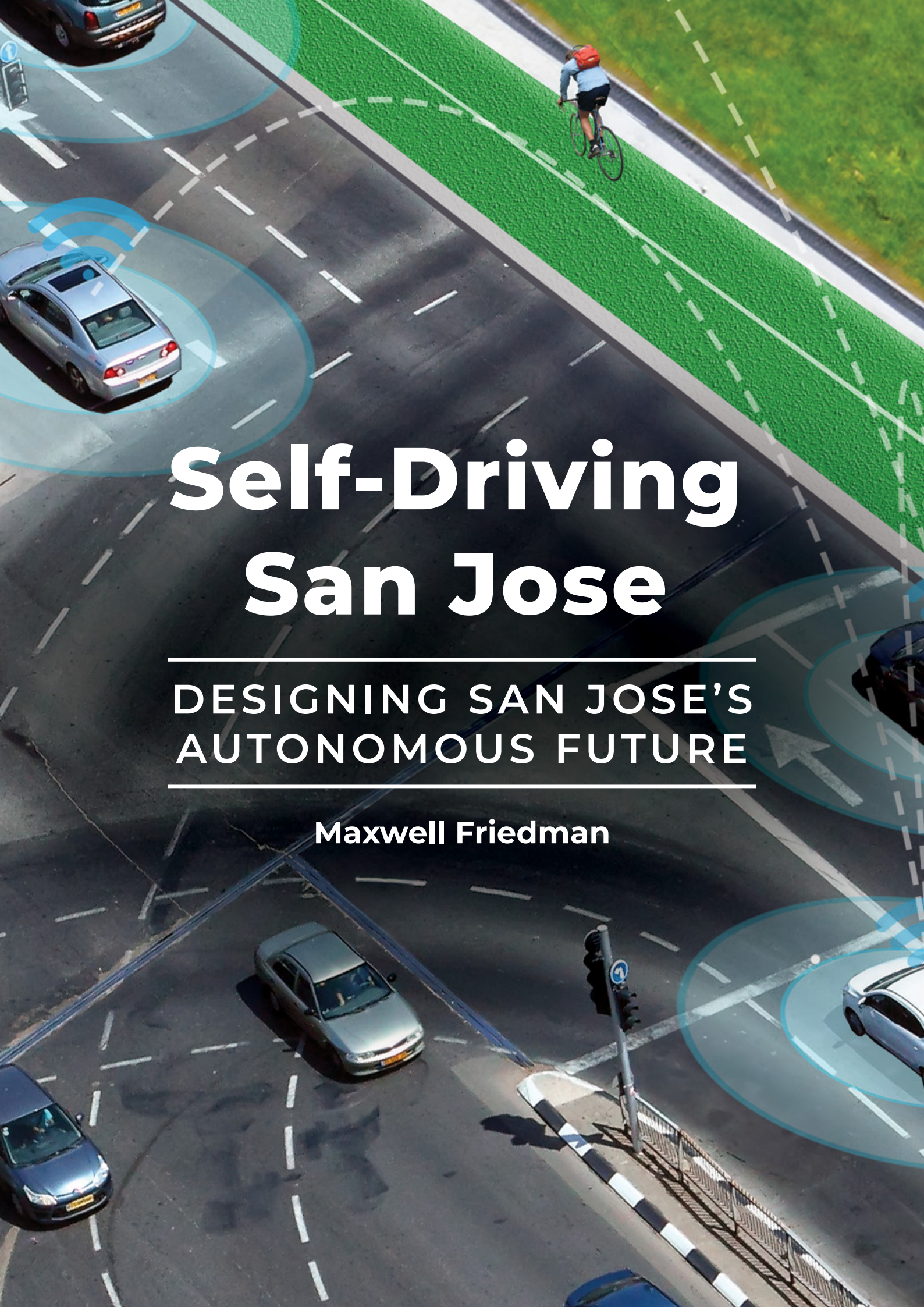

Self-Driving San Jose

DESIGNING SAN JOSE'S AUTONOMOUS FUTURE

Maxwell Friedman

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Introduction

1.1 Executive Summary

Autonomous vehicles hold the power to disrupt transit on a scale not seen since the introduction of the original automobile. It is imperative that planners begin developing strategies to prepare our cities and ensure that they are sufficiently equipped to handle this monumental modal shift. Additionally, planners must stay ahead of these changes by implementing policies to provide equitable access to shared autonomous vehicles and ensure that they function sustainably. As it stands, local governments that have made major efforts in planning for autonomous vehicles are few and far between. The disruptive nature of autonomous vehicles offer a new chance to foster a new "society-wide conversation about transportation, functions of cities, use of streets and how all of these issues impact equity, environment, social cohesion and happiness, local economies, and more" (Riggs et al.). The integration of level 5 fully automated vehicles into our cities provides a unique opportunity to return control of our car-centric streets to pedestrians. This report aims to anticipate the policy and design-based needs and challenges that will accompany the rise of autonomous vehicles in San Jose, CA and supply a series of recommendations based on said needs.

While San Jose is ahead of most cities in preparing for autonomous technology, there is still a long way to go before the city is fully prepared for the disruption this technology will bring. Thus, providing a policy and design-based roadmap for cities to follow is critical as the arrival of this technology nears. While there are countless readings available on how cities will be affected by autonomous vehicles on a broad scale, none provide direct information on San Jose. The goal of this paper is to provide unique, San Jose-specific insights into how the city can prepare for this major technological advancement. The City of San Jose Department of Transportation can draw insights from this research as the city, in line with most other American cities, currently has minimal formal writing on how they plan to prepare for this shift in transportation. This research aims to serve as a foundational framework for developing a San Jose-specific autonomous vehicle action plan.

The organizational structure of this report is split into 5 primary sections. The first section sets the table for the report by presenting the overarching research question of the study and briefly detailing the methodology used in conducting said research. The next section is a comprehensive background which focuses on the history and existing state of autonomous vehicles, an overview of San Jose and its transportation history, and a description of past and planned autonomous vehicle-related planning documents and pilot programs in San Jose. The following two sections are dedicated to methodology with a first a comprehensive literature review and then case studies. Finally,

the report derives results through forecasting the effects of AV on San Jose and supplying policy and design-based recommendations to address these effects. Overall, this report found that San Jose should focus its planning efforts into policy and design choices that address equity, urban design, safety, and sustainability. Moreover, it was found that San Jose should follow the lead of other cities such as Seattle and Miami in creating an AV-specific action plan to guide these policy and design-based decisions.

Figure 1. Visualization of AV Sensing. Source: Adobe Stock

1.2 Research Question and Methodology

01

How can The City of San Jose best prepare for the anticipated modal shift brought forth by the rise of autonomous vehicles through both design and policy-based solutions? How will the rise of autonomous vehicles affect the built environment and transportation infrastructure?

In this study, two research methods were conducted to gather insights into the future of AV planning in San Jose. These research methods include an in-depth literature review and case studies of analogous cities in regards to their preparation for AV technology. Through this research, a series of recommendations were developed for enacting policies and preparing the built environment of San Jose for AV technology.

The organization of this report moves from broad to specific as it pertains to autonomous vehicle planning. The literature review provides the most extensive approach to AV as it looks at the state of autonomous vehicles and emerging trends on a global scale. The case studies are more refined through their focus on specific cities and their approach to AV planning. Lastly, this report reaches its most narrow lens as it then applies the lessons learned from the previous methodology to both forecasting the effects of AV in San Jose and offering a series of policy and design-based solutions in response.

A comprehensive literature review was conducted to create a baseline understanding of the state and future needs of autonomous vehicles in San Jose and the broader United States. The literature review takes a broad approach to understanding the future impacts of autonomous vehicles by splitting the literature into 4 categories of research; equity and public health, economic impact and land use, and design and the built environment. Each distinct category offers specific insights by which San Jose can plan its approach to handling the rise of AV. Special consideration was given to literature that provided concrete data through forecast modeling to anticipate the impacts of AV. This is due to a large amount of research on AV being speculative due to the emerging nature of the technology.

The second research method I elected to conduct was case studies of four cities and their written plans for autonomous vehicles and the built environment. Studying similar cities to San Jose can provide valuable insights into their approach for preparing for autonomous vehicles. I decided that four cities would be sufficient as a bulk of this report goes over the existing plans of San Jose since they are also one of the few cities with written language on AV technology and existing pilot programs. I collected data through a thorough review of the cities' General Plan, transportation plan, emerging mobility plan, and any other pertinent planning documents or pilot programs. Special consideration was given to cities with planning documents dedicated entirely to autonomous vehicle planning.

The four cities selected for the case studies are Seattle, WA, Miami, FL, Elk Grove, CA, and San Francisco CA. These four cities were chosen for a variety of reasons. First, they share several similarities including size and geographic proximity with San Jose but are different enough that their preparation into potential approaches to AV will likely not overlap with each other or San Jose. Additionally, the primary reason for choosing these cities is their proven commitment to preparing for AV through pilot programs and AV-specific planning documents.

These case studies were conducted after a thorough literature review as the goal was to understand the broad needs and limitations of AV planning before diving into specific localized approaches. Ultimately, the case studies were analyzed for any recurring themes with special attention given to any unique approaches to handling AV integration.

1.3 Important Terms

Autonomous Vehicles (AV)

Vehicles capable of traversing a transportation network with little to no human intervention. This is achieved through various sensors that monitor the surrounding environment in real time. Autonomous vehicles are more commonly known as self-driving, driverless cars, autopilot, etc.

Connected Autonomous Vehicles (CAV)

A vehicle that is both autonomous (previously defined) and making use of connected technologies. Connected technologies allow the vehicle to connect to devices within the car in addition to external networks. This provides real-time information to the autonomous vehicle regarding traffic data as the car communicates with other CAVs and network systems.

Complete Streets

A collection of guiding policies and principles that aim to create "safe, convenient, accessible and comfortable streets for all ages and abilities regardless of transportation modes (Bobisse Pavia 2019)"

Multimodal

A trip that involves two or more modes of transportation. For example, this might involve a trip that begins with an e-scooter and ends with a train ride.

First and Last Mile

The first and last mile refers to the first and last, often difficult, sections of a multimodal trip. This is a major issue and key subject in transportation planning as the first and last mile serves as a major barrier in encouraging people to use public transit and other multimodal modes of travel.

Mobility as a Service (MaaS)

Several forms of mobility-based services combined into a single app in which people can plan, book, and pay for trips and delivery-based services.

Shared Mobility

People sharing public or privately owned vehicles including public transit, car share, etc.

Wayfinding

Tools by which a person can discern their position and follow a route to their destination. This includes signage, apps, landmarks, and physical maps

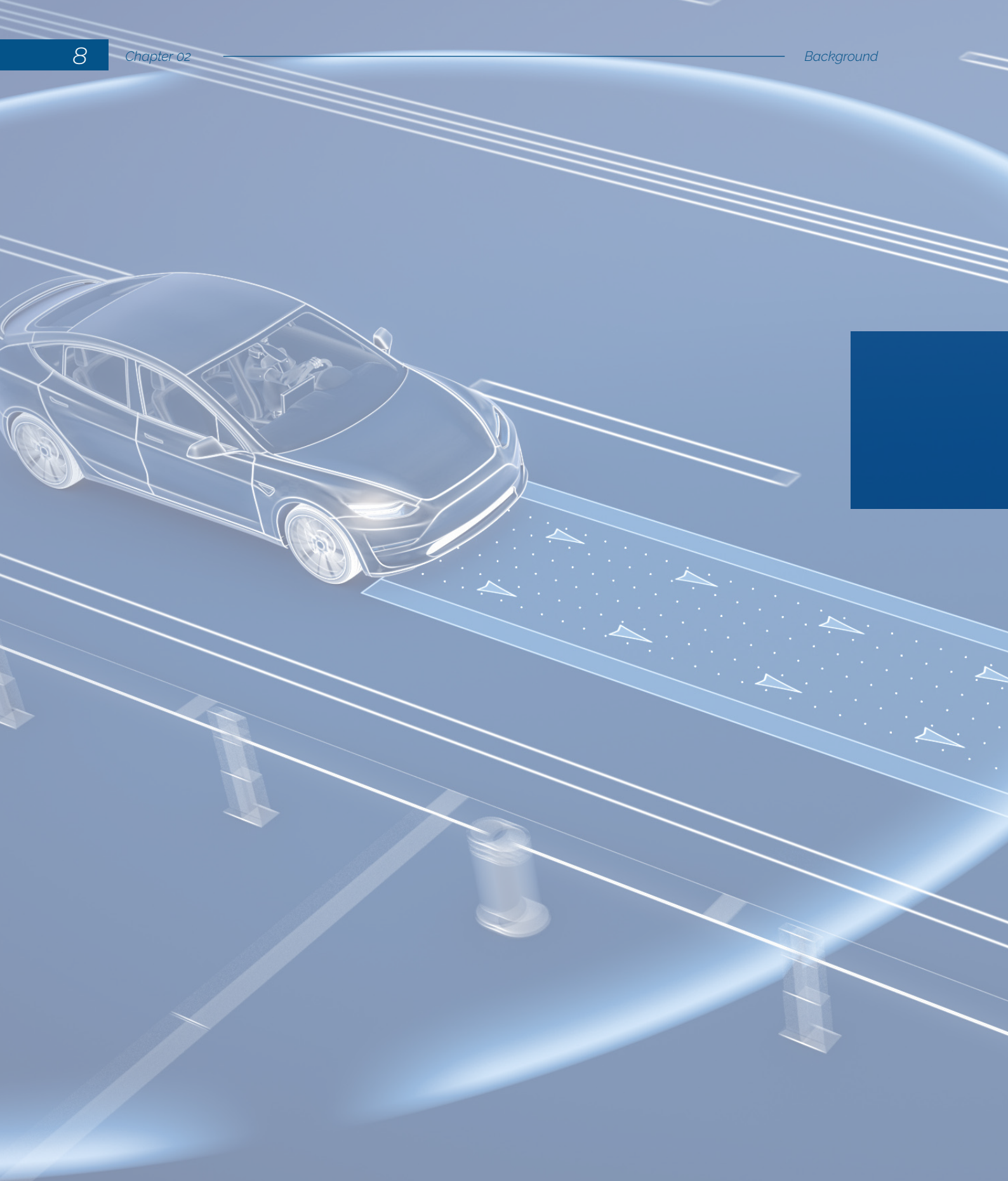


Figure 2. Autonomous Vehicle Sensing Illustration. Source: Adobe Stock

02

Background

2.1 Overview

San Jose, CA has consistently stood at the bleeding edge of technological innovation in transportation. The city has already made major strides in testing AV technology through several pilot programs in the field of autonomous transportation technology. With that in mind, it would align with San Jose's past efforts to be one of the first cities to drastically alter its built environment and enact policy to accommodate the rise of autonomous vehicles.

Experts say that Autonomous vehicle technology could reach level 5 full automation within the next 10 to 40 years (William Riggs et al. 2019). Integrating fully driverless vehicles into the framework of our transportation systems stands to substantially disrupt the way we travel. Autonomous vehicles will remove human error from the driving equation, drastically lowering the number of traffic fatalities. They will entirely eliminate drunk driving and other dangerous human-based issues with cars. Autonomous Vehicles will likely be electric powered providing a green alternative to gas-based single occupancy vehicles. The interconnected nature of AV will allow it to be hyper-efficient, likely reducing congestion through its connection to a network of traffic data and other AVs. Additionally, the aforementioned efficiency of AV operation will free a significant amount of right of way which can then be repurposed into pedestrian friendly functions such as bike lanes, transit boarding islands, and pick-up and drop-off zones.

While there are many potential societal benefits to AV integration, there are also many potential downsides that if left unchecked stand to worsen existing systemic transportation issues such as sprawl, emissions, and disparities in transportation access. In turn, it is vital that San Jose adequately prepare for the inevitable rise in AVs by enacting policy to mitigate the potential downsides of AV and incentivize the benefits.

02

2.2 Autonomous Vehicles

Autonomous vehicles are vehicles that use a combination of sensors, cameras and other remote sensing technologies to aid the vehicle in controlling "some or all of the major driving functions (Bobisse Pavia 2019)" Their range of control over the vehicle can be split into five major categories (APA n.d):

1. Driver Assistance (adaptive cruise control, blind spot detector)
2. Partial Automation (self-parking, highway autopilot)
3. Conditional Automation (human drivers serve as a backup to autonomous system that can operate under most conditions)
4. High Automation (Full automation with a steering wheel for occasional manual driving)
5. Full Automation (no steering wheel in the vehicle)

In their current form, autonomous vehicles are primarily allowed level two, partial automation control of legal, privately-owned vehicles on the road. This level of automation was popularized by Tesla with their freeway autopilot and automatic parking assistance. Level three conditional automation vehicles are currently being tested on city streets such as San Francisco in which Waymo test vehicles can be seen autonomously navigating the city. This model of automation requires a person present in the vehicle as a safety valve in case any unpredictable situations arise. In 2023, California DMV approved the first instance of full commercial deployment of level three conditional automation through Mercedes-Benz' DRIVE PILOT automated driving system (California DMV 2023). This system will allow the vehicles to take full control of the motor functions under certain conditions. Drivers may only engage in the automated driving system on California State Highways and must remain under 40 miles per hour. According to reports, autonomous driving technology still struggles with more complex driver functions such as unprotected left turns against traffic (Verger 2021). As can be seen with the quick integration of level 3 automation in California, as driving technology advances it can be assumed that the rollout of autonomous vehicles will be streamlined as technology allows.

Throughout history, new transportation technology has ushered in massive modal shifts that upend the existing status quo of transit. From the original automobile to the airplane, advancements in travel have consistently changed the way we commute. When the original automobile was introduced with the Ford Model T, the world was unprepared for the monumental upheaval that it would cause to the predominant system of transportation. In turn, planners of the time were forced to plan for automobiles in a reactionary fashion as opposed to a proactive approach. This led to needs of the open market dictating the built environment as cities desperately tried to catch up to the demand brought by the rising popularization of cars. This reactionary approach then resulted in the death of walkability and human-centric design in cities as The United States optimized its infrastructure for cars in prioritizing car-centric design. The United States has developed into a society in which "car is king". The desire for a personal automobile is ingrained into the fabric of our culture. This cultural zeitgeist cannot be so easily reversed.

Instead, autonomous vehicles offer a best of both worlds approach in which they can utilize the existing cultural obsession with cars and car-centric infrastructure to ease consumers into a more environmentally-friendly, economically-viable solution while gradually shifting our built environment to a walkable scale. However, it is vital that cities act proactively in planning for autonomous vehicles so as to not exacerbate existing issues with single-occupancy vehicles.

The following is a comprehensive list of all autonomous vehicle related senate and assembly bills in California. Bills that are specific to a certain locality within California are highlighted in light blue (National Conference of State Legislatures n.d.).

2.3 State Guidance

Bill	Description
SB 1298 (2012)	Requires the Department of the California Highway Patrol to adopt safety standards and performance requirements to ensure the safe operation and testing of autonomous vehicles, as defined, on the public roads in this state. Permits autonomous vehicles to be operated or tested on the public roads in this state pending the adoption of safety standards and performance requirements that would be adopted under this bill.
AB 1592 (2016)	Authorizes the Contra Costa Transportation Authority to conduct a pilot project for the testing of autonomous vehicles that are not equipped with a steering wheel, a brake pedal, an accelerator, or an operator inside the vehicle, if the testing is conducted only at specified locations and the autonomous vehicle operates at specified speeds.
AB 1444 (2017)	Authorizes the Livermore Amador Valley Transit Authority to conduct a shared autonomous vehicle demonstration project for the testing of autonomous vehicles that do not have a driver seat in the driver's seat and are not equipped with a steering wheel, a brake pedal, or an accelerator.
SB 145 (2017)	Repeals a requirement that the Department of Motor Vehicles notifies the Legislature of receipt of an application seeking approval to operate an autonomous vehicle capable of operating without the presence of a driver inside the vehicle on public roads. Repeals the requirement that the approval of such an application is not effective any sooner than a specified number of days after the date of the application.
SB 1 (2017)	This bill encourages the California Department of Transportation and cities and counties to, when possible, cost-effective and feasible, use funds under the Road Maintenance and Rehabilitation Program to use advanced technologies and communications systems in transportation infrastructure that recognize and accommodate advanced automotive technologies that may include, but are not necessarily limited to, charging or fueling opportunities for zero-emission vehicles, and provision of infrastructure-to-vehicle communications for transitional or fully autonomous vehicle systems.
AB 87 (2018)	Authorizes law enforcement or a public employee who is engaged in directing traffic or enforcing parking laws and regulations, to remove a vehicle that uses autonomous technology without a valid permit that is required to operate the vehicle on public roads. The bill authorizes the release of the vehicle after the registered owner of, or person in control of, the autonomous vehicle furnishes the storing law enforcement agency with proof of current registration and a valid driver's license, and either a valid permit that is required to operate the autonomous vehicle using autonomous technology on public roads or a declaration or sworn statement to the Department of Motor Vehicles that states that the autonomous vehicle will not be operated using autonomous technology, as specified.
AB 1184 (2018)	Authorizes the City of San Francisco to, if approved by voters, levy a tax on trips taken in autonomous vehicles that originate within the City and County of San Francisco provided by a transportation network company, i.e. TNC. Such taxes may be up to 3.25 percent of the fare for each trip. The bill includes some limiting and optional conditions to such fees, including A discounted fee shall be charged to any shared trip (i.e. greater than one passenger) not to exceed 1.5 percent of the total fare; the city may charge a lower rate for trips taken in zero-emission vehicles; revenues collected from such a fee would be required to fund transportation operations or infrastructure and the authority is sunset in 2045.
SB 500 (2021)	Beginning January 1, 2030, requires, to the extent allowed by federal law, any autonomous vehicle that is model year 2031 or later, has a gross vehicle weight rating of less than 8,501 pounds, and is equipped with Level 3, 4, or 5 automation (as defined by SAE International) to be a zero-emission vehicle, as defined, to be operated on California public roads.

SB 500, the most recent of these bills, offers huge potential ramifications to the integration of autonomous vehicles into the future California transportation systems. This is because it nearly guarantees that autonomous vehicles in California will improve the overall sustainability of the state transportation network. This increased sustainability is due to the requirement that all autonomous vehicles on or after the year 2030 that utilize level 3, 4, or 5 automation be zero-emission vehicles. This, in turn, would guarantee that they are not adding to the existing levels of GHG emissions in California. If autonomous vehicles rise to the level of popularity that is expected, then it can be inferred that this bill will not only increase sustainability and lower GHG emissions among AVs but across the entirety of California's transportation framework. Moreover, SB 1 highly encourages and funds the creation of electric vehicle charging stations which would support the requirement set forth by SB 500.

As AV technology advances, legislation will need to evolve in step with the technology. While California has made legislative efforts to ensure that AV is sustainable, there must be similar policies enacted to ensure that the technology is equitable, multimodal, and economically viable. Additionally, California needs to dedicate funding in the form of grant programs to best equip cities with the proper infrastructure to facilitate these goals.

2.3 Federal Guidance

USDOT Automated Vehicles Comprehensive Plan

USDOT developed this plan to provide guidance in supporting to "safe integration of Automated Driving Systems (ADS) into the surface transportation system [of the United States] (USDOT 2021)" The planning document offers national guidelines in autonomous vehicle operation and deployment through three broad themes; protect users and communities, promote efficient markets, and facilitate coordinated efforts. Within these themes there are 10 distinct goals by which state and local governing bodies should facilitate AV planning. The goals are as follows:

1. Prioritize Safety
2. Emphasize Security and Cybersecurity
3. Ensure Privacy and Data Security
4. Enhance Mobility and Accessibility
5. Remain Technology Neutral
6. Protect American Innovation and Creativity
7. Modernize Regulations
8. Promote Consistent Standards and Policies
9. Ensure a Consistent Federal Approach
10. Improve Transportation System-Level Effects

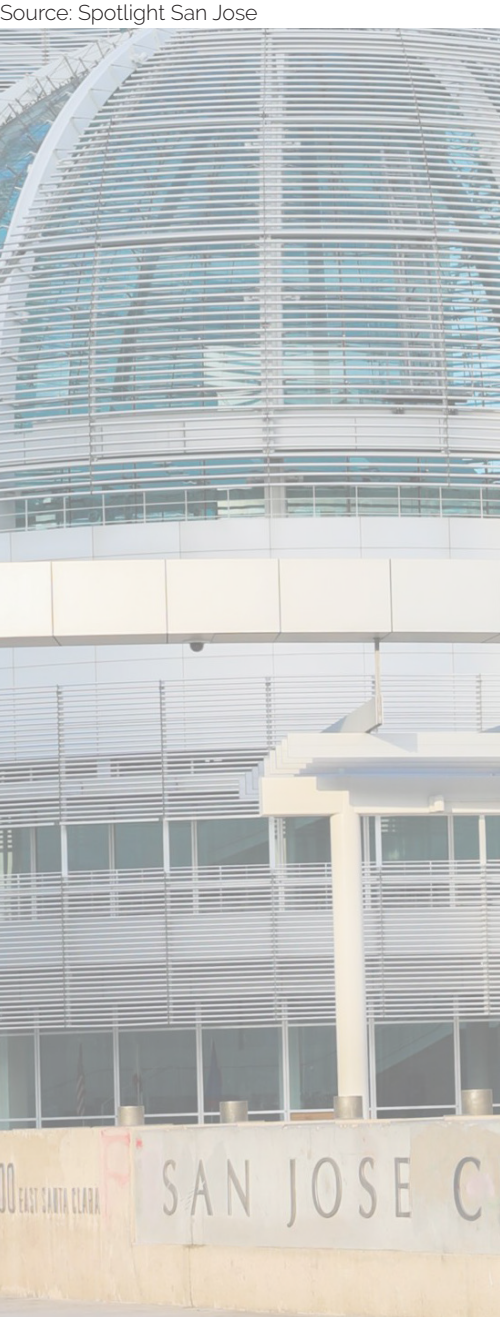
These 10 goals provide a guiding framework by which cities can localize their approach to AV planning. Through these foundational principles San Jose policymakers and planners can develop approaches that best fit their own needs while pursuing these national goals in autonomous planning.

02

2.4 The City of San Jose and Transportation

A Complicated History

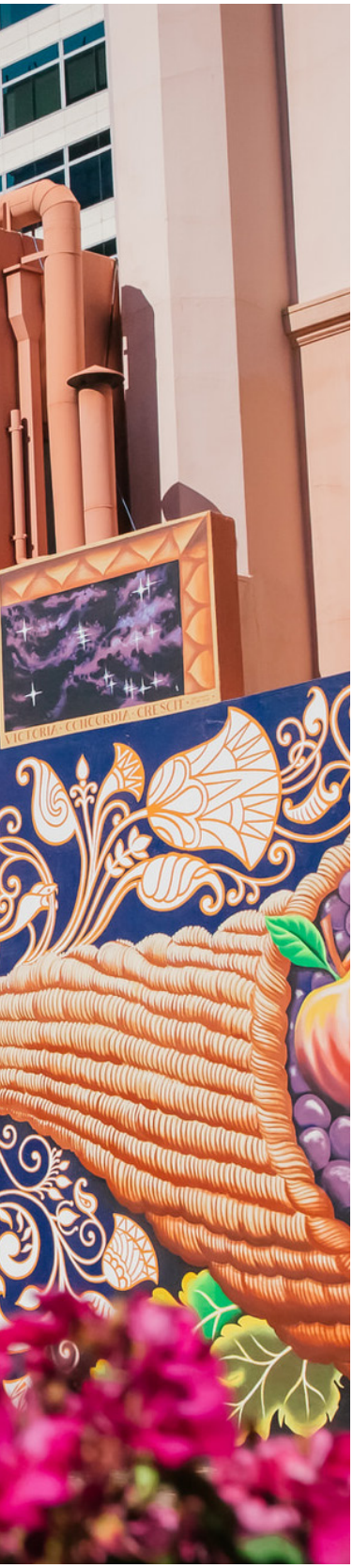
Figure 3. San Jose City Hall.
Source: Spotlight San Jose



San Jose, CA is the 10th largest city in the United States with just under a million people. Known as the capital of Silicon Valley, San Jose has long been a driver in technological innovation. This innovation extends to the city's transportation infrastructure as San Jose has consistently been at the forefront of technological advancements in travel. In line with this, San Jose has the 3rd highest rate of electric vehicles in the nation and the most EV charging stations (Kolomatsky 2021) demonstrating the city's willingness to adopt new transit technology. Waymo, the industry leader in autonomous vehicles under the umbrella of Google, is headquartered just outside San Jose in Mountain View, CA. Currently, the San Jose DOT has already tested semi-autonomous delivery robots known as Kiwibots and an autonomous shuttle pilot program through Mercedes-Benz. Additionally, the Department of Transportation lists autonomous shuttle services as one of their long term goals in the Downtown Transportation Plan and has plans to create an autonomous shuttle system connecting Diridon Station to the Mineta Airport. In turn, it can be assumed that San Jose will likely stay on course in continuing to pave the path in integrating Autonomous Vehicle technology.

San Jose has been the host of "rapid and largely unplanned growth (City of San Jose 2011)" since the 1960's. In the 1970's San Jose was ranked the fastest growing city in the United States for the entirety of the decade. This unprecedented growth was only further exacerbated by the coming technological boom of the 1990's. Due to said growth, San Jose hosts some of the worst suburban sprawl in the country. Moreover, to account for the increased traffic congestion brought by the growing population, the city constructed several major highways that bisect and disconnect communities. Today, one can only find pockets of walkable neighborhoods due to the overall prioritization of car infrastructure in the city. Downtown San Jose, one of the few walkable areas in the city, has been shrinking due to residents opting to live outside of the city center in one of San Jose's many suburbs. Moreover, San Jose is considered a bedroom community meaning that a majority of its inhabitants

Figure 4. San Jose Mural. Source: The City of San Jose



commute outside of the city to work. While San Jose is known as the capital of Silicon Valley, the vast majority of technology company headquarters are situated north of San Jose along the western side of The Bay in towns such as Palo Alto and Stanford. These factors contribute to San Jose's existing discrepancies in access to transit and the overall efficacy of its transportation systems.

Racism and Its Effect on Transportation Access

San Jose's history is mired by racism ingrained into the urban fabric through discriminatory redlining policy enacted in the 1930's. Neighborhoods which held high populations of people of color were categorized as "hazardous" for mortgage lending and in turn locked out of home loans. This system created a vicious cycle of nearly inescapable poverty for residents of the neighborhoods deemed "hazardous".

These redlined neighborhoods were not only the host of discriminatory housing practices but were altogether neglected by the city in regards to overall maintenance. East San Jose, an area that has historically held a high concentration of minorities, was notoriously in a state of disrepair and overall neglect by the city. Residents described the conditions as "unpaved streets and crowded houses, with no sewers, no sidewalks, no services, no lights (Loukaitou-Sideriset et al. 2023)" Instead of investing in improving these neighborhoods, San Jose acquired property in "blighted" areas through eminent domain and subsequently demolished and redeveloped them as part of the wave of urban renewal in the 1950's. This redevelopment displaced many low-income residents who could no longer afford the housing prices of the newly developed area.

In line with the redevelopment and displacement of underrepresented communities brought about by urban renewal, San Jose began the construction of several major highways. Interstate 280 and Highway 87 bisected Downtown and displaced huge portions of existing communities. In total, it is estimated that 1,800 to 2,700 homes were demolished in the construction of freeways during this period in San Jose. This resulted in the displacement of approximately 4,149 people, over half of which were people of color. These highways severely impacted the mobility of residents in the area by limiting their access to transportation modes outside of car travel.

2.5 San Jose AV Planning and Pilot Programs

Kiwibot Pilot Program

Kiwibots are semi-autonomous delivery robots that aim to disrupt delivery based services by providing deliveries on a smaller scale. The City of San Jose Department of Transportation partnered with Kiwibot through a pilot program to test the efficacy of the technology. The delivery robots operated within the bounds of Downtown San Jose traveling on the sidewalks at about walking speed. The technology is classified as semi-autonomous meaning that they are capable of navigating most scenarios fully autonomously but have remote human operators who can take over in certain scenarios that are difficult for the robots to navigate. The robot is roughly 2 feet by 2 feet give or take with a temperature controlled inner-compartment to hold small food deliveries. The aim of the Kiwibot pilot program was to test the efficacy of a short-range alternative to ride-share based delivery apps such as Uber Eats and DoorDash. There are several drawbacks to the technology in its current form that would make it difficult to implement on an economically viable scale. The first is its current lack of true autonomy. This drawback requires the company to staff remote operators to pilot the machines. In turn, this adds fees to the potential price of delivery. Moreover, the vehicles cannot travel far and move at about walking speed. This functionality raises questions of whether this would impact the overall walkability of cities as most of these trips could easily be made by foot. However, many ride-based food deliveries are also within walking distance and would thus be replaced by a more environmentally friendly alternative.

Figure 5. Kiwibot Autonomous Delivery Robot. Source: Wikipedia

Mercedes-Benz Pilot Program

In 2017, San Jose began plans for its pilot program to test the Mercedes-Benz autonomous vehicles. This pilot incorporated an app-based autonomous ride sharing service in which select San Jose residents would be given the opportunity to test the ride sharing technology by hailing the autonomous vehicles. This marked the first time that a city in the United States had allowed a private company to test such a service. One of the

Figure 6. Mercedes-Benz Autonomous Pilot Vehicle. Source: Car and Driver

primary catalysts for this program was San Jose's Smart City initiative in which the city aims to "to provide the most creative, impactful technologies to disrupt industries and transform lifestyles…" and "become a global leader for civic innovation (The City of San Jose n.d.)". The pilot program began with an intensive community engagement workshop in which the reactions and needs of community members in regards to autonomous vehicle technology were gauged. Ultimately, the program was suspended indefinitely due to COVID-19. While San Jose was unable to test the ride-sharing capabilities of AV, this program demonstrated a willingness within the city to innovate in the realm of autonomous vehicles and cement San Jose as a pioneer for the technology.

Figure 7. Glydways Airport Connector. Source: SFGate

Airport Connector

The City of San Jose is planning to build a transit connection between Diridon Station and Mineta San Jose Airport. However, this connection will be unique in that it will involve the use of autonomous vehicles to transport passengers between the two major transportation hubs. The City of San Jose has enlisted the help of Glydways, a company that specializes in autonomous vehicle technology, to create this autonomous connection. Their plan was chosen from a group of 23 different companies, including Elon Musk's The Boring Company, that offered solutions in bridging the gap between these two hubs. The Glydways chosen plan will involve the creation of 5.5 foot dedicated paths providing a direct route for the pods to follow. This dedicated path allows the vehicles to circumvent the existing issues with integrating autonomous vehicles into existing traffic systems. The pods themselves can carry a maximum number of 4 passengers. This method of transit falls into the category of Personal Rapid Transit (PRT), in which small personal sized vehicles hosting three to six passengers travel in a dedicated lane separated from the exciting street network. The project is tentatively planned to be constructed as early as 2026-2028 (Fortuna 2023). Many have rallied against the proposed project insisting that a dedicated bus system or similar proven transit option would be more effective. However, the efficiency and low-carbon foot combined with the overall uniqueness of the Gyldways pods was enough to sway San Jose decision makers.

Figure 8. Glydways Airport Connector Front View. Source: Bloomberg

San Jose Emerging Mobility Action Plan

To help guide the implementation of innovative transportation technologies in San Jose, the city has developed the Emerging Mobility Action Plan (EMAP) to guide emerging mobility services. The plan cites the deployment integration of autonomous vehicles as "inevitable (The City of San Jose 2022)". EMAP approaches planning for autonomous technology as a situation of "when" rather than "if". As mentioned in EMAP, "California Public Utilities Commission granted Cruise a permit to provide the first driverless automated vehicle passenger service to the public in the state". While there are currently only plans to operate the Cruise autonomous ride-hailing service in San Francisco, the company has projected that it will soon after expand to San Jose and the South Bay.

EMAP has given special attention to the potential downsides of automation on the city's workforce. As autonomous vehicle technology expands, new jobs will require different skills, widening the skills and wage gap. Manufacturing and auto industries will need to adapt to ensure that jobs are not lost to this technological shift.

Lastly, EMAP provides a detailed list of key terms and definitions of common terms in the world of emerging mobility. These definitions were used in conjunction with other sources to develop the following list of important terms within this paper.

Figure 9. San Jose Emerging Mobility Action Plan Cover. Source: The City of San Jose

Vision Zero

Vision Zero is a traffic safety initiative in San Jose with the goal of reducing and eventually eliminating traffic related deaths and injuries altogether. This goal is pursued through a comprehensive action plan consisting of six guiding tenets. A significant cornerstone of this initiative is using data analytics to systematically reduce traffic fatalities through gleaning insights on where and why traffic collisions are happening. This initiative also involves the creation of a task force of both public stakeholders and public agencies to guide the work of Vision Zero. Recently, Vision Zero has directed significant

Figure 10. San Jose Vision Zero Ad Campaign. Source: The City of San Jose

efforts into community engagement and overall awareness campaigns through the use of ads along high collision roadways urging drivers to use caution and stay alert when behind the wheel.

This initiative is incredibly relevant to autonomous vehicle planning in San Jose as AVs offer a unique opportunity to achieve the traffic safety goals of this initiative. AV is predicted to offer a level of traffic safety and precision beyond the level of any human driver. The technology will entirely eliminate human error in exchange for robotic efficiency.

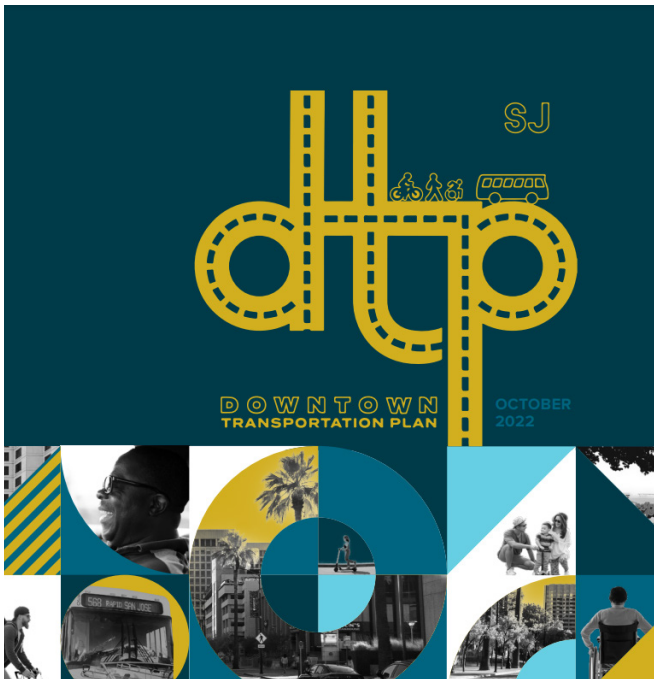


Figure 11. San Jose Downtown Transportation Plan Cover. Source: The City of San Jose

San Jose Downtown Transportation Plan

This plan serves as a long-range strategic plan to improve both to and from Downtown San Jose over the next 20 years. The plan is organized into four big transportation moves that will help shape the transportation framework of Downtown San Jose into the desired outcome by 2040. The four big moves are improving transit, supporting short trips on foot and by bike, using excess capacity efficiency, and simplifying the street grid. Within these four big moves are over 50 transportation projects, programs, policies.

The plan highlights a project that could potentially benefit from autonomous vehicle operation when the technology allows. This project is strategy 16 involving the use of neighborhood shuttles or microtransit to connect service gaps within the transit network downtown. Instead of competing with VTA bus services, this project aims to fill gaps within their existing network. This plan can potentially improve issues of filling the gap of the "first and last mile" downtown by connecting people to Diridon Station, San Jose Mineta Airport, and other transit hubs. Below is a map of potential shuttle routes. Autonomous microtransit would be able to easily navigate these paths and provide consistent transit connections throughout Downtown San Jose for its residents.

Figure 12. San Jose Downtown Transportation Plan Autonomous Shuttle Route Map.. Source: The City of San Jose

03

Literature Review

3.1 Introduction

To understand and plan for the rise of AV in San Jose it is important to understand the overall impact that AV will have on our society as a whole. Being an emerging technology, the vast majority of literature on the impacts of autonomous vehicles is speculative. In line with this, most of the research available is based on predicting said impacts through modeling the effects of AV and interviewing relevant stakeholders. In developing an understanding of the potential impacts autonomous vehicles might have on the urban fabric of San Jose, this literature review takes a broad approach to understanding the topic. The following research aims to foster an understanding of the topic at hand based on three distinct themes. The first is a review of literature pertaining to AV's potential impact on equity and public health. Next, the focus shifts to a review of literature pertaining to AV's impact on the economy and land use. Lastly, considering the previous themes, an analysis was conducted of AV's potential impact on urban design and the built environment.

3.2 Equity and Public Health

Anticipating AV's impact on transportation equity is difficult due to the complex nature of the term. One must first define what equity means to a given society in order to develop an understanding of its potential impact. An effective way to anticipate the impact of AV on transportation access and equity is to develop a model to simulate said impact. Jesse Cohn et al developed a travel demand model to examine the potential impacts of AV on equity based on eight distinct scenarios in Washington, DC. Metrics used to evaluate equity impact include trip duration, job accessibility, trip distance, and mode share (Cohn et al. 2019). The model found that AV will enhance job accessibility and reduce travel time in Washington D.C's equity emphasis areas. Additionally, the model found that total auto trips and vehicle miles traveled are expected to increase with the rise of AV. This, in turn, could exacerbate the existing issues of pollution in disadvantaged communities if policy is not adopted to mitigate said issue. Overall, this study found that if implemented correctly, the positive outcomes of AV will outweigh any potential negative outcomes. The key to ensuring an equitable AV future is through careful policy decision making.

To ensure equity in the impending rise of AV, it is important that cities are adequately prepared to handle this modal shift. Yonah Freemark et al. analyze the preparedness of local governments in planning for AV in their study "Are Cities Prepared for Autonomous Vehicles?" (Freemark et al. 2019). In this study, relevant planning documents from the 25 largest U.S cities are reviewed to determine the amount of written planning in place in response to the coming rise of AV. Additionally, planning and transportation officials were surveyed on how

they plan to prepare for AV. Freemark et al. found that There is very little written planning for AV in existing planning documents. 64% of cities have no mention of AV in their comprehensive or transportation plans. San Jose, however, is one of the few cities with a specific Emerging Mobility Action Plan that specifically mentions the city's plans for AV. Moreover, San Jose is one of the few cities with a pilot program testing the effectiveness of AV.

Another major barrier to the integration of AV into our transportation framework is user acceptance. To analyze the public's trust of autonomous vehicles Dirk Heinrichs and Rita Cyganski conducted a survey in Germany in which they asked respondents to consider their willingness to replace their existing primary mode of travel with different types of AV vehicles (Heinrichs and Cyganski 2015). These replacement AV options include vehicle on demand, fully automated vehicle, vehicle with valet parking, automated vehicle with interstate pilot, and an automated vehicle in general. Of the 1000 respondents, fewer than 15% reported a willingness to replace their primary mode of travel with AV. The primary uses that respondents were willing to replace were taxis and valet parking. In analyzing this study, it is important to remember that the public transportation landscape in Germany is drastically more comprehensive and effective than that of the United States. This might explain the general apprehension to replace their "primary mode of transportation" as it is potentially more efficient than a car. Public perception of autonomous vehicles would potentially be different in the U.S due to its car-centric nature.

The previous study illustrates the importance in developing a sense of trust in autonomous vehicles as a viable replacement for human-driven vehicles. To better understand the potential barriers to the implementation of AV, Eva Fraedrich et al. developed a framework of "transitional pathways" to the emergence of AV in their research "Transition pathways to fully automated driving and its implications for the sociotechnical system of automobility" (Fraedrich et al. 2015). They mention the importance of public trust in machine's piloting their vehicles and provide a potential solution to the issue. Eva Fraedrich et al. speak to the importance of "the machine's ability to mimic humanity" in instilling a sense of trust in the passenger. To mimic humanity an AV could have a name, gender, voice, etc. This concept is known as anthropomorphism.

To understand the impact of AV on equity it is vital to understand its impact on public health. Sohrabi et al. developed a conceptual model in their study "Impacts of Autonomous Vehicles on Public Health: A Conceptual Model and Policy Recommendations" to identify potential public health impacts as a result of AV (Sohrabi et al. 2020). The model was split into seven points of impact including transportation infrastructure, land use and the built environment, transportation equity, and jobs related to transportation. The authors found that 17 of the 32 potential outcomes can adversely impact health while only eight can positively impact public health. Ensuring positive outcomes is dependent on developing supporting policies such as ride-sharing policies and regulating urban area development. Some of the key findings from this study include AV's being expected to eliminate 94% of crashes by removing driver's error from the driving equation. The authors also list cybersecurity as a major barrier to public health as "hacking and misuse of vehicles can result in catastrophic crashes".

When discussing transportation related equity it is important to understand the historic inequities ingrained into our transportation systems so that we might overcome these disparities in the future. "Structural Racism and Pedestrian Safety: Measuring the Association Between Historical Redlining and Contemporary Pedestrian Fatalities Across the United States, 20102019" by Nandi L. Taylor et al. discusses the prevalence of a lack of transportation access among historically redlined communities (Taylor et al.2023). This comprehensive study analyzed traffic fatality data and applied a model to determine if there is a correlation between redlining and traffic-related pedestrian fatalities across 15,289 census tracts within historically redlined areas.. The authors found that there is indeed a clear relationship between these factors as "grades worsened from A to D, rates of pedestrian fatalities increased". As mentioned

previously, AV's are predicted to eliminate 94% of crashes by removing human error from driving (Sohrabi et al. 2020). This, in turn, will greatly benefit these disadvantaged areas as the pedestrian fatality rate will undoubtedly decrease.

3.3 Economic Impact and Land Use

Economic viability is an important concern when considering the efficacy of a potential modal shift. Moreover, economic limitations will have ramifications on potential changes to the built environment. "Autonomous mobility-on-demand systems for future urban mobility" by Marco Pavone explores a hypothetical deployment of autonomous mobility on demand system in New York City and Singapore using a modeled approach (Pavone 2016). Specifically, this study focuses on the effect that this system might have on these respective economies. Interestingly, they found that the demand for taxis in Manhattan can be met with only 8000 AVs. This equates to only 70% of the size of the current Manhattan taxi fleet pointing to the efficiency of AVs. The study also found that mobility needs of the entire population of Singapore can be met with "a number of robotic vehicles roughly equal to 1/3 of the current number of passenger vehicles.". A similar study by Chris Brownell and Alain Kornhauser titled "A driverless alternative: fleet size and cost requirements for a statewide autonomous taxi network in New Jersey" modeled the economic viability of an autonomous mobility on demand service in New Jersey. They found that a"smart paratransit" system in which autonomous vehicles pick up several passengers in one trip from central transit points is the most economically viable option (Brownell and Kornhauser 2014). This system would require a fleet of 1.6 to 2.8 million to meet the entire state's mobility needs, while the cost to consumers would only be $16.30 to $23.50 per day. Again, this study emphasizes the economic viability and efficiency of autonomous mobility on demand service.

Continuing the theme of the economic viability of AV, Daniel J. Fagnant and Kara Kockelman provide a detailed cost breakdown of the estimated impact of AV on the U.S economy based on different levels of market penetration (Fagnant and Kockelman 2015). They found that with only 10% market penetration the annual economic benefits of AV could be in the range of $27 billion. The authors estimate that each singular AV would provide $2,000 to $4,750 annually in societal benefits. Altogether, the estimated economic impact of AV at its peak (90% market penetration rate) is modeled at $450 billion per year. However, this number does not include external costs such as emissions, employment, and security and data privacy. They also figure that AV will initially likely be unaffordable to most Americans. In turn, it would be beneficial to direct federal funding to implementing a shared autonomous mobility service as mentioned in the previous paragraph.

There is a major risk that the overall cost of AV tech will be too much to overcome for both the consumer and the U.S economy as a whole. James M. Anderson et al. detail these concerns in the book "Autonomous Vehicle Technology: A Guide for Policymakers" in their chapter Guidance for Policymakers and Conclusions (James M. Anderson et al. 2014). This chapter details various economic barriers to implementation such as the price of the vehicle themselves. Currently, the sensors necessary to safely operate an AV costs tens of thousands of dollars effectively doubling the price of a standard automobile. However, there will likely be technological advances in the future that lower these costs.

Understanding the future impact of AV on land use patterns begins with understanding its effect on sprawl. Historically, sprawl leads to issues such as congestion, emissions, and negatively impacts a city's downtown core. William Larson and Weihua Zhao use various models to anticipate the effects of AV on the classic monocentric city model in which density decreases as you move farther away from the core downtown and into the surrounding suburbs (Larson and Zhao 2020). This study was conducted to analyze the potential for AV to impact sprawl, energy consumption and housing affordability. The authors found that in most modeled outcomes AV led to greater housing affordability by making the lower priced suburbs more accessible. Unfortunately, this also led to a higher rate of energy consumption from the

longer commutes which in turn would create more congestion and higher emissions rates. It is worth noting that other studies have found that AV would more likely improve congestion as self-driving vehicles would reduce crash rates and drive more efficiently. The study found that AV in a scenario in which self-driving vehicles are introduced to cities with no guiding policy regulations would undoubtedly lead to sprawl. This can be seen in the modeled increase in total houses by about 26% and the city radius expanding by 11.3 miles. Conversely, the authors found that limiting parking in the central business district would have an inverse effect as the city radius decreases in this scenario. The final model in which autonomous taxis are the primary mode of AV shows no discernible effect on sprawl.

Riggs and Boswell counter the previous claims that unmitigated AV will lead to sprawl in their 2016 article "Why autonomous vehicles probably won't induce sprawl" (Riggs Boswell 2016). They cite three major factors as to why sprawl is unlikely to occur in response to AV integration. These factors are "the presence of existing land use, transportation, and infrastructure controls and growth management plans, trends in housing consumption and residential preferences, and social dynamics and the emergence of more informed decision-making". Some scholars argue that AV will lead to the end of the walkable city but alternatively AV would result in road diets from the efficiency of AV and in turn make way for wider sidewalks and bike lanes. In the context of California, sprawl is unlikely as the state has incentivized smart growth through "California's Affordable Housing for Sustainable Communities program, funded from the carbon market established by AB-32, can be applied to affordable and transit connected housing units in the urban core". This grant will disincentivize a new generation of exurbs in response to AV.

3.4 Design and The Built Environment

Understanding the effect of AV on urban design and the built environment is a culmination of understanding the economic and equitable outlook of AV. Once these factors are anticipated one can begin to make inferences on their effects on how cities should be built based on proactive and reactive design choices. Eva Fraedrich et al. dive into the topic of the implications of AV on the built environment in their study "Autonomous Driving, the Built Environment and Policy Implications" (Fraedrich et al. 2019). In this paper they derive these potential impacts from quantitative online surveys and qualitative interviews with relevant transportation planners and other stakeholders in Germany. They then model these effects through different use cases. Altogether, the authors found that AV could potentially encourage sprawl as mentioned in the previous paragraph by encouraging people to move farther away from city centers. This is due to the passenger's newfound ability to invest their time spent traveling into other work since they are not occupied with driving the vehicle. Moreover, this could lead to increased emissions rates. On a more positive note, the study found that the rise of AV will free space that was once dedicated to parking. This opens the door for new developments in an urban fabric such as public transport lanes, broader and better sidewalks, more bike lanes, and green areas. Additionally, fixed stops for AV would be an important addition to the built environment as pick up and drop off points will likely become essential needs of the new transportation landscape.

Continuing the theme of a heightened need for pick up and drop off points with the integration of AV, Tim Chapin et al. describe a "drop off revolution" in their study "Envisioning Florida's Future: Transportation and Land Use in an Automated Vehicle Automated Vehicle World" (Chapin et al. 2016). They anticipate how the built environment will need to adapt over time to accommodate the impending rise of AV. As mentioned before, AV will likely result in a reduction of vehicle ROW and an overall increase of available space for new infrastructure from smaller lane widths, fewer lanes, and less parking. With AV not needing parking, there will be a major need for pick up and drop off points as to not cause congestion from the frequent stopping of vehicles. The authors estimate that lanes can be reduced by about 20% if AV vehicles stay roughly the same size as current manually driven vehicles. This 20% of newly acquired space

should be partially built into multimodal transit stops to drop off and pick up passengers. An additional design concern for future city planners to consider is how to best share this space with bike lanes. The authors end by comparing AV to the Model T in that it will completely disrupt and reshape the existing transportation systems in the United States.

William Riggs et al. delve into the specifics of the aforementioned lane reductions in their work "A Design Framework for Livable Streets in the Era of Autonomous Vehicles" by anticipating that the ideal AV street would be 9' wide (Riggs et al. 2018). This forecasted design guideline is part of a liveability framework developed by the authors to imagine what an optimal AV urban and suburban area might look like. An interesting design concept suggested by this reading is the creation of flex zones in the middle of the suburban street that serve as infill for the newly freed right of way. The flex zone would serve as a green space for social gathering and in turn strengthen the sense of community in the neighborhood through the built environment. While this is an interesting concept, I think AV optimized suburban streets would be better served to use this newly freed ROW space as an extension of the existing sidewalk/bike lane rather than creating a disconnected middle park area between flowing traffic.

Marc Schlossberg et al. second the notion of a AV freeing ROW for pedestrian use by exploring the specifics of this concept in their study "Rethinking the Street in an Era of Driverless Cars" (Schlossberg et al. 2019). Instead of the previously mentioned 9' AV street, the authors contend that a 8' street would be "easily navigable" by an AV and could even be traversed by manually driven cars at slow speeds. Additionally, with the capability of self-parking off site, there would be less of a need for on street parking. By narrowing lanes to 8' and removing only one lane of parking there would be a total of 24' feet of ROW with which the city can use for pedestrian friendly infrastructure such as bike lanes, transit hubs, etc. In a similar vein, The Blueprint for Autonomous Urbanism describes the potential for AV to ease congestion through converting existing traffic lights to continuously moving roundabouts. With the interconnectivity and efficiency of AV, there will be little need for vehicles to stop at intersections. This, in turn, will create a new level of efficiency by which vehicles can travel.

It is important to consider the larger scale impact AV could have on the built environment by considering its future role in the design suburbs. William Riggs et al. do just that by analyzing the potential impacts of AV on urban design in two contexts: street-car suburb and post-war suburb in "Autonomous Vehicles and the Built Environment: Exploring the Impacts on Different Urban Contexts" (Riggs et al. 2018). This exploration stems from a dialogue started at the Autonomous Vehicle Symposium using a "charrette" method of participant engagement. Altogether, the authors found that streetcar suburbs are better suited for the rise of AV because they already have a multimodal transportation footprint and a density that would support shared-vehicles. There are also major opportunities for traditional suburbs as they typically are built around big box strip malls that require major amounts of parking. This parking would be prime real estate for new infill development with the rise of AV and in turn lead to increased density.

There will assuredly be issues that arise if the primary mode of travel were to transition from manually driven cars to AV. Sunghee Lee et al. provide a potential solution with a zonal approach to incrementally integrating AV into Seoul, Korea in their paper "Redesigning Urban Elements and Structures Considering Autonomous Vehicles: Preparing Design Strategies for Wide Implementation in Cities". The authors have created a "patchwork urban design concept developed based on the distinction between AV-only and regular zones" (Lee et al. 2022). Essentially, there are AV and HV specific zones and roads designated as AV and HV only to connect the two. This would separate the two modes of travel as there would likely be issues if the two modes were to be merged without proper planning. This is a potential first step solution in an incremental approach to gradually reduce the number of HV areas and increase the amount of AV only areas. Ultimately, it is worth considering the potential benefits of separating AVs entirely from traditional cars and if this would result in a smoother transition into a new era of

automated transportation.

This zonal approach could potentially lead to negative outcomes by leading to streets that prioritize the AV over pedestrians. Benjamin Schneider explores a new proposal from an architecture and engineering firm which would see New York City's transportation infrastructure significantly changed to accommodate AV (Schneider 2017). Their proposal, named Loop NYC, is essentially a superhighway for only AV that outlines the edges of Manhattan and bisects the city through several AV only highway crossings. This is a dark view of how AV's could potentially exacerbate the existing car-centricity in the US by prioritizing AV over human-centric transportation. While it is widely accepted that transportation modes are optimized through their own isolated ROW (e.g. subway tunnels and bike lanes), it is imperative that policy makers consider whether this is to the benefit of AV or pedestrians. Overall, this study highlights the need for cities to work proactively in developing guiding policy decisions to control the rise of AV and not design cities reactively like had historically been done with cars. The NACTO Blueprint for Autonomous Urbanism seconds this by urging cities to "seize their chance now to shape new technologies, rather than wait for technologies to shape them".

3.4 Conclusion

Through conducting an in-depth literature review I was able to glean several major takeaways from my readings. These takeaways are each unique to the themes in which they were derived but inform each other.

Regarding equity and public health, the impression that I drew from the readings was that cities are completely underprepared for the coming effects of AV. Most surveyed city officials believe that AV planning and policy is a concern for future planners and not a pressing issue. The reality is that AV technology is here and if planners do not act fast they will allow corporations to control our future autonomous transportation network.

The most important takeaway from the economy and land use theme is the overall economic viability of AV as a replacement for traditional cars. While the technology is expensive now, it is speculated that advancements in the technology will allow for AV to be affordable to the masses. Additionally, it has been modeled that AV will greatly benefit the U.S. economy through greatly reducing the number of collisions and improving the overall efficiency of traffic across the board.

Lastly, the theme of design and the built environment provided several vital pieces of information to understanding the future impacts of AV. Specifically, there was a shared belief amongst most literature that AV will result in a major reduction in both total lanes and lane width due to the precision of AV driving. This newly freed space offers a unique opportunity to develop this ROW into pedestrian friendly infrastructure. The bulk of the readings were concerned with what to do with said space. Recommendations ranged from expanded sidewalks and bike lanes to parks bisecting suburban lanes. Altogether, this process deepened my understanding of AV and the potential impact it will have on our society.

04

Case Studies

4.1 Overview

In order to best understand the needs of San Jose in advancing AV into its framework, it is vital to build an understanding of the approaches taken by analogous cities. Major insights can be gleaned from looking into the current planning efforts of other cities by diving into their relevant planning documents and pilot programs. In conducting these case studies I have elected to focus my efforts into four cities; Seattle, Miami, Elk Grove, and San Francisco. I have chosen these cities as they are all leading the charge in researching and folding AV technology into their existing transportation infrastructure. Moreover, each respective city shares some level of similarity to San Jose whether it be geographic location, size, or density. However, each city is unique in their urban makeup and hosts a slew of individual challenges in AV planning and therefore brings specialized perspectives into the mix.

Through researching these cities, I am looking for three overarching themes; existing planning documents regarding AV, pilot programs, and insights that can be applied to San Jose.

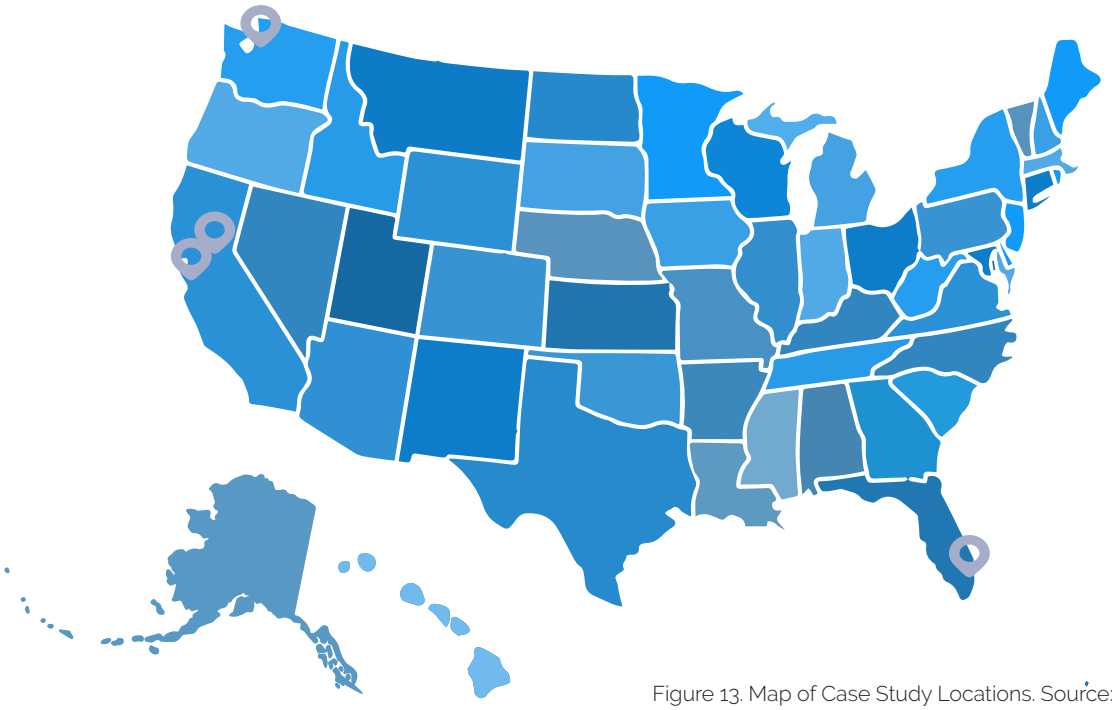


Figure 13. Map of Case Study Locations. Source: Author

Seattle, Washington
City Population: 733,919
Metro Population: 4,018,762
Area: 142.07 sq mi
Density: 8,775.03/sq mi

4.2 Seattle, WA: Bellevue Seattle AV Strategic Plan

Seattle and Bellevue's AV Strategic Plan was born out of a glaring lack of statewide policy governing AV deployment. This missing regional policy offered Seattle and Bellevue a unique opportunity to develop a localized approach to integrating the emerging technology in a way that aligns with both city's goals. Within this plan lies a section titled Roadmap for our desired future. This chapter serves as a toolbox in which planners and relevant decision makers can use its policy recommendations in molding the future of AV in Seattle and Bellevue. This chapter clearly defines six overarching goals for AV. Each goal contains its own respective solutions to successfully achieving said goal. The goals are as follows:

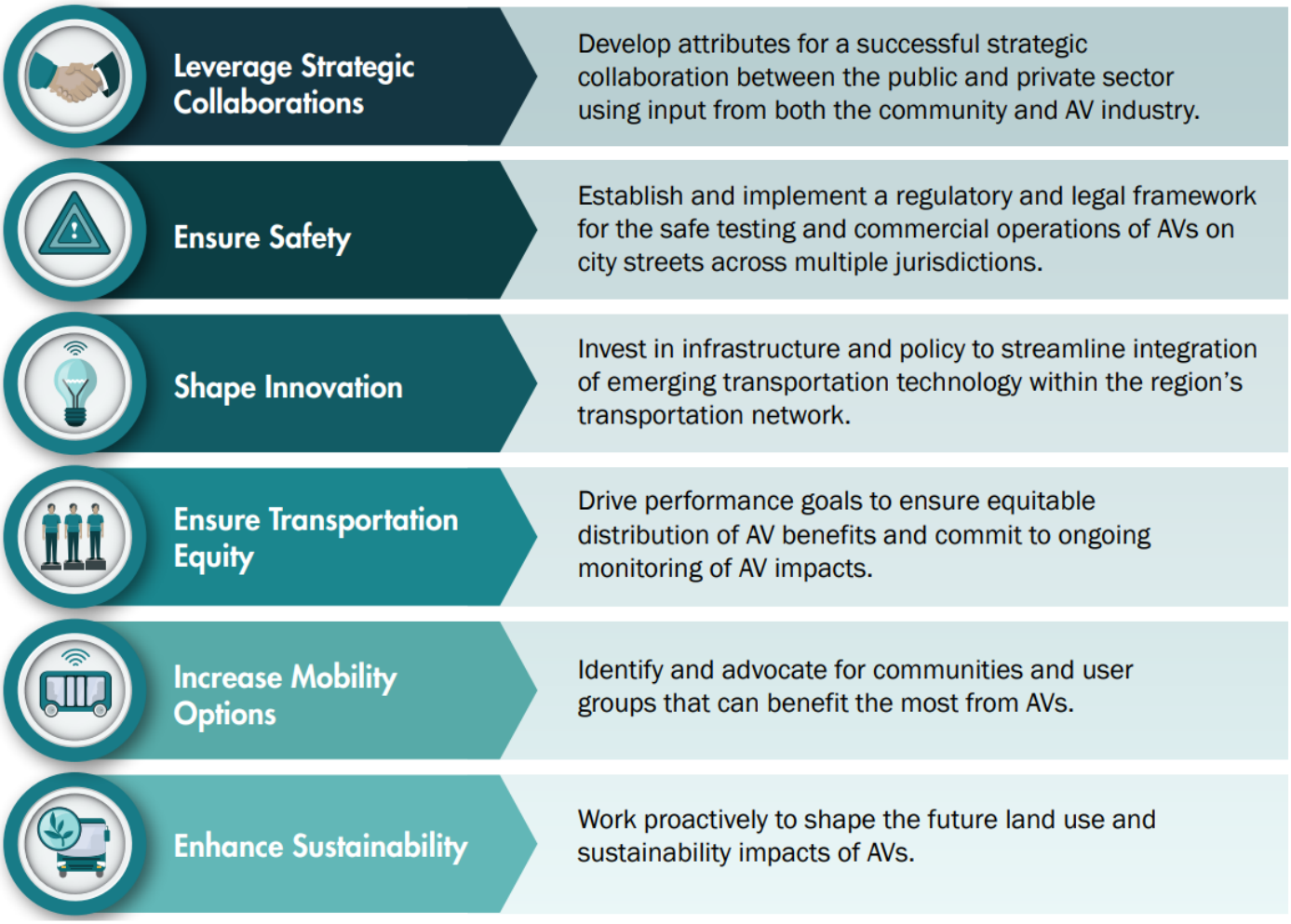


Figure 14. Bellevue Seattle AV Strategic Plan Goals. Source: Bellevue Seattle AV Strategic Plan

Leverage Strategic Collaborations

This section paints a vivid picture of the potential downsides of unregulated AV rollout. If left to chance the market will dictate the direction of autonomous vehicles and in turn would mean following the path of what is most profitable. This could unintentionally result in AV's being disproportionately located in privileged communities as the market could if that is the most economically beneficial path as dictated by the market. To mitigate this, the strategic plan suggests fostering a strong relationship between private sector AV companies and governing public agencies. This mutually beneficial relationship would result in a shared trust that would allow seamless integration of equitable policy into the framework of autonomous vehicles. One recommended action in creating this back and forth, public-private relationship is establishing a data exchange in which AV companies can easily access city data and Seattle and Bellevue can then access AV-related data.

Another major goal in establishing this public-private partnership is to create a public-private model in which cost-sharing incentives and financial contributions from businesses and future clients are created. This would ensure that AV remains profitable in the long run since in the short term private AV companies cannot survive from city funding alone. Once this public-private partnership is thoroughly established, the plan suggests clearly outlining AV regulation framework for the companies.

Ensure Safety

Currently, Seattle and Bellevue lack regulations and legal framework offering protection to pedestrians on public roads in the event of an AV-related collision. Conversely, this is an area that California already has governing regulation in. It is for this reason that providing guidance on how to ensure safety in AV deployment is so important. The plan urges that if left to chance, AV companies may "prioritize profits before the safety of our public road users".

To reduce the risk of this unintended outcome, there are several solutions posited by the plan to ensure the safety of users and pedestrians. A critical step in ensuring safety is creating "permit requirements for AV testing and commercial operations." This would create safety regulations that must be followed in order for an AV company to obtain a permit for testing during the early stages of the technology. It is also vital to keep safety regulations consistent on both a local, regional, and federal level.

A crucial step in establishing safety regulations for AVs is creating a legal framework to require that AVs are held to the same level of accountability legally as a human driver. If not, AV companies will be negatively incentivized to prioritize profit over safety.

Shape Innovation

The role of shaping innovation in AV deployment can largely be achieved through careful customization of the built environment and broader transportation infrastructure. One method suggested by the plan is to expand electric vehicle charging infrastructure to incentivize the use of fully electric autonomous vehicles.

Seattle and Bellevue are also urged to create designated AV testing areas to encourage innovative AV technology integration. A great potential application of this is testing for the forecasted increased need for curb space for picking up and dropping off. The plan points to Los Angeles DOT and their flex curb space using smart technology to manage said curb space.

Ensure Transportation Equity

As mentioned previously, a major concern in leaving the rise of AV unchecked is that it will be disproportionately unavailable in disadvantaged neighborhoods. Historically, this has been an unfortunate trend afflicting lower-income neighborhoods and communities of color. The plan summarizes the history of underrepresentation of transportation solutions in communities of color by adding, "communities of color contribute less to pollution, they disproportionately experience the long-term impacts of this racism, including limited access to opportunities and wealth. 30 Ensuring transportation equity starts with quantitative

benefits analysis, which can also help to improve public sentiment surrounding AV technology".

To prevent transportation inequity in AV Seattle can focus on public outreach to foster a community-wide understanding of the advantages and limitations of AV. Moreover, public outreach can serve as an education opportunity in educating the public on the use and applications of AV and potential government-funded discount opportunities to bridge the gap in access in lower-income neighborhoods.

The plan also includes mapping locations of AV services as a key step in ensuring AV equity. This may come in the form of both physical wayfinding to pick up and drop off points and apps used to locate AV.

Increase Mobility Options

This section is primarily focused on diversifying AV-related transportation solutions and in turn preventing a future in which AV is dominated by single-occupancy vehicles. Beyond AV, the framework of mobility in the United States is largely consumed by one mobility option; the car. Seattle and Bellevue point to AV's power to introduce new forms of transportation to the fabric of our transportation networks such as "shared commute pods, low-speed circulators within medical, business, or residential campuses, and PUDO (pick up and drop off) services to provide access to essential destinations for people of different abilities and ages".

In exploring AV's potential to introduce expanded mobility options, this plan offers several cases of unique, community-focused AV-based transportation solutions. These uses include long-haul freight, paratransit, and wheelchair accessible taxis. The plan also delves into existing transportation options that can be optimized through AV advancements. Examples include last mile shuttles and areas in which running a large bus or rail line is impossible.

Lastly, this section mentions the dire need to shift the narrative surrounding AV once it is possible to demonstrate the value to the public. Currently, there is a huge amount of work to be done to change the public perception of AV. People are often resistant to changes to the status quo. In turn, it will take a massive public outreach effort to slowly shift public opinion of AV to a more positive outlook.

Enhance Sustainability

A major possible pitfall of AV integration is AV unintentionally exacerbating existing sprawl. AV would make long commutes much easier by allowing the driver to shift roles to that of a passenger who can then focus on other tasks. This could then entice people to move further away from their jobs in the urban core and into the suburbs. This expanded sprawl would then lead to more vehicle miles traveled and in turn more greenhouse gas emissions.

The plan suggests implementing regulations to incentivize the use of electric and low-emission vehicles in AV use. Better curb management is another significant step in improving sustainability in AV regulation.

In planning for sustainability in AV deployment, it is important to focus on reducing deadhead miles. Deadheading refers to miles traveled without a passenger.

Miami, Florida
City Population: 442,241
Metro Population: 6,091,747
Area: 56.07 sq mi
Density: 12,284.47/sq mi

4.3 Miami-Dade, FL

Miami-Dade county on its surface may seem like it does not share many similarities with San Jose. Geographically, it is difficult to find a county in The United States that is farther from The Bay Area. However, the two counties share key similarities in population size (Santa Clara County has 1.886 million people as of 2021 and Miami-Dade County has 2.663 million) and proximity to the coast. Furthermore, both areas are diverse, multicultural melting pots that serve as thriving economic hubs and job markets for their region.

The Miami-Dade Transportation Planning Organization (TPO) and Miami-Dade County are looking to leverage the emergence of connected autonomous vehicle (CAV) technology to support the shift towards a multimodal transportation system. The overarching goal is to plan for CAV deployment with a "holistic and integrated perspective and partnership".

Miami-Dade TPO Connected Autonomous Vehicle Strategic Plan, April 2023

While this AV strategic plan is significantly shorter than that of Seattle and Bellevue, it offers some key insights and unique perspectives into the process of planning for autonomous vehicles. The plan was primarily informed by a combination of public perception and opinions of relevant Florida transportation professionals via a Study Advisory Group and a Vision Workshop. By way of these discussions, a series of key findings were developed.

The primary suggestion of this plan is the creation of the SMART CAV Concept of Integrated Operations (CIO). This is essentially a "a framework designed to integrate and leverage CAV and other travel technologies". An essential piece of this structure is a partnership between CAV network owners and operators. Said partnership would involve identifying performance goals and benchmarks to guide the integration of CAV technology through the use of a SMART CAV monitoring system using real-time data analysis. The monitoring system would be used as a baseline to judge whether the previously mentioned benchmarks are being met. The next step in the CIO is a two-fold process of conducting pilot projects related to AV. With lessons gleaned from pilot projects in mind, the next step in the process is updates to the overall framework of AV in Miami-Dade through considering lessons learned from all of the previous steps. The image below provides clarification on the organizational structure of the concept.

AV/CV/ITS Freight Applications Pilot Program

Miami-Dade intends on testing the efficacy of autonomous freight. The freight industry is a major driver in the overall economy of Miami-Dade. Currently, The Florida Department of Transportation is testing autonomous freight in Miami-Dade through their AV/CV/ITS Freight Applications pilot program. The goal of this pilot program is to demonstrate the level of safety and efficiency by which autonomous freight can operate and the positive impact that these attributes can have on Miami-Dade's economy. Additionally, this pilot program aims to test the efficacy of autonomous freight efficiency techniques such as platooning in which multiple trucks travel in a single file line in close proximity to reduce drag and lower the total fuel

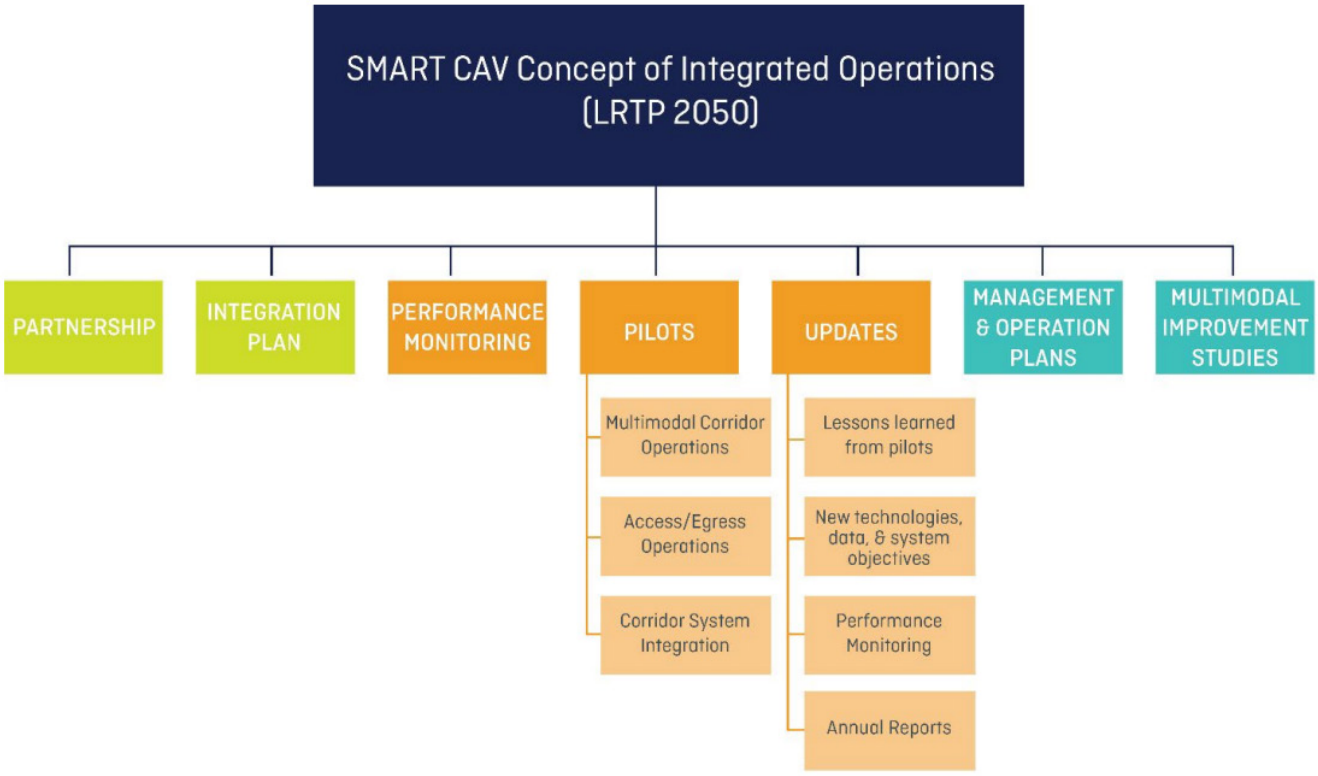


Figure 15. Smart CAV Concept of Integrated Operations. Source: Miami-Dade Transportation Planning Organization

consumption of the vehicles.

Autonomous Vehicles (AV) Deployment Pilot Program

In September 2022, The Miami-Dade Department of Transportation and Public Works (DTPW) began testing a fully-electric autonomous shuttle system at Zoo Miami. The four month program was deployed in partnership with Beep, an industry leader in autonomous mobility. The goal of this program is to test the potential of autonomous shuttles to bridge gaps in through providing first and last mile solutions. The insights from this program will inform the Miami-Dade DTPW's coming long-term transportation plan as they prepare the city for coming changes in transportation. A secondary goal of this project is exposing the general public to the positive impacts of autonomous vehicles. Creating a positive public perception around AV is vital to their success in the long run.

Key Takeaways

There are several lessons to be learned from Miami-Dade's work in autonomous transportation planning that can be applied to San Jose. San Jose should follow Miami-Dade's lead in testing the efficacy of automated freight. Like Miami-Dade, San Jose's economy could be bolstered from the efficiency of automated freight. San Jose DOT has already tested small-scale autonomous delivery systems through the Kiwibot pilot program. It would be beneficial for the city to continue their research into automated delivery systems through autonomous freight. Not only could this program improve the safety and efficiency of freight but it could additionally reduce the overall GHG emissions in San Jose through zero-emissions trucks. This city must be cognizant of the potential decline in driving-based job opportunities brought about through autonomous freight and plan accordingly to mitigate this hit to the job market.

Elk Grove, California
City Population: 176,124
Metro Population: N/A
Area: 42.20 sq mi
Density: 4,190.44/sq mi

4.4 Elk Grove, CA

While Elk Grove, CA is in many ways dissimilar to San Jose, their AV readiness plan is exhaustively comprehensive and is therefore worth analyzing. Additionally, looking to non-analogous cities for inspiration can provide unique insights as their approaches and solutions in AV planning are often drastically different.

Elk Grove Autonomous/Connected Vehicle Readiness Plan

The structure of this plan is split into three categories; background, effects, and recommendations. Being that this report is primarily concerned with garnering insights and recommendations to prepare for autonomous vehicles, the focus of this analysis will be placed on the recommendations section of the plan. Within the recommendations section there are two distinct types of recommendations. These categories are infrastructure strategies and policy responses.

A unique infrastructure-based strategy posited by the readiness plan involves the use of smart street lighting. The recommendation involves investing in a comprehensive network of smart street lights which use the Internet of Things to relay real-time updates on traffic and crashes to guide AVs to their optimal route. The plan's following recommendation of upgrading the city's transportation data network to a cloud-based network would enable this sort of interconnected system. With both the cars and transportation infrastructure in constant communication the roads will function with an unprecedented level of efficiency. While a cloud-based network would revolutionize the traffic management of Elk Grove, the plan ultimately recommends that the city wait on implementing such a system until "after data architecture and cybersecurity protocols are in place".

The plan recommends the eventual replacement of street signage with smart signs that can be read by AVs. This would allow AVs to navigate Elk Grove's streets with a better immediate understanding of their traffic laws. This recommendation falls into the plans greater solution of having a network of "AV ready assets". Additional examples of these assets include 6" reflective thermoplastic striping, high-definition mapping of the transportation network being readily available, and connecting the existing electronic transportation infrastructure system to a fiber optic system. These AV ready assets would then need to be kept track of within a comprehensive maintenance management system.

In regards to policy recommendations, this plan offers many similar strategies to the previously mentioned cities. Similar strategies include lobbying for effective communication and data sharing through public-private partnerships between the city and the AV operators. Another similar strategy is conducting community and stakeholder outreach to boost the overall approval and narrative surrounding AV.

This plan differs in policy recommendations from the previous plan in that it recommends a restructuring of transit systems based on AV technology. The plan calls for automating certain transit services such as bus lines to offer lower labor costs and increased frequency of service. While labor costs would be lowered, it is important to note that this would be at the cost of available jobs. The plan also recommends the

implementation of transit-only lanes. This is not a new concept in the world of transportation by any means but for a small city such as Elk Grove, AV might offer a unique opportunity to delve into transportation solutions more common in larger cities. Lastly, the plan considers the need for a potential rezoning of the city due to an influx of new development demand from a decrease in the need for parking. Based on the needs of the community, it is important to either encourage or restrict certain types of development. Moreover, as can already be seen in San Jose, Elk Grove should consider reducing or eliminating minimum parking requirements for new developments to match the updated demand for parking.

San Francisco, California
City Population: 808,437
Metro Population: 4,623,264
Area: 46.9 sq mi sq mi
Density: 17,237.5/sq mi

4.5 San Francisco, CA

While often associated with San Jose due to their shared status as major bay area cities, San Francisco holds many unique transportation planning-based challenges. Despite their proximity to one another, the urban framework of both cities are actually quite dissimilar. For example, population density, topography, and weather each differ drastically between the two cities.

SFTP 2050 Strategic Topic Paper: Autonomous Vehicles

The San Francisco County Transportation Authority developed a strategic white paper to provide information and guidance on the state of autonomous vehicles in San Francisco. The bulk of this paper consists of speculative forecasting of the potential effects of AV integration rather than a series of recommendations. In this, the paper differs from the planning documents of the previously mentioned cities. The forecasting of this paper is structured through a series of open-ended questions relevant to the future of AV. These questions include should AVs be managed as fleets or individually owned vehicles, how will AV change travel patterns, and is AV ride-hailing economically viable.

Before delving into these questions, the paper provides an up to date overview of current autonomous vehicle regulation on a local, state, and federal level. Federal regulation of AV is primarily concerned with vehicle safety standards and managing emissions. Conversely, on the state level, the focus is set on laws and regulations surrounding the permitting of AV to operate within the state. The paper notes that while cities can set and enforce traffic laws, they have little control of which AVs can or cannot operate on their roads. This is controlled by the California DMV. However, cities can contribute to the rules and regulations governing AV at the state and federal level through being active in conversation with The California Public Utilities Commission (CPUC).

The California Department of Motor Vehicles governs the use of autonomous vehicles on public roads in California. This is achieved through the issuing of three distinct levels of AV testing permits. To receive a permit, an applicant must identify the limits to which their AV can safely operate through the creation of an Operational Design Domain (ODD). The applicant will then be restricted to operating within these bounds. The different levels of permits are as follows (California DMv n.a.):

- Testing with a Driver - This allows for AV to be tested with a driver available to take over at all times.
- Driverless Testing - This allows for AV to be tested without a driver present.
- Deployment - This permit allows AV companies to make their services commercially available to the public.

The paper ends with a brief section on recommendations and next steps. The primary recommendation is to maintain an active stream of communication with state and federal agencies to both participate in regulatory proceedings and collaborate with other agencies in data collection and reporting. As with the other previously mentioned cities, this report stresses the importance of public-private partnerships with AV developers as well as important stakeholders. This will help align decisionmakers with the

overall goals of San Francisco. Lastly, the report recommends that San Francisco identify ways in which it can mitigate the potential increase in VMT brought about from the rise of AV. This is a common worry in preparing for AV integration and should be planned for accordingly through the use of policy. Potential solutions include congestion pricing to incentivize shorter trips for AV.

Emerging Mobility Guiding Principles

In 2019, San Francisco County Transportation Authority (SFCTA) and San Francisco Municipal Transportation Agency (SFMTA) collaborated in developing 10 guiding principles to govern the use of emerging mobility within the city. The principles are as follows:

1. Collaboration between emerging mobility service providers San Francisco with a shared goal of improving the city and its overall transportation systems.

2. Safety in emerging mobility in line with The City of San Francisco's Vision Zero efforts and goals of enhancing public safety and security

3. Transit must be supported by emerging mobility technology rather than drawing riders away from transit. Technology should encourage the use of high-occupancy transit modes.

4. Congestion must be considered in deploying emerging mobility. Technology should not increase traffic congestion or negatively impact modal choices, emergency vehicle response times, and transit performance.

5. Sustainability should be fully supported by emerging mobility technology. Technology should be in accordance with the city's emissions reduction goals and encourage the use of non-auto-based modes.

6. Equitable Access must be a priority in deploying emerging mobility. Technology should support access to services to all people regardless of race, age, gender, sexual orientation, etc.

7. Accountability involves the sharing of data between emerging mobility service providers and the City of San Francisco to ensure that services are meeting the City's goals and standards through in-depth evaluation.

8. Labor is an important consideration in emerging mobility technology. Technology must be fair in pay and labor policies, promote equitable hiring practices, and be in agreement with San Francisco's local hire principles.

9. Disabled Access must be prioritized in emerging mobility technology. People with disabilities should receive the same level of access to technology as people without disabilities.

10. Financial Impact is an important consideration in emerging mobility. Technology should have a positive financial impact on San Francisco.

These principles are vital to the deployment of AV technology. When applied to AV there are clear solutions to consider when planning in alignment with these guidelines. For example, to provide disabled access to AV ride-hailing services there should be a minimum number of larger AVs with wheelchair access. This will not only improve accessibility to the mode but provide a major expansion to existing paratransit services. In promoting sustainability it is important to enact policy that requires AV to be electric so as to not increase emissions levels in the city. Labor should be a major consideration in AV planning as the technology has the potential to greatly reduce the number of existing driving-based jobs.

Forecasting The Effects of AV

Through the presented methodology, we can begin to understand the effect that AV will have on San Jose's future. Depending on San Jose's approach to the technology, there are two diverging paths by which the city can be shaped by AV. One path leads to a largely beneficial outcome in which the many potential advantages of AV are realized and San Jose experiences enhanced mobility options, reduced GHG emissions, expanded opportunities for pedestrian-friendly development. The alternative path is that of the existing issues in San Jose's transportation framework worsening. If left up to the market, the rise of AV may result in single-occupancy vehicles, negative environmental impacts, and limited access to disadvantaged groups. It is these branching outcomes that make autonomous vehicles a highly divisive topic in planning. Many experts argue over whether the technology will provide major societal benefits and enhance our overall transportation network or rather worsen existing systemic problems in our existing transportation systems. The following section forecasts a series of both positive and negative outcomes that should be considered in planning for autonomous vehicles in San Jose.

05

Figure 16. Autonomous Freight Illustration. Source: Adobe Stock

5.1 Positive Impacts

05

How can The City of San Jose best prepare for the anticipated modal shift brought forth by the rise of autonomous vehicles through both design and policy-based solutions? How will the rise of autonomous vehicles affect the built environment and transportation infrastructure?

Reduced Demand for Parking

In order to maximize the usefulness of the urban makeup of San Jose, Self-parking autonomous vehicles will require a comprehensive overhaul of the current parking infrastructure within the city. As it stands, San Jose's parking framework consists of surface lots, street parking, and multi-level parking garages. This area (not including street parking) accounts for roughly 5% of the total surface area in San Jose. In downtown San Jose (Smith 2013), this number is even larger, rising all the way to roughly 21% of all surface area. By shifting this parking usage to off-site garages for self-parking AV, 9.52 total square miles of land in San Jose can be shifted to more beneficial uses such as housing, commercial, plazas, and parks. Moreover, street parking can be repurposed into bike lanes, bus lanes, and pick up and drop off zones. However, this will require a new style of parking garage to house the self-parking AVs.

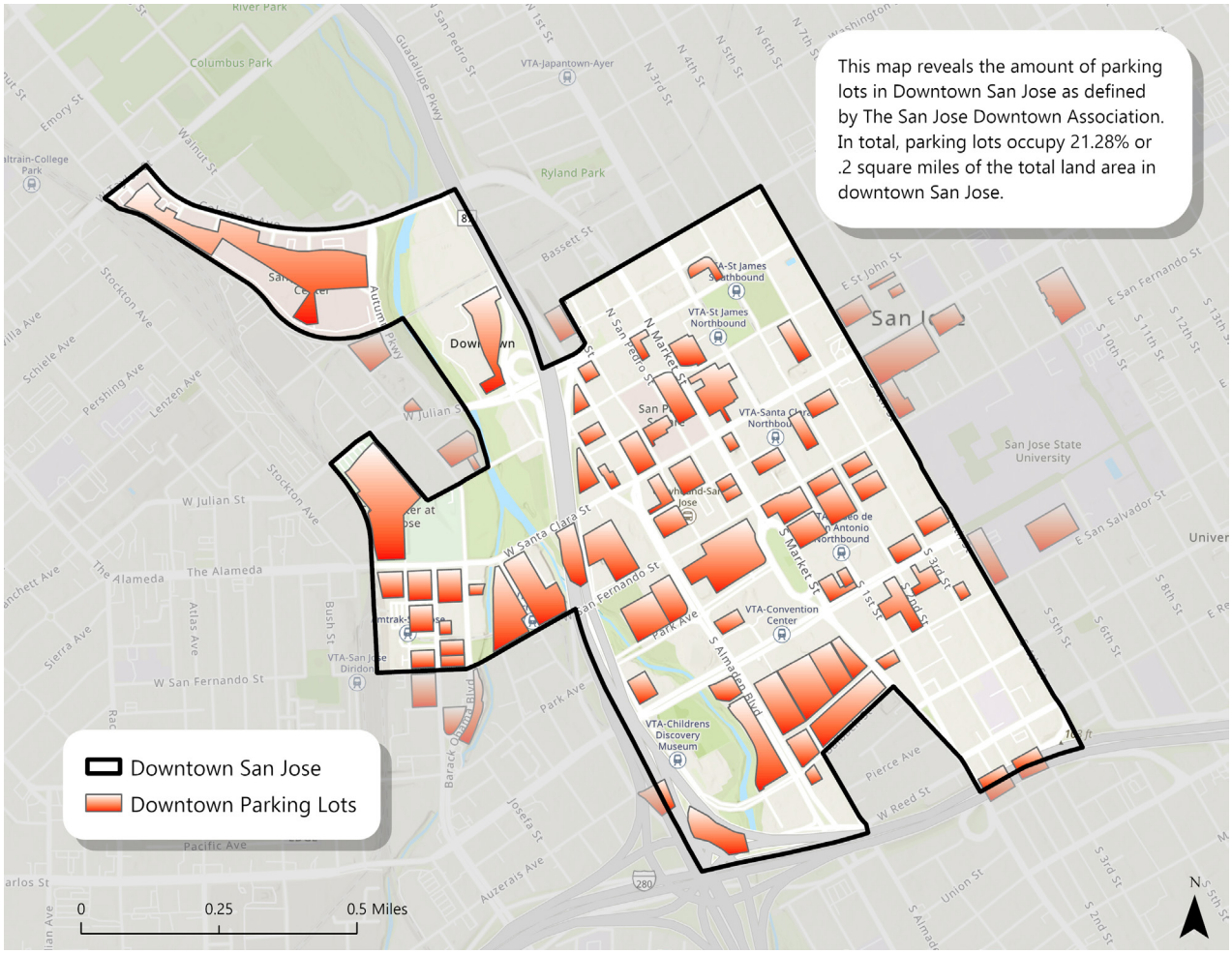


Figure 17. Map of Downtown San Jose Parking Lot Total Area. Source: Author using data from The City of San Jose

In 2017, a study was conducted on how to best optimize an off-site garage intended for autonomous vehicles only. The study found that parking cars in a stacked grid would save anywhere from 62% to 87% of space compared to a traditional parking garage (Nourinejad et al. 2017). By utilizing this style of off-site autonomous parking garage, San Jose can fulfill the parking needs of its residents at a fraction of the space currently occupied by parking.

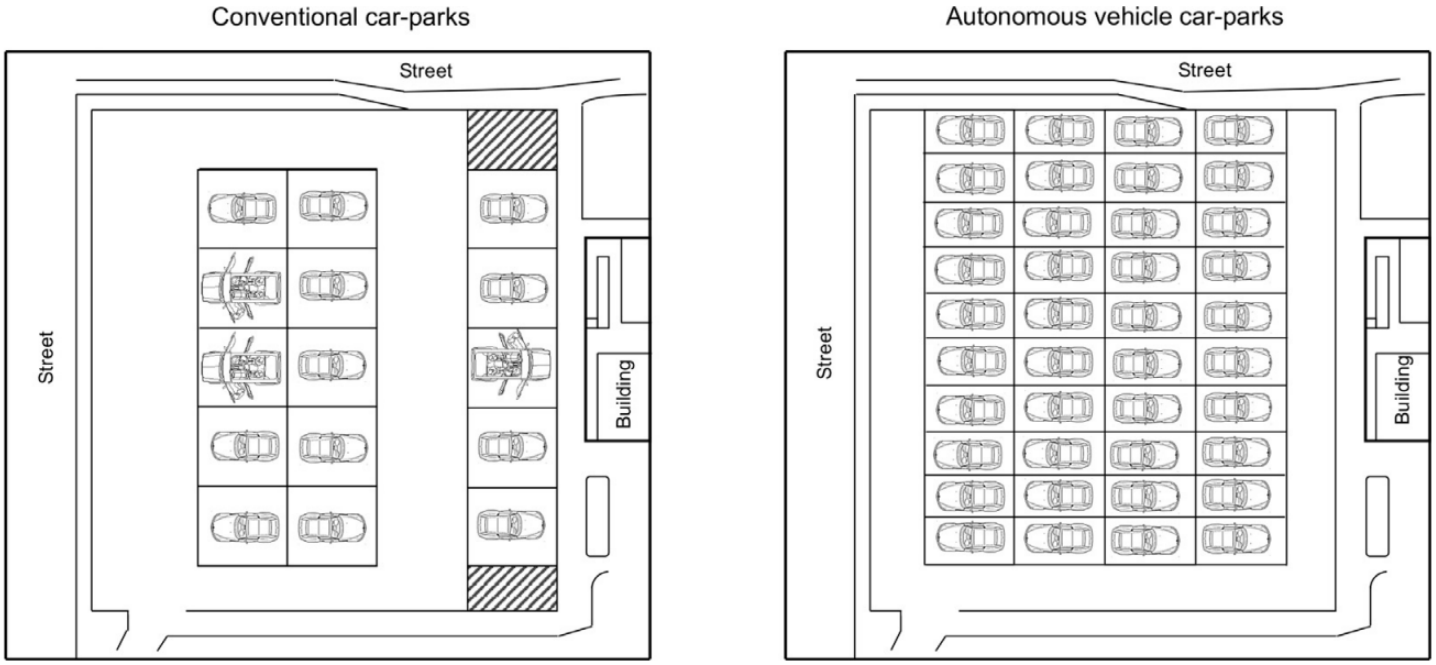


Figure 18. Autonomous Vehicle Optimized Parking. Source: Nourinejad et al. 2017

Reduced Lane Size

The robotic nature of autonomous vehicles allows them to operate with a level of precision previously impossible to a regular human driver. If San Jose's network of vehicles were shifted to fully autonomous vehicles then it can be assumed that the precision of AV would allow them to navigate the city with considerably less right of way (ROW) needed. Experts estimate that autonomous vehicles will be able to efficiently operate in a lane that is 9' in width (Schlossberg et al. 2018). The typical lane is between 11' and 12'. Through simple math, we can calculate that a standard 4 lane city street such as E Santa Clara St in Downtown San Jose would require 12' less in total ROW for AV to function. Additionally, as mentioned previously, there will be a much lower demand for on-street parking due to the ability of AV to pick up and drop off riders and then self-park. This would allow for on-street parking to be retrofitted for other uses. In total, a street such as E Santa Clara Street would see a potential total of 30 feet freed for alternative uses such as bike lanes, pickup and drop off zones, etc.

Solving the issue of first and last mile

Autonomous vehicles could hold the key to solving the issue of first and last mile in San Jose. First and last mile refers to the gap in transit service between one's house and transit such as Diridon Station in downtown San Jose. This term refers to a gap that is beyond what is typically considered walking distance, forcing commuters to use an additional mode of transportation to complete their trip such as bikes, e-scooters, and rideshare. Occasionally, this distance can steer potential transit users away from alternative modes altogether and back into their cars.

The ability of AV to both pick up and drop off riders at their designated location

and then return to their original parking station would considerably enhance the ease at which people can access transit. On the other hand, this may reduce transit ridership as people cut out the middleman and simply take AV instead of transit. AV is a double edged sword in that it can potentially solve or worsen the existing issues of the first and last mile in San Jose. The duality of this issue reinforces the need for careful planning through strategic policy to make sure that AV does not take away from the overall ridership of transit.

Increased Demand for Curb Space

A transition to a primarily autonomous network of vehicles in San Jose would require a reexamination of how the city utilizes curb space. No longer will it be necessary for the city to dedicate huge swaths of curb space to parking. Instead, this space should be retrofitted to meet the inevitable increased demand for pick up and drop off zones. Moreover, the city can utilize smart curb management systems to identify vacant spots and relay this information to AV. The interconnectivity of AV will be able to identify the closest vacant drop off location and easily navigate to said zone. Additionally, curb space usage can be further enhanced through smart systems which change the usage of curb space in real-time based on the present need.

Reduced Greenhouse Gas Emissions and Overall Congestion

If implemented correctly, autonomous vehicles can reduce the overall levels of greenhouse gas emissions. This hinges on the assumption that AV will be electric. SB 500 requires that all autonomous vehicles Level 3 and beyond be zero-emission by the year 2030. As AV reaches greater market penetration, this legislation will directly result in reduced emissions in San Jose and California as a whole as residents ditch their traditional cars in favor of AV. This legislation is certainly a step in the right direction in ensuring the sustainability of AV. However, there are more steps to be taken in order to further reduce GHG emissions from AV.

The interconnected nature of AV will also result in less congestion and delays on roads and highways. Connected autonomous vehicles are able to communicate remotely with one another and can in turn anticipate traffic patterns and calculate the most efficient path in real-time. Moreover, with greater AV integration forecasted to create a much safer environment on the road there will no longer be major delays from collisions on major roadways.

Safety and Accessibility

AV holds the power to revolutionize safety on our streets. Current data suggests that "Over 40% of these fatal crashes involve some combination of alcohol, distraction, drug involvement and/or fatigue" (Fagnant a et al. 2015). Once fully integrated, autonomous vehicles will entirely eliminate crashes resulting from the previously mentioned human error-based collisions. Consequently, traffic safety should see a 40% reduction in fatal crashes resulting in roughly 12,946 lives being saved per year (National Highway Traffic Safety Administration 2012). In all likelihood this number is substantially higher as experts estimate that 90% of all crashes are primarily due to human error (National Highway Traffic Safety Administration 2008).

Accessibility to mobility options will see a major increase under AV operation. This will result in a newfound independence for those who previously could not drive such as seniors, people with disabilities, and those under the driving age. There will need to be consideration on requiring a certain amount of AV rideshare vehicles to be ADA-friendly to further accommodate disabled passengers.

Increased Mobility Options and Freight Trips

If planned accordingly, AV will boost the overall number of mobility options available to San Jose residents. According to the San Jose Downtown Transportation Plan, a long-term goal of the city is to develop autonomous shuttles to bridge gaps in transportation that are not covered by the existing public transit. As previously mentioned, the city also has plans

to create an autonomous airport connector shuttle to transport passengers from Diridon Station to The San Jose Mineta Airport. These expanded mobility options are just scratching the surface of the capabilities of autonomous technology in providing additional modes of transit. AV can fill gaps in existing bus service lines that are too infrequently used to man with human drivers. Service hours and frequency of public transit can also be expanded with the usage of autonomous technology.

San Jose can see major positive impacts to its economy through autonomous freight technology. Not only will freight trips be made more frequently but autonomous technology will unlock an entirely new level of efficiency in freight travel through platooning. Truck platooning is when multiple trucks follow each other in a single file line in extremely close proximity. This, in turn, reduces air drag and lessens the total fuel consumption of the fleet. This feat is only achievable through the machine-like precision and constant communication between autonomous vehicles. Altogether, automating freight can provide major benefits to both the local and national economy but will potentially come at the cost of a major source of driving-based jobs.

5.1 Negative Impacts

05

How can The City of San Jose best prepare for the anticipated modal shift brought forth by the rise of autonomous vehicles through both design and policy-based solutions? How will the rise of autonomous vehicles affect the built environment and transportation infrastructure?

Rise in the Usage of Single-Occupancy AV

If left unchecked, AV can greatly increase the usage of single-occupancy vehicles and draw people away from transit. Being that single-occupancy vehicles are the primary mode of transportation in San Jose and the greater United States it is fair to assume that the easiest transition for San Jose's population would be to simply replace their non autonomous private car with an autonomous counterpart. In California 65.5 people drive alone to work while in the United States as a whole 08.5 people drive to work alone (Bureau of Transportation Statistics). Continuing this trend would negate many of the potential societal benefits and unique opportunities at hand in multimodal travel. The potential advantages of AV in promoting multimodal travel must not be squandered. AV provides the unique opportunity to fill existing gaps in under supported bus lines and non routes through the use of autonomous connector shuttles as mentioned in The San Jose DOT's Downtown Transportation Plan. Moreover, AV can promote shared mobility through the creation of a robust shared ride hailing service in which multiple passengers can share a larger autonomous shuttle at a discounted rate. Efforts must be made by local governments and transit agencies in San Jose to steer AV technology away from single-occupancy and towards alternative mobility options.

Sprawl and Increased VMT

Autonomous vehicles will have significant impacts on the travel behavior of San Jose residents. These changes in travel behavior will have many positive side effects such as many people experiencing increased mobility such as people with disabilities, the elderly, and children under the age of 16. However, there are two clear negative impacts of increased AV usage; sprawl and increased VMT. San Jose's roots as a bedroom community have resulted in an urban framework that is sprawling with low-density developments compared to its higher-density neighbors in nearby San Francisco and Oakland. In response to this, drawing people into the downtown core of San Jose has been a major point of emphasis for San Jose planners and government officials. This issue stands to be worsened by the ease at which San Jose residents can commute with AV. There is a real possibility that with the increasing cost of housing in the bay area and the ease at which people can passively commute with autonomous vehicles that large swaths of San Jose residents will opt to leave the city for the lower cost of living found in cities on the outskirts of the Bay Area. This will in turn result in a massive boost to the overall VMT of the region and likely negatively impact traffic congestion.

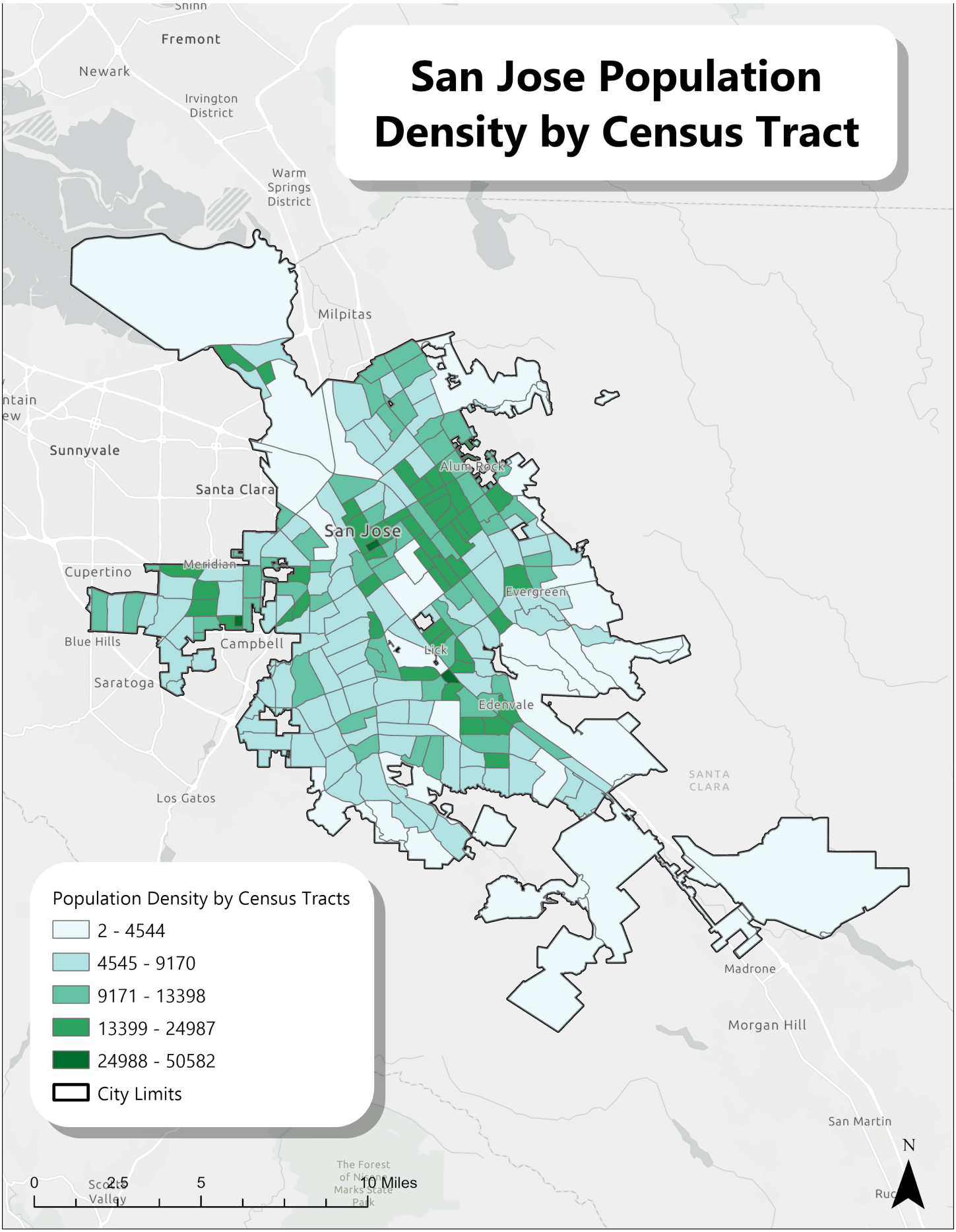


Figure 19. Map of Population Density of San Jose. Source: Author Using 2020 Census Data

Data Security

Privacy of users data is a major concern in planning for AVs. Autonomous vehicles hold a large amount of sensitive information about their riders including real-time location, crash data, common routes, and home addresses. Some of this data such as crash data can be used to both increase the effectiveness of AV operations and the placement of traffic calming infrastructure through programs such as San Jose's Vision Zero Initiative. However, there must be safeguards on users data to ensure that user's information remains confidential.

The interconnected, computer-based nature of AVs leaves the vehicles prone to security threats such as hacking and viruses. Potential acts of terror, violence, and theft are considerable concerns that need to be planned for and prevented at all costs. The security and privacy of AVs is something that manufacturers need to address proactively before full commercial release so as to avoid any potential disasters. The U.S. has shown that it can manage vital systems of a similar importance securely such as air traffic control systems. Measures should be taken on a national level beyond that of the manufacturers to guarantee the safety of AV users from any potential security breach.

Liability

While AV will undoubtedly result in a safer traffic environment due to eliminating human error, situations will still arise in which a collision is unavoidable. For example, in the event of an unforeseen environmental issue such as falling debris or a deer veering into the road the question becomes how should AV be programmed to respond. The vehicle will be forced to make split second decisions that could endanger other drivers. Moreover, if a collision does occur who will be held liable? Decisions must be made in determining who will be held liable in the event of an autonomous accident between the vehicle owner, manufacturer, and additional involved parties.

Loss of Jobs

A major potential drawback of autonomous vehicles is the impact it will have on the jobs of drivers. There are more than 3.5 million truck drivers in the United States. As of 2019 (US Census Data), Uber reported that it had a driver base of over 1 million employees (Uber). This number has assuredly grown since then with the rising popularity of ride-hailing services. With many cities currently testing the efficacy of autonomous freight and autonomous rideshare, it is a distinct possibility that millions of Americans will lose their jobs as a direct result of the rise of autonomous vehicles. This would be a massive hit to the overall economy in the United States. It is imperative that cities work to mitigate the mass loss of jobs that might result from AV.

Equity Concerns

If the market is able to entirely dictate the trajectory of AV technology then there is a distinct possibility that AV can worsen existing disparities in transportation access to underserved communities in San Jose. As it stands, lower-income have had to overcome major hurdles in transportation access within the city. Lower-income communities are disproportionately affected by the harmful side effects of GHG emissions as oftentimes freight is routed away from higher-income neighborhoods and into disadvantaged communities. If left unchecked, AV rideshare operators may opt to disproportionately service communities of higher socioeconomic status as it may result in higher profits. Additionally, AV routes should be carefully planned so as to not exacerbate existing traffic through disadvantaged communities.

The pricing of AV rideshare and public transit services may also prove inaccessible to lower-income users. If San Jose utilizes shared autonomous mobility as a primary mobility service within the city then certain residents may be priced out of the equation.

Difficulties in Bridging the Gap in Autonomous Vehicle Integration

There are likely to be growing pains as the status quo shifts from traditional cars to AV. An important question to consider is how can

both exist on the road harmoniously during the transition period between modes. Questions are likely to arise in whether AVs and traditional cars should be separated into mode-specific lanes. This is a strategy that can already be seen in countless cities including San Jose with the integration of bus only lanes. As mentioned previously, liability is also a concern in the event of a crash involving a human driver and an AV. Public perception and general understanding of the technology will be a significant hurdle to overcome for San Jose. People are generally skeptical of monumental shifts to the status quo and relinquishing control of a vehicle to a machine will assuredly take time for many to accept.

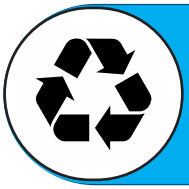
06

Results

Based on the previously mentioned outcomes of AV integration, a series of policy and infrastructure strategies have been compiled to best prepare San Jose for autonomous vehicles. These recommendations are grouped into the following categories; equity, sustainability, urban design and the built environment, and safety. Within each category, a series of short and long term goals have been developed to best suit the needs of San Jose in both the near and distant future.

EQUITY

Ensure equitable access to AV technologies through monitoring the impacts and creating incentives for all socioeconomic groups to use the technology



SUSTAINABILITY

Protect our environment through establishing policies to drive sustainable growth in AV deployment

SAFETY

Further establish a legal framework to ensure the safe deployment of AV. Create infrastructure to further bolster the safety of pedestrians in the city

URBAN DESIGN AND THE BUILT ENVIRONMENT

Shape San Jose's infrastructure to best accommodate and benefit from the rise of AV. Use AV as a vessel for enhancing the experience of the pedestrian throughout the city

6.1 Equity

Equity is a vital component in ensuring the overall effectiveness of autonomous vehicles. It is important that the technology be fully accessible to all people regardless of socioeconomic status. If left unchecked, private AV operators may be incentivized to operate disproportionately in areas with higher average incomes. Moreover, considering San Jose's complicated history with transportation access for underserved communities, it is important that the city starts out on the right foot by incentivizing equitable distribution and access of AV. The following are a series of recommendations through which San Jose can foster an equitable autonomous vehicle network.

A. Create private-public partnerships to ensure equitable access to AV technology.

San Jose should maintain a steady line of communication and mutual understanding with private AV operators. This partnership will help create a shared set of goals for the growth of the city's autonomous fleet and infrastructure. Through this shared understanding, San Jose can work in partnership with private companies in ensuring that their services (specifically rideshare) operate within all neighborhoods regardless of socioeconomic status. If necessary, San Jose can take steps to enact regulations requiring that AV operators remain equitable in their area of operation. Fostering a positive relationship with AV manufacturers and operators is a crucial first step in guaranteeing the long-term goals of the city are met.

B. Incentivize the creation of affordable AV public transit. Increase AV mobility options

San Jose should create expanded AV mobility options including but not limited to shuttles, buses, paratransit, and rideshare. Moreover, AV holds the power to expand the frequency total routes of existing transit modes through filling the gaps with automated services.

C. Create an AV paratransit program to provide accommodations for people with disabilities

One of the most significant benefits of autonomous vehicles is the opportunity to provide access to mobility to seniors and disabled people who previously were not able to drive. The city can take steps to require that a certain amount of vehicles within the autonomous ride-sharing fleet are ADA-compliant.

D. Mitigate the loss of jobs by providing an alternative job source and programs to driving-based jobs.

While there are huge economic benefits to automated jobs that require a driver, the unfortunate reality of the situation is that autonomous vehicles will force a huge amount of San Jose residents with driving-based jobs into unemployment. To mitigate this surge in unemployment, San Jose should offer programs in education and retraining to those in driving-based jobs to ease their transition into other in-demand industries. San Jose should also provide automatic unemployment insurance for those in driving-based jobs to ease their transition period between industries.

E. Create a discounted pricing program for qualifying low-income residents

San Jose already offers shared mobility discounts for qualifying low-income users such as the Baywheels Bikeshare For All program. To ensure that AV rideshare and related autonomous mobility services are accessible, there should be similar programs in place with autonomous rideshare and other autonomous mobility services to offer discounts to qualifying low-income users.

F. Create incentive programs for AV rides that begin or end in transit hub areas

There is a major concern that AV will steer people away from other transit options such as buses, light rail, and trains. Alternatively, San Jose can harness the potential of AV to solve the issue of the first and last mile by offering discounted fares when commuting to or from a transit hub such as Diridon Station. San Jose State University in partnership with Lyft has offered a similar rideshare discount system for rides beginning or ending at the university. The City of San Jose should borrow from this idea in creating a discounted fare system for rides beginning and ending in designated transit hubs.

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G. Create public outreach campaigns to educate underrepresented communities on the benefits of AV

Equity and accessibility in autonomous vehicle technology begins with the public understanding its advantages and limitations. If San Jose is to incentivize the use of autonomous vehicles among underserved communities then it is important that the public understands the various services and programs at their disposal. Public outreach can boost the overall ridership of not only its own services but transit in the city as a whole.

6.2 Sustainability

Sustainability is a crucial factor in San Jose's autonomous future. Not only is it important to consider the effect on the environment when planning for autonomous vehicles but there are many secondary benefits to pursuing a sustainable autonomous future. Through sustainability San Jose can improve the overall quality of life of its residents by reducing smog and harmful emissions. Electric vehicles also produce less noise pollution which has been linked to negative impacts on the mental health of residents. Overall, through enacting the following sustainable policies and practices San Jose can both foster a positive environmental footprint and improve the quality of life of its residents.

A. Communicate the need to reduce deadhead miles traveled by AV and optimize operability to ensure that most VMT include a passenger in the vehicle

Deadhead miles refers to the miles traveled by an autonomous vehicle without any passengers aboard. These miles traveled are an inefficient use of time and fuel that should be reduced through optimized paths and rideshare strategies. The rideshare network must be strategic in picking up new passengers in the same area that the previous passenger was dropped off. This task can be achieved through requiring that autonomous rideshare only stops in designating pick-up and drop-off zones to maximize the amount of potential riders in the area.

B. Bolster the existing electric vehicle charging network to encourage the use of fully-electric autonomous vehicles

As AV market penetration rises, there will be an increased demand for electric charging stations due to California's SB 500 requiring that all AV be fully electric by 2030. While San Jose already has a great start on creating an electric charging network within the city, more can be done to service residents through equipping parking garages and lots with more charging stations. Additionally, off-site rideshare parking facilities should all be equipped with enough charging infrastructure to allow AV to function effectively without the need for refueling.

C. Create incentives for residents to use shared autonomous mobility such as autonomous buses and shuttles as opposed to single-occupancy, private-owned rideshare

One of the largest hurdles in fostering a positive autonomous future in San Jose is steering ridership into shared autonomous mobility as opposed to continuing the existing trend of single-occupancy ridership through privately-owned AV. San Jose should develop incentive programs to encourage the use of shared autonomous mobility such as rideshare, shuttles, and buses. Within rideshare, riders should be encouraged to share trips with other passengers heading to the same pick up and drop off zone through discounted fares. Moreover, public outreach should be employed to boost public perception surrounding shared mobility and its relative cost-effectiveness to private vehicle ownership.

D. Once AV is established as low-emission, incentivize the use of low-emissions AV technology to limit the usage of single-occupancy, traditional gas vehicles

SB 500 requires that fully autonomous vehicles be zero-emission by the year 2030. In turn, incentivizing the use of AV over traditional cars will substantially boost the sustainability of San Jose until a similar measure is taken for all automobiles. Shifting the primary mode of transportation away from traditional cars begins with public perception. San Jose can create a comprehensive outreach campaign in addition to pricing incentives to persuade its residents to take sustainable autonomous alternatives.

E. Employ freight platooning to boost fuel-efficiency of freight

Through autonomous technology it is possible to optimize sustainability and fuel efficiency through platooning. As previously described, this is when trucks drive in close proximity to reduce drag and increase fuel efficiency. While this concept extends beyond the bounds of San Jose it is still important for the city to garner an understanding of the topic through autonomous freight-based pilot programs similar to the one seen in Miami-Dade. San Jose should also consider looking into the efficacy of employing low and zero-emissions freight. Alternatively, policy can be enacted that requires hybrid freight to operate in a low-emissions mode when in residential neighborhoods.

F. Diversify AV trip patterns

The routes taken by AV must be diversified to ensure that no one neighborhood is disproportionately burdened by the increased noise and potential emissions that result from traffic on their street. San Jose can work in partnership with AV manufacturers and operators to enforce a maximum average daily traffic on certain residential streets that are likely to see enhanced activity from AV. San Jose should give extra consideration to the routes of autonomous freight as they produce more noise and emissions than an averaged sized vehicle.

6.3 Safety

Autonomous Vehicles stand to revolutionize safety on roadways. The technology holds the power to operate with a level of precision and efficiency well beyond the capabilities of a human driver. This precision will usher in a new era of traffic safety on San Jose streets. However, there is necessary planning to be done to both ease the transitional period when AV and traditional cars share the roads and to further bolster safety once AV technology reaches a state of full market penetration. The following are recommendations by which San Jose can enhance the safety of its roadways in preparation for autonomous vehicles.

A. Create advancements in data security to ensure the privacy of riders

Autonomous vehicles will store sensitive, private information of their users. This information must be protected from any potential breach. AV operators must be unified in their approach to protecting the data and information of their users. It is vital that manufacturers are proactive in developing AV that has safety measures in place to eliminate the risk of privacy breaches. One method of achieving this safety is through the anonymization of data. Once location data is created it should have no linkage to any of the passengers personal information so they can remain fully anonymous.

B. Cloud-based data management for CAV network operation

The safety capabilities of autonomous vehicles does not need to stop with remote sensing technology. A connected cloud-based network can be used to allow AV to interact with other vehicles in real-time to have a constant understanding of the environment around them. To assist in this functionality, San Jose should build CAV sensing technology into its existing transportation infrastructure and then relay the information tracked by these sensors and cameras back to the autonomous cloud network. This will help AV better understand the movements of vehicles that are not within its connected network.

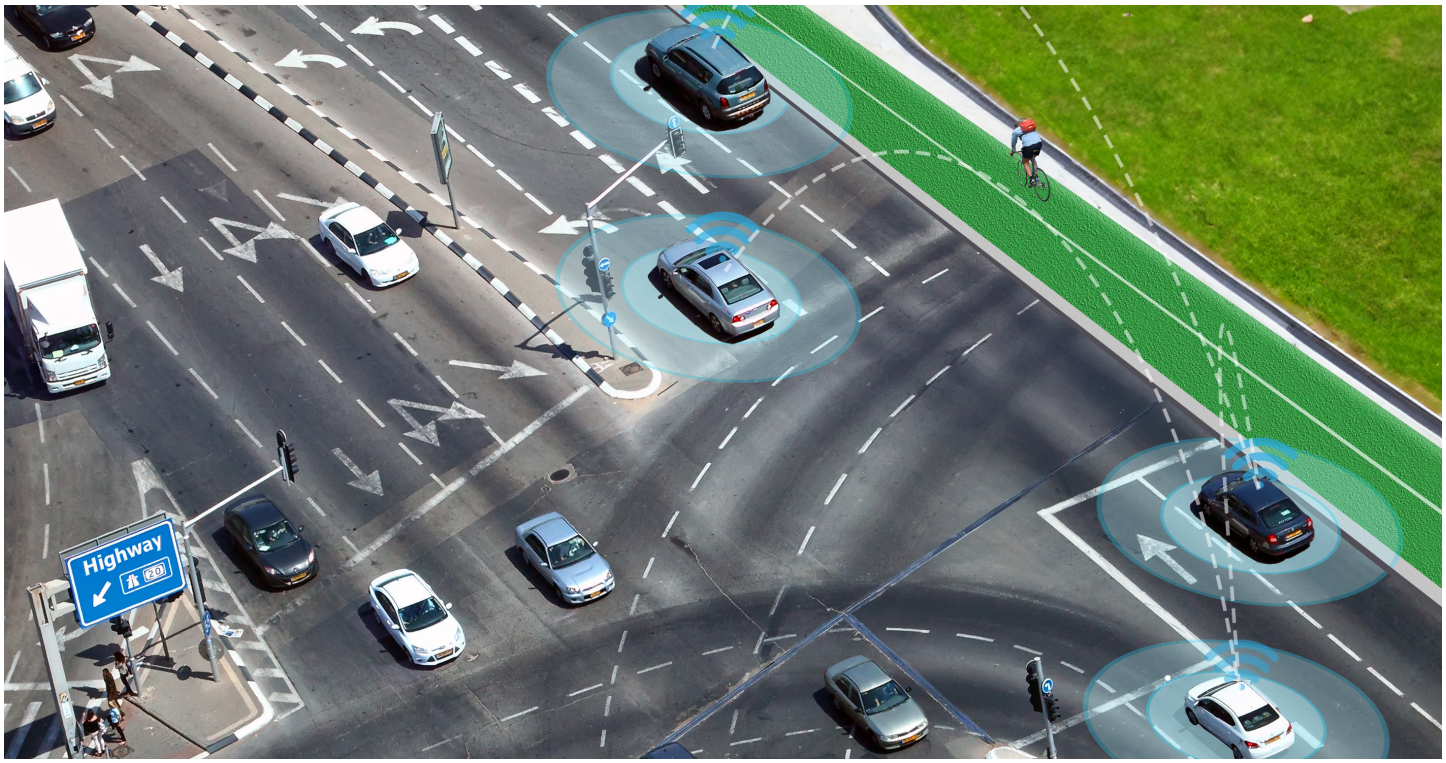

Figure 20.Rendering of Autonomous Sensing Technology on a Street. Source: Author

C. Enhanced roadway striping. Uniformity of roadways is vital to the functioning of CAV

In the short term, having a maintained network of solid roadway striping is the best method San Jose can use in preparing the city for autonomous vehicles. Clearly visible roadway striping will allow autonomous vehicles to more easily navigate roadways. It is important that San Jose stay diligent in upkeep on their existing striping by keeping a constant watch on the network for striping that needs updating. Additionally, gaps must be filled in areas without adequate roadway striping.

D. Develop a series of AV only lanes to ease the transition between traditional cars and AV

There will likely be many struggles in the initial coexistence of AV and traditional cars. To ease this relationship, San Jose should create a series of AV only lanes to reduce the interaction between the two modes. This will help reduce potential collisions between AV and traditional cars as well as allow AV to travel more efficiently as the autonomous technology will not have to anticipate the unpredictable movements of human drivers.

E. Require new cars to connect their updated location to the cloud of existing AV so that AV can better react and adapt to their unpredicted movements

San Jose should set a precedent that traditional cars must communicate and connect with the network of connected autonomous vehicles. This will ensure a greater sense of safety during the transitional period when AV and traditional cars must share the road. AVs will be able to anticipate and react to unpredictable human drivers if they are able to understand their precise location beyond the capabilities of their own sensors. If all vehicles are connected to a shared geographic network then extra care must be placed on ensuring the security of passengers location data.

F. Bolster the existing Vision Zero Initiative efforts and tailor them to the needs of AV safety

The city of San Jose Department of Transportation has been a national leader in the pursuit of traffic safety through their Vision Zero initiative. This initiative aims to reduce and eventually eliminate traffic injuries and fatalities. AV has the potential to be a significant instrument in achieving this goal. In turn, Vision Zero should tailor its efforts and funding into AV-based safety measures. This can come in the form of improving traffic signals and roadway striping to better interact with the AV network and sensors.

G. Create statewide regulations in permitting AV for testing and commercial operation to ensure that AV is not deployed prior to it functioning at a safe level

It is vital to the overall effectiveness of AV and the safety of riders and pedestrians that AV is not allowed to operate before it has passed rigorous safety tests. San Jose must set a standard by which AV must pass to operate within city limits through strict permitting regulations. Currently, AV permitting operations is primarily handled by the California DMV but it may behoove San Jose to require additional safety regulations before AV is allowed to function with full autonomy on its streets.

H. Enact regulations that require that AVs and by extension their operator be held accountable to the same legal ramifications that a human driver is held accountable when committing traffic violations

Liability is a significant unknown in planning for AV technology. There is no existing precedent on how to handle liability in the event of a crash involving AVs. San Jose must hold AVs and their operators accountable for traffic violations to the same degree as regular drivers so as to not incentive bending traffic laws. This issue may potentially be handled at the federal level since it is a problem facing not just AV in San Jose but the technology as a whole.

6.4 Urban Design and The Built Environment

In order to accommodate the growth of autonomous vehicle technology it is important that San Jose update its existing infrastructure to optimize the technology and facilitate its integration into the existing transportation framework in San Jose. Additionally, in changing the built environment of San Jose in response to AV, priority should be given to the experience of the pedestrian through reorganizing streets and their ROW to feature bike lanes, paseos, and other pedestrian friendly infrastructure. Being that urban design and the built environment are largely visual, this section will feature several realistic renderings of the potential solutions in action in the framework of San Jose.

A. Create wayfinding signage and mobile apps to map the locations of pickup and drop off zones and autonomous rideshare/transit.

An easy and impactful first step in preparing San Jose's built environment for autonomous vehicles is creating wayfinding. Wayfinding can come in the form of traditional signage directing passengers to pick-up and drop-off locations. Computerized kiosks can also be utilized to show real-time data on the location of pick-up and drop-off zones and active autonomous rideshare and transit. This kiosk system can also serve as a method for accessing autonomous rideshare for users that do not have access to a mobile phone. It is incredibly important that there are methods by which people without a phone or credit card can access autonomous rideshare and transit. In turn, kiosks should be fitted with a cash-based payment system by which riders can book their trip.

Figure 21. Visualization of AV Wayfinding Apps and Signage. Source: Author

B. Convert existing surface parking lots into pedestrian friendly infrastructure such as parks and paseos and optimize parking garages for AV

As AVs become more present on the streets of San Jose, there will be less of a need for surface parking lots and a greater need for off-site parking garages to store AVs. This creates the opportunity for parking lots to be transformed into whichever use most benefits the surrounding area. As it stands, 21.28% of Downtown San Jose is parking lot space (City of San Jose Open Data).. This could come in the form of parks, paseos, plazas and other pedestrian friendly third spaces. Additionally, being that San Jose is in the midst of a housing crisis, it would also benefit the city to use this opportunity to build housing. Ideally, this would come in the form of mixed-use commercial and residential developments. This will ensure that street life in the given area remains active by activating the bottom floor commercial. Off-site parking garages are projected to be a major need in hosting a successful operation of AVs. The best way to meet this necessity is to retrofit existing parking garages to suit the needs of AV. In the short term, the seldom used top floors can be converted into higher density AV parking zones to accommodate off-site parking needs.

C. Repurpose on-street parking into bike lanes and pick-up and drop-off lanes

Experts anticipate that autonomous vehicles will severely reduce the demand for on-street parking as AV reaches higher-market penetration. This creates a unique opportunity for San Jose to convert existing on-street parking into alternative functions. Being that autonomous vehicles will primarily pick-up and drop-off individuals at their desired locations, it is vital that San Jose build the proper infrastructure to accommodate this increased demand for pick-up and drop-off zones. The easiest solution is converting portions of the underutilized on-street parking into pick-up and drop-off locations. The city should use traffic pattern analytics to discern areas of high start and stop rates and target said locations for this use. Beyond pick-up and drop-off, on-street parking can be converted into pedestrian friendly uses such as bike lanes and expanded sidewalks.

D. Redesign San Jose streets to accommodate AV

It is estimated that autonomous vehicles will require significantly less right of way to operate efficiently due to machine-like precision beyond the capabilities of a regular driver. In the short term, San Jose can create narrow AV-only lanes in which AV can operate without interfering with human drivers. Once AV reaches ubiquity, there are several steps that should be taken to further optimize San Jose's roadways for AV. One method is converting intersections into roundabouts to optimize AV routes. Since AV is interconnected, AV will easily be able to navigate roundabouts and potentially boost traffic wait times by forgoing traditional traffic light stops. Additionally, as previously mentioned, AV will allow for a major reduction in lane sizes. This newly freed lane space can be returned to the pedestrian by converting it into larger sidewalks and bike lanes.

Figure 22. Before and After Rendering of a San Jose Parking Lot Transformed into a Paseo. Source: Author

Figure 23. Before and After Rendering of a San Jose Parking Lot Transformed into a Park. Source: Author

Figure 24. Before and After Rendering of a San Jose Parking Lot Transformed into a Park Aerial View. Source: Author

Figure 25. Before and After Rendering of E. Santa Clara Street Optimized for AV with Bike Lane and Pick-Up and Drop-Off Zone. Source: Author

E. Create a system of smart curb management that can adapt to the changing needs of San Jose mobility in real-time.

Curb management is likely to be a major priority in ensuring successful autonomous traffic operations. As previously mentioned, smart traffic pattern analysis should be utilized to best structure the existing curb space into its most efficient uses. Moreover, once technology allows, San Jose can employ a system of smart, real-time curb management that changes based on the existing need of the curb space. For example, during times of high passenger usage more curb space can be dedicated to pick-up and drop-off and then later can be repurposed for freight loading or street sweeping depending on the present need.

F. Reorient suburban streets to create a “flex space” of parkland and bike lanes in the center

Being that San Jose is home to a large amount of suburbs, planning for autonomous vehicles must extend to the low-density neighborhoods. Streets in low-density neighborhoods require different approaches than that of a busy street in the downtown core. However, suburban streets will similarly benefit from the additional space allowed by AV and thus their streets would benefit from a redesign that prioritizes the pedestrian experience. A potential solution is reorienting the streets to feature a green “flex space” of parkland running down the middle to facilitate community interaction. The flex space should be fitted with a bike lane to doubly serve as a class IV separated bikeway.

Figure 26.Before and After Rendering of N. 3rd Street with AV Optimized "Flex-zone". Source: Author

07

Conclusion

7.1 Key Takeaways

This study has demonstrated the need for San Jose to develop AV-specific plans and policies. Using the groundwork developed by this research, San Jose planners and policymakers can begin the process of creating AV-specific planning documents and policies to guide San Jose towards a positive autonomous future. By prioritizing equity, safety, and sustainability and preparing the built environment for the coming autonomous technology, San Jose can proactively shape its own autonomous landscape. A future in which San Jose has adequately prepared itself for autonomous vehicles holds the power to transform transportation within and beyond the city through revolutionizing traffic safety, access to transportation modes, the efficiency of roadways, and vehicle-based sustainability. The first step in this process is creating a San Jose Autonomous Vehicle Action Plan by which San Jose can have concrete language and goals to shape its autonomous vehicle policy decisions.

7.2 Limitations and Suggestions for Further Research

On a broad scale, the primary limitation of this research is the nature of the subject as an emerging technology. The novelty of autonomous vehicle technology makes it difficult to discern what does and does not work in planning for its rise. As the technology becomes more mainstream, we will naturally develop a better sense of the best approaches in handling this novel technology. Conversely, being that autonomous technology is so early in its life cycle, most of the research surrounding its potential impact is largely speculative. In turn, the long-term policy and design-based recommendations presented by this research may prove obsolete as we learn more about the technology in the coming years.

Within the bounds of this study, further research could be conducted in soliciting the thoughts and suggestions of relevant transportation planners. This research took a broader approach by instead looking at the existing planning documents and pilot programs of different cities. However, understanding the viewpoints of individual planners and stakeholders can offer unique insights into the best practices in planning for autonomous technology.

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