.[10]

The elasticities discussed above suggest how transit ridership would increase with a reduction in fares. However, not every new transit rider will shift from single occupant vehicle (SOV) mode. Some new transit riders will shift from rideshare, bicycle or pedestrian modes, and some may be induced to travel when they otherwise would not have made the trip. SOV trips account for approximately 50 percent of all Bay Area trips.[11] Thus, as a simple rule of thumb, it can be assumed that every two new transit trips eliminates one SOV trip, a mode shift factor of 0.5. The mode shift factor would be higher (i.e., a new transit trip is more likely to eliminate an SOV trip) in Bay Area locations outside San Francisco and the inner East Bay, since these locations have a higher starting SOV mode share.

Implementation Approach

Among other obvious differences between the Bay Area and smaller cities that have implemented completely fare-free transit systems, transit systems in the Bay Area have higher farebox recovery ratios (depending on the transit agency), which means there would be a greater financial burden to maintain and expand the system without fares.

The total operating costs for transit in the Bay Area are approximately $2.5 billion, with the majority of funding attributed to state and local sources. The farebox recovery for all Bay Area transit service is 38 percent (which is higher than the national average of 32 percent). Farebox recovery ratios differ widely by service provider; BART is 73 percent while the average for motor bus service is 19 percent.[12] [13]

Bay Area transit agencies would need to find new sources of funding or ensure additional funds from existing sources, which would likely be a challenging task. In Chapel Hill, NC, the university pays for a significant portion of the annual operating costs by including a transit fee for all students; vehicle registration fees and sales taxes make up the balance of funding. A Transit Operations fee is used to fund the Corvalis, Oregon, free transit, payable via the monthly water bill. The Bay Area could consider similar fees, or other creative funding ideas, such as a hotel fee, given the significant tourist population, or a per-trip transportation network company (TNC) fee, as a way to offset presumable negative impacts on transit ridership.

Bay Area transit agencies would need to increase transit service to coincide with this strategy. MTC and other transit agencies in the Bay Area have collaborated on the Core Capacity Transit Study, which identifies specific projects and strategies to alleviate overcrowding.[14] These projects could be the starting point for identifying which routes to increase service, though simply alleviating existing overcrowding would likely not be enough to increase ridership going forward.

Response to free transit will likely differ in urban and suburban parts of the region. Ridership levels may increase more in areas that are home to residents with lower incomes. Furthermore, walking may decrease in more densely populated areas, as preliminary reports have found in Tallinn, Estonia. Each of the successful free-transit examples demonstrated the increase in transit ridership was also due to improvements in transit service, so areas with poor transit service (real or perceived), such as infrequent service or inconveniently-located transit stops/stations, may not see increases in ridership even after fees are eliminated.

Affordability

Free transit could provide enhanced mobility for low-income residents. While the city of San Francisco offers a low-income transit fare program, only about 6 percent of riders use the program, compared to 20 percent of residents who qualify for the program.[15] This gap could be due to the inconvenience of

applying for and complying with program procedures, and fare-free transit could remove these barriers and simplify riding transit (as it could do for any/all income levels).

Strategy Packages/Bundling

As discussed, the increases in ridership (in free and fee-based transit systems) consistently coincide with increases in transit service (increases in frequency, capacity and routes/access). To accomplish efficient increases in transit service, many strategies may need to be considered, including the consolidation of existing transit agencies and transit routes, or complementary services to improve access to transit, such as the improvement in bikeshare or shuttle services. Additional parking restrictions or increases in pricing for driving may also help to offset the perceived conveniences of driving.

Modeling Methodology

This strategy should be analyzed using MTC's travel model. Six different types of prices are explicitly represented in the travel model: (i) bridge tolls; (ii) express lane tolls; (iii) transit fares; (iv) parking fees; (v) perceived automobile operating cost and gas taxes; and (vi) cordon tolls.[16] The model could be run with a significant reduction in transit prices. Note, however, that setting model transit prices close to (or at) zero might create a breakdown in some model relationships, so iterative model runs should be used to explore these effects. The model may not be able to fully capture the impacts of free transit. For example, one value of free transit from the rider's perspective is the simplicity of not dealing with account-making or payment, which isn't as easily modeled as a price change.

2. Mobility as a Service

Description

Mobility-as-a-Service (MaaS) is an emerging concept without a firm definition, but typically refers to an on-demand service that provides convenient access to multiple transportation modes or services, resulting in a user-friendly and streamlined experience. MaaS includes the ability to plan and pay for trips utilizing multiple modes and services through a single platform. The platform would include functions such as trip planning based on preferences, a single payment method (possibly subscription-based), modal option comparisons, real-time updates and customizable features. Collectively, these components of MaaS are intended to provide a value proposition competitive with personal car ownership. The ability to link modes into a near-seamless, single-payment experience can encourage users to shift from using SOVs to a mixture of modes (including multimodal trips as well as a mixture of modal types depending on day, time, trip purpose). The primary benefit of MaaS to the traveler is a reduction in logistical hurdles, complexity, and stress associated with planning and paying for multimodal trips.

This strategy assumes that one or more robust MaaS platforms become deployed and widely available in the Bay Area.

Examples

While MaaS is still a relatively new approach that is being enabled by technological advances, there are already several ongoing and planned MaaS pilots, and many other instances of transportation services adopting some combination of the key MaaS components.

- **Whim App, Helsinki, Finland.** The Whim app offers three different bulk packages covering taxis, rental cars and public transit, each featuring varying degrees of limited or unlimited trips. The most expansive package, "Whim Unlimited," costs 500 Euros per month and offers unlimited rides on all modes, except it only covers taxi rides under 5 km. This price point was designed to be approximately equal to average car ownership costs in Helsinki. Results from Whim's first year of operation, 2016, show the following shifts in trip mode share among users: private car share dropped from 40 percent to 20 percent, public transit rose from 48 percent to 74 percent, and taxis from 3 percent to 5 percent.[17] Interestingly, bike trip share fell from 9 percent to zero. Whim's website indicates that bikesharing options will become part of the service offering starting in the spring of 2018. No updated usage data is available, but at least 6,000 users were registered a few weeks after Whim's launch, equating to approximately 1 percent of Helsinki's population.

- **Hannovermobil, Germany.** Hannovermobil, one of the earliest MaaS services, saw 50 percent of users give up car ownership, but was very limited in scope (1,300 users).[18] Under this program, subscribers pay a monthly fee (slightly more than a standard transit pass) to access public transit, carshare, long-distance rail and discounted taxi rides. Users are billed monthly for carshare and taxi fees. The program does not include bike share. Since its implementation in the mid-2000s, the main limiting factors of the pilot – flexibility and usability – have all been improved through smartphone technology, prompting the recent launch of Hannovermobil 2.0.[19] [20]

- **The SMILE Project, Vienna, Austria.** The SMILE Project, a platform that "provides information, booking, payment and use of a broad range of different means of transport," also found that users shifted toward more sustainable modes.[21] Since starting to use the app, 48 percent used transit more, 21 percent drove less, and rates of driving plus transit and bikeshare also increased.[22] Total usage is still just a few thousand individuals, and this niche early-adopter market is likely different in demographics and preferences than the broader traveler population.

- **ConnectStar, Houston district of Texas Department of Transportation (TxDOT).** This program's goal is to leverage a third-party platform, Metropia, which provides a one-stop shop for all local modes, linking trip information and payment.[23] The app aims to allow users to shop for multi-modal rides in a simple manner and also serves as a platform for implementing dynamic pricing strategies to manage traffic demand. This pilot further embodies MaaS by creating user-customized features such as suggested routes and targeted deals.

- **Minnesota Department of Transportation (MnDOT).** MnDOT is developing a MaaS platform that can serve as an agency funding source, with app development being funded through a FHWA grant to find fuel-tax funding alternatives.[24]

- **Valley Metro Rail, Phoenix, Arizona.** Valley Metro was awarded a Mobility On Demand Sandbox grant to develop a MaaS platform that expands an existing transit app to include real-time information; singular accounts for public and private modes; and trip planning features, such as showing users the cost of fuel saved, amount of CO2 saved from using alternative modes of travel, as well as travel time.

VMT Reduction Potential

The U.S. pilots discussed above (TxDOT, MnDOT and Valley Metro Rail) are still in their early phases and have not quantified the impacts MaaS or MaaS elements have on vehicle trips or VMT. The examples from European efforts are more developed at sufficient scale to provide a meaningful proxy for a system-wide MaaS program implementation strategy and could inform the estimated impacts of similar projects in the Bay Area.

Using pricing mechanisms to achieve policy goals are not an intrinsic component of the MaaS systems being developed by private companies. However, the platform does offer a convenient means to implement innovative pricing schemes that could help achieve public goals, such as raising costs during peak hours to reduce congestion, levying surcharges for SOVs and AVs with zero- or single-occupant trips, decreasing all travel costs during emergencies, or offering adjusted fees for underserved or low-income individuals. Additionally, MaaS providers can offer bulk or flat rates on a subscription basis (see next section for more information).

While a full understanding of the impacts of MaaS on VMT is not yet available, there is an expectation that there will be some reduction in SOV trips because of increased multimodal trip selection and reduced private vehicle ownership or use. However, the full impacts will depend on policies implemented by public agencies, such as pricing mechanisms or incentives to reduce passenger vehicle trips. Alternatively, some policies (or lack of policies) could result in scenarios in which passenger vehicle trips increase (such as ridehailing trips) and trips by other modes decrease (such as transit or active transportation trips). Additionally, some experts anticipate that there will be a rich set of user data collected through MaaS platforms, which will allow transportation providers to make their services more efficient; for example, transit agencies may identify underutilized routes or gaps in service based on a better user travel choice data collected by a MaaS system.

Implementation Approach

Some MaaS pilot projects are being undertaken primarily through private app developers that coordinate with public and private service providers to integrate various offerings (e.g. Whim in Helsinki, Qixxit in Germany, and SMILE in Vienna, Austria), while some public agencies in the U.S. are taking a leadership role in developing mobile apps and integrated systems.

Although the development of MaaS apps will likely be led primarily by private companies, public agencies will have an important role to coordinate stakeholders and set guidance to achieve policy goals. Early steps include public agencies engaging with private companies to coordinate data specifications, standards, and sharing agreements. As a regional entity, MTC could work with all local stakeholders and coordinators in other parts of the country to help establish a data system plan for the Bay Area that will ensure digital compatibility between transportation providers. MTC can leverage the work started with the Clipper Card® program and the existing relationships with the many different transportation providers in the region. MTC could consider developing a MaaS strategy blueprint for the Bay Area, similar to the Los Angeles Transportation Technology Strategy developed for the City of Los Angeles DOT.[25]

Public agencies will also want to engage early in the process to make sure policy options are incorporated into MaaS systems from the beginning. MaaS efforts led only by private companies could result in establishing systems that results in increased VMT and movement away from other policy goals.

To realize the full benefits of a MaaS system, it is best to incorporate a full range of mobility options in the region. Until a wide range of transportation services are unified in a MaaS system, usage may be limited depending on the available options. MaaS systems will likely include TNCs as modal options to facilitate first/last mile segments and personal preferences/needs. As car services become less expensive (especially when automation becomes mainstream), MaaS systems could be a tool to increase use of TNCs, which could lead to increased VMT. Pricing strategies to shift riders to shared modes may be required to avoid increases in VMT from TNCs.

Affordability

MaaS does not inherently guarantee lower prices on any modes. However, the MaaS platform does offer a streamlined means to allow users to select tailored packages for affordable transit. MaaS providers could coordinate subsidized rates or passes for low-income users, persons with disabilities or other individuals as desired. This singular account allows a one-stop shop for applying subsidized fares on both public and private services.

Strategy Packages/Bundling

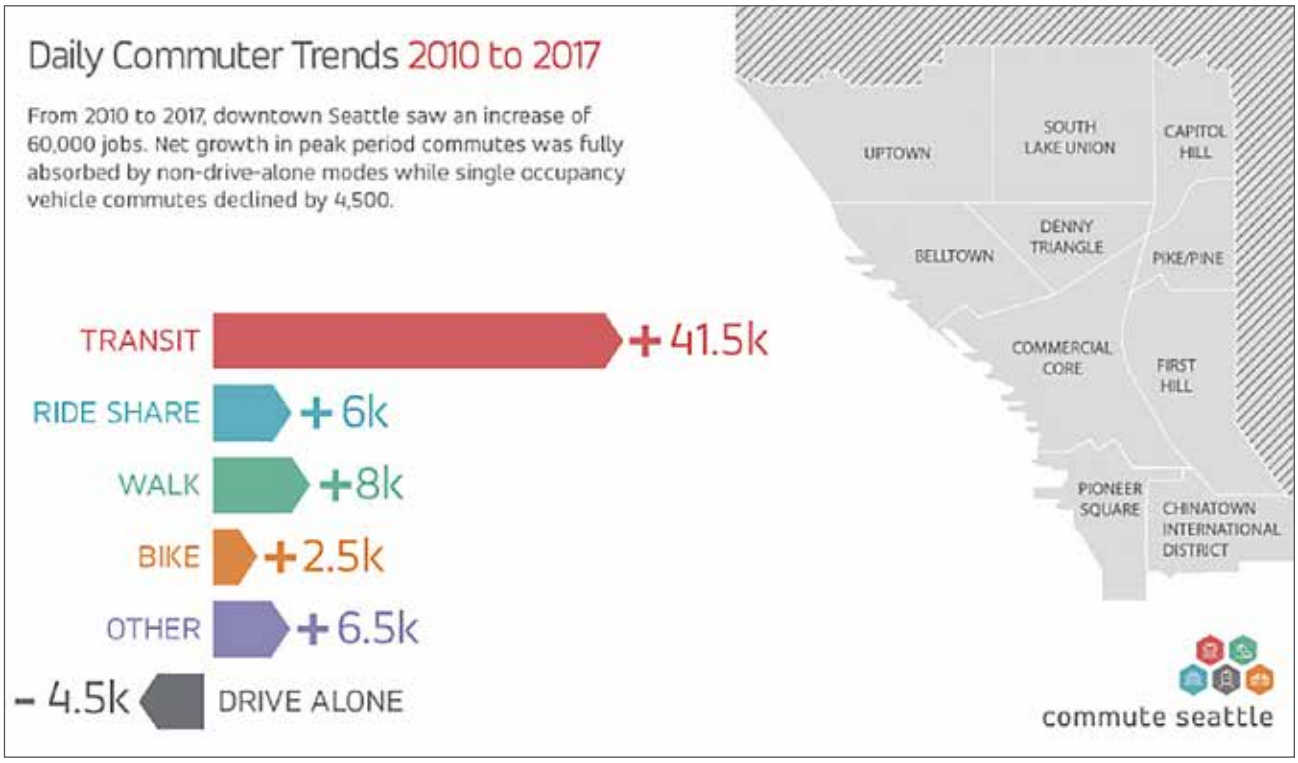
A comprehensive MaaS platform bundles a number of individual TDM strategies, including:

- **Integrated Trip Planning.** By developing a single source for multimodal data feeds, private sector companies can integrate a variety of different services into trip planning applications to show pricing, routing and timing options across a variety of services. Efforts to streamline data for many different modes into singular locations are already underway, such as Google's General Transit Feed Specification (GTFS), which allows transit agencies to publish scheduling information in a common, easily readable format and allows for additional functionality for providing real-time transit updates. In addition to public transit data, this strategy would require incorporating data from private transportation service providers, similar to Google Maps displaying TNC options when looking up route directions, and allow developers of multi-modal planning applications to access those data. This would require leadership of an agency, such as MTC, which would act as the coordinator for data specifications and collection, and agreement and participation by participating transportation providers.

- **Integrated Accounts and Payment.** Integrating fare payment into trip planning apps reduces the complexity in multimodal trip planning, thereby encouraging car-free travel. Ideally, all modes could be paid for using a single app, in which payment information is entered only once upon sign-up. The inclusion of payment options in planning apps reduces the number of steps needed to book trips. This would require cooperation between public and private entities, including trip planning app developers and all of the participating transportation service providers. MTC's role could be to create a structure or formal incentive for standardizing and linking various modes and services. This proposal expands the Clipper Card concept, which uses a singular payment card for many transit agencies, to also include additional options. Clipper currently covers 22 Bay Area transit agencies as well as Ford GoBikes, the Bay Area bike share system. Clipper could provide a singular payment account for the full suite of transportation options in the Bay Area, including bike share and shuttle options. MTC would have to negotiate details with additional transportation providers to expand the integrated payment concept.

- **Bulk Passes.** While they are not necessarily a core component of MaaS, bulk passes/deals are a potentially valuable way to increase the engagement and impact of MaaS. This option could build upon existing monthly passes for transit service and monthly subscription pilot tests by TNCs to provide travelers with a single package to access any participating transportation services.[26] Existing MaaS platforms in Europe, such as Whim and Hannovermobil, have developed programs around bulk offerings. Seattle's public transit system has also had success with bulk transit passes. The Seattle region has experienced an acceleration in its shift toward transit and away from driving alone, and it credits that mainly to a large scale employer-based transit bulk package program **(Figure 1)**.[27] Other demonstrations have also started to provide bulk passes for a variety of modes, such as the Whim app in Finland.[28]

Figure 1. Seattle Daily Commuter Trends



Modeling Methodology

Because MaaS is an emerging concept with no fully implemented examples in existence, there have been no comprehensive evaluations of its impact on vehicle use. Without empirical evidence, it may be impossible for MTC to estimate the impacts of this strategy in a manner that would be defensible for SB 375 purposes.

Some evidence of MaaS impacts on vehicle use is likely to emerge in the next few years, given the current pilot projects and fledgling service offerings. If so, this evidence could potentially be used to estimate strategy impacts regionwide. Evaluation of this strategy would likely require an off-model approach. An evaluation approach would likely consider the impacts of MaaS in different place types. For example, if evaluations of MaaS are done in urban areas with robust transit systems, those impact findings should be applied to transit-rich traffic analysis zones (TAZs) or superdistricts. MaaS impacts are expected to be different in more suburban locations.

Any estimation of MaaS impacts will need to carefully consider the mode shifts. VMT reductions would likely result only when SOV trips are replaced with transit or nonmotorized trips. If a MaaS platform leads to a shift from SOV to TNC trips, VMT could potentially increase. Assuming empirical evidence of MaaS becomes available, the approach to estimate Bay Area strategy impacts would likely involve applying the following factors:

- **SOV trip reduction effectiveness –** among regular users of MaaS, the percent of SOV trips that are replaced with transit or non-motorized trips
- **Penetration rate –** the fraction of adult drivers that are regular users of MaaS

To estimate VMT impacts, MTC could apply these factors at the TAZ or superdistrict level along with population, baseline SOV mode share and average vehicle trip distance.

3. Parking Tax

Description

This strategy could levy an additional fee or tax for off-street parking facility owners or users. Raising the price for parking will discourage vehicle use. It could also potentially raise revenue that could be used for transit or non-motorized transportation improvements. And longer term, higher priced parking will discourage the provision of excessive off-street parking (as long as cities eliminate excessively high minimum parking requirements), which can free up land for other purposes and make destinations more accessible to transit and non-motorized modes. To implement this strategy, a government agency could apply a fee on a parking developer or provider based on the size of the facility or number of parking spaces. Alternatively, a government agency could apply a tax in the form of a flat fee or percentage of parking cost at the point of sale.

Examples

A number of municipalities have implemented parking taxes, including cities in California. The following are examples of parking taxes in U.S. cities.

- **San Francisco.** The City of San Francisco applies a 25 percent tax on all off-street parking. The city has also required parking facility operators to provide receipts and record all customer transactions to make enforcement and auditing more efficient, as San Francisco and other cities (e.g., Los Angeles) have had trouble collecting the tax because many of the transactions had been cash-only.[29] The tax generates $84 million in revenue per year; with the passage of Proposition A in 2006, 80 percent of the parking tax revenue is dedicated to transit, via the San Francisco Municipal Transportation Agency (SFMTA). Note that the parking tax is expected to be a declining revenue source because of "the reduction in surface lots and the increased use of ride sharing."[30]

- **Oakland.** The City of Oakland imposes an 18.5 percent parking tax, the second highest in California after San Francisco. The ordinance also prevents parking facility operators from absorbing the tax or suggesting that the tax would not be added to the cost of a space.

- **Los Angeles**. The City of Los Angeles has had a 10 percent Parking Occupancy Tax on off-street, non-residential parking since 1990. It also requires operators to pass the tax on to users. For FY 2010-11, the City was projected to collect $84 million in revenue from the parking users' tax.[31]

- **Chicago.** The City of Chicago initially imposed a flat tax based on fee ranges (e.g., $1.00 tax for hourly parking fees of $2-$5, $1.75 tax for hourly parking fees of $5-$12, and $5.00 for fees over $12). In March 2013, the Governor of Illinois signed in a law allowing some cities and counties to charge parking taxes by percentage rather than flat tax. In July 2013, Chicago implemented an 18 percent tax on weekends and 20 percent on weekdays for daily parking, and a 20 percent tax for weekly and monthly parking.[32]

- **Pittsburgh.** The City of Pittsburgh, PA, has the highest parking tax in the country at 37.5 percent (since 2009), and from 2004 through 2006, the tax was as high as 50 percent.[33] In 2014 and 2015, the city collected approximately $44 million per year in parking tax revenue.[34] Recently, the Pittsburgh Urban Redevelopment Authority has started redirecting tax revenues associated with new parking developments to affordable housing projects.[35]

VMT Reduction Potential

Assuming a competitive market with limited spillover parking options, private operators will likely pass on new fees or taxes to users, which will reduce parking demand. The impact of reduced parking demand on VMT will depend on the level of pricing, method of implementation and local context, including pricing of other parking options and access to active and shared modes modes. For example, mode shifts will depend on availability and quality of other modal options; one model suggested that drive-alone work trips would decline by 10 percent in low-quality transit areas versus 36 percent in high-quality transit areas.[36]

Parking fees will also have differing impacts depending on trip purpose. In a study of a parking tax in San Francisco from 1970 to 1973 on 13 city-owned garages, researchers found that, when faced with higher parking costs, drivers for shopping trips would reduce the hours they parked while commuters would not park at the facilities at all.[37] A stated preference survey focused on non-work trips found that an increase in shopping center parking prices from zero to 38 to 50 cents would reduce vehicle trips to shopping centers by 7.1 percent to 10.5 percent.[38]

The impact of the increased pricing on parking demand can be approximated using appropriate elasticities. A number of studies have estimated the change in travel and parking demand in response to parking pricing strategies. According to a review by Todd Litman, studies generally show that shifting from free to priced parking typically reduces drive-alone commuting by 10 percent to 30 percent. [39] A TCRP review of parking demand found that elasticities for parking demand range "from -0.1 to -0.6, with -0.3 being the most frequently cited value."[40] This research suggests that applying a 25 percent parking tax – similar to San Francisco's rate – would result in a 7.5 percent reduction in parking demand.

Note that the effects of an increase in parking prices varies widely by location. Also, there is evidence that the introduction of parking prices in locations where parking was previously free will have a greater demand effect than a similar price increase in locations where parking was already priced. Recent modeling for San Francisco, funded by FHWA's Value Pricing Pilot Program, found that VMT reductions in San Francisco resulting from parking fees would be relatively modest because parking prices are already high in parts of the city and SOV mode share is relatively low. The study found that a $3 parking fee implemented throughout San Francisco would reduce VMT by only 1.4 percent.[41]

Table 1. Travel Response to Parking Pricing in Selected Studies

Study	Scope	VMT Reduction
San Francisco County Transportation Authority (2016). *San Francisco Parking Supply and Utilization Study: Summary Report.*	Modeled analysis; Nonresidential, off-street parking, San Francisco, CA	$3 fee reduces VMT by 1.4%
Lari, Adeel, Douma, F., Yang, KL, Caskey, K., Cureton, C. (2014). *Innovative Parking Pricing Demonstration in the Twin Cities: Introducing Flexibility and Incentives to Parking Contracts.* Research report for Minnesota DOT.	City-owned parking contract holders, Minneapolis, MN	Free transit pass + $2 daily fee reduces SOV share from 83% to 68% $7 daily fee reduces SOV share from 72% to 60%
Hess, Daniel (2001). *Effect of Free Parking on Commute Mode Choice: Evidence from Travel Diary Data.* Journal of the Transportation Research Board 1753: 35-42.	CBD, Portland, OR	$6 daily parking fee reduces SOV commute share from 62% to 46%
Van Hattum (2009). *Parking Cash-out: Where "Smart growth" and Effective Transit Intersect.* Downtown Minneapolis Transportation Management Organization.	Seven employer sites, Minneapolis-St. Paul, MN	Parking cash-out reduces SOV travel by 12%

Parking taxes or fees also incentivize developers to build less parking as part of new construction, as long as local governments do not set minimum parking requirements that exceed market demand. Reductions in the available supply of parking will help to discourage vehicle use. The response of developers to a parking tax or fee would vary widely depending on land values, development type, perceived parking demand, etc., but it has been well-documented that the provision of parking adds significantly to the cost of development. The cost to construct typical surface parking is $5,000-10,000 per space, while the cost to construct an aboveground parking structure closer to $20,000 per space (not including the cost of land).[42] Donald Shoup has estimated that local government parking requirements add 32 to 45 percent to the cost of office buildings and 67 to 93 percent to the cost of shopping centers.[43] This illustrates the magnitude of the cost to provide parking, and the strong incentive for developers to reduce parking provision if possible.

Implementation Approach

Local jurisdictions could implement and levy a parking tax or fee. However, it is important to note that this strategy will be more likely to succeed if it is implemented across a wide area to limit the chances that drivers will be able to access proximate cheap or free parking. MTC can coordinate all member counties and municipalities to create a regionally coherent parking fee strategy. As noted above, it would be essential that local governments also modify any ordinances that require excessive provision of parking as part of new development or major redevelopment.

Alternatively, the Bay Area Air Quality Management District could establish an Indirect Source Rule (ISR) that would require developers across the region to mitigate or pay a mitigation fee for emissions associated with facilities that generate or attract vehicle trips, such as a shopping center or a housing development. This ISR would apply only to new developments or major redevelopments and thus would have a very different impact than a fee placed on exiting off-street parking. In particular, the ISR would have impacts in locations experiencing population or employment growth, which tend to be more suburban or exurban areas with available land. On the margin, the ISR would tend to discourage new development that is expected to be accessed primarily by SOV travel and would encourage new development with multimodal access. In this way the ISR would help to discourage provision of excessive new parking spaces.

The impacts and feasibility of a parking fee will vary widely depending on the supply, market rates, land values, alternate mode options, and other factors in and around each location. In locations where off-street parking is already priced, the implementation of a fee would be relatively simple. In locations where off-street parking is free, imposing a new fee would present major challenges. Large parking lots at suburban shopping centers and office parks would need to install access controls or provide payment options coupled with frequent enforcement. This would be impractical and prohibitively expensive in low density portions of the region, and would likely create spillover problems as well. Perhaps the only option in these locations would be to assess a parking fee on the developer or land owner, which would serve the purpose of discouraging the building of excessive parking supply.

At many locations in the region where parking is priced, on-street parking tends to be underpriced relative to off-street parking.[44] This creates the problem of drivers circling excessively to find on-street parking, contributing to local congestion and leaving off-street parking facilities underutilized. Thus, a key component of this strategy would be to increase on-street parking prices so they are commensurate with, or higher than, off-street rates. In addition, some jurisdictions own and operate their own parking facilities, often with low or no parking charges. These jurisdictions should match market rates to help the area manage vehicle travel. Locally levied fees will also raise revenue for the local government.

As noted above, broadly speaking, there are two approaches for implementing a parking fee or tax based on parking use or on parking facility size:

- **Parking Use.** Jurisdictions could apply an additional charge in the form of a flat fee or percentage of parking cost at the point of sale. San Francisco already has a 25 percent tax on commercial off-street, non-residential parking, and Oakland has an 18.5 percent tax. San Francisco also improved the operational efficiency for the parking tax program by requiring generation of receipts for each sale and implementing an auditing system.

  A **parking fee** will likely increase total parking revenues, as parking is a relatively inelastic good; however, as a tax, the government will collect the revenue.[45] A tax on a percentage of cost would only apply to parking that is already priced, which is typically in central business districts. Increasing the cost of parking could reduce the supply of publicly available priced parking over time; however, it may have the unintended consequence of incentivizing parking owners to avoid pricing their parking and bundle parking with rents. A direct tax or fee to parking facility users would have an immediate impact on driving behaviors. Costs applied to the driver, whether as a direct tax or costs passed from the parking provider, would increase the total trip cost and consequently would reduce parking and SOV travel demand.

- **Based on Parking Facility Size.** Jurisdictions could apply a fee to a parking developer or provider based on the size of the facility or number of parking spots. This type of fee would apply to all off-street parking facilities, whether or not the parking spots are used or not and whether or not users pay to park. Because this approach would apply to all parking facilities (rather than just priced facilities), this would help limit drivers who would otherwise just shift to cheaper or free parking options. Also, because this would increase the cost of parking development and management, this approach would likely help reduce the parking supply to match demand.

This could be implemented as a special property tax assessment, which would require reporting and assessment of parking spaces.[46] Alternatively, an Indirect Source Rule fee could be implemented by the Bay Area Air Quality Management District (BAAQMD), which would levy a fee on parking developers based on the expected attraction of vehicle trips. Charges levied on owners based on facility size rather than on use can disincentivize developers from building facilities unless there is enough demand for facility owners to pass the additional costs on to the drivers.

As with any tax or new fee, there will be substantial public and political opposition to this strategy. However, these fees raise new revenue that can be directly applied to transportation improvements, which are often visible and popular with the public (assuming administrative and operational costs are not higher than parking revenue). Some cities have created Parking Benefit Districts in which the revenues raised in those areas are used for transportation improvements in those same areas.

Affordability

For drivers, impacts of a new parking costs will depend on where and how they are applied. In locations with high existing parking prices (i.e., CBDs), the drivers who already pay for parking tend to be higher income, so the new fee would fall on those who can most afford it. Parking fees imposed in locations where parking was previously free might impact some low-income drivers, including low-wage service workers at some retail and office locations. To mitigate these impacts, discounts could be provided for qualified drivers below a certain income threshold.

The price of parking typically does not capture the externalities related to car travel and associated parking. In a 1992 evaluation, U.S. DOT estimated that only approximately 5 percent of commuters across the U.S. pay the full cost of parking, and 1 percent of non-commute trips involved priced parking.[47] While this may not be representative of current conditions in the Bay Area, it suggests that a large share of drivers do not face parking fees at their destinations, and not only in suburban areas; SFMTA's census found that 10 percent of on-street parking spots in San Francisco are unmetered.

Strategy Packages/Bundling

Taxing commercial parking facilities will make free parking more valuable. As noted earlier, this could incentivize property owners to bundle parking with rents. Parking fees should be considered in conjunction with policies to manage parking supply (e.g., reduce or eliminate parking minimums) and limit or prohibit bundled parking.

Modeling Methodology

This strategy should be analyzed using MTC's travel model. MTC currently accounts for parking pricing within its travel model, with the cost of parking added into the overall cost of the trip. The following excerpt from the Travel Model One documentation explains how parking pricing is represented in the model.[48]

The travel model segments space into travel analysis zones (TAZs). Simulated travelers move between TAZs and, in so doing, burden the transportation network. Parking costs are applied at the TAZ-level: travelers going to zone X in an automobile must pay the parking cost assumed for zone X.

The travel model uses hourly parking rates for daily/long-term (those going to work or school) and hourly/short-term parkers. The long-term hourly rate for daily parkers represents the advertised monthly parking rate, averaged for all lots in a given TAZ, scaled by 22 days per month, then scaled by 8 hours per day; the short-term hourly rate is the advertised hourly rate – generally higher than the rate daily parkers pay – averaged for all lots in a given TAZ. Priced parking in the Bay Area generally occurs in greater downtown San Francisco, downtown Oakland, Berkeley, downtown San Jose, and Palo Alto.

When forecasting, we assume that parking prices change over time per a simple model: parking cost increases linearly with employment density. Across the scenarios, therefore, the parking charges vary with employment density.

Because parking is represented in the model, it will be possible for MTC to model the mode shift and corresponding VMT reduction impacts of a parking fee or tax.

MTC's travel model does not distinguish between on-street and off-street parking. The TAZ-specific hourly parking rates described above are assumed to apply to all parking in that TAZ. As noted above, successful implementation of this strategy will require that local governments set on-street parking prices commensurate with off-street. If not, MTC's travel model will overestimate parking price change and overstate the VMT reductions resulting from this strategy.

Depending on what types of parking facilities are taxed and how extensively parking facilities are represented in the model (including unpriced facilities), MTC may need to incorporate baseline parking supply that may not already be accounted for in the model.

4. Ridesharing and Teleworking

Description

This strategy uses technology, incentives and operational improvements to achieve a reduction in travel demand through more efficient use of the Bay Area's transportation network. Reducing travel demand by 3-5 percent can yield a 50 percent drop in congestion-related delays. This is the percent reduction observed on holidays, such as on Indigenous Peoples/Columbus Day, when some residents do not travel to work.[49] Ridesharing consists of two to 15 passengers who share a ride, generally using a participant's own vehicle in the case of carpooling, or a company-provided or leased van in the case of vanpooling. Passengers may share the operating expenses and the driving responsibility. Currently an estimated 16,000 empty seats cross the Bay Bridge on a daily basis, as most vehicle trips crossing the Bay Bridge are made by solo drivers.[50] Filling these seats could allow more people to travel without having to add road capacity to the transportation network. As automobiles transition to connected and autonomous vehicles, pricing and incentives to increase pooling will be critical to preventing a significant increase in congestion.

Teleworking, also known as telecommuting, replaces travel to and from the worksite with telecommunications technologies. A tax credit could be offered to employers implementing telework policies and could reimburse employers for telework-related expenses such as computers, hardware, software, phone systems, remote connections to company servers and broad-band internet services. In addition to saving time and money for employees, teleworking can be an effective strategy for reducing drive-alone commute trips.[51]

Examples

Ridesharing

A number of ridesharing programs are currently active throughout the United States. To encourage carpooling, public agencies and employers provide programs for commuters to find others traveling the same route between their homes and workplaces. Some agencies offer additional incentives, including $2 to $3 credits for the cost of the ride to drivers and riders. In addition, informal carpooling, referred to as casual carpooling or slug lines, emerged in the 1970s in San Francisco and Washington, D.C., and has steadily grown. The examples below focus on programs provided by Bay Area agencies.

- MTC has provided carpool matching for Bay Area residents since the early 2000s. The program started as an online ridematching service and has evolved as new technologies have emerged. In 2014, MTC grew the program by establishing zero-cost partnerships with private-sector carpool matching apps.
- San Mateo County invested $1 million in carpool incentives for weekday a.m. and p.m. peak trips that began or ended in San Mateo County. As part of the pilot program, San Mateo County offered riders $2 off trips with Scoop, a carpooling app, and provided drivers a $2 bonus for driving with Scoop.[52]
- The Contra Costa Transportation Authority implemented a similar program to San Mateo County's but with a total budget of $100,000.[53]

A number of agencies as well as employers provide a fleet or incentives for vanpooling. Vanpooling is currently a qualified transportation fringe benefit under Section 132(f) of the Internal Revenue Code. Section 132(f) provides a way for employees to pay for their commutes by public transit, vanpool or bicycle on a tax-free or subsidy basis. Parking at a fee-based park and ride lot or at the workplace is also an allowable pre-tax deduction. Carpooling, however, is not considered a qualified fringe benefit, since vehicle occupancy could not be verified when the code was written, though recent advances in technology have made verification feasible. MTC's 511 Rideshare program provides incentives for vanpooling, including no long-term financing for leased vans, free bridge tolls for registered vanpools with 11-15 seats, dedicated support services from 511 and up to $500 in gas cards for starting a new vanpool.[54]

Teleworking

- Virginia's Telework Tax Credit provides individual employers up to $50,000 in tax credits each year for telework-related expenses. The tax credit applies to employers who incur eligible telework expenses, such as expenses for computer hardware and software, data processing equipment, telecommunications equipment, and high-speed Internet connectivity equipment, up to $1,200 for each new participating employee in telework. In addition, the credit can be used for up to $20,000 to conduct a telework assessment in order to assess equipment and training needs, barriers/issues, and develop telework policies and procedures, etc. The credit is subject to specific requirements, such as requiring the employer to have a signed telework agreement with each new teleworking employee and to file an application to reserve a portion of the credit, which is limited statewide to $1 million per year.[55]

VMT Reduction Potential

Ridesharing

MTC offered a "First Trip Credit" in the first half of 2018 to carpool riders and drivers who downloaded the Scoop carpool app and took a first trip. Over 9,000 riders and drivers used the credit and took 267,000 one-way person trips as members of a carpool during the six-month time period. These trips included the first subsidized trip and subsequent trips made during the survey period. About 75 percent of the participants were riders, thereby reducing vehicle trips, and of those, 60 percent would have otherwise driven alone or been driven by a ridehail service if they had not used the carpool service. The estimated cost per vehicle trip reduced was $1.85.

In San Mateo County the $1 million allocation resulted in about 175,400 vehicle trips reduced. The average daily expenditure for incentives was $3,000 for an average daily vehicle trip reduction of about 800 cars.[56]

Teleworking

Teleworking can reduce congestion during peak periods by eliminating trips entirely. According to the Society for Human Resource Management, results from a 2014 survey reveal that 48 percent of employers offer one or more flexible work arrangements to employees, including telework, flextime and compressed work weeks.[57] The Virginia Telework program conducted an evaluation of its program through surveys of participating employers and found that 5 percent of participating employees had never teleworked previously. Of the 15 participating employers who responded to the survey, they estimated a daily VMT reduction of approximately 9,000 miles.

Implementation Approach

Ridesharing

A number of agencies and employers have supported ridematching efforts for many years with limited success. However, new apps are making it easier to match riders to drivers and are optimizing routes to avoid lengthy pickups and drop-offs. Agencies can support the development and deployment of these apps to encourage increased ridesharing.

To add more impact, carpooling tax incentives could be administered at the state and federal level. With occupancy technology integrated into most carpooling apps, the number of people in a vehicle can be verified, and therefore carpooling tax benefits could be added under Section 132(f). The State of Washington offers a Commute Trip Reduction Tax Credit for all employers and property managers who provide financial incentives to their employees for ridesharing, carsharing, using public transportation and nonmotorized commuting. This tax credit is valued at up to $60 per employee per a fiscal year, up to $100,000 per employer/property manager annually.[58]

Lastly, increasing efficiency and flow in carpool/ high-occupancy vehicle lanes could be accomplished through operational improvements, enforcement and occupancy policy changes. Operational improvements on highways and arterials, including transit signal priority, bus queue jump lanes or bus-on-shoulder lanes, can give time savings advantages to high-occupancy vehicles and can be highly impactful in reducing travel demand.

Teleworking

The State of California could offer state tax credits to businesses that implement telework policies and incur operational expenses. Employers could be required to submit documentation for the number of days each employee worked from home per year, as well as their approximate commute distance, for purposes of estimating emissions and congestion savings. This program could also be administered as an incentive program, with a fund source that is administered by a local or regional agency.

Public agencies could also support programs to offer a network of offices/work spaces, either for free or a fee, to any member of the public who could work remotely but is unable or would prefer not to work from home. They could subsidize existing co-working spaces to offer spaces to any member of the public who wishes to work remotely. Local agencies or states could also consider additional funding for public libraries to establish co-working spaces, maker-spaces, etc. Public libraries may also consider ongoing revenue streams, such as fee-based or membership-based usage of these spaces, to fund operations beyond the initial construction and establishment.

Affordability

Ridesharing

Expanded ridesharing offerings can provide travelers access to more affordable commute options, particularly for non-drivers and those who shift from driving alone. Additionally, there are time savings for vehicle trips with access to HOV or HOT lanes.

Teleworking

Telework directly reduces employee transportation costs and increases time savings. There may be new overhead costs for the employees to work remotely, including operating and equipment costs that are typically covered when working in an office. However, employers could return savings from reduced office operating costs to employees. Additionally, if a tax credit or other incentive for telework is provided, employers could help defray employee telework expenses using those credits or incentives.

Strategy Packages / Bundling

If considering ridesharing and teleworking as a bundled measure, the effect each strategy has on each other should be considered. For example, increased teleworking could reduce the pool of commuters that might consider ridesharing on a daily or overall basis. Additionally, both strategies can be included as options as part of broader commuter trip reduction programs.

The other strategies identified in this paper also could provide support to this strategy. Carpool matching could be leveraged as a choice within a suite of MaaS options. The pricing strategies presented in the next section could include discounts to encourage residents to pool with others. For example, employers could offer preferred parking, reduced parking fees, or taxes for carpool and vanpool vehicles to incentivize ridesharing. Trip reductions from ridesharing also could be maximized by implementing in areas with tolling options; reduced tolls (such as HOT lanes) could be offered for high-occupancy vehicles.

Modeling Methodology

Ridesharing strategies that provide financial incentives to commuters for carpooling can be modeled in MTC's travel model while teleworking strategies require off-model methodologies. The approaches presented below are based on research of traditional policies and programs offered in the past. However, it is possible that newer programs that leverage advancements in technology could increase adoption of these offerings beyond the assumptions used in the approaches described below.

Ridesharing

This strategy should be analyzed using MTC's travel model. The perceived operating costs for carpool trips are represented in the travel model. Therefore, mode shifts resulting from a tax credit or other financial incentive provided to commuters can be modeled.

Teleworking

To assess the VMT impacts of this strategy, the share of employers that newly offer a teleworking option to their employees must be determined based on the policy scenario being analyzed. This employer adoption rate can be based on a review of similar existing telework policies.

Once the share of employers offering teleworking due to the policy is estimated, the share of employees that take up teleworking must be determined. A review of studies conducted in 2007 found that 50 percent of employees are in positions that can telework and, if offered the option, 50 percent of employees would telework an average of 1.5 times per week.[59] Using these assumptions, the total annual trips avoided by new teleworking employees can be estimated and multiplied by the average vehicle trip distance to calculate VMT reduction. Because teleworking is particularly appealing to employees who live far from work, MTC should consider that trip distances for employees who telework are likely longer than the overall average vehicle trip distance.

5. Toll All Freeways and Bridges

Description

This strategy involves collecting tolls on all freeways and bridges in the Bay Area. Tolls could be fixed per roadway segment or charged based on distance traveled. Toll rates could be increased at peak periods or other highly congested periods to reduce congestion and encourage use of carpooling or transit. Charging drivers for use of the road network will reduce the demand for driving SOVs and raise additional revenue that can be used to improve transit and other alternatives to SOV travel, assuming prices are set appropriately.

Examples

This strategy has not been implemented in any urban area in the United States, although some European countries have universal tolls on all freeways, with variations described below.

- **Austria.** Vehicles under 3.5 tons are required to purchase a sticker, for specific time periods (10 days, €9, 2 months, €26.2, 1 year. €87.30) for access to limited access highways in the country. Vehicles over 3.5 tons are subject to mileage-based fees. In addition to the highway tolls, there are additional tolls for facilities, such as bridges and tunnels on highways in Austria.[60]
- **France**. All limited access highways are tolled, based on segments.[61]
- **Switzerland.** Annual sticker required for use of all limited access highways for all vehicles (€40 annually).[62]

Seattle recently announced plans to study tolling of all city roadways, as part of efforts to reduce traffic congestion and GHG emissions.[63] While tolling of all freeways does not exist in the United States, many states and regions level tolls on individual roadway facilities. Currently, eight Bay Area bridges have tolls, most with toll rates of $5 for a SOV and $2.50 for a carpool (the Golden Gate Bridge has higher tolls). In addition, many state DOTs are converting HOV lanes to high-occupancy toll (HOT) lanes, amid national decreasing carpool rates leading to excess capacity on HOV lanes. Bay Area Toll Authority (BATA) is currently working with Caltrans to convert some existing lanes to HOT lanes and construct new lanes to create a seamless regional network of HOT lanes in the region.[64]

In the Bay Area, four locations currently have HOT lanes: Interstate 580 in eastern Alameda County, Intertate 680 in southern Contra Costa County, Interstate 680 in Alameda County (Sunol Grade), and state Route 237 in Santa Clara County. Other California tolled express lanes can be found on Interstate 15 in San Diego and State Route 91 in Riverside and Orange counties. Tolls on the I-15 express lanes vary depending on congestion levels; the SR 91 express lanes use a variable pricing system based on the time of day. Some facilities allow low-emission vehicles to use HOT lanes for free, however caps on these vehicles are in place as they become more popular.

VMT Reduction Potential

The potential of this strategy to reduce VMT depends on the magnitude of the tolls. As the price of driving increases, VMT will decrease as drivers shift to other modes, shorten trips or forego discretionary trips altogether. Research on fuel price elasticity can provide a starting point for estimating VMT effects. A report published by the Federal Highway Administration synthesized several prominent studies on travel demand relative to fuel cost, finding a wide range in elasticities, ranging from -0.1 to -0.63.[65] These values imply that doubling the cost of driving would reduce driving by 10 to 63 percent.

The VMT impacts of tolling will differ from the impacts of fuel prices or VMT fees. On one hand, tolling may be more likely to deter vehicle travel because the cost is more directly felt by the user. On the other hand, some drivers will be able to avoid highway and bridge tolls by using surface streets, limiting impacts on VMT. For a limited subset of trips, tolls might actually increase VMT as drivers would follow more circuitous routes to avoid tolls.

In 2009, the City of Seattle commissioned a study on system-wide tolling. The study estimated a drop in per capita VMT from 24.1 (2009) to 21.7 (2030) with the variable priced tolling on all freeways and principal arterials in the Seattle metropolitan area. The tolling scheme would collect $6.1 billion in revenue annually.[66]

Variable or peak period tolling has been shown in some cases to reduce congestion, however tolling has not been used explicitly as a strategy to reduce VMT. In some situations, converting HOV to HOT lanes can induce VMT as these lanes increase capacity by allowing SOV drivers to pay to drive in express lanes.[67] In other parts of the country, tolling and increasing toll rates have had minimal impacts on VMT.[68]

Although priced individual lanes have not had significant impacts on VMT reductions, tolling entire

highway facilities would be much more likely to result in VMT reductions. An assessment of increased charges during peak periods on the San Francisco-Oakland Bay Bridge in 2010 suggests that "every dollar increase in average toll during the time series [approximately one year before and after the fare increase took place] was associated with a loss of 103,600 motorized vehicles crossing the bridge each month." The study also showed a high reduction in carpool vehicles once carpool rates changes from free to a discounted rate.[69] If the bridge toll increases are coupled with significant transit improvements as well as carpool options, particularly in the Golden Gate, Bay Bridge, and San Mateo/Dumbarton bridge corridors, the potential for VMT reduction is high.[70]

Implementation Approach

BATA could implement a regional tolling strategy, in cooperation with Caltrans and local governments. New tolls and increases to existing tolls will require legislation from the State and approval from local voters. Implementation of this strategy throughout the Bay Area would be challenging and require many years of planning and coordination.

MTC could expand its current plan to develop a regional HOT network to include all lanes of all freeways. Tolls could be placed on all freeways, charged by distance/segments of freeway, as measured by entry/exit points. In some cases, parallel local routes could be charged to prevent local spillover traffic. BATA could collect tolls using the all-electronic tolling highway system currently in place, expanding toll collection as checkpoints are built. All vehicles would be charged for all freeway segments as they pass through checkpoints. At each checkpoint, drivers pay a discounted rate by using an in-vehicle transponder that communicates with checkpoint sensors (FasTrak®) or are billed retroactively at a higher price point using a pay-by-plate method. The pay-by-plate method provides access for vehicles without in-vehicle transponders. MTC can modify the sensors on these roads to charge vehicles in all lanes, as opposed to express lanes.

Another option would be to consider using satellite connected in-unit transponders to collect tolls based on distance traveled on the freeways. All vehicles would have in-unit transponders connected to satellite systems that track vehicle miles on tolled roads. This collection method is identical to one of the proposed methods used to measure VMT, though limited to specific roads. California could require that all vehicles include the essential technology to be included on all cars sold in the state by 2035 (or earlier). Additionally, owners of older vehicles (or vehicles purchased outside of California) could be required to install after-market metering devices enabling the same functionality (providing a grace period for all vehicles to come into compliance). In-vehicle systems would automatically report miles traveled on tolled roads each month to a central agency. Invoices would be generated and sent to the registered owner of the vehicle to collect fees on a monthly basis. Requiring all vehicles to carry satellite transponders to measure distance will be very difficult to enforce for all vehicles driving on Bay Area roads, especially those that originate outside of California. Unless there is a national requirement for location-based tracking software included in all registered vehicles, this collection method would most likely not be feasible.[71]

Figure 2 below shows currently planned Bay Area road pricing projects.

Figure 2. Map of Road Pricing Improvements, Plan Bay Area 2040

Generally speaking, most people don't want to pay more for a service unless there are clear benefits involved. Linking tolls to specific projects or funds with visible benefits may increase public acceptance of the tolls. Bay Area residents will also likely be more supportive of a pricing strategy that includes higher-priced express lanes than a flat fee for all lanes, as this allows drivers to make choices that best meet their needs.

A recent poll indicated that toll increases on Bay Area bridges would be a popular tactic to raise money for transit.[72] This likely indicates that current bridge pricing is too low and Bay Area residents/workers expect that higher tolls could reduce travel times and/or improve transit options. Compared to the Bay Area, tolls for tunnels between New York and New Jersey are significantly higher: $12 and $10.50 for peak and off-peak hours, respectively, with carpool vehicles charged $6.50 during peak periods. MTC can also consider variable pricing for bridges, based on congestion, or other factors. MTC could also consider holding toll rates constant on lightly-used bridges and increasing tolls only on the most congested bridges.

Toll roads are not a new concept, however, toll collection methods are evolving over time. Offering options for payment will likely help improve public acceptance by allowing drivers to pay tolls in a way that satisfies their preferences regarding convenience and privacy.

MTC would need to conduct studies, possibly in partnership with municipalities to identify risks of traffic diversion from tolled freeways to local roads. Such diversion can increase wear and tear on local roads, reduce safety, increase air and noise pollution, and generally reduce the quality of life among impacted neighborhoods. In areas where traffic diversion is a threat, the local municipality can consider restricting freight access; applying tolls to parallel local roads; establishing one-way streets during peak periods; or installing traffic calming infrastructure to reduce an influx of vehicles seeking alternative, free, routes. The City of Seattle found some vehicle diversion to local streets when modeling a scenario of tolling all freeways and principal arterials in the metropolitan area.[73] A real-world study of heavy-duty freight truck diversion to local roads as a result of increased tolling on the Ohio Turnpike found a significant increase in freight traffic on local roads, which would pose serious threats to safety, air/noise quality, street maintenance and congestion.[74]

HOT lanes in California have largely been well received, however this is likely because drivers see HOT lanes as providing a choice: the opportunity to pay extra when desired to increase travel times or the opportunity to drive for free.[75]

Affordability

Charging tolls for freeways may disproportionately impact low-income individuals who have few alternatives to driving on the freeways, especially low-income individuals in areas without feasible transit alternatives. This highlights the need to couple this strategy with the improvements in transit and other alternatives to SOV travel. The tolling scheme could be structured to provide discounts for low-income households, similar to discounted programs offered by utilities for low-income households.

According to surveys and focus groups conducted by MTC in 2012, 62 percent of low-income and minority respondents reported a willingness to pay for occasional use of HOT lanes.[76] A similar response was reported by the San Diego Association of Governments prior to its construction of HOT lanes on I-15.[77] Studies of the SR 91 HOT lanes in Southern California show that approximately 75 percent of HOT lane users are from low- or middle-income households.[78]

Fee collection can be a challenge for unbanked individuals. Currently, FasTrak transponders allow users

to load the transponders with cash, a practice that should be continued. The prevalence of unbanked individuals may be less significant in future years, but it still will be important to provide options for these individuals.

Increased tolls can also impact the price of goods and services, as the price to ship goods becomes more expensive.[79] MTC could consider reduced tolls for heavy-duty freight vehicles and commercial service vehicles.

This strategy would need to be accompanied by an increase in transit service and potentially vanpools along freeway routes to provide alternatives to use of SOVs. Transit riders on tolled roads can be offered monetary rewards or credits to encourage transit ridership and help offset the cost of driving on tolled roads when needed. The city of Los Angeles manages a Transit Rewards Program, where transit riders can earn a $5 toll credit after taking 16 one-way trips on express lane corridors.[80] Additionally, MTC can consider dedicating lanes for bus rapid transit, microtransit or other higher capacity vehicles where appropriate.[81]

Strategy Packages/Bundling

As discussed above, significant transit system improvements should accompany this strategy to provide viable alternatives to SOV travel on tolled facilities. This strategy could be bundled with the Free Transit strategy, using toll revenues to offset the loss of transit fare revenues.

MTC may consider incorporating other TDM strategies with freeway and bridge tolling. Dynamic pricing can help to manage peak-period demand and maximize efficient use of the roadway system. Surcharges for TNCs could be warranted if the use of these services continues to grow rapidly and threatens regional VMT reduction goals.

Modeling Methodologies

This strategy should be analyzed using MTC's travel model. The model currently includes both bridge tolls and express lane tolls. Model analysis of this strategy would require coding all applicable roadway links as tolled facilities and then setting toll levels in the model appropriately.

The appropriate toll levels for modeling should be developed using an iterative process that seeks to reduce VMT and raise revenue for transit while minimizing diversion onto local roads and impacts on low-income drivers. As a starting point, MTC should consider current Bay Area HOT lane tolls. For example, in 2015 the southbound express lanes on I-680 charged SOVs between $0.30 and $7.50 for the 14 mile extent of the lanes, or between $0.02 and $0.54.[82] [83]

Other modeling assumptions would include:

- Increase in bridge tolls. A recent poll suggested majority support for a $3 increase in bridge tolls, phased in over 10 years.
- HOV discounts. HOV 3+ vehicles should pay a reduced toll rate, similar to the current practice on Bay Area bridges.
- Transit vehicles pay no toll
- Heavy-duty trucks would pay tolls according to a schedule based on the number of axles or truck gross vehicle weight rating. For reference, Bay Bridge tolls are currently $15 for 3-axle vehicles, $20 for 4-axle vehicles and $25 for 5-axle vehicles (e.g., combination trucks). New toll rates on highways should not increase as dramatically for heavy trucks, given that they have few or no alternatives and are closely tied to the economic health of some industry sectors.

If this strategy were coupled with transit system improvements, both sets of changes should be modeled together. Future improvements should be coded to the transit network, including system expansions, travel time reductions and frequency increases. The travel model will then better capture those travelers who divert from SOV to transit mode due to both the freeway and bridge tolls and the transit improvements.

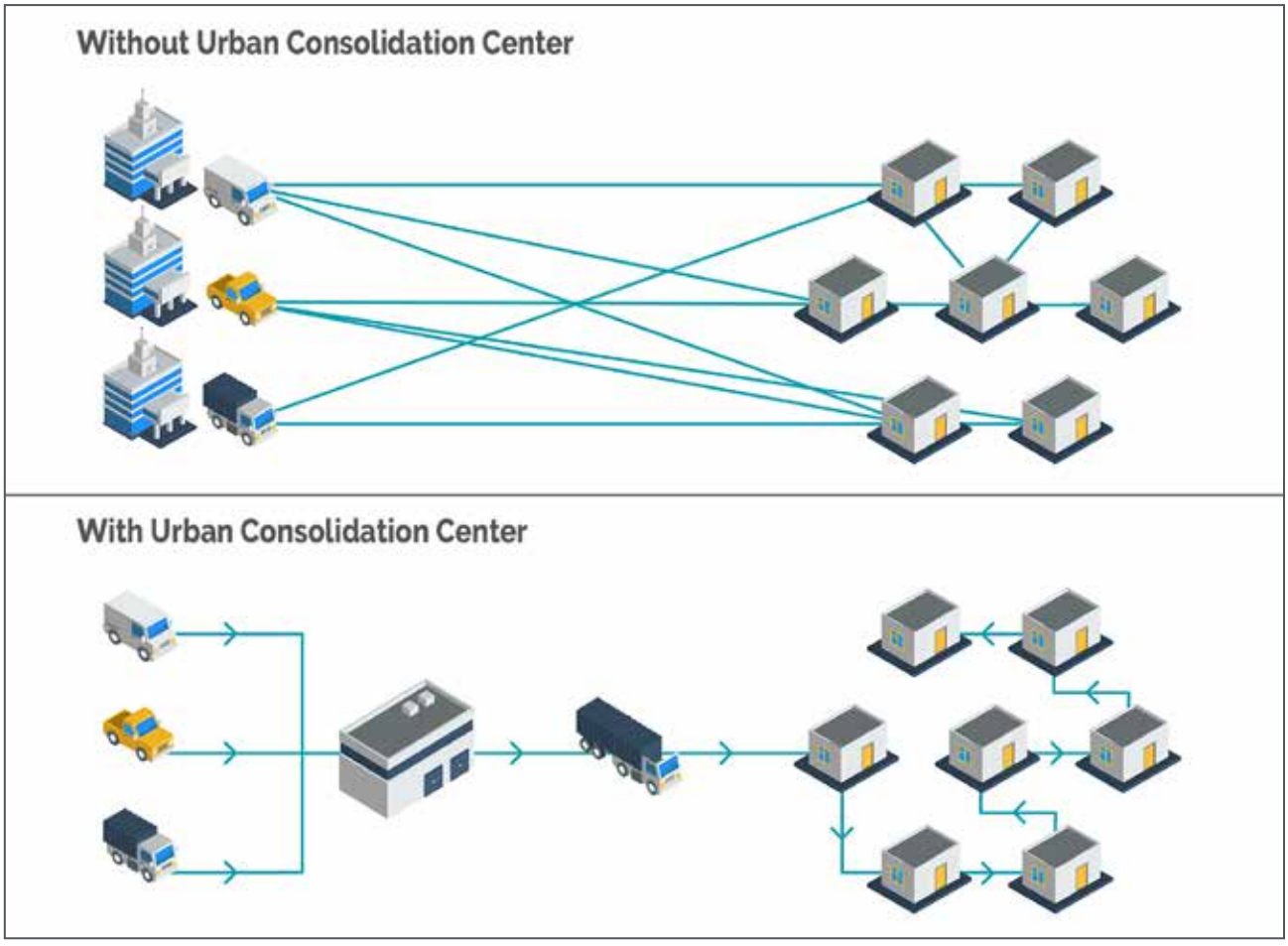
6. Parcel Lockers and Freight Consolidation Centers

Description

Freight consolidation centers help to reduce truck VMT by collecting and storing freight at central locations to enable more efficient delivery. This strategy can help to partially mitigate the urban truck VMT caused by the rapid growth of online retail sales. Consolidation can occur at different scales. This strategy includes urban consolidation centers, microconsolidation centers and parcel lockers.

Urban Consolidation Centers (UCCs). UCCs are distribution centers where suppliers can send packages for delivery consolidation. Delivery vehicles sort packages and maximize truck capacity for efficient delivery. UCCs are typically located outside of an urban area, as they require a fairly large building footprint.

Comparison of UCC and Standard Delivery System



SOURCE: McKinsey & Company. An Integrated Perspective on the Future of Mobility, Part 2: Transforming Urban Delivery. 2017.

Microconsolidation Centers (MCCs). MCCs are smaller consolidation centers which allow redistribution of goods from larger vehicles to bikes and other modes.[84] MCCs require less space than UCCs and can even operate in shared, temporary and or/unconventional spaces, such as unused parking lots at night, because deliveries can be transferred directly from a heavy-duty freight truck to smaller vehicles.

Parcel lockers. Parcel lockers are secure lockers where customers can pick up medium-sized packages using an electronic code. Some lockers are climate controlled, allowing customers to pick up groceries or other items that need to be kept at a cool temperature. The United States Postal Service (USPS) and private delivery companies, such as Amazon, currently provide parcel lockers as an option for delivery. USPS requires customers to register for an account prior to using USPS lockers, while registration is not required by Amazon. USPS's registration, combined with other operational processes, likely contributed to a slow adoption rate.[85] From a customer's perspective, conveniently located lockers provide a free and secure alternative to home delivery, especially in unsecured buildings. Lockers can be located in public buildings (such as libraries) or in highly trafficked commercial buildings (such as grocery stores). Customers can combine trips to a store/other frequented destination with a package pickup. Parcel lockers are easy to install, inexpensive to operate and have been successfully implemented in cities across the world.[86] There are over 2,000 Amazon lockers operating in the United States.[87] In China, parcel lockers accept approximately 6 percent of all deliveries.[88]

Examples

UCCs, MCCs and parcel lockers have been constructed in cities around the world, with some evidence of success in reducing VMT and congestion. Many of the documented examples and associated research are in Europe or Asia. UCCs, MCCs and parcel lockers are typically privately owned and operated. The following two cases are examples of public-private partnerships.

- **London MCC.** The Camden borough of London launched a MCC to deliver parcels to Council offices as a pilot project aimed to reduce congestion and emissions in London. The center, operated by DHL, receives deliveries from over 180 suppliers and delivers them to over 250 separate addresses in London. A study of the center found reductions of 46 percent of VMT and 41 percent of CO2 emissions from delivery vehicles after implementing a UCC to consolidate deliveries for Camden and Islington Borough Council offices.[89]
- **West Sussex, UK Parcel Lockers.** West Sussex tested the operation of Amazon lockers at three library locations, in exchange for fees to use the library space. There were no demands on library staff and the lockers were well-received by customers.[90] Most private parcel lockers are located in private buildings (e.g. Amazon Lockers in Whole Foods stores).

VMT Reduction Potential

There have been no rigorous empirical studies of the VMT impacts of regional pilots for UCCs and parcel lockers in the United States. Researchers have examined some individual examples of consolidation centers and also modeled high-level impacts at a regional level. Much of the research to date has occurred in Europe and Asia, and many studies rely on modeling.[91] [92] This research suggests that UCCs can have a substantial impact on vehicle travel and emissions. According to one study of a 371 square meter facility in an existing warehouse in Bristol, UK, "more than 16,224 vehicle trips have been eliminated since its opening, resulting in 158 tons of CO2 saved, 5,136 kg of NOx saved, and a 79 percent reduction in delivery trips for retailers."[93] A McKinsey paper estimated that UCCs can generally allow companies to reduce mileage by 45 percent to deliver the same amount of goods, though the decreased shipment cost may create some amount of rebound that would mitigate those.[94]

Research suggests parcel lockers also have the potential to reduce VMT and emissions. A modeling analysis of hypothetical populations showed that parcel locker use can contribute to a 66 percent reduction in emissions per parcel for urban areas and a 91 percent reduction in exurban ones.[95] A sensitivity analysis of the travel model revealed that the convenience of the parcel lockers remains preferable so long as the distance the customer needs to travel by car to reach the locker does not exceed 0.6 miles in an urban context and 3.7 miles in a suburban one. (This study assumed users pick up their packages by car, but emissions reductions would be even greater if done by walking or biking). These high reductions are corroborated by another study, which estimated that parcel lockers could reduce vehicle emissions by up to 70 percent in the densest, most conveniently located areas.[96] While not included in these study estimates, it is worth noting that parcel lockers not only reduce VMT but can also reduce emissions from delivery vehicles idling while the driver carries a package to the final destination. Parcel lockers also reduce the percentages of unsuccessful deliveries (from the receiver not being home to collect the package), which require additional miles for second and third attempt deliveries.[97] According to research by UPS, 50 percent of shoppers are interested in receiving packages at alternative delivery locations if hours and fees were favorable.[98]

A study of real-world parcel locker delivery company InPost, which operates in Poland, also showed large emission reductions. Comparisons of InPost's lockers with an at-home delivery service saw a roughly 95 percent reduction in delivery emissions per parcel by using the lockers.[99]

For additional VMT and emission reductions, low-emission delivery services can be employed to transfer packages from parcel lockers to customers. The cargo e-bike company, The City Hub, claims that each of its bikes can replace two standard delivery vehicles, yielding a high reward per vehicle, as they can often bypass traffic and reach destinations more quickly than standard delivery trucks.[100] E-bike delivery has "already replaced up to 60 percent of inner-city vehicle routes in some European countries."[101] The combination of UCC/MCC and parcel lockers creates an ideal operating environment for small, electric first-last mile delivery vehicles, including e-bikes. Transitioning freight to these carriers as opposed to large or even mid-sized trucks could have a powerful impact on emissions, given that the per-mile emissions rates of each are at opposite ends of the spectrum.[102]

Implementation Approach

UCCs, MCCs and parcel lockers are primarily developed and operated through private entities. Local governments can encourage UCCs and MCCs through preferential zoning or property tax relief or identifing unconventional spaces for MCC temporary operations.[103] MTC can provide guidance for local governments to encourage UCCs, MCCs and parcel lockers.

Although the responsibility of implementation of UCCs and parcel lockers falls largely to private entities, MTC and local governments can encourage development in a number of ways.

- **Guidance.** MTC could study delivery patterns and appropriate areas for UCC, MCC and parcel locker locations. Too few locations will be insufficient to consolidate and distribute deliveries over the region, and too many locations would result in minimal VMT reductions.
- **Incentives for Developers/Property Owners.** MTC or local governments could provide financial incentives to developers or property owners to install and operate parcel lockers. Private companies (such as Amazon) often pay property owners fees to include the lockers onsite but additional subsidies may help expedite installation. As mentioned previously, MTC should first determine an appropriate number of UCCs, MCCs and parcel lockers to maximize VMT reduction potential.

- **Requirements for Developers.** MTC or local governments could also require a goods movement plan or consideration for new developments, including residential.
- **Delivery Movement Restrictions.** Deliveries could also be restricted to certain time periods in specified areas. Deliveries would be able to be dropped off at UCCs/MCCs at any time, whereas delivery to final destinations could be restricted to off-peak.[104] Peak-period deliveries could also be charged with a congestion fee.

UCCs are typically located outside of urban areas, where there is ample space to manage storage, sorting and distribution. MCCs can be located in urban areas, and potentially operate in temporary spaces. In order to be effective, parcel lockers should be located in high-traffic areas. MTC can work with local governments to identify suitable areas for locker installation and encourage use. Additionally, local governments could provide space in public buildings, such as libraries, or subsidize installation costs. In Japan, local governments currently subsidize parcel locker installation costs by 50 percent in 500 locations, such as train stations and convenience stores.[105]

Establishing parcel lockers as a mainstream option for deliveries should be well-received by the public, assuming that standard delivery options are still available. MTC should be fully transparent regarding any subsidies or fees for UCCs/MCCs and parcel lockers, especially for those on public- or government-owned property.

Affordability

This strategy should have no significant affordability impact. UCCs, MCCs and parcel lockers can reduce the cost of shipping and relieve congestion on local roads. The use of parcel lockers would be optional for residents and should not impose any financial burdens.

Modeling Methodology

This strategy would likely necessitate an off-model analysis approach unless the commercial vehicle component of MTC's model is updated. Currently, MTC's model relies on previous model elements to represent commercial/freight vehicles, as follows:

> *Specifically, commercial vehicle demand is represented using methods developed for Caltrans and Alameda County as part of the Interstate 880 Intermodal Corridor Study conducted in 1982 and the Quick Response Freight Manual developed by the United States Department of Transportation in 1996. When combined, these methods estimate four classes of commercial travel, specifically: "very small" trucks, which are two-axle/four-tire vehicles; "small" trucks, which are two-axle/six-tire vehicles; "medium" trucks, which are three-axle vehicles; and, "combination" trucks, which are truck/trailer combinations with four or more axles.*[106]

The travel model does not represent the individual segments of truck travel that would be influenced by expansion of UCCs/MCCs and parcel lockers.

Off-model analysis of this strategy will be difficult because of the very limited empirical evidence of the strategy impacts and a high degree of uncertainty regarding the extent of deployment of UCCs/MCCs and parcel lockers. An approach to analyzing parcel lockers would involve the following steps:

1. **Define portions of the region where parcel lockers are feasible.** Parcel lockers will be feasible only in denser areas, so a TAZ or superdistrict-level threshold should be selected based on population density.
2. **Estimate number of daily parcel deliveries and parcel delivery trucks per single-family and multi family dwelling unit, in affected areas.** Recent research has measured parcel delivery frequency in

different urban contexts and could be applied to the Bay Area.

3. **Estimate parcel delivery truck VMT serving affected areas.** This calculation can be informed by research involving simulations of parcel delivery truck tours as well as interviews with parcel delivery companies. Research has estimated the typical daily VMT for parcel delivery trucks in different urban contexts as well as the number of deliveries per day. This research could be used to estimate the daily parcel delivery truck VMT serving the affected areas.
4. **Estimate fraction parcel deliveries affected by parcel locker deployment.** This key assumption reflects the extent of parcel locker deployment and usage, and should be informed by experiences in Europe and Japan. This parameter will have a high degree of uncertainty and should be subject to sensitivity analysis.
5. **Calculate reduction in parcel delivery truck VMT.** Combining the results of step 3 and step 4 can estimate the VMT reduction resulting from this strategy.

Overall, analysis of this strategy would involve more assumptions and uncertainties than the analyses of other strategies. Further research would be needed to determine if reporting an estimate of VMT reduction is warranted. If not, the strategy could still be describe and pursued, with impact analysis to come at a future date.

7. Required TDM Plans and Strategies for New Development

Description

Developers could be required to create and implement a plan for reducing single-occupancy vehicle trips generated by the new developments. Developers could also be required to transfer the implementation of any plans to subsequent property owners. Local governments could be required to review, approve and monitor TDM development plans to ensure compliance.

With the upcoming implementation of Senate Bill 743, there will be an increased emphasis on the use of TDM strategies in the review and processing of land development and transportation projects. As a result of SB 743, vehicle miles traveled (VMT) will replace Level of Service (LOS) as the primary performance measure for the determination of significant transportation impacts under the California Environmental Quality Act (CEQA).

Examples

Several cities and counties have implemented TDM requirements for new developments, including San Francisco; Buffalo, NY; Arlington County, VA; and Fairfax County, VA.

- **City/County of San Francisco.** San Francisco's SHIFT program is designed to work with developers to provide more onsite amenities that will encourage smarter travel options so people can get around more easily without a car. The primary focus of this program is to reduce VMT associated with new developments. The SHIFT Program applies to nearly all types of new development and changes of use. Developers identify trip reduction targets for applicable developments and choose TDM strategies to meet the target, which are reviewed by the City/County of San Francisco. Ongoing monitoring and reporting is required to ensure compliance. The program was adopted by the San Francisco Planning Commission in February, 2017, and impacts have not yet been estimated.[107] [108]
- **City of Buffalo, NY.** In 2016, the City of Buffalo passed an ordinance requiring developments over

5,000 square feet and renovations over 50,000 square feet submit a TDM plan as part of development approval. TDM plans are required to include (1) an estimate of travel demand by mode (vehicular, transit, pedestrian and bicycle) for the proposed development, and (2) strategies to be implemented that will reduce vehicular travel demand (vehicle trips) and therefore parking demand. Developments located within ¼ mile of a rail station are required to reduce vehicle trips and parking demand by 20 percent; all other proposed developments/locations are required to reduce vehicle trips and parking demand by 10 percent. Developers can choose from a list of TDM strategies or propose an alternative strategies if approved by the City. Developers are required to pass along the TDM Plan requirements to the property owner, who must submit status reports every two years thereafter, and may also be required to implement additional strategies to meet the 10 percent or 20 percent reductions in VMT. The first status reports will be submitted later in 2018; as such, impacts have not yet been estimated.[109]

- **Fairfax County, VA.** Fairfax County requires developers to encourage the use of transit, ridesharing, biking, walking and other alternatives in order for their development plans to be approved. Various factors, such as accessibility to transit and type of development, help to define the level of TDM participation needed. The TDM Plans are tied to the land, so that if/when the developer sells the development to a property owner upon completion of construction, the TDM requirements are transferred to the new property owner. Monitoring, reporting and remedying activities are defined and include requirement of a survey (of residents/site visitors) every three years and trip counts annually or biennially (depending on location). After three consecutive trip counts demonstrate that the development site goals have been met, the property owner is released from the TDM requirements.[110] Published results were not available.

- **Arlington County, VA.** Arlington Transportation Partners (ATP) and Arlington County Commuter Services manage a program that coordinates the design and implementation of TDM projects in large building projects, called TDM for Site Plans. Staff in this program work with developers and property managers to increase the availability and awareness of alternatives to SOV travel. Applicable developments are

required to create a TDM plan, which includes a detailed site plan, transportation plan, parking plan and TDM strategies. Upon acceptance of the plan, TDM Site Plan staff conduct annual visits to review plan compliance. Many TDM sites are also required to conduct TDM Plan Performance studies in the years following – up to in perpetuity every 5 years. The studies may include calculating average vehicle occupancy, count of vehicle trips to and from the site, online survey of residents/employees, intercept surveys at building entrances, and/or an interview of the property manager. Fees for review and annual site visits are charged to developers and may include contributions to support public transportation services.[111] Published results were not available.

Implementation Approach

TDM Plans could be required for all types of new developments – both residential and commercial. The size and scale of the new development would also be considered and accounted for in the eligibility requirements.

If provided with appropriate authority by the state, MTC could adopt a regional ordinance that requires TDM Plans for new developments. The regional ordinance could include a minimum set of eligibility requirements and TDM strategies that each local government/jurisdiction could elect to exceed, so as to provide for flexibility in local land use policy. Furthermore, each local government could retain the review and approval process authority. A regional-scale program such as this has not yet been implemented in the U.S.

As described in the Buffalo, Fairfax, and San Francisco examples, building location is a key factor in reducing VMT. For developments that are in close proximity to transit, or that are located in dense areas, the reduction goals may be higher than those in rural areas or places without transit access. Typically, in urban and/or transit rich areas, there are also more potential TDM strategies available to implement. The minimum requirements in the regional ordinance could require developments within close proximity to transit have a higher level of TDM strategies required or a higher trip reduction goal.

Fees could be set at the discretion of the local jurisdiction, so as to compensate for staff time in review and approval of TDM Plans. San Francisco Department of Planning charges review fees for projects that need to comply with their SHIFT program. The city also has the ability to charge a Transportation Sustainability Fee to offset needed growth in transportation services as a result of their projects.

Affordability

This strategy could slightly increase the cost of new development and major renovations, unless developers reduce onsite parking spaces enough to offset the cost increase. It would have no significant impact on transportation costs. In order to minimize the impact on low-income communities, some developments could be granted compliance flexibility or even a waiver if located in disadvantaged communities. However, lifting the requirement for TDM plans in these communities could also deprive residents of new TDM services in those communities.

Strategy Packages/Bundling

In all of the example cities, the developer is able to choose a package of TDM strategies to implement in order to achieve the required trip/parking/VMT reductions. Thus, this strategy involves bundling of individual TDM strategies. The following table shows possible TDM strategies that could be compiled into a "menu" from which developers can choose to implement, compiled from the example cities of San Francisco and Buffalo.

Table 2. TDM Strategies for Buffalo and San Francisco Program

BUFFALO		
• Promotion and education of sustainable options • Alternative/flexible schedules (includes telework) • Bicycle facilities • Guaranteed Ride Home	• Shared parking • Unbundled parking • TMA membership • Onsite TDM coordinator • Enhanced transit facilities • Carshare	• Roadway improvements (sidewalks, transit shelters/ access, bicycle lanes/paths)

SAN FRANCISCO		
• Improve walking conditions • Bicycle parking • Showers/lockers • Bikeshare membership • Bicycle repair station • Bicycle maintenance/ repair services • Fleet of bicycles • Bicycle valet parking • Carshare parking or membership • Delivery supportive amenities	• Delivery services • Family TDM amenities • Onsite childcare • Contributions or incentives for sustainable transportation • Shuttle • Vanpool support (multiple implementation options) • Multimodal wayfinding signage • Real-time transportation information signage	• Tailored transportation marketing services • Healthy food retail in an underserved area • Onsite affordable housing • Unbundled parking • Parking pricing • Parking cashout • Reductions in parking

Because this strategy affects only new development, the region should consider coupling this strategy with parking taxes or fees, which can reduce SOV travel at existing developments.

VMT Reduction Potential

The level of VMT reduction resulting from this strategy will depend on several factors, including:

- **Amount of new development –** Because the strategy would apply only to new development or redevelopment, its impacts will be greatest in areas experiencing the most growth.
- **Development size threshold for application –** Similar to the San Francisco and Buffalo programs, the TDM plan requirement would apply only to new developments and major renovations over specified size thresholds. The lower those thresholds, the more development affected and the greater the VMT reduction.
- **Stringency of plan requirements –** Some developer-oriented TDM strategies are much more effective at reducing VMT than others. If given a menu of strategy options for compliance, developers will

typically select the lowest cost options. Thus, the VMT reduction will depend greatly on the types of TDM strategies that are required.

- **Level of enforcement and compliance reporting –** Developers may ignore TDM plan requirements if they are not enforced or may offer the TDM strategies initially but then fail to maintain the services or infrastructure. Maximum VMT reduction will only be achieved if there is consistent enforcement of the TDM plan requirements, as well as required regular reporting and periodic verification that the TDM strategies are maintained.

Given all these factors, the potential VMT reduction for the entire region is difficult to estimate and the example programs described above have not been studied in detail to estimate VMT impacts.

MTC's experience with trip caps may provide an upper bound estimate of the potential for VMT reduction. The Mountain View district-wide trip cap for North Bayshore demonstrated a 34 percent reduction in employee vehicle trips per day. However, trip caps are likely to be more effective at reducing VMT than TDM plan requirements because large developments can be monitored and held accountable for achieving trip reductions.

Some of the individual TDM strategies that would be included in a TDM plan have been evaluated for their VMT reduction potential and could help with a full strategy assessment. For example, vanpools have been evaluated in multiple studies. The evaluation of the Connect Redwood City! project, funded by MTC's Climate Initiatives Program, found that a new vanpool program reduced 3,774 VMT per participant per year.

Modeling Methodology

The evaluation of this strategy would likely require an off-model approach. Because the impacts of this strategy for a given development would vary depending on the type of development and the surrounding land use context, MTC would first need to define a set of development types and place types for the analysis. For each of these combinations, MTC would need to estimate the likely vehicle trip reduction potential, assuming full compliance, based on literature and other evaluations. These factors would need to be carefully reviewed in order to ensure they are conservative and not aspirational, given the potential requirements for new developments. The table below illustrates how these assumptions might be organized. MTC already classifies TAZs as Urban, Suburban or Rural, so this same classification could be used. We recommend assuming the strategy has no impact in Rural areas. It may be possible to estimate different strategy impacts for office versus retail versus other commercial development types; however, MTC does not maintain TAZ-level data on employment or commercial land use acreage by the type of commercial establishment, so we assume only a single commercial development type is used for the analysis.

Table 3. Development Types and Place Types for Analysis

	DEVELOPMENT TYPE		
PLACE TYPE	Residential multifamily	Residential single family	Commercial
Urban	SOV reduction factor	SOV reduction factor	SOV reduction factor
Suburban	SOV reduction factor	SOV reduction factor	SOV reduction factor
Rural	SOV reduction factor	SOV reduction factor	SOV reduction factor

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