San Mateo Countywide Automated Vehicles Strategic Plan

Existing Conditions Report

DRAFT

Prepared by:

WSP

Prepared for:

SAN MATEO COUNTY Transportation Authority

C/CAG City/County Association of Governments of San Mateo County

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1 Introduction

1.1 Purpose

The San Mateo County Automated Vehicles (AV) Strategic Plan is a project jointly sponsored by the San Mateo County Transportation Authority (SMCTA) and the City/County Association of Governments of San Mateo County (C/CAG). This report is intended to guide the development of the San Mateo County AV Strategic Plan by summarizing a better understanding of current conditions in the county for the project team's reference and to help inform an opportunities analysis in a subsequent report.

The intent of the AV Strategic Plan project is to reflect on where the county currently stands as it relates to AVs and present a path forward for deployment of shared, connected, and automated vehicles in the best interests of San Mateo County. The objectives of the AV Strategic Plan project are to identify the current state of AVs in San Mateo County, establish a shared vision for AV deployment, identify opportunities and challenges for AV deployment in the county (including regulatory, legal, and operational), identify opportunities for AV pilots and other AV-related projects, and develop an AV action plan with prioritized next steps that align with potential funding availability.

1.2 Overview of AV Technology

The focus of this strategic planning effort is on automated vehicles, or AVs. AVs are complex systems of hardware and software that perform the primary driving functions of vehicles (steering, acceleration, and braking) with varying degrees of decreased human intervention. The automated driving system (ADS) includes sensing, communicating, monitoring, navigating, and decision-making, depending on the level of automation.

1.2.1 Automation Levels

The Society of Automotive Engineers (SAE) Standard J3016 standardizes six automation levels, ranging from no automation (level 0) to full automation (level 5). A diagram of what these levels include is shown in Figure 1. Levels 1 and 2 are widely available on the market today, assisting drivers with some functions while requiring them to maintain the primary responsibility of operating the vehicle. Levels 3 and 4 require less direct human interaction, as the vehicle performs all of the dynamic driving tasks. Specific conditions, such as a fixed route, pre-mapped geographic area, or favorable weather conditions, may be required to enable autonomous operations for vehicles within these levels. Level 3 and 4 vehicles are being actively piloted and tested today across the world and within the San Francisco Bay Area. However, these types of vehicles are not yet available for purchase or widespread commercial use. Level 5 vehicles are fully autonomous (requiring no human backup). Level 5 vehicles are not currently operated on public roads and are still years away from deployment. The California Vehicle Code defines an autonomous vehicle as having the technology capable of "driving without active physical control or monitoring by a human operator", which falls under Level 4 or 5.[1]

[1] https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=VEH&division=16.6

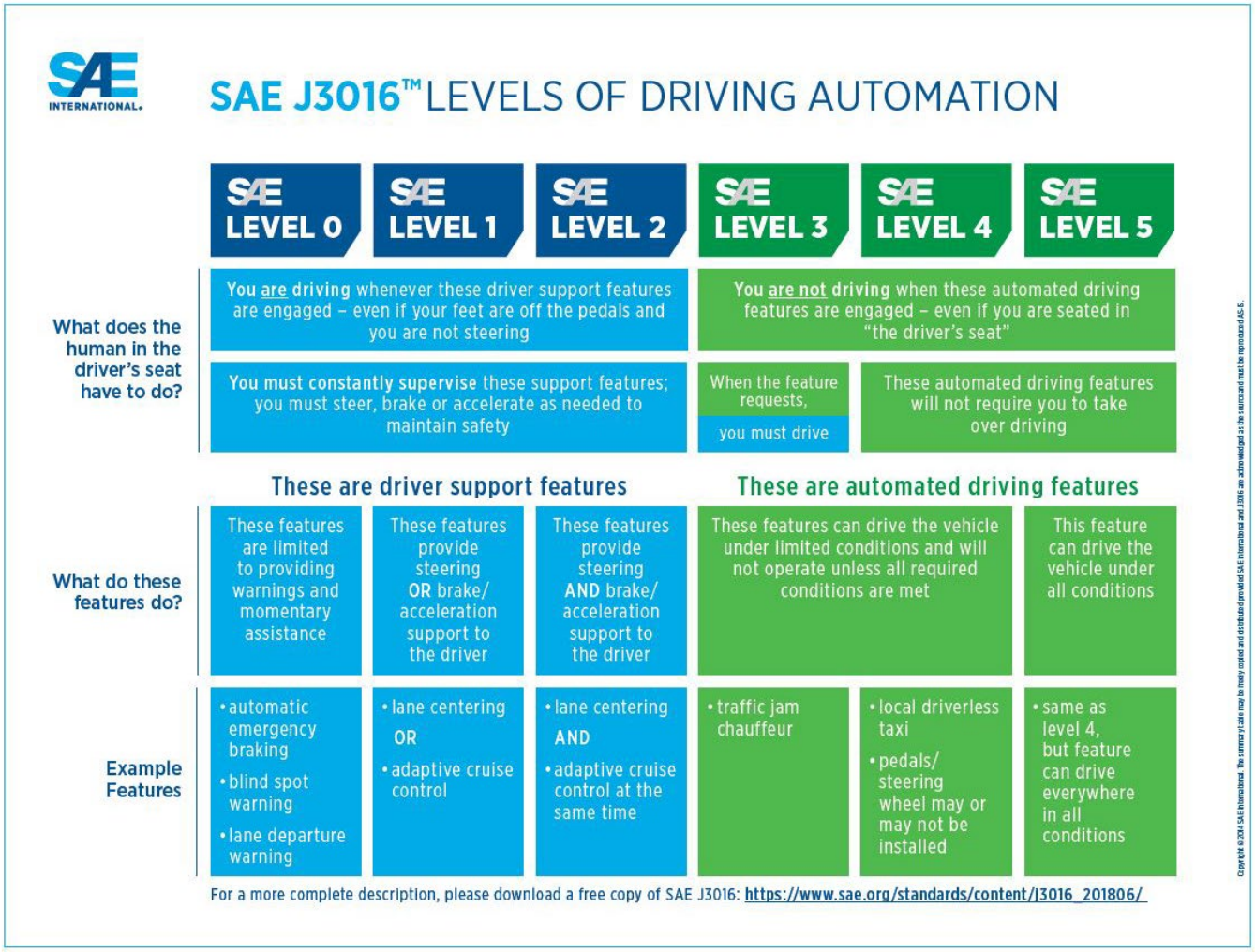

Figure 1: SAE Levels of Driving Automation

Source: SAE International, SAE J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, 2021-04-30, https://saemobilus.sae.org/content/J3016_202104/.

1.2.2 AV Market Trends by Mode

Understanding market trends in automation requires examining specific modes under the umbrella of AV. These include freight, transit, ride hailing services, and personal vehicles. Each of these modes described below will experience independent rates of adoption depending upon what becomes safely possible while addressing market needs.

- **Freight** (near-term to market): The movement of goods using a variety of vehicle types for long-haul, short-haul, and last mile personal delivery devices.
- **Transit** (near/mid-term to market): The movement of people by public transit agencies, using a variety of vehicle types such as full-size buses, specialty on-demand vehicles, and low-speed shuttles.

- **Ride hailing services** (near/mid-term to market): A fleet of vehicles that are owned and operated by a private company to serve shared or single-occupant, on-demand services.
- **Personal vehicles** (longer-term to market): The traditional model of a private automobile that a person purchases or leases from their local car dealer for personal use.

1.2.3 Connected Vehicles and AVs

AVs can benefit from another suite of emerging technology called connected vehicles (CVs). CV technology refers to robust, standardized vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) communication, broadly representing communication between vehicles, infrastructure, and other road users, such as pedestrians and cyclists. The primary purpose of CV technology is to provide real-time data to quantify crash risks and deliver warnings to help road users avoid crashes. Although CV technology is not intended to provide automatic intervention, it can provide AV technology with an additional source of information.

The common use of the term "connected and automated vehicle" or "CAV" allows for the beneficial combination of the two technologies, as shown in Figure 2. In this context, CV can be regarded as an additional data input or "sensor" in the ADS's suite of sensors. Many uses of the term CAV are driven mainly by the AV component. The terms CV and AV are often used separately as well.

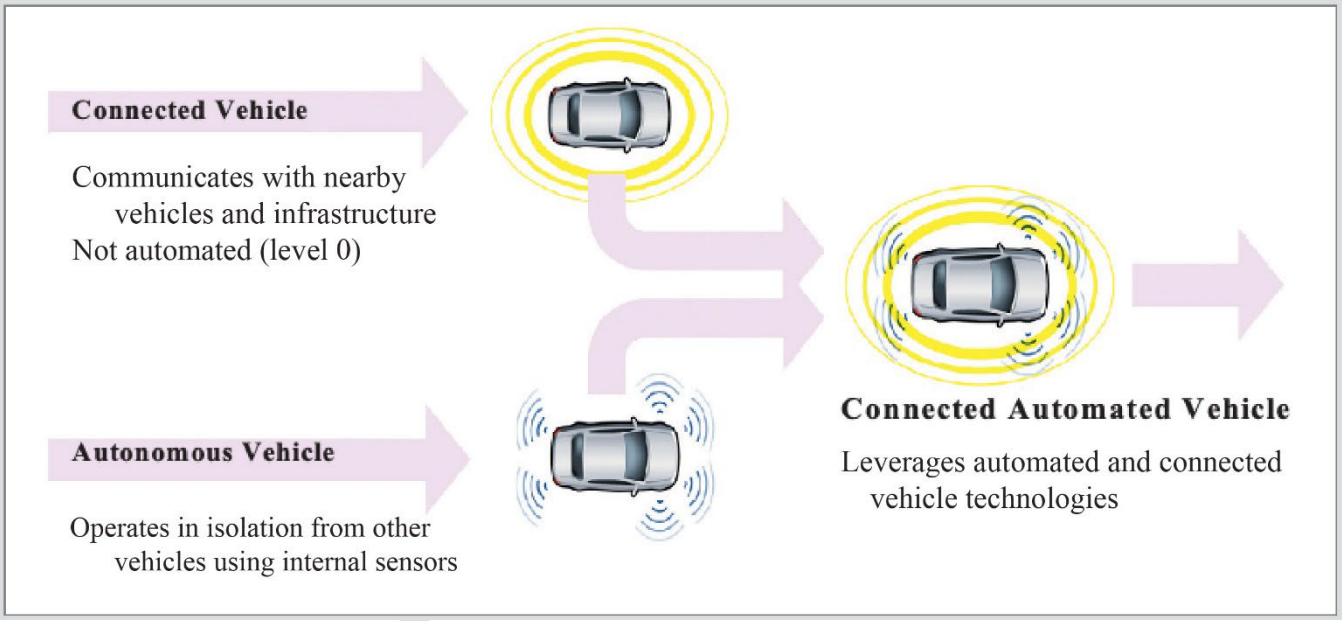

Figure 2: CAV Combines CV and AV Technology

Source: USDOT

1.2.4 Shared Mobility and AVs

Another transportation trend that is relevant to this study on AVs is shared mobility. Shared mobility refers to any transportation service that is utilized by multiple users. By definition, it includes all forms of

public transportation, as well as some individual modes of transport. Sharing can take place simultaneously within the same mode (i.e., ridesharing) or consecutively (i.e., car sharing).

Shared mobility has experienced rapid change over recent years, diversifying as digital information and app-based tools have evolved. Better service information is supporting the transition by helping users understand the range of shared mobility options offered. This increase in the availability of shared private services has started to blur the line from a passenger perspective between public and private transportation. These trends offer an opportunity for better collaboration between public authorities and the private sector, related to infilling routes that have proven difficult to support individually. For example, it could allow for first and last mile feeders to support higher capacity transit. While this may take some riders away from public transportation in the short term, there is the opportunity to support a more robust, efficient, and higher ridership public transportation network with support from private operators.

Shared AV shuttles are an early example of automation that has experienced world-wide exposure for this use case. These vehicles are typically electric, confined to a specific operational domain, and take the form of a purpose-built vehicle without traditional controls (like a steering wheel or pedals).

2 Existing Transportation Network Conditions

This section documents existing countywide plans, programs, and assets that in some way reference AVs or could be used to inform an AV program. This section is intended to provide information on existing county priorities that will help form the county's mission, vision, and goals related to AVs.

2.1 San Mateo County Transportation Plans

San Mateo County, which consists of the cities shown in Figure 3, produces a number of different transportation-related planning documents. While few of the planning documents specifically reference AVs, many of the priorities and constraints that are covered are directly applicable to AV efforts. This subsection presents the high-level countywide plans and their connections to AVs.

Figure 3: The Cities of San Mateo County

Source: San Mateo County Department of Housing

Alternative Congestion Relief/Transportation Demand Management Plan

The SMCTA Alternative Congestion Relief/Transportation Demand Management (ACR/TDM) Plan is a guide for initiating and selecting projects and programs that aim to reduce reliance on automobiles for travel and to increase the efficient use of the transportation network in San Mateo County. Historically, one of the County's primary TDM programs has been Commute.org, the county's transportation demand management agency that operates shuttle services throughout San Mateo County, as well as other non-automobile resources and incentive programs. Support for this program will continue, but with additional funding available, there is interest in exploring other projects and programs as well.

AV and shared AV pilot programs are called out specifically in this plan as an eligible recipient of distributed funding, alongside other ITS solutions such as mobility hub plans, transit signal improvements, data purchasing, real-time information, and dynamic parking signs. ITS projects are presented as innovative ways of using transport and traffic management tools. ITS projects can enable travelers to be better informed and can result in safer, more coordinated, and smarter uses of transportation networks.

C/CAG ITS Strategic Plan

The vision for the San Mateo County ITS Strategic Plan, created in 2005, was to "improve mobility, improve travel time reliability, and enhance the transportation system safety for all travelers in San Mateo County through the integrated and strategic use of advanced technologies and interagency cooperation".

The plan identified seven transportation elements where ITS initiatives could be introduced or improved. The plan noted the benefits of each initiative, the participating agencies, and prioritized them for the County. Within these seven elements, there were 14 concepts that were particularly aligned with the goals of this AV Strategic Plan. They are listed below by countywide priority.

High Priority

- Allocate funding and resources for the Operations and Management of ITS elements and communications network
- Bring already deployed ITS devices into full and stable operation
- Make Regional transportation management center (TMC) fully operational with respect to San Mateo County
- Upgrade existing traffic signal systems (e.g., replace antiquated equipment, expand coordinated systems, update signal timings, etc.)
- Bring ramp metering system, as approved, into operation and integrate with signal operations where appropriate

Medium Priority

- Expand the existing fiber network and expand franchise agreements
- Connect to Caltrans' proposed fiber optic backbone on US101

- Implement a link between local traffic monitoring systems and the regional 511 traveler information system
- Implement a center-to-center link between Caltrans' Transportation Management Center (TMC) and existing or future TMCs within San Mateo County
- Deploy additional traffic monitoring and incident verification equipment where appropriate on the County's freeways and highways

Low Priority

- Install fog sensing equipment where appropriate on the County's highways
- Prepare a Parking Management System Study for various locations
- Implement a real-time Parking Information and Guidance System, where appropriate
- Design and implement Smart Corridor(s) in selected areas

Some of these investments and initiatives have been implemented, while others are still ongoing or planned. By establishing a reliable ITS infrastructure, San Mateo County will lay the groundwork for a digital infrastructure that can support AV technologies in the future. Each of these concepts from the C/CAG ITS Strategic Plan could be leveraged by local, county, or statewide agencies either prior to or in coordination with the deployment of AV projects to maximize cost savings, efficiencies, and safety benefits of future AV pilots and programs. This is particularly true for connected AVs, which will benefit from reliable and comprehensive communications with infrastructure (and other vehicles) in order to obtain safety-critical information such as traffic signal phases, congestion/traffic back-ups, and incident management.

Countywide Transportation Plan 2040 (2017)

The goal of the San Mateo Countywide Transportation Plan (SMCTP) 2040 is to “integrate transportation and land use plans and decisions in support of a more livable and sustainable San Mateo County.” It presents a shared transportation planning framework for the county up to the year 2040. The elements of the plan are land use and transportation, roadway system, bicycles, pedestrians, public transportation, transportation system management, transportation demand management, parking, modal connectivity, and goods movement. The plan contains a two-paragraph overview of the potential of connected and automated vehicles to “almost immediately improve traveler safety by introducing collision-avoidance features and reducing congestion by reducing delay caused by collisions.”

The plan seeks to promote higher density development and transit-oriented development in San Mateo County. It also encourages site design that reduces the appeal of single occupancy driving, for example preferential parking for rideshare vehicles or parking spaces closer to building entrances. The SMCTP 2040 plan highlights the need to integrate land use and transportation planning. This policy can assist countywide adoption of automated vehicles since integrated site designs will improve access for residents or workers using AVs at many locations. This will be especially true for higher levels of automation, when AVs can navigate themselves to a parking spot, which will free up space previously used for parking at destinations.

The plan also calls for a minimization of motor vehicle traffic generated by new development within and near the county. To improve safety and efficiency, the county should encourage the use of shared AVs over single occupancy AVs in relation to any of the transit-oriented developments or other high-density developments. Because AVs have not yet seen widespread deployment, the County has an opportunity to shape how they are deployed, and to do so in the interests of the county as a whole.

The plan addresses the equitable distribution of project benefits between communities of concern and the rest of San Mateo County, so that minorities, low-income residents, people with limited English proficiency, zero-vehicle households, people with disabilities, seniors, single-parent families, and renters paying more than 50% of their income on rent may benefit from transportation projects as much as everyone else. Some of these residents in communities of concern may benefit from the availability of affordable, shared AVs. Particularly people with disabilities and seniors for whom it is not safe to drive may find increased accessibility through access to AVs that could bring them closer to their ultimate destination than the nearest transit stop.

Short Range Transit Plan

The San Mateo County Short Range Transit Plan (SRTP) applies to fiscal years 2023-2028 and includes four scenarios for service plans in the county that were written with recovery from the COVID-19 pandemic in consideration. Though the decline in ridership over the pandemic caused a decline in fare revenue that has been challenging for service operators, SamTrans has also had the challenge of recruiting and retaining operating staff.

SamTrans made several efforts to increase ridership from 2019-2022. One adjustment was to offer microtransit in lieu of fixed-route operations. SamTrans planned two on-demand microtransit services for East Palo Alto and Half Moon Bay to offset changes SamTrans is making to the fixed-route service in those areas.

The introduction of on-demand microtransit and the challenges of recruiting and retaining operating staff and constrained budgets combine to create the conditions conducive to a public, shared AV pilot, particularly for first/last mile connections to higher capacity transit. Other transit operator needs, such as precision docking at stop locations, information on safety-critical situations (i.e., vehicles turning right in front of a bus about to depart a stop location or alerts on pedestrians in low-visibility locations), or bus platooning (a set of two to three buses operating with very short headways on high demand routes) could be supported by enhanced CAV technologies.

2.2 San Mateo County Transportation Programs

San Mateo County also supports several transportation-related programs. Similar to the County Transportation Plans, while few of the programs apply to AVs in particular, many of the priorities and constraints that are covered are directly applicable to AV efforts. This subsection presents AV connections to countywide transportation programs.

C/CAG TDM Program

The C/CAG 2021 update to the Transportation Demand Management Policy offers numerous Transportation Demand Management options for Transit-Oriented Developments (residential or commercial development concentrated near higher-order transit stations or routes), Transit Proximate

Developments, and Non-Transit Proximate Developments. Measures that may offer opportunities for cities within the county to encourage adoption of shared automated vehicles include, as well as key opportunities for the expansion of AV deployment within these measures include:

- **Measure 1: Free/Preferential Parking for Carpools:** Key opportunities for the expansion of AV deployment within these measures include:
    - Free and preferential parking to incentivize carsharing/ridesharing. With parking spots reserved for carpools and rideshares, more residents and visitors may opt for shared travel modes, especially in busy downtown business districts where free parking is limited. Rideshare AV services can benefit from the availability of parking near major urban destinations by easing the process of dropping off and picking up riders from the same location. This measure could be applied to various zoning types, including non-residential, retail, and medical/lodging.
- **Measure 4: Actively Participate in Commute.org or Transportation Management Association Equivalent:** Provision or funding of a dedicated shuttle program/consortium or equivalent transit service and provision of guaranteed ride home
    - The dedicated shuttle program could be provided using AV shuttles or similar AVs. Even if in the short term, the shuttle is not an AV, having access to shuttle-based transportation may help travelers grow accustomed to shared transportation services, a service model through which AVs are likely to be provided.
    - A guaranteed ride home program lowers the risk for travelers who are unsure of using a new transportation service. If the service does not meet their needs for their return trip, they are provided with a backup solution to get home. This may help encourage travelers to try new mobility services, like AVs.
- **Measure 18: Car Share On-Site:** Provision of car-share/vehicle fleets or subsidizing car share membership
    - AVs are likely to be provided and managed as fleets before they are available to purchase or lease by the general public, due to the large upfront costs and complexity of maintenance. Therefore, a car-share model may be a cost-effective approach to managing the deployment of AVs in the medium term.
- **Measure 20: Shuttle Program/Shuttle Consortium/Fund Transit Service**: Free shuttle service to single project sites or multiple sites through a consortium
    - In addition to the potential for a shuttle service to utilize AVs, as discussed previously, this measure provides opportunities for funding partnerships, such as developers funding enhanced transit service to or from their project site in collaboration with SamTrans. Developers may be more interested in supporting a shuttle service that is in some way innovative, such as one that uses AV technology, if it can be done in a way that is cost-effective and/or can attract riders.

Office, industrial, or institutional workers, as well as residents (especially seniors and youth) are some of the constituent groups that may benefit from these measures. Workers would benefit because many of the programs are geared toward commute trips. Residents would benefit from additional transportation options for commute and non-commute trips within and to/from the County. Seniors and youth are more likely to not be able to drive their own vehicle, so additional options, including through the use of AVs, would be particularly beneficial for these two groups.

San Mateo County's Transportation Demand Management Agency

Commute.org is San Mateo County's Transportation Demand Management (TDM) Agency. The agency's members include 19 cities and towns as well as the County of San Mateo. Commute.org and its members seek to promote, encourage, and incentivize people to use transportation options other than driving alone. The goal of TDM programming is to shift demand for transportation across all available modes including walking, biking, transit, telework, and ridesharing.

The agency's core programs fall into three categories:

- Engagement Programs: The objective is to increase the adoption of commute alternative programs by providing TDM tools, education, resources, programs, and expertise.
- Commuter Programs: The objective is to provide commuters with the tools, programs, and incentives that not only encourage their shift to non-drive alone modes, but also provide ongoing support and incentives for them to continue using preferred commute mode(s). This includes a guaranteed ride home program, carpool and vanpool incentive programs, a bicycle incentive program, and a try transit incentive program.
- Shuttle Program: The objective is to provide safe and reliable first/last mile shuttle services between employment and residential sites in San Mateo County and Caltrain, BART, and San Francisco Bay Ferry stations/terminals so that people can utilize public transit as a primary means of commuting to or from the county.

As was stated in the prior section, AVs could be used to provide a ridesharing service, dedicated shuttle program, guaranteed ride home program, or a carshare fleet.

2.3 San Mateo County Transportation Assets

This section documents the many transportation assets in San Mateo County that could support or be supported by AV pilots and deployments. It includes ITS and CAV, key travel corridors, transit services, and bicycle and pedestrian networks.

2.3.1 ITS and CAV

Intelligent transportation systems (ITS) and connected vehicles (CV) are technologies that have the potential to support AVs in the future by making them safer and more efficient. ITS includes a suite of transportation technology and applications designed to make streets, highways, and transit systems smarter and more efficient. CV technology enables communications over a secure wireless network so that cars, buses, trucks, traffic signals, smart phones, and other devices can share information in real-time, transforming how people and goods travel. Most industry leaders agree that AVs would be much

safer and more efficient if they could be connected to ITS infrastructure and able to leverage their benefits. This section describes some of the existing ITS projects and assets in San Mateo County that align with the goals of the AV Strategic Plan and could potentially support AV deployment in the future.

C/CAG Smart Corridor

The San Mateo County Smart Corridor project is a countywide traffic management system that uses technology and ITS devices (including dynamic message signs/trailblazer signs, video detection sensors, and CCTV cameras) to help local cities, the County, and Caltrans manage congestion during normal operating conditions, major freeway incidents, and special events.

The Smart Corridor project is a way for the C/CAG to implement ITS equipment and initiatives on predefined local streets and state routes that will benefit from those improvements. The improvements were phased in three funded segments, shown in Figure 4, one from San Bruno to the Santa Clara County line in the City of East Palo Alto, one in South San Francisco, and another as a joint effort by the cities of Daly City, Colma, Brisbane and the C/CAG. The primary goal of the project is to limit the impact that incidents on the freeway have on the traffic on local streets.

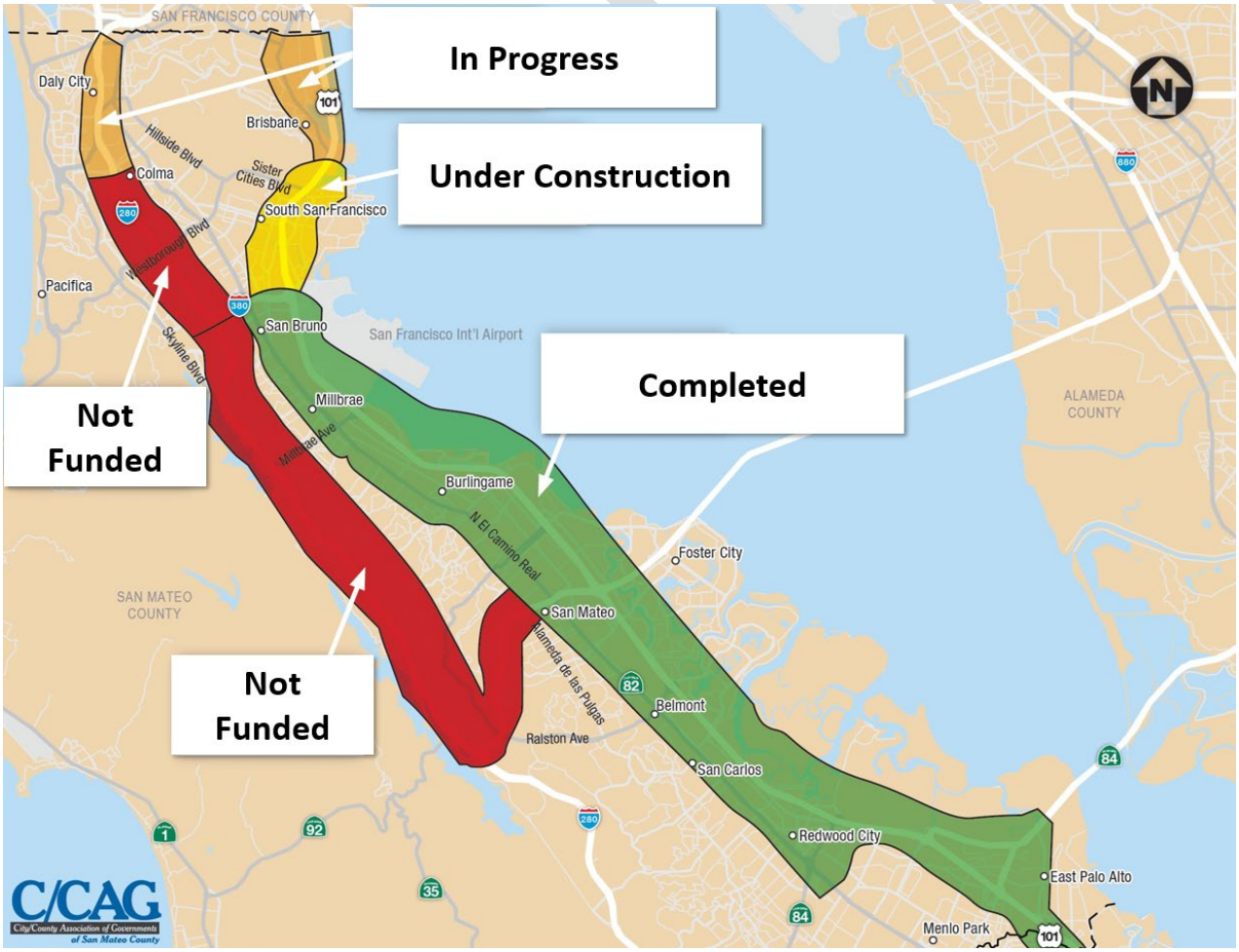

Figure 4: San Mateo County Smart Corridor Project Limit and Status

Source: C/CAG

Many of the ITS technologies deployed as part of the C/CAG Smart Corridor could also be leveraged by and/or supported by AVs, particularly when it comes to both collecting and sharing data with connected AVs, as was described in Section 1.2.3.

Another key asset that is part of the Smart Corridor program is the fiber optic cable infrastructure. The fiber connects all devices in the field and allows operators at their traffic management center remotely controlling signals to optimize traffic flow, give priority to emergency vehicles at key intersections, and give priority to transit vehicles to decrease transit travel time. The fiber network enables data sharing, supports coordination across multiple jurisdictions, and facilitates technology-based transportation management strategies. Fifty miles of fiber optic cable have been installed to date. An additional 8.5 miles are under construction in South San Francisco, to be completed winter 2023/24, and 5.3 miles of additional fiber optic cable are planned for Daly City, Colma, and Brisbane.

Finally, the Smart Corridor program has made great progress installing the other key ITS assets described above. Table 1 shows the numbers of Smart Corridor ITS devices that are existing, under construction, and planned for future deployment.

Table 1: Existing, Under Construction, and Future/Planned Smart Corridor ITS Assets

Devices	Existing	Under Construction	Future/Planned
Trailblazer Signs	117	7	13
Traffic Controllers	236	49	6
Vehicle Detectors	40	7	7
CCTV Cameras	270	81	57
Dynamic Signs	0	4	0
Total	663	92	83

Source: C/CAG

C/CAG Intelligent Transit Signal Priority

This project is a joint effort between C/CAG, SamTrans, and Sustainable Silicon Valley. The project aims to provide transit priority on congested corridors in the City of East Palo Alto, one of the most transit-dependent communities in the county. With funding from C/CAG, a transit signal priority pilot was deployed on University Avenue at the following intersections: Bay Road, Runnymede Street, Bell Street, and Donohoe Street.

The pilot had very positive impacts based on several key performance indicators:

- Reduced northbound intersection delays by 45% and southbound intersection delays by 19%. These reductions translate to 18% and 7% reductions in travel time for northbound and southbound respectively.
- Increased the average speed on the University Ave. corridor by 11% in the Northbound direction and 4% in the Southbound direction.

- Offered a transformational opportunity for the county to make its transit system more intelligent and streamlined than ever before with a cost-efficient solution.

These improvements significantly improved bus travel times by decreasing the amount of time buses spend idling at traffic signals. AV pilots could be integrated in the area to take advantage of the travel time benefits provided by these signals. Similar high-frequency location data would be provided by AVs as is provided by the buses. This would enable the measurement of performance to the same key performance indicators presented above in order to measure the effectiveness of AV using transit signal priority compared to buses.

Toward an Autonomous Future in San Mateo County Virtual Workshop (2021)

On November 17, 2021, San Mateo County Transportation Authority (TA) and San Mateo County Transit District (SamTrans) hosted a workshop on the future of automated vehicles in the county. Speakers represented two groups: public agencies or companies that are making or deploying automated vehicle technologies. Public agency speakers included representatives from the Santa Clara Valley Transportation Authority, Connecticut Department of Transportation, Contra Costa Transportation Authority, and Utah Transit Authority. AV industry and technology company speakers included Via Transportation, Cruise, and Zoox.

The workshop was primed with the following commentary:

- Whether automated vehicles will become a preferred mode and surpass the demand of transit, and will they gravitate towards private vehicles or shared vehicles? Transportation Network Companies (i.e., Uber and Lyft) did initially increase Vehicle Miles Traveled (VMT), so is it safe to assume that rideshare companies relying on automated technologies will increase demand and VMT as well?
- Our travel demand models will likely need to shift to encompass the new uses of AVs.
- The value of retaining Level of Service (LOS) as a measure of vehicle traffic in addition to VMT, since many automation technologies are designed to improve the flow of traffic and minimize congestion.
- Early research shows that the deployment of these technologies may have a significant positive impact on the mobility of people with disabilities.

Panelists agreed that while various levels of automation are available today, a safe, affordable network of shared automated vehicles could be many years from operation even in California, which is ahead of other states in permitting and regulatory processes and statewide legislation for electrifying public vehicle fleets.

The mitigation of safety hazards with AVs was discussed by the panel, with some referencing guidelines from the State of California on AVs communicating with first responders to prevent accidents and conflicts with public buses, fire trucks, ambulances, and other public safety vehicles. Some panelists noted the importance of agencies and departments assigning staff members to work with companies that own and operate AVs, particularly within fire and police departments.

2.3.2 Key Travel Corridors

San Mateo County is located between San Francisco and San Jose on the San Francisco Peninsula. The County extends east to west from the San Francisco Bay to the Pacific Ocean. The urbanized portion of the county is located primarily between the San Francisco Bay to the east and I-280 to the west. The area between I-280 and the coast has a more rural character, including extensive open space preserves, parklands, beaches, and small communities arrayed along Highway 1, the largest being Pacifica. Figure 5 below show the key highway corridors in San Mateo County.

Figure 5 presents a map of the roadway system in San Mateo County. 10% of total miles are state highways, 15% are county roads, 73% are city streets and roads, and 2% are other roads. The types of roadways throughout the county may, in part, determine which types of AV pilots can be conducted, and where.

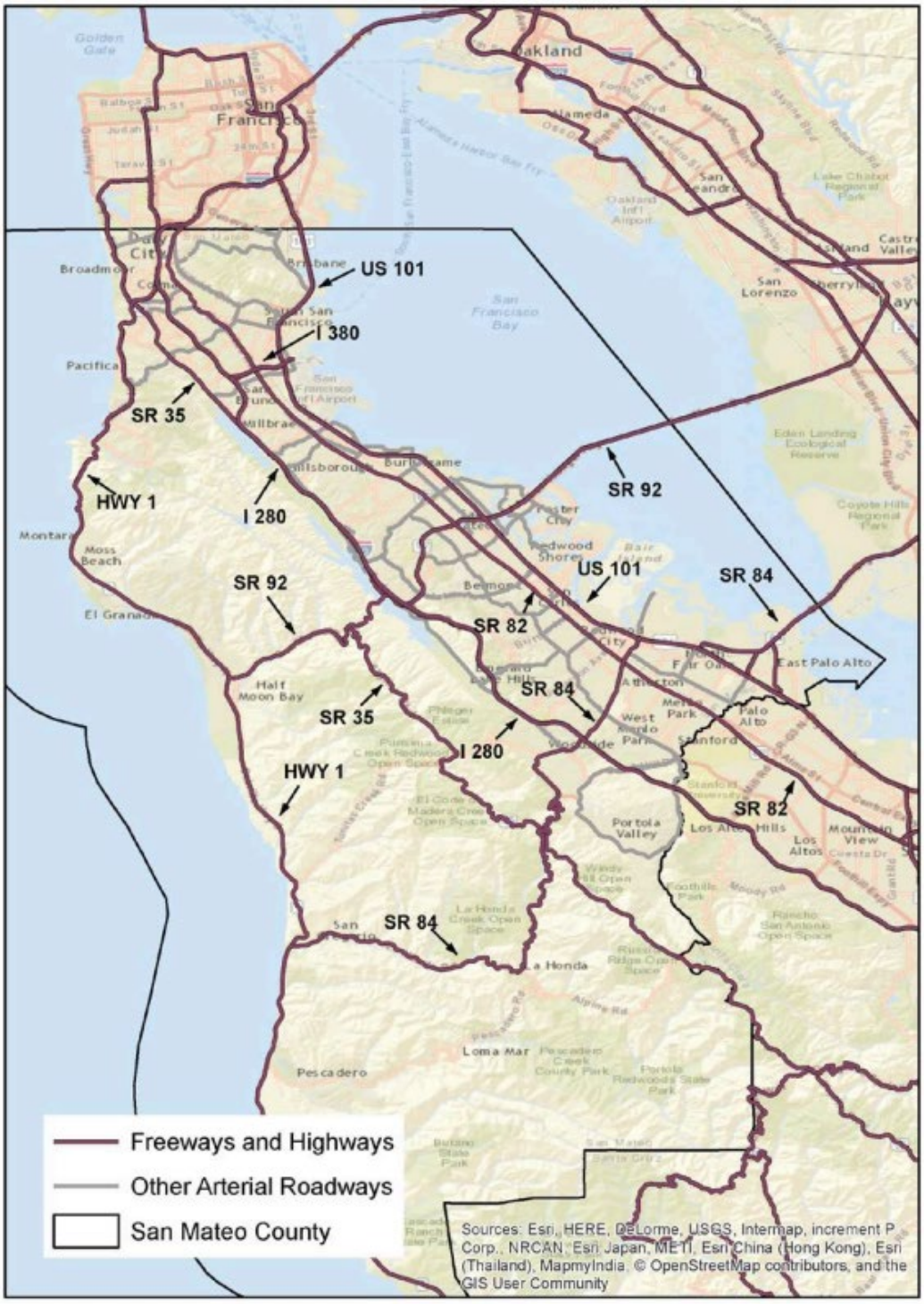

Figure 5: Map of the Roadway System in San Mateo County

2.3.3 Transit Service

Transit services within San Mateo County are provided by SamTrans, Caltrain, BART, and Commute.org. SamTrans provides local bus service within the county, local and commuter bus services into San Francisco, and paratransit. A system map is shown in Figure 6. Caltrain and BART are commuter rail systems. Caltrain runs through the entirety of the county, roughly parallel to Highway 101. BART serves the northern part of the county, including San Francisco International Airport. Commute.org runs the county's transportation demand management (TDM) program, including a shuttle program. Understanding where existing services are provided offers a baseline for opportunities to supplement this service with AVs, either by adding vehicles to existing routes or serving new routes and areas.

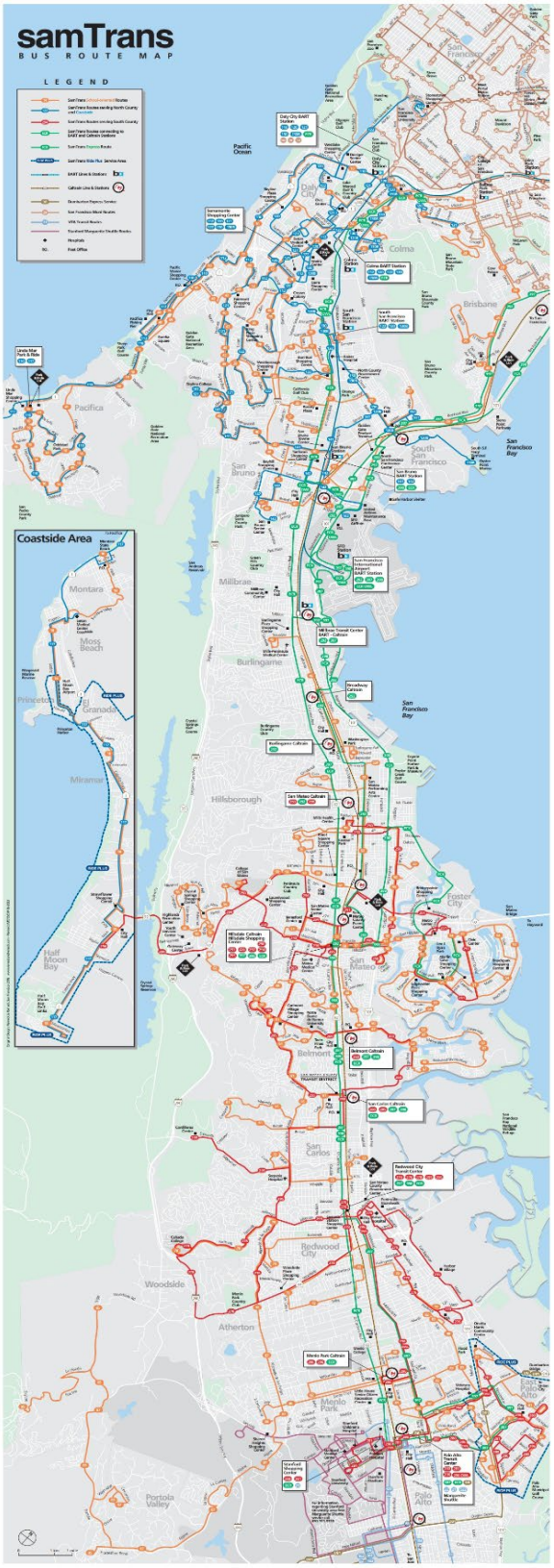

Figure 6: SamTrans System Map

2.3.4 Bicycle and Pedestrian Networks

While active transportation modes are largely a separate topic from automated vehicles, there are policies and technologies that may overlap and complement each other that need to be considered in order to enhance the safety of both groups. Pedestrians and bicyclists, often referred to within the AV context as vulnerable road users (VRUs) due to their high level of exposure on shared roadways, are currently one of the biggest safety challenges for AV developers. Considering the interactions between the two sets of modes, for example by deploying smart infrastructure that can detect VRUs and communicate information on their location to AVs, could increase the safety of both sets of road users.

The 2021 C/CAG San Mateo County Comprehensive Bicycle and Pedestrian Plan offers a holistic approach to safety, where traffic fatalities and serious injuries are considered unacceptable.[2] The plan strives to prevent collisions by providing the appropriate designs on all public roadways. This may be achieved through new construction, resurfacing and restriping, or street reconstruction. The development of signals that prioritize

[2] https://ccag.ca.gov/programs/transportation-programs/active-transportation/

crossing for bicyclists or pedestrians can improve their visibility in the crosswalk and therefore increase safety. The deployment of intelligent traffic signals that can detect small vehicles, such a bike or scooter, may make these travel modes safer and more efficient while working seamlessly with AVs as well.

3 Existing AV Policies and Programs

AV technologies are being researched and developed by a variety of automotive and technology companies. As this development is happening, there is also growing interest from public agencies in piloting and deploying these emerging solutions to drive innovation and solve existing transportation challenges. However, there is often a gap between the ultimate potential of AV technologies and what they are currently capable of, and it is important for any potential deployers to be aware of this gap prior to pursuing a project, or when making decisions between pursuing different AV technologies.

Efforts at the federal, state, and local levels have attempted to step in and provide guidance or regulation, or simply to share lessons learned, to help local agencies with less experience in AVs to understand the current state of the industry and how it may be used to meet their needs. These efforts are summarized in this section. The purpose of this section is to identify what types of measures related to AVs have been implemented, and to understand the obstacles and opportunities to implementing AV measures in the past and in the future.

3.1 Local (San Mateo County)

This report builds on a virtual workshop that was held for San Mateo County on November 17, 2021, and was summarized in Section 2.3.1. The workshop focused on bringing attention to the advent of AVs to San Mateo County communities and to help the county better understand the impacts AVs may have on local roads and streets. This Countywide AV Strategic Plan was one of the recommended actions identified by stakeholders at the workshop.

There have not yet been any official AV policies, programs, or deployments in the county, either before or after that workshop, until the development of this Existing Conditions Report as part of an AV strategic planning process. Interest in AVs still exists, and more specifically there is an interest in ensuring that AVs are deployed in a balanced way, including personal vehicles, transit vehicles, and other shared applications, as well as in conjunction with other countywide projects, such as express/managed lanes projects.

While most regulations on AVs occur at the state or federal level, there are some aspects where local or municipal regulations could have an impact. For example, while most driving laws are managed at the state level, critical elements such as parking, curb space access, dedicated facilities, and the ability to use sidewalks are almost always governed at the local level. This was demonstrated when transportation network companies (e.g., Uber or Lyft) began operating in many cities. They generally entered without any pre-approvals or authorities. As a result, some cities temporarily (or permanently) limited the ability to pick up and discharge passengers at public airports or other facilities. A similar situation could occur for AVs. This is particularly true for smaller AVs, such as personal delivery devices. The introduction of personal delivery devices for last-mile package delivery could, in certain circumstances, be impacted by local regulations not allowing such devices on public sidewalks.

3.2 Regional

San Mateo County is one of nine counties forming the San Francisco Bay Area under the regional transportation planning and financing metropolitan planning organization Metropolitan Transportation

Commission (MTC). MTC supports programs to helps the region plan for a future with safer streets and fewer collisions due to the deployment of automated vehicles, including the Innovative Deployments to Enhance Arterials Shared Automated Vehicles (IDEA SAV) Program.[3] This program has provided financial and technical support for cities, counties, and transit agencies interested in deploying shared AVs to improve transit service and equity.

3.2.1 Peer Agency Planning Efforts

San Mateo County's peers within the region include Contra Costa Transportation Authority (CCTA), Santa Clara Valley Transportation Authority (VTA), San Francisco County Transportation Authority (SFCTA), and Alameda County Transportation Commission (CTC). While these entities, and most notably SFCTA and CCTA, have some experience with automated vehicles, none of the four have developed their own public-facing AV Strategic Plans.

SFCTA has published a strategic topic paper on the topic of AVs, that provides information on why they have been involved with the pilot programs on their public streets. The idea is that, through these pilots, San Francisco may be able to gain insights into how AV deployment may be shaped by local plans and policies – such as the curb and parking management plans referenced in the prior section. Insights from pilots can be used to help shape the near-term and long-term work program, policy development, and investment priorities of SFCTA as well as other city agencies.

As far back as 2018, CCTA led a pilot demonstration of a low-speed, electric, 12-passenger automated EasyMile shuttle. The public and private funding for this project included direct and in-kind resources from local, regional, and state agencies, a private land owner/developer, an engineering firm, and EasyMile, the vehicle vendor. EasyMile shuttles are designed from the ground up as AVs, and are not equipped with a steering wheel, brake pedal, or accelerator. CCTA is now piloting a similar shuttle in partnership with Beep, another automated shuttle operator, and is working on other automated vehicle deployments. In addition, testing in Contra Costa County can be conducted at GoMentum Station, an AV testing facility. Similar facilities exist across the country and are often built on land previously paved and used for aviation or military services, in this case the Concord Naval Weapons Station.

Counties in other states that have developed their own AV Strategic Plans include Maricopa County in Arizona, Oakland County in Michigan, and the MetroPlan Orlando metropolitan planning organization in Florida. The reasons for doing so can be gleamed from Oakland County's vision statement:

> *With the emergence of Connected and Automated Vehicles (CAV) on Oakland County roadways, the Road Commission for Oakland County sees ample opportunity to continue to be at the forefront of supporting technology development, staff preparation, industry partnerships, and immediate deployments to enhance the safety and mobility of its residents and to plan for and fund a forward-looking transportation network.*

More broadly, the National Association of Counties (NACo) has developed the Connected and Automated Vehicles Toolkit: A Primer for Counties to provide an overview of and framework for engagement with the AV industry, as well as the closely related connected vehicle industry.

[3] https://mtc.ca.gov/operations/programs-projects/intelligent-transportation-systems/connected-automated-vehicles

3.2.2 Peer Agency Pilot Projects

There have been several pilot deployments focused on Levels 3-4 of automation undertaken by local and regional governments or allowed within their jurisdictions. These have generally utilized low-speed automated shuttles without traditional vehicle controls (such a steering wheel and foot pedals) or retrofitted existing vehicles. They can either operate only on pre-defined, fixed routes or within a pre-determined zone. In most deployments to date, a human "safety operator" has still been on board to interact with passengers and take over vehicle control if necessary.

There are many opportunities for agencies to deploy AVs to supplement or replace existing transit service. Generally, these vehicles are ideal for short-distance service, where they can be used to tackle the first/last-mile problem. Deployments to date have generally also been showcase opportunities, for an agency or organization to show they are innovative and supportive of AV technology.

Automated shuttles have also been opportunities for data capture to help guide future developments. For example, a one-year automated shuttle pilot in Las Vegas was sponsored by AAA, who was interested in seeing how people perceive AVs and whether their perceptions may change if they are directly exposed to the technology. This shuttle was deployed in an area of the city that attracts many tourists, and approximately half of the passengers were from outside the state of Nevada, which allowed AAA to reach a broader audience and not just the local public.

Automated shuttles can also be used for campus circulation, at a university, employment center, office park, or airport, such as Bishop Ranch in Contra Costa County or Treasure Island near San Francisco. Deploying these vehicles locally also provides an opportunity to educate the local public on emerging technologies. A transit agency or organization who pilots these technologies early on will be better able to adapt to future innovations, because both internal agency processes and the public will be better prepared for and accepting of AV technology.

Lessons learned for public agencies from some of the early AV deployments include the need for services deployed as transit systems to comply with applicable industry regulations and standards, even in cases where due to the funding source compliance may not technically be required. For example, some AVs are not ADA-accessible, though they may have some accessible features, and this has been an issue. In addition, due to the high costs of AV-enabling technology, automated shuttles are not inexpensive. As with most investments in new technology, they require significant upfront costs, with the benefit of overall cost-savings not seen during deployment or perhaps even within the lifetime of a product. Many pilots to date have therefore been leases rather than purchases of the vehicles, as sustainable, long-term funding of deployments has been a challenge.

3.3 State

While regulations on vehicle safety are governed at the federal level, vehicle operators fall under the purview of the state – similar to how vehicle safety recalls occur at the federal level, which driver licensing and ticketing occurs at the state level. States have not acted uniformly in their legislation and policy regulations for automated vehicles. Some states have steadily introduced policies for years, while others have yet to submit any policy or write any reports on the topic.

In California, the California Department of Transportation (Caltrans), California State Transportation Agency (CalSTA), California Department of Motor Vehicles (DMV) and the California Public Utilities Commission (CPUC) each have important roles with respect to AVs. Caltrans is the owner and operator of state-owned highways and therefore has a key role in AV operations. Caltrans is responsible for installing and operating the roadway infrastructure that AVs interact with including lane striping, signage, traffic signals, ITS equipment and other digital infrastructure. Caltrans also conducts research to support AV and CAV deployment such as operating a CV testbed on El Camino Real in Palo Alto.[4] This test bed includes 16 intersections equipped with vehicle-to-infrastructure technology that can communicate directly with CV-equipped vehicles, including CAVs. Caltrans has operated the CV testbed since 2005 and used it to test new traffic signal applications such as the Multimodal Intelligent Traffic Signal System (MMITSS). Caltrans is planning to expand the testbed concept and MMITSS to other parts of California.

CalSTA is responsible for providing state leadership on AV policy and ensuring that AVs are deployed in accordance with state goals and priorities. CalSTA participates in the California Multi-agency Workgroup on AVs comprised staff from several California agencies, including Caltrans, California Environmental Protection Agency, CalSTA, DMV, California Air Resources Board, Department of Public Health, California Energy Commission, and Office of Planning and Research. According to the group's principles, which are described in detail on the OPR website,[5] AV deployments in the state shall prioritize:

- Shared use
- Low emissions
- Right-sized
- An efficient multimodal system that:
    - Strengthens high-quality transit service rather than duplicating it
    - Replaces low-quality transit service
    - Strengthens active transport
    - Provides efficient freight transport and delivery
- Efficient land use
- Complete and livable streets
- Transportation equity

DMV and CPUC are responsible for regulating AVs and issuing permits for AV testing and deployment in California. One of their primary actions to date has been issuing permits that set rules for how companies can deploy their AVs on public roadways, including whether or not a safety operator is

[4] https://caconnectedvehicletestbed.org/home
[5] https://opr.ca.gov/docs/20181115-California_Automated_Vehicle_Principles_for_Healthy_and_Sustainable_Communities.pdf

required to be onboard and whether passengers are permitted. Within these restrictions, individual jurisdictions within the state have limited regulatory control over what the state allows and does not allow. Another tactic that the state of California has used is to guide data collection from AVs, by requiring companies testing on its roadways to share certain data on disengagements and collisions. Other states require less data sharing from AV companies, which has moved some testing away from California, but given that many of the companies are headquartered in California, they often choose to continue to test in the state and comply with these requirements.

3.4 Federal

Although some attempts have been initiated, a cohesive structure for how AVs will be regulated at the federal level has not yet been established. The eventual approach that the federal government takes, how it is structured (i.e., using voluntary standards or mandated requirements), and how much variation there is between states and between the United States and other countries will all contribute to the regulatory framework within which AVs are ultimately adopted.

The federal government controls safety and standards for vehicles. National Highway Traffic Safety Administration (NHTSA) and Federal Motor Carrier Safety Administration (FMCSA) have started to develop safety standards and testing protocols for AVs. FMCSA has proposed a series of regulatory updates to ensure the safe introduction of automated systems into commercial motor carrier systems. NHTSA and the United States Department of Transportation (USDOT) have also introduced a series of guiding documents on AV policies that support the policy introduction of AVs. Although Congress has attempted to introduce relevant legislation, including the AV Start Act, to date no federal AV legislation has passed.

Government-sponsored tests and data (e.g., from the federal Department of Transportation and Department of Defense to state and local governments) have been used to provide a more reliable source of unbiased and publicly available information on current technological capabilities, thus reducing the need for access to proprietary information or requirements at the state level. Many federal grant programs have included data sharing and other reporting requirements. Past and current grant programs specific to AVs supported by USDOT have included:

- Strengthening Mobility and Revolutionizing Transportation (SMART) Grants: $100 million appropriated annually for fiscal years (FY) 2022-2026 to provide grants to eligible public sector agencies to conduct demonstration projects focused on advanced smart community technologies and systems in order to improve transportation efficiency and safety.
- Automated Driving System Grants (ADS): A 2019 program that awarded $60 million in federal grant funding to eight projects in seven states to test the safe integration of automated driving systems (ADS) on the nation's roadways.
- Complete Trip Program (ITS4US): $38 million to 5 awardees for projects that will enable communities to showcase innovative business partnerships, technologies, and practices that promote independent mobility for all.
- Accelerating Innovative Mobility (AIM): $14 million across 25 projects in 24 states to support and advance innovation in the transit industry. AIM challenge grants will help transit agencies

explore new service models that provide more efficient and frequent service, which will help retain riders.

- Integrated Mobility Innovation (IMI): $20 million across 25 projects that demonstrate innovative and effective practices, partnerships, and technologies to enhance public transportation effectiveness, increase efficiency, expand quality, promote safety, and improve the traveler experience.

AV projects have also been eligible for broader transportation grant programs, such as Infrastructure for Rebuilding America (INFRA) and Rebuilding American Infrastructure with Sustainability and Equity (RAISE).

With the help of these grant programs and other public and private funding alternatives, the industry is working within this minimal amount of government regulation, though it has led to some uncertainty. Federal regulation in the future could affect the options for vehicle design and development, while state regulation could affect operating capabilities and licensing and enforcement issues. Both are critical to the "mainstream" deployment of AVs.

3.5 Existing Providers and Available AV Technology

This section provides an inventory of existing AV providers of available technology, including possible Bay Area businesses to partner with for future efforts. Many AV companies have their global or US headquarters in the Bay Area, and have tested on roadways near or possibly even in San Mateo County.

The California DMV has issued Autonomous Vehicle Testing Permits, which require an operator onboard each vehicle during testing, to forty companies. Of these, seven companies have also received an Autonomous Vehicle Driverless Testing Permit, which allows them to operate without an operator on board. Of these seven, three companies have also received Deployment Permits, which permit them to operate with members of the public onboard as passengers. Key information of each of the forty companies approved by the California DMV is provided in Table 2. Additional information can be found at the link provided for each company.

Table 2: Brief Description of Companies that have received a CA DMV AV Testing Permit

Company	AV Permit Type	Brief Description
Cruise	Driverless Testing Permit Deployment Permit	The AV arm of General Motors. Testing in San Francisco, with rides open to the public subject to registration and only during pre-approved hours.
Nuro	Driverless Testing Permit Deployment Permit	Small vehicles without an operator cabin that are street-legal and used for deliveries.
Waymo	Driverless Testing Permit Deployment Permit	Formerly known as Google's self-driving car project. Rides can be hailed in San Francisco and Phoenix, and are soon expanding to Los Angeles.
Apollo	Driverless Testing Permit	Developed by the Chinese company Baidu.
AutoX	Driverless Testing Permit	Software as a service company that also operates in China.

Company	AV Permit Type	Brief Description
WeRide	Driverless Testing Permit	Chinese company developing Level 4 autonomous systems for taxis, buses, vans, and streetsweepers.
Zoox	Driverless Testing Permit	Subsidiary of Amazon, designing small passenger shuttles. Headquartered in Foster City.
aiMotive	Driver required	Provides “automated driving embedded solutions and the tooling to create and validate them” to automakers like Stellantis.
Apex.AI	Driver required	Software development kit for mobility applications. Headquartered in Palo Alto.
Apple	Driver required	Apple’s self-driving car project has not been openly discussed by the company or shown in any of their marketing material, but they do have an AV Testing Permit with the CA DMV.
Aurora	Driver required	Self-driving technology for semitrucks and passenger vehicles.
Beep	Driver required	Provide operations support for shared mobility networks that utilize AVs.
Black Sesame Technologies	Driver required	Focused on vision and imaging technologies to increase accuracy and range, for both vehicle and roadside sensors.
Bluespace.Ai	Driver required	Focused on an approach to perception and prediction that captures the full motion of any object.
Bosch	Driver required	Large German engineering company developing AVs and applications like automated parking.
Deeproute.Ai	Driver required	Level 4 autonomous driving company working on urban logistics and robotaxis. Also deployed in four Chinese cities.
Didi Research America	Driver required	Chinese vehicle for hire company with an American research subsidiary that works on automation.
Gatik AI	Driver required	Autonomous delivery company focused on the middle mile.
Ghost Autonomy	Driver required	Autonomous driving software for consumer cars.
Helm.AI	Driver required	Unsupervised learning for AI and autonomous technologies.
Imagry	Driver required	Level 3/4 software developer.
Intel	Driver required	Large, Santa Clara-based technology company with an interest in automation. Purchased Mobileye, a driver assist and autonomous driving technology, in 2017.
Mercedes Benz	Driver required	German automotive company with a level 3 AV.
Motional	Driver required	Spin off of Hyundai and Aptiv, a technology company. Headquartered in Boston.
Nio	Driver required	Chinese automobile manufacturer focused on electric vehicles, with efforts in automation for personal vehicles.
Nissan	Driver required	Japanese automobile manufacturer with highway driver assistance and interest in other types of automation.
Nvidia	Driver required	Santa Clara-based technology company focused on AI computing. Vehicle-based systems include autonomous driving, in-cabin functions, and driver monitoring.

Company	AV Permit Type	Brief Description
Pegasus	Driver required	Autonomous driving startup, headquartered in San Jose and Shanghai, with a vision for Levels 4 or 5 of autonomy.
Plus AI	Driver required	Designing modular solutions to scale across vehicle types and applications.
Pony AI	Driver required	Working on both robotaxi and semitruck services, with deployments in China.
Qcraft AI	Driver required	Multiple product options under development, including personal vehicles and shuttles, with a presence in California and China.
Qualcomm	Driver required	Large technology company with a major presence in connected vehicle technology, and some work in driver assistance and autonomy.
Ridecell	Driver required	Fleet automation and management services for shared mobility platforms.
Telenav	Driver required	Connectivity solutions for vehicles across platforms.
Tesla	Driver required	Known for making promises of full self-driving, with some advanced driver assist available in private vehicles on the road today.
Valeo	Driver required	Working on driver assistance systems that use LiDAR sensors.
Vingroup	Driver required	Vietnamese company with an automotive arm that is developing electric and automated vehicles.
Vueron	Driver required	LiDAR perception software provider that provides a platform for autonomous driving.
Woven by Toyota	Driver required	Mobility technology subsidiary of Toyota, working in many areas, including advanced driver assistance systems and automation software.
Xmotors.AI	Driver required	US subsidiary of Chinese electric car startup Xiaopeng Motors. Website is no longer active (link provided is to a 2018 article on their CA DMV permit approval).

Notable companies that do not yet have a DMV permit are shown in Table 3. Some of these companies may not require a permit to operate, due to the size of their vehicle, while others may just not have chosen to deploy in California at this time.

Table 3: Brief Description of Other AV Companies

Company	Brief Description
Cyngn	Focused on industrial vehicles in warehouses and not on-road vehicles, but included because the company is headquartered in Menlo Park.
Daxbot	Small personal delivery devices that can operate on the ADA-accessible sidewalks.
EasyMile	Driverless shuttles with many deployments across the country. They operate a purpose-built vehicle that requires Federal approvals to operate on public roads.
Kiwibot	Food and package delivery service that uses sidewalk robots, primarily on college campuses.

Company	Brief Description
May Mobility	AVs that provide first and last mile microtransit and circulator services.
Perrone	Retrofit AV kit that can be applied to any vehicle type.
Refraction AI	Delivery robot that operates in bike and car lanes, with pilots to date focusing on restaurant food delivery.
RRAI	Retrofit AV kit can be applied to any vehicle type.
Starship	Small personal delivery devices for parcel, grocery, and food delivery on sidewalks.
udelv	Multi-stop driverless deliveries provided by a vehicle with 80 separate and varyingly-sized compartments.

4 Conclusions and Next Steps

This section presents the findings of this report and how they will be leveraged for future project deliverables. **This section will be updated once the stakeholder and public outreach tasks are completed with any ideas that are discussed on possible focus areas, pilot deployments, and next steps.**

4.1 Possible Focus Areas

Based on the review of existing transportation network conditions in San Mateo County provided in Section 2, and how these conditions could be supplemented with the current state of AV service presented in Section 3, this section identifies possible focus areas or constituent groups that could use targeted AV strategies.

Possible focus areas for targeted AV strategies include:

- Highly congested corridors, such as the US101 highway corridor and busy arterials such as El Camino Real
- Specific SamTrans, Caltrain/Caltrain shuttles, city shuttles, WETA routes
    - Hotspots
    - First/last mile connections
- Bicyclist and pedestrian safety use cases – at targeted locations or for targeted needs (i.e., sensors on transit buses or on bikeshare bikes)
- Park and ride facilities, transit centers
- Partnering with transportation network companies (Uber, Lyft, etc.) or area AV providers

Possible constituent groups for targeted AV strategies include:

- Older adults
- People with disabilities – considering separate needs for visual, hearing, mobility, and cognitive impairments
- Students and families with young children
- People without access to personal vehicles or who cannot drive
- People who do not live near a transit service and/or are not familiar with public transit
- People with limited English proficiency (i.e., making sure events or marketing is provided in other languages)

Types of AV pilot deployments and applications that could be conducted at these locations and with these groups may include:

- Shared AV shuttles or automated buses that operate on fixed routes in mixed traffic, within a maintenance garage or yard, and/or in a separate corridor/dedicated lane/guideway to improve transit service in the County
- Mobility on demand AVs within a pre-defined service area potentially targeting underserved areas
- Advanced driver assistance systems deployed on public fleet vehicles, such as transit buses, shuttles, or maintenance vehicles to improve driver safety
- Single-day demonstrations of AV vendor technology, including outreach to communities with varying needs and priorities to increase public education and acceptance of AVs
- Coordination with smart infrastructure or ITS deployments, to test the ability of current ITS infrastructure to support and enhance CAVs and also receive data from CAVs

4.2 Next Steps

The findings presented in this Existing Conditions Report, as well as continued stakeholder and community engagement, will be used to define the scope and priorities of San Mateo County's AV program. The mission, vision, and goals of the AV program will be aligned with those of the similar programs within the county and the state, presented in this report. This exercise of prioritization will serve to set a vision for shared, connected, and autonomous vehicle infrastructure in the county. Proposed roles for the various agencies in the county with respect to AV deployment and desired outcomes will also be a result of this prioritization exercise.

The scope and priorities of San Mateo County's AV program will then be further refined in an AV Strategies Report that recommends potential AV pilots, projects, and activities. These strategies will build on and leverage the existing programs, services and assets documented in this report. Important components will include evaluating potential impacts on the transportation network, regional mobility, and the community at-large, as well as linking the recommended strategies to potential funding programs.

The final list of recommendations will be presented as a 5-year AV Action Plan. This effort will then culminate in the development of an AV Strategic Plan report that will collect previously developed technical memorandums, including this one, into a final, comprehensive public document.

5 References

The following documents and literature were used to gather input for this document.

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