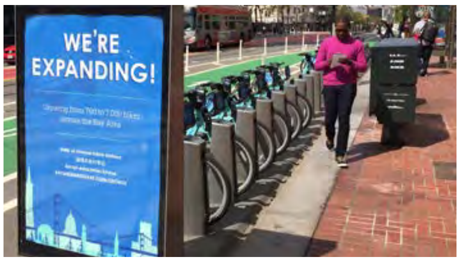

City of San Francisco

Meeting the Smart City Challenge

Volume 1

SmartCitySF.com

Notice of Funding Opportunity
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SFMTA
Municipal
Transportation
Agency

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EXECUTIVE SUMMARY

San Francisco is already a global leader in smart cities. Our culture is vibrant and technology-infused, breeding innovation and leveraging city-led initiatives to incubate and disseminate knowledge while pointing paths to the future. The San Francisco Municipal Transportation Agency's (SFMTA's) experience with SFPark has positioned us to take on this next and larger Smart City Challenge. In this proposal, San Francisco answers the USDOT call to be the nation's premier city laboratory offering a holistic, community-driven approach.

The Problem: Five Key Reasons San Francisco Is Responding to the Smart City Challenge

Transportation is the lifeblood of our communities. It connects us to opportunity, to one another, to the things that make life meaningful. Yet for too long, our transportation system has yielded policies that directly and indirectly separate and disadvantage residents; generate excess pollution, congestion, and expense; and lead to unnecessary deaths. San Francisco is applying for the following reasons:

1. The City is in an affordability crisis. Our burgeoning economy is causing displacement for some and longer commutes for all.
2. Thirty residents lost their lives in 2015 in San Francisco traffic fatalities. We do not accept that a certain number of fatalities are just "the cost of doing business." We must get to zero.
3. Transportation comprises 43% of San Francisco's greenhouse gas pollution, yet we strive to be a carbon-neutral city.
4. We have made great strides in walking, public transit, bicycling and shared modes; however, these networks are fragmented and are not meeting the needs of the other half that drive.
5. The region's population and jobs will grow by 25 percent by 2040. Without innovation to meet housing and transportation inequities, the region risks its economic competitive advantage.

Our Vision: Customer focused and community oriented transportation for all

We will work with the USDOT and Vulcan to leverage our pioneering efforts to innovate transportation systems that meet the public good and increase their benefit for San Francisco and all cities. Building upon SFMTA's Phase 1 Vision, we assert that the future of the transportation system is customer-focused, integrates with land use, and is active (walking and cycling). Our vision is of shared mobility, i.e., the shared use of a vehicle, public transit, bicycle, or other mode, that enables travelers short-term access to transportation modes on an as-needed basis.

- **Shared** to reduce the fleet size and travel costs, and improve mobility and access for all users;
- **Electric** (when motorized) to minimize air pollution, emissions, operating costs, and noise;
- **Connected** to minimize fatalities and collisions and to maximize operating efficiency; and
- **Automated** to minimize congestion, parking demand, and operating costs.

Shared, electric, connected, automated (SECA) vehicles are our best chance to meet the infrastructure legacy of the past, the resource challenges of the present, and the opportunities of the future. Our future transportation system will allow people to meet their daily needs, enabling them to focus on work, errands, family, and building community. Ultimately, we can set the process in motion by prioritizing space for walking, public transit/shared mobility and bicycling, and over time for more community-oriented needs including open space, affordable housing, and city amenities.

Our Goal: The power of a 10 percent shift

Consistent with the SFMTA's Strategic Plan, we will pursue the following goals with our partners over the three-year demonstration period:

- Shift up to 10 percent of single-occupancy vehicle (SOV) trips to public transit, shared and active modes;

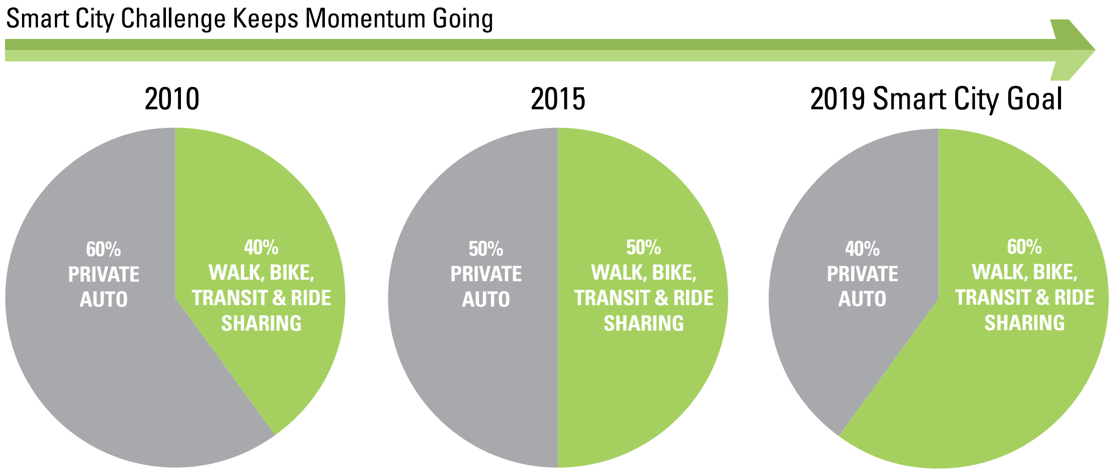


Figure 0.1 Mode shift for trips to, from, and within San Francisco

- Reduce transportation emissions 10 percent through electrification and demand management;
- Reduce collisions and fatalities 10 percent, leveraging our Vision Zero investments;
- Reduce the share of lower-income residents' household income on transportation by 10 percent; and
- Reduce freight delays and collisions by 10 percent.

Our Approach: Work with the community, employ technology and pilots to shift behavior

The SFMTA and its partners propose a series of interrelated pilots over three years that build upon each other to shift driver behavior to more sustainable transportation modes and safer driving habits. We will iterate with our community, academic, and technology and mobility provider partners to share our lessons learned and best practices to other cities across the nation and the world.

Our three-tiered approach (regional, city, and neighborhood) goes beyond a typical pilot deployment of advanced technologies to create a model platform that other cities can replicate and customize. Specifically, at the neighborhood level, we will launch a Community Challenge. Selected neighborhoods will be chosen from many proposals. Table 0.1 summarizes the pilots, demonstration and outcomes of our comprehensive approach.

We want to demonstrate and understand how virtual (Internet) streamlined information and physical infrastructure changes (i.e., hubs, automated and connected vehicles, carpool curb space, and shared mobility hubs) can provide the needed supply- and demand-side feedback to optimize our transportation system at regional, city, and neighborhood scales. Our approach complements and builds upon a more typical supply-side approach of transportation feedback control, such as ramp metering or traffic signal synchronization, which relies on sensors, cameras, and infrastructure, with a demand-side approach. This is the breakthrough innovation of San Francisco's approach. We are proposing to change user behavior at a scope and scale that is commensurate with our challenges. This demand-side approach will provide targeted feedback to travelers (individuals and freight) by employing behavioral economics and nudging via an Internet and smartphone app-based mobility (or TaaS) platform. We will bring our Shared-Electric-Connected-Automated (SECA) vision to life through a virtual and physical platform, as well as macro- and micro-level infused demonstration pilots. This is key to enable the critical understanding that can facilitate user uptake and proof of concept testing. Examples include:

Regional Approach: More than a third of all trips in the city are regional—a strategic opportunity for:

- Transportation as a Service (TAS): Information and payment integration of all mode providers with pooling, delivery services, safe driving, and smart parking (building on our experience with SFPark) platforms.

- Regional High Occupancy Lanes and Curbs: A smart "spine" unifying infrastructure and information through pilot lanes, curbs and connected vehicle technology and wireless for public transit and pooling.

City Approach: Our citywide networks offer opportunities to increase equity for all users, including job access (ladders of opportunity):

- Municipal Mesh Networks: Collision avoidance on municipal/public transit vehicles to detect vulnerable road users. Connected wireless mesh provides free Wi-Fi on-board for public transit/taxi passengers.
- Connected Vision Zero corridors: Connected vehicle technology to improve safety, health and mobility.
- Late Night Worker Shuttles: Pilot services for late night workers in service and hospitality and health industries to provide affordable and reliable rides home in the city.

Neighborhood Approach: San Francisco's transportation system must meet a diverse set of needs (e.g., low-income, disabled, older adults, children, working families, etc.). We are proposing a Community Challenge grant to engage our city's neighborhoods to be the first to try out these innovative mobility options.

- The Community Challenge stems from our successful neighborhood challenge programs.
- Neighborhoods can choose from a menu of pilots including but not limited to: active and public transportation, shared mobility hubs with EV charging and Wi-Fi/parklets, traffic safety, and automated vehicle testing for delivery/municipal fleets and first- and last-mile connectivity.

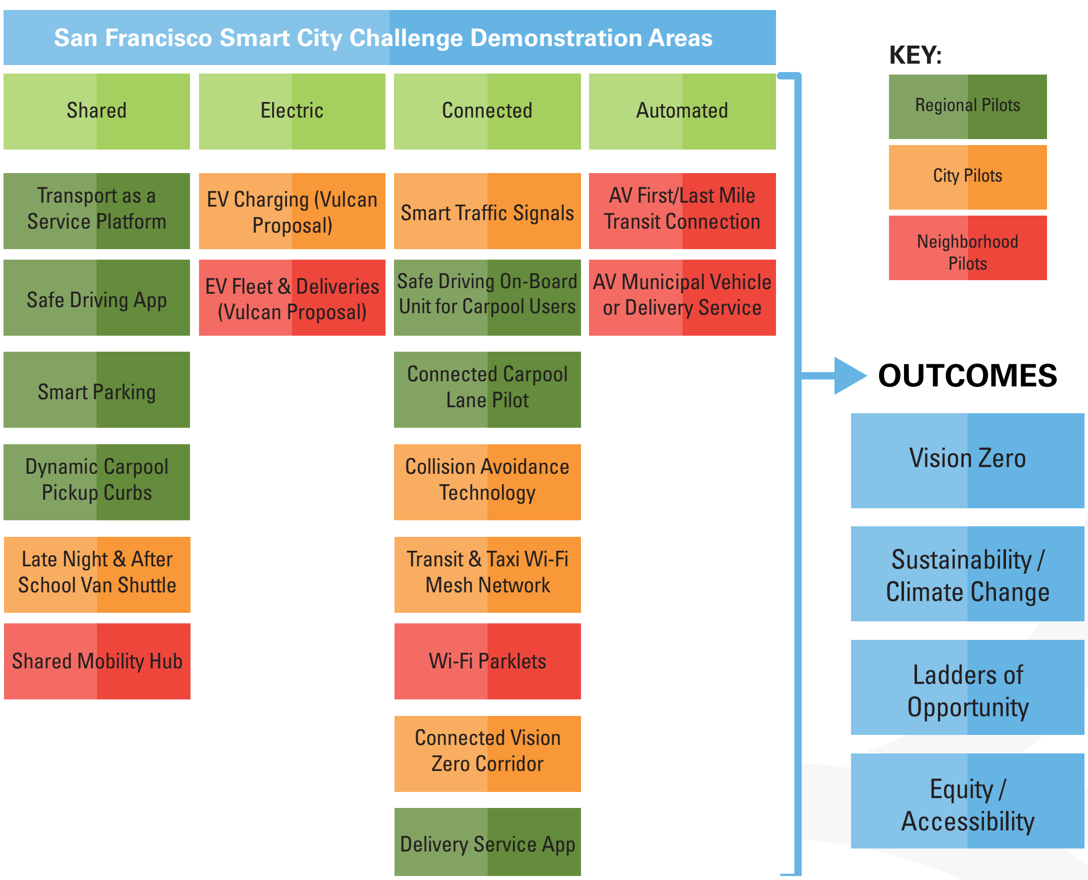


Figure 0.2 San Francisco Smart City Demonstration Areas

<table>
<tr><th>Scale</th><th>Proposal</th><th>Demonstration Components</th><th>Demonstration Goals</th></tr>
<tr><td rowspan="2">Regional</td><td>Transport as a Service Platform (TaaS)</td><td>• Multi-modal information and payment app
• Safe Driving feature app
• Delivery Service feature app
• Smart Parking feature app</td><td rowspan="6">Reduce:
• SOV trips and auto reliance
• Vehicle ownership
• Collisions/ fatalities
• Delivery/circling time
• Emissions and fuel use
• Travel costs and time

Increase:
• Job access
• Public transit ridership
• Walking and bicycling trips
• Shared mobility trips
• Public transit and pooling reliability and travel times
• Digital equity

Proof of concept: accessibility, affordability, operating costs

Model policy, legislation and technology transfer for all cities</td></tr>
<tr><td>Connected High Occupancy Lanes (City streets, US101, I-280)</td><td>• Connected high occupancy lanes (transit & pooling)
• Designated pick-up curbs
• Instant matching with smartphone apps
• Carpool pickup plaza mobility hub for those without smartphones (equity/accessibility)</td></tr>
<tr><td rowspan="2">City</td><td>Municipal Mesh Network (Vision Zero Corridors)</td><td>• Collision Avoidance and Wi-Fi for public transit/taxi/large municipal vehicles
• Connected Vehicles - Vision Zero Corridors</td></tr>
<tr><td>Shared Van Shuttle Service</td><td>• Late night worker van shuttle
• After school van shuttle</td></tr>
<tr><td rowspan="2">Neighborhood via Challenge</td><td>Shared Mobility Hubs</td><td>Community Challenge: Shared mobility hub with EV charging, Wi-Fi & Parklets, transit & active transport</td></tr>
<tr><td>Automated Vehicle Pilot</td><td>• Delivery and/or Municipal service
• First mile, last mile transit connection service</td></tr>
</table>

Table 0.1 San Francisco Comprehensive Approach

- People of all backgrounds will be encouraged to participate in neighborhood pilot programs.
- After a robust outreach process, residents will volunteer their neighborhoods to host pilots.
- By engaging with neighborhoods, San Francisco will work hand-in-hand with communities to address problems of digital equity and limited and costly (time and money) mobility.

San Francisco is the smart choice for the Smart City Challenge

San Francisco can uniquely deliver desired Smart City Challenge outcomes because of its location, massive network, unprecedented and unparalleled access to technology partners, and San Francisco's interdisciplinary research alliance with the University of California, Berkeley. We offer:

1. **Unrivaled mobility innovation:** The San Francisco region is the nation's premier test bed for groundbreaking discoveries and trend-setting policies. Our pace of transportation innovations in shared mobility, electrification, and automated vehicles occurs nowhere else on earth.
2. **4:1 leveraging of the Smart City Challenge total award amount:** To date, our relationships and partnerships have resulted in over 70 companies outlining their support for this project. Over 40 companies have committed to leverage the USDOT grant to the City to a value of at least $153 million should the grant be secured by San Francisco.
3. **Proven track record of success through SFPark:** SFPark, a dynamic parking management system that achieved behavioral change through pricing experimentation (funded by the USDOT Urban Partnership Program), serves as a model across the U.S. and 12 nations around the world.
4. **Smart City Institute Partnership:** We have created the Smart City Institute to provide a physical space adjacent to City Hall to bring together our partners under one roof to work together and solve these complex transportation and other municipal challenges. Beyond that, our approach to policies,

innovation, and research puts us in a position to lead the world.

5. **Perfect combination of urgency and early adoption culture:** Our residents are eager for innovative mobility solutions.
6. **Confidence in data and risk management:** Our track record and reputation shows we know how to collect, warehouse, and protect critical data from both a privacy/security and proprietary (business competition) perspective. Our decades of experience and robust institutional frameworks ensure that we can provide a low-risk test bed with the highest impact.
7. **A guaranteed return on investment for the nation:** Investing in our vision and approach is likely the best option for USDOT to achieve a substantial return on its investment with outcomes that will prove replicable, scalable, and sustainable over the long term.
8. **An ideal urban laboratory for the nation:** San Francisco offers varied topography, urban form, and micro-climates that match the majority of cities across the nation within its city limits, except for snow. This, and its open and inclusive trend-setting culture, groundbreaking transport and land use policies, and our proximity to Silicon Valley, is why 13 automated vehicle companies are already here.

Furthermore, San Francisco—unlike all U.S. cities and most others across the globe—manages all of its rights-of-way, parking, public transit (Muni service), and taxi operations under a single roof: the San Francisco Municipal Transportation Agency (SFMTA). This enables a supportive and integrated policy environment essential to realize such an ambitious vision.

A centerpiece of our proposal is creating the Smart City Challenge Exchange

National Association of City Transportation Officials (NACTO): A small group of cities created the Urban Bicycle and Urban Street Design Guide in the absence of city-specific guidance. These groundbreaking documents are now used by more than 50 cities across the nation and beyond, including state departments of transportation. San Francisco, a founding member of NACTO, will work with NACTO to share our ideas and gain policy input from its member cities.

Tech Transfer Program: We will bring together the experience of UC Berkeley's Technology Transfer Program and the positive track record of the Natural Resources Defense Council's Urban Solutions program to build a learning network to ensure everything we learn and pilot can be scaled up and replicated in real time. The Tech Transfer program currently reaches a network of 25,000 public and private transportation agency personnel worldwide. The partnership among the City, UC Berkeley, equity and environmental partners, and innovative companies will define and promulgate the transportation system of the future to educate the next generation of smart city scientists.

A legacy opportunity for the nation: Impacts beyond the three-year demonstration program:

- With USDOT and Vulcan support, San Francisco will successfully deliver the world's first shared, electric, connected, and automated transportation network.
- The City's framework of scalable regional, citywide, and neighborhood-based pilots will address a wide variety of challenges and maximize learning within the Bay Area and across the nation and globe.
- San Francisco's phased community-based pilot programs ensure support, adoption, and scaling potential.
- San Francisco has the innovative and academic know how to implement, study, and share knowledge learned from the Smart City Challenge.

San Francisco's partnerships with the USDOT and Vulcan are critical to catalyze the ecosystem of potential partners and their financial pledges. And we have indeed mobilized. We have accelerated our partnering opportunities more so in the last three months than in the past year, with tremendous proactive engagement by all partners around this project. It would be an honor and a privilege to be chosen to bring this new era of mobility from theory into reality with USDOT Smart City Challenge support. We see the Smart City Challenge as a catalyst and call to action to provide leadership, initiative, and expertise for the nation and the world.

SECTION 1: TECHNICAL APPROACH

As San Francisco continues its rapid growth, we are increasingly focused on the future of our transportation network. Our network does not just move millions of people—it creates opportunity for communities. These opportunities are particularly important to communities of concern, where people face limited mobility choices. Mayor Ed Lee and the SFMTA believe in transportation as a great equalizer. By providing free public transit to youth, seniors and people with disabilities, San Francisco has already begun to provide ladders of opportunity between and across San Francisco's communities. But we can go further.

Our philosophy: The only way to bring about lasting changes in mobility choices and to level the playing field is to work directly with and empower the players.

Our path forward: The City will accelerate true, community-led planning initiatives that result in neighborhood-level transportation transformations that will boost economic vibrancy and provide a chance to train the workforce of the future.

With Smart City Challenge funds, San Francisco will bring more economic opportunity to our underserved and low-income communities in a very new way.

We will not just ask our communities what their mobility needs are. We will give them real responsibility and stewardship of their own small-scale transportation demonstration pilots, with city support and guidance. Community ownership of these projects will help ensure longer-term support and adoption of these innovative transportation treatments.

1.1 Smart City Community Challenge for Neighborhoods

San Francisco's approach to the Smart City assumes that preparing for the future is as much a political challenge as a technical challenge. Good outcomes are more likely to breed public and political support. Therefore, to minimize deployment risk, this proposal will undertake repeated small experiments instead of riskier "big bang" efforts. We are passionate about this approach because it actively invites and engages residents to embrace and envision the Smart City Challenge. Neighborhoods will have a chance to select from pilot options that best match their needs and values (e.g., freight and delivery shuttles, first-mile/last mile services, etc.).

In San Francisco, as in other cities, technological change—especially change related to something as central to our society as the car—is inherently political. To suggest new approaches it is crucial for grassroots participation to democratize change fully. A rapidly changing San Francisco has left many feeling alienated and disenfranchised in their own city. To break this recent trend, the Smart City Community Mobility Challenge and associated community engagement plan provide a real opportunity to harness these changes toward a more equitable, safer, and greener future. To do this we will:

- Make community engagement a central part of our strategy by creating a public "Smart City Community Mobility Challenge," a contest to collect, identify and overcome the worst "shared mobility challenges" with community-supported innovative technologies and behavioral change;
- Create an engaging, community-friendly web platform for the public to easily submit their ideas and that also provides step-by-step assistance and webinars in helping community groups develop capacity to write grassroots applications;
- Engage with existing community advocacy groups and host public workshops in communities less accustomed to Internet-based public engagement and media to ensure all of San Francisco's communities are aware of the Challenge and able to participate; and
- Provide continuous support and technical assistance from outreach and technical teams to help community groups.

The City is unevenly organized. For instance, 70,000 people move to San Francisco each year (while 60,000 people leave), and it is not easy for these people to enter into San Francisco's civic life. Existing organizations often do not attract newcomers. By providing tools that are truly public for creating ideas and submitting applications, we are creating another Ladder of Opportunity with broader, cheaper mobility options enabling people to better control their own fate. By making it easy to submit and participate, we are building capacity citywide for more San Franciscans to voice their opinions and participate in civic life and discourse. At the same time, we will aggregate problem sets from individuals to have a greater understanding of what city residents want from their transportation network.

1.1.1 Many Small Experiments

By creating the process for a repeatable "Smart City Challenge," we will be able to:

- Test many small, relatively inexpensive experiments,
- Assist a variety of San Francisco's diverse neighborhoods,
- Iterate twice a year or more,
- Improve the process of producing change,
- Test for replicability seeing if things that work in one neighborhood can work in another, and
- Collect data to guide future experiments or larger initiatives.

1.1.2 Process

Figure 1.1 shows the process for our Community Challenge. The diagram appears in multiple layers. The top layer shows the repeated cycle of running the Challenge. The middle layer shows the sub-process of soliciting public input and turning that input into applications, and the bottom layer shows the "funnel" where a large number of easily generated ideas are boiled-down over time into a small number of completed applications.

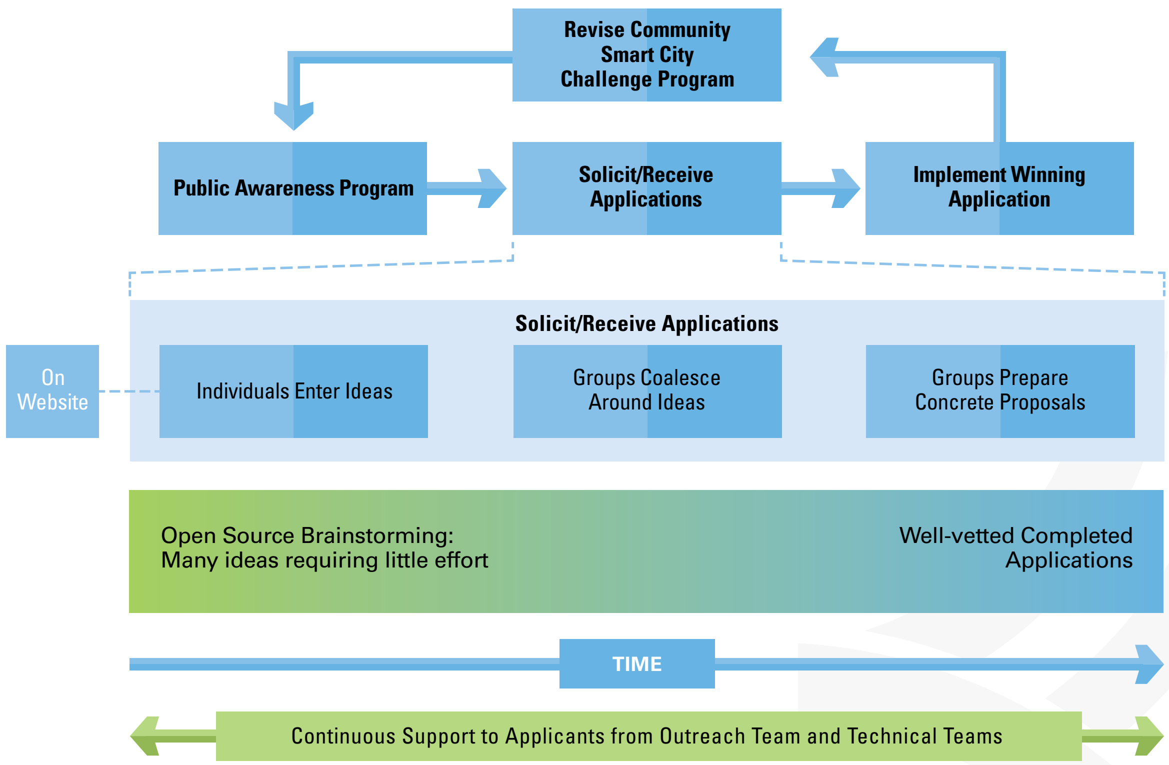


Figure 1.1 Community Challenge Process

1.1.3 Community Engagement Plan

The Community Engagement Plan bridges the gap between theoretical policy-making and popular, community-driven solutions. This approach gives all residents—rather than a vocal few—a platform to tackle congestion, pollution, local circulation patterns, or reckless driving. It will: 1) build trust between City officials and communities and 2) nurture the next generation of mobility advocates to champion the smart city approach beyond San Francisco. Along with this bottom-up approach to developing a Community Mobility Challenge, we must develop an approachable application process. While the private sector and SFMTA work to lay the infrastructure for connected and automated vehicles, we must also identify the widely acknowledged challenges in the community and develop innovative solutions to address them together. The crowd-sourcing platform and in-person meetups will help develop proposals in a democratic way to ensure the fullest ideas, with demonstrable community support, make it to the application stage. In addition to providing a project narrative and demonstrating community needs, applicants must show that their project has received considerable community support when they present their concepts on the Smart City Community Mobility Challenge website or at in-person meetups. This process and feedback are critical to adoption, understanding, and success.

1.1.4 Community Engagement Plan Goals

1. Start the conversation about mobility challenges and the existing transportation network,
2. Publicize the City's efforts in becoming a smart city and what that means,
3. Educate the public on alternative mobility options and their associated benefits and trade-offs,
4. Redefine the role of transportation advocates by broadening and expanding the pool of stakeholders and potential grant applicants,
5. Empower all community members to leverage modern technology for positive and lasting change, and
6. Develop the next generation of shared mobility advocates.

1.1.5 Process

Figure 1.2 shows a more detailed view of the Solicit/Receive Applications phase of our vision.

Once an application is selected as a Community Mobility Challenge neighborhood, the neighborhood team will be matched with a technical working group, comprised of partners from the Smart City Institute and governmental staff to form a neighborhood smart city working group. Regular neighborhood smart city working group meetings, staffed by the SFMTA, will work through an iterative process to match the neighborhood's shared mobility problem(s) with potential solutions suggested by the technical working group or developed through committee meetings. Potential solutions will be piloted, and their acceptance will be measured by regular opinion polls. Effectiveness of the pilots will be measured by UC Berkeley research staff.

Once pilots are accepted by the selected neighborhoods, a new Community Mobility Challenge cycle will open and the process will repeat. Beyond the three-year pilot, we envision that this process will continue and gain further momentum. Many of the requests can be fulfilled through an existing $2 million annual fund established for neighborhood projects. Our vision is to grow this fund through public-private partnerships and future grants, as appropriate.

1.2 Holistic, Integrated Smart City Approach

San Francisco is proud to have overcome many challenges through pioneering policies and innovations and an equity-focused lens. However, many more challenges lie ahead that are seemingly beyond the City's control. We are seizing this grant opportunity to help catalyze a series of breakthrough solutions that address the following challenges:

1. **Affordability crisis**. The City and Bay Area's burgeoning economy has outpaced affordable housing and transportation options causing

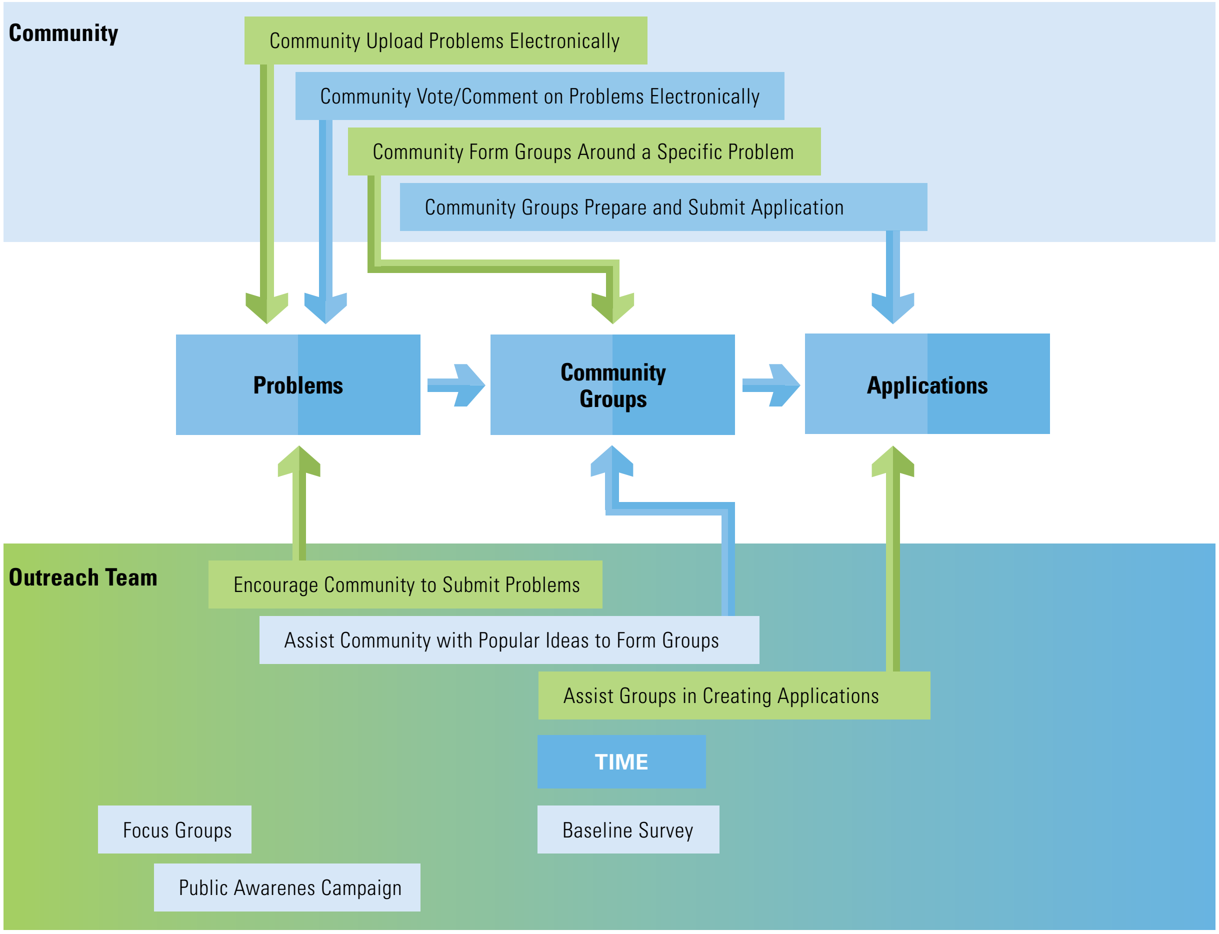


Figure 1.2 Smart City Problem Solving Via the Community Challenge

displacement for some and longer commutes for all. A private vehicle costs an average $10,000 per year. For many this is an unsustainable 18% of household income going to mobility. Viable active and shared mobility options are needed for residents to reduce travel costs and increase their ladders of opportunity.

2. **Traffic safety crisis.** 30 residents lost their lives in 2015 in preventable traffic fatalities. Historically most fatalities occur on less than 12% of the City's streets and disproportionately in low-income areas. Consistent with the City's Vision Zero goal of reducing traffic fatalities to zero by 2024, we do not accept that a certain number of fatalities are just "the cost of doing business." Technology driven speed control, proximity and collision avoidance tools can dramatically reduce fatalities and increase safety for our vulnerable users.

3. **Accessibility matters.** While we have experienced a great proliferation of on-demand transportation options, they are inaccessible, unavailable, and priced out of range for most residents. We need universal design principles in current scheduled/on-demand and future automated mobility options especially for the aging, disabled, and low income.

4. **Fragmented and disconnected transportation system.** With the assistance of local and federal active transportation programs responding to public demand, the City and the nation have made great strides in walking, public transit, bicycling and shared modes. However, San Francisco's transportation networks are still fragmented for all and are not meeting the needs of the other half that drives. Moreover, the cost of re-creating an urban landscape is prohibitive. Rather than pouring billions into a physical

reinvention of the City, via new technologies we can strategically spend millions to more fully integrate the transportation system via the provision of real-time information to travelers with single payment and paperless transfers across different modes to make getting around the city easier, cheaper and more convenient.

5. **Climate change.** We need to electrify our transportation fleets to create resilient, clean mobility systems. Our transportation system still comprises nearly half of San Francisco's greenhouse gas pollution, and our infrastructure is vulnerable to climate events.

6. **Service gaps** in our public transportation network encourage auto reliance. Reliable and available transportation for all trip purposes, all times of the day, everywhere across the City is what residents need to switch from driving their own vehicle.

An Overarching Approach: San Francisco Smart City Institute

Our vision offers bold and innovative ideas to demonstrate and evaluate the benefits of various smart city concepts that align with the Challenge's 12 Vision Elements. This level of effort requires the contributions of the City, academia, community, and technology companies. The City has created the Smart City Institute to facilitate these interactions and our smart city incubator. The Institute, housed at 50 UN Plaza, a block from City Hall, is an optimal, neutral space for city, community, business and academic staff to meet and work together to solve city problems including transportation. The Institute will be the meeting place, organizer and advisor to the Smart City Challenge. An impressive set of carefully chosen partners representing the City's government agencies, infrastructure network operators, and service providers will work together to meet the USDOT's Smart City goals. Its transportation lens will focus on empowering

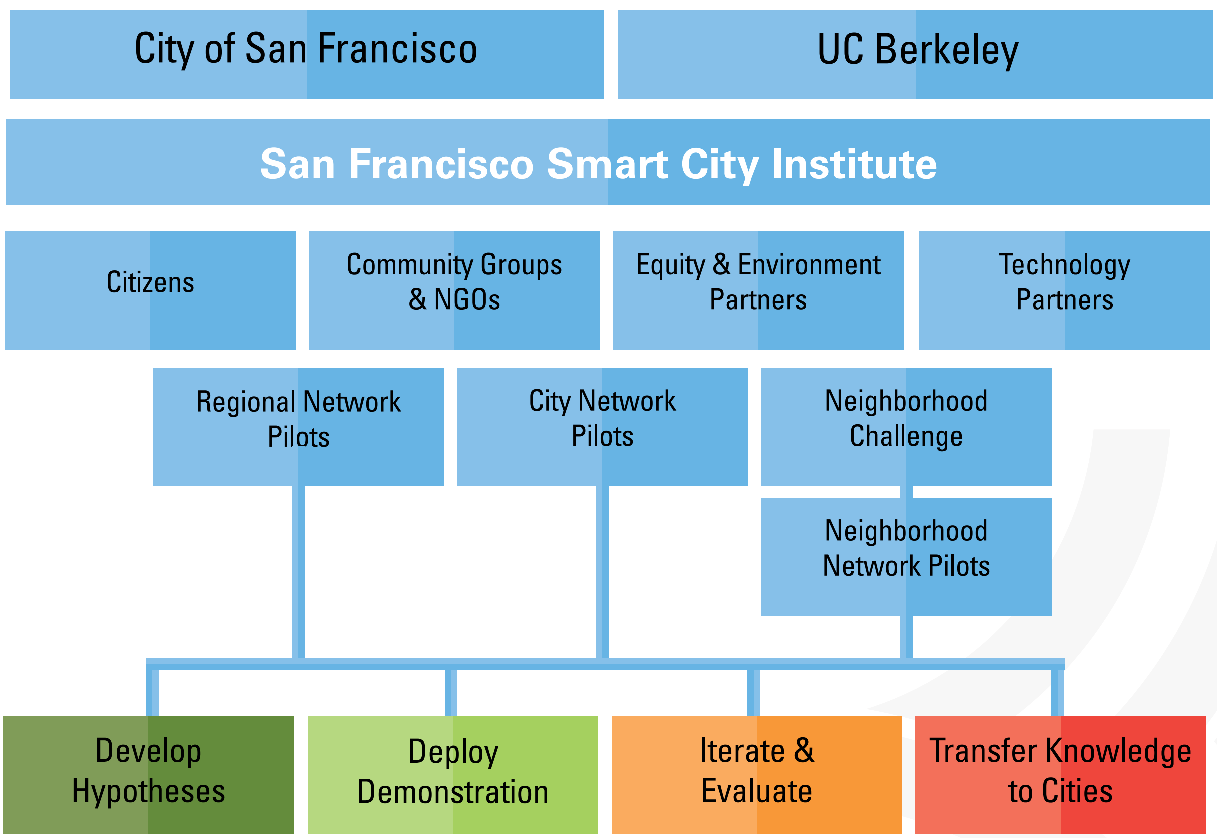


Figure 1.3 The City, the University, and the Smart City Institute

vulnerable populations, making more efficient use of existing infrastructure through innovation for moving people and goods, fostering the sharing economy, reducing collisions and fatalities, and improving resilience to climate events.

Pattern of Implementation: General Sequencing

At a high level, Smart City Challenge work will generally follow this schedule:

- **Year 1: Concept Development.** As required by the Smart City Finalist Notice of Funding Opportunity, the City will focus most of its initial efforts on adding detail and structure to the Smart City deployment plan. These plans include the deliverables outlined within the Smart City Challenge Phase II for Project Management, Concept of Operations, Systems Engineering, Performance Management, Data Privacy and Security, Data Management and Independent Evaluation, and Safety Management and Assurance as well as reporting as required.

- **Year 2: Design, Deploy, and Test.** The component equipment, systems, and subsystems will be designed, deployed, and tested in real-world conditions. Refinements will be made to the deployment based on user and community feedback. These iterative processes include proof of concepts to fine-tune the user experience and create sustainable business models.

- **Year 3: Evaluate, Operate and Bolster.** The Concept of Operations and other key documents and plans developed in Phase 1 and followed in Phase 2 will continue to drive the Evaluation and the Operations in Phase 3. Stakeholder involvement and public outreach will play an ongoing role and promote constructive feedback to further enhance performance measure validation and provide information regarding which efforts and deliverables should be replicated on a wider scale.

1.2.1 Overview of Demonstrations and Applications Tested

Our vision embraces both a macro (regional, city) and micro-level approach (neighborhood) to fulfill this goal. It is a phased approach that leads us to the goal of reducing reliance on single occupancy vehicles (SOVs) through shared and connected mobility, which will ultimately be automated on a wide-scale basis. We need supply-side infrastructure (e.g., connected vehicles, curb space for shared vehicles and freight delivery, and mobility hubs), but we also need a service platform that informs users of their choices and is focused on demand-side management (e.g., price, travel time comparisons and incentives). Our vision links supply-side technology management with demand-side feedback to users, creating a pathway forward to providing innovative and shared mobility for all of our citizens (young, old, disabled, low income, and all alike). Each focus area is divided into demonstration concepts, as summarized below. Experiment budgets are shown in *Volume 2: Budget*.

San Francisco has an ambitious plan. These pilots are guideposts for our vision; however, they are not fixed. They are adaptable based on feedback from our community of users and technology partner providers. We could find that we need to scale up or scale down in terms of the number of projects. If we are awarded this grant, we are also open to discussions regarding the use cases and test locations with USDOT, our partners, and our residents. Furthermore, we expect that there will be winners and losers among our pilots. We will likely encounter success that we can expand and grow. In some cases, we may learn that the viability of the pilot demonstration as proposed is not sustainable. Our vision is to use feedback control on the demand and supply sides to optimize our pilots for a 10 percent reduction of single occupant vehicle trips, fatalities, emissions, freight delays, collisions, and household transportation budgets across the pilots and our transportation system. Beyond the proposed three-year pilot, we hope to expand upon our successes and understanding to continue to grow our smart city initiative in conjunction with all of our citizens, partners, and the Smart City Institute.

Scale	Pilot #	Pilot Projects	Text Reference	Pilot Outcomes
Regional	R1	Transportation as a Platform - Integrated multi-modal mobility app platform	1.2.2.1 #1	• Proof of concept • Behavioral change to reduce SOV trips and auto reliance • More equitable/accessible transportation through enhanced modal choice/options • Increased public transit and shared mode (e.g., carsharing, ridesharing) usage • Reduced collisions/ fatalities (safety) • Reduced delivery time (logistics) • Reduced circling time (safety/efficiency) • Reduced travel time and cost (accessibility) • Reduced emissions (sustainability) • Increased quality of life (prosperity)
	R2	Safe driving feature in the multi-modal app platform	1.2.2.1 #2	
	R3	Delivery service app feature in the multi-modal app platform	1.2.2.1 #3	
	R4	Smart parking app features in the multi-modal app platform	1.2.2.1 #4	
	R5	Regional connected carpool (HOV) lanes	1.2.2.2 #1	• Proof of concept • Behavioral change to reduce SOV trips • Reduced crowding on regional public transit • Increased people throughput, job access, and quality of life (accessibility/prosperity) • Reduced VMT, travel time, and travel cost (accessibility) • Reduced emissions (sustainability) • Improved safety • Reduced carpool lane violations (efficiency) • Enabled productivity during commute (prosperity)
	R6	Safe driving on-board unit for carpool users	1.2.2.2 #2	
	R7	Dynamic carpool pick up curbs	1.2.2.2 #3	
City	C1	Smart traffic signals (Vision Zero), MMITSS deployment along corridor	1.2.3.1 #1, 2	• Proof of concept • Increased public transit and freight delivery speeds (efficiency/logistics) • Decreased emergency vehicle response times (efficiency/ quality of life) • Reduced pedestrian collisions (safety) • Reduced truck signal delay (efficiency/logistics) • Reduced truck speeding (safety) • Reduced collisions (safety) • Decreased collisions in sensitive population corridors (safety/equity) • Reduced emissions (sustainability) • Increased digital equity (ladders of opportunity)
	C2	Collision avoidance and Wi-Fi for public transit/taxi/large municipal vehicles (municipal mesh network)	1.2.3.2 #1	
	C3	A connected vehicle Wi-Fi for public transit/taxis/municipal vehicles (municipal mesh network)	1.2.3.2 #2	
	C4	Connected Vision Zero Corridors (municipal mesh network)	1.2.3.1, #1, #2 1.2.3.2 #3	
	C5	Shared van shuttle services: late night worker van and after school shuttle	1.2.3.3 #1, 2	• Proof of concept • Behavioral change to reduce SOV trips • Reduced travel time and trip costs (equity) • Increased access (ladders of opportunity) • Increased quality of life (prosperity) • Reduced number of reported crimes (safety)

Table 1.1 Pilot Projects and Outcomes

Scale	Pilot #	Pilot Projects	Text Reference	Pilot Outcomes
Neighborhood	N1	Shared mobility hub with EV charging (EV charging – Vulcan proposal)	1.2.4.1 (all)	• Proof of concept • Behavioral change to reduce SOV trips • Increased public transit and shared mobility use • Decreased private vehicle ownership and use • Increased digital equity in neighborhoods (ladders of opportunity) • Increased business patronage/revenue (prosperity) • Increased job access (ladders of opportunity) • Decreased travel times and cost (accessibility) • Increased quality of life (prosperity) • Reduced emissions (sustainability)
	N2	Wi-Fi parklets and community design	1.2.4.1 (all)	
	N3	AV delivery and/or municipal service	1.2.4.2 (all)	• Proof of concept • Reduced travel times and cost (accessibility) • Reduced costs to businesses and municipal fleets (efficiency/logistics) • Reduced freight collisions (safety) • Reduced reliance on SOVs • Reduced emissions (sustainability) • Increased quality of life for first and last mile (prosperity)
	N4	AV First/Last mile public transit connection service	1.2.4.2 (all)	

Table 1.1 (continued) Pilot Projects and Outcomes

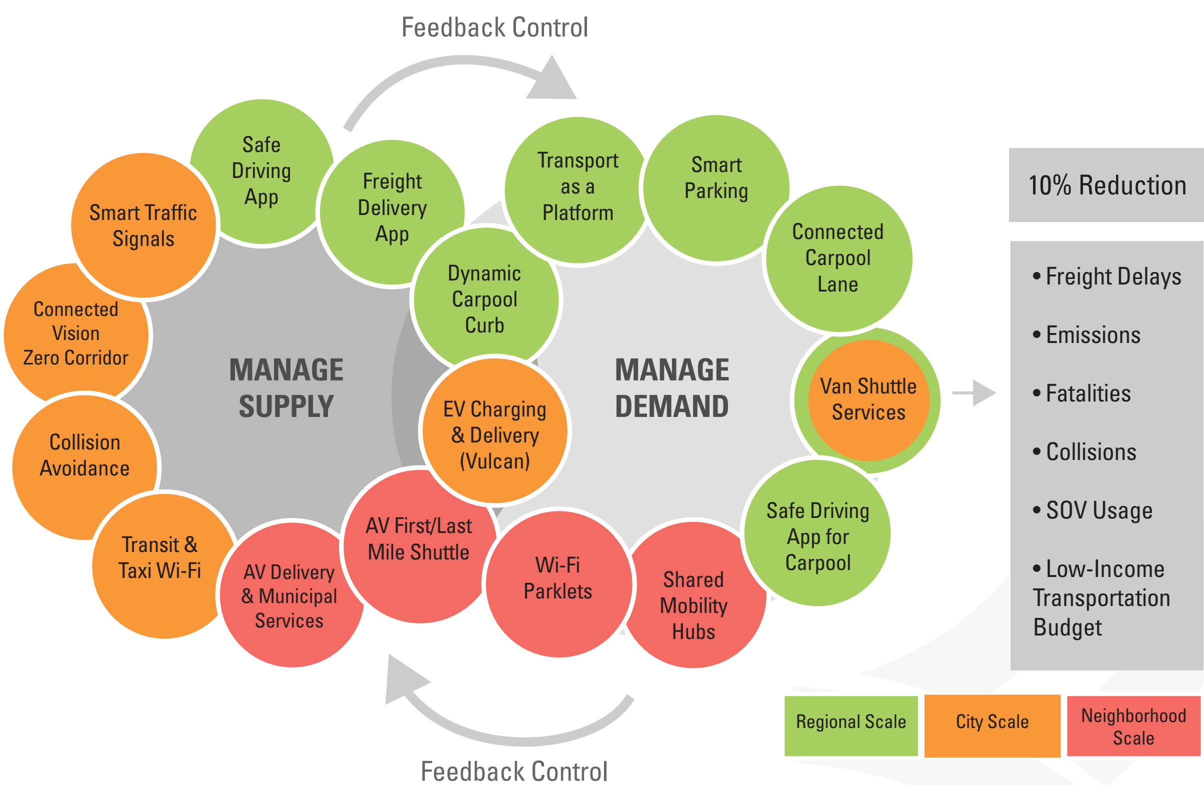


Figure 1.4 Pilots and Feedback Control

1.2.2 Regional Network Demonstration Pilots

In this section, we provide an overview of our 16 demonstration pilots and describe their implementation. Smart city pilots will deploy massive amounts of big data that provide an unprecedented ability to dynamically iterate, innovate, and calibrate the pilot projects and optimize for desired outcomes (Figure 1.5). Provided below is the overview of the deployment plan for the pilot concepts. Regional-scale projects will include the City of San Francisco, but also the greater Bay Area, as a large percentage of travel is intercity (e.g., commuters, tourism). This will involve a macro-level approach to the research, i.e., larger-scale surveys and pilots, larger study population, and sample size. The two regional-scale projects are the Transport as a Service (TaaS) platform and regional connected carpool lanes described below. Note that all of the data collected during the pilot (ranging from sensors to surveys to activity data, as appropriate) will be stored in the proposed data warehouse (described later in the proposal) at UC Berkeley. The regional pilots are linked to our SECA vision by creating the virtual platform for shared mobility and the commodification of transportation as a service (compares travel times and costs across modes, shifting people away from SOVs). It provides critical information to travelers and goods movement suppliers, prompts critical driving feedback to improve safety, and smart parking information to reduce circling and emissions.

1.2.2.1 Transport as a Service (TaaS) Platform

The centerpiece of the San Francisco Smart City Challenge proposal is the TaaS mobility platform. Through this portal, app users will be able to access the platform of mobility services customized in real time to the traveler's needs and characteristics. Our TaaS approach is unique: It provides targeted information to users that incentivizes and nudges them toward more sustainable transportation options (e.g., shared, electric) that optimize the transportation system. It will be informed by a panel study that provides critical feedback to evolve, sustain, and attract new users. This innovative mobility platform will push notifications to travelers and freight delivery operators that help them to make the best mobility choices given time of day, day of week, number of passengers, travel time, and travel cost. This platform helps travelers make the best decisions among modes given available options through positive and negative incentives and gamification or nudging. The goal of the TaaS platform is to facilitate the vision to shift up to 10% of SOV trips to a shared or active mode in three years. The TaaS platform is divided into several demonstration components: 1) the multi-modal app; 2) a safe-driving feature; 3) a delivery service feature; and 4) a smart parking feature. They are described below with the City leading implementation.

1. **Multi-Modal App** (Pilot R1): The app will provide the user access to various mobility services customized in real time to their needs and characteristics. Users can input their desired destination and be given real-time information on mobility options (e.g., public transit, bikesharing, carsharing, ridesourcing or transportation network companies (TNCs), taxis, bicycling, and walking), travel time and route, and cost. Payment will be done directly through this app or via the smartphone's default payment method (e.g., PayPal).
   - *Desired Outcome:* This platform helps travelers make informed decisions and can nudge their travel behavior toward more sustainable travel.
   - *Timeline:* In Year 1, the multi-modal and back-end apps support will be developed in partnership with technology providers. In Years 2 and 3, the app will continue to evolve and develop based on critical research feedback (described in the next section). Ultimately, the app will be supported by a sustainable business model that is created by the public and private project partners over the three-year pilot.

2. **Safe-Driving Feature** (Pilot R2): The feature will be embedded into the TaaS platform and used to detect unsafe driving patterns (e.g., speeding, hard braking), which in turn will be used to provide feedback to drivers and input to safe-driving media campaigns and driver educational programs. The objective of this feature is to reduce unsafe driving behaviors,

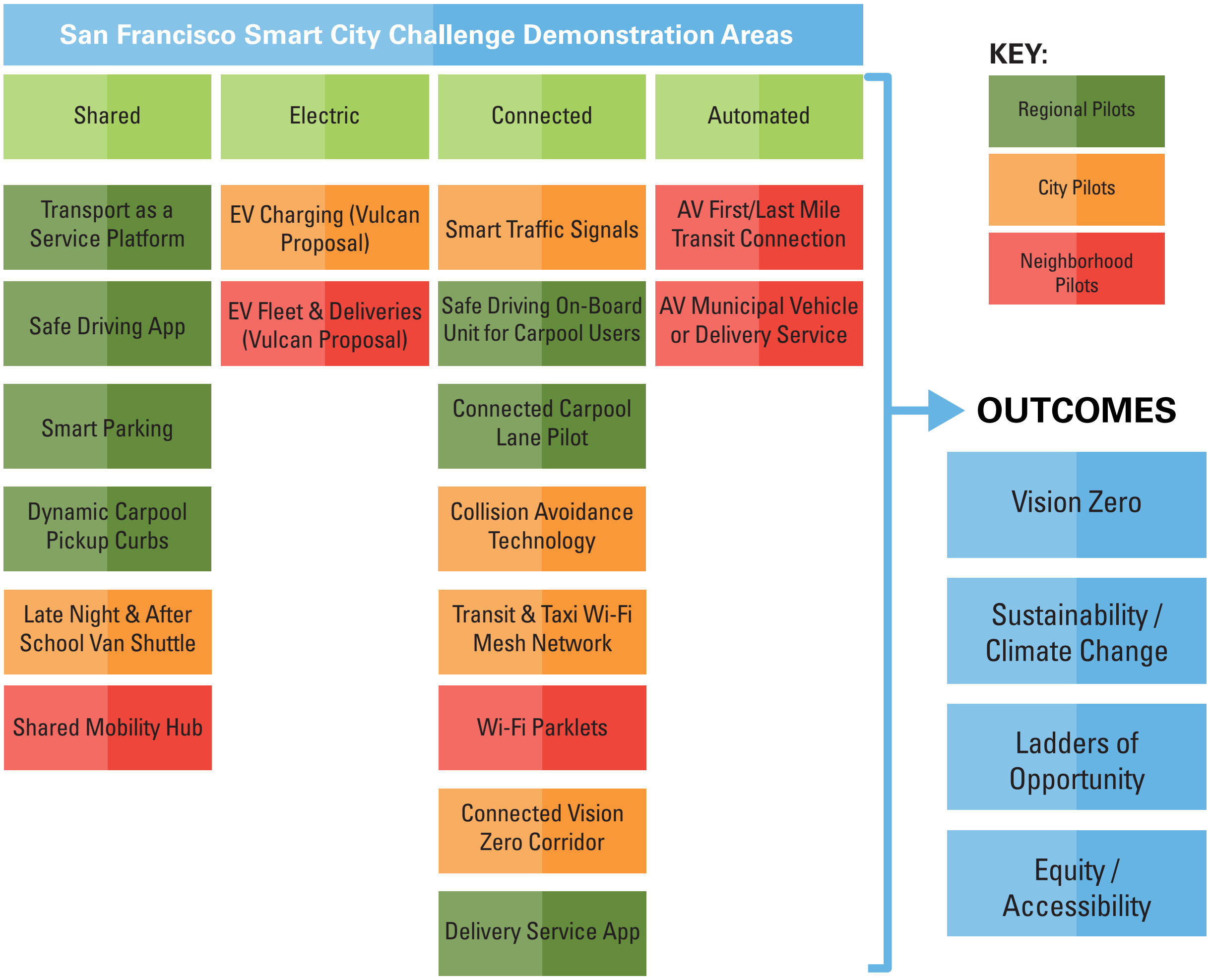


Figure 1.5 Smart City Challenge Demonstration Areas and Outcomes

and in turn to reduce collisions, injuries, and fatalities. Spatial and temporal data from the app can be overlapped with layers for collision history, infrastructure, etc.

- *Desired Outcome:* This platform helps users make informed decisions on travel and can nudge their travel behavior.
- *Timeline:* In Year 1, the team will identify industry partners (e.g., Zendrive, Mobileye) to develop the app feature, design the behavioral research study and participant recruitment. In Year 2, the app feature will be tested and revised iteratively, and data collection will continue. In Year 3, the data collected will be analyzed, evaluated, and reported, incorporating lessons learned into a safe driving media campaign or program.

3. **Delivery Service Feature** (Pilot R3)**:** The feature will be embedded into the TaaS platform and be used to improve the efficiency of freight delivery and logistics planning. The feature will provide feedback to the driver on optimal route choice and delivery times as well as incidents that may delay delivery. The objective is to improve efficiency (travel times), safety (collision avoidance), and reduce circling and idling. To deploy this app, we will identify industry partners (e.g., Shipbird) to develop the app feature and communicate evaluation results into a safe driving media campaign or program.
   - *Desired Outcome:* The freight service feature aims to improve efficiency, safety (reduce collisions), and reduce circling and idling.
   - *Timeline:* Deployment of this feature will be similar to the safe-driving feature.

4. **Smart Parking Feature** (Pilot R4)**:** The feature will be embedded into the TaaS platform used to intelligently manage the supply and demand of parking. SFPark is a similar app already developed and deployed in San Francisco. It has been highly successful in managing on-street and off-street parking in the city. The TaaS platform will build upon concepts from SFPark, including employing market-based pricing of parking and real-time information of parking supply and price through the app.
   - *Desired Outcome:* The smart parking feature hopes to reduce circling for parking, thus reducing congestion, greenhouse gas (GHG) emissions, and VMT.
   - *Timeline:* Deployment of this feature will be similar to the safe-driving feature.

1.2.2.2 Regional Connected Carpool Lanes

The regional connected carpool lanes demonstration proposal consists of three components: 1) connected carpool lane pilot, 2) safe driving on-board unit for users, and 3) dynamic carpool pick-up curbs as described below.

1. **Connected Carpool Lane Pilot:** Pilot R5 will combine innovative carpool matching services (e.g., ridesourcing apps such as Uber and Lyft, and carpool matching apps, such as Carma, Waze, and Scoop) with the re-striping of existing traffic lanes into high occupancy vehicle (HOV) lanes to quickly and inexpensively expand regional commuter carpooling and provide public transit access to these lanes. This will capitalize on the Bay Area's existing casual carpooling culture, which boasts up to 9,000 daily users. The pilot will partner with industry partners to identify and implement viable HOV lanes based on aggregated user data, crowdsourcing, travel demand modeling, and simulations. HOV lane infrastructure (e.g., vehicle occupancy detectors, connected vehicle occupancy sensors) will be installed and monitored. Initial corridors for HOV lanes include major arterials in San Francisco (e.g., Battery St, First St, Bryant St, 19th Ave, Van Ness Ave, Lombard St) and freeways in the City (e.g., I-80, I-280, US 101).

Figure 1.6 Mobility App Concept Interface

   - *Desired Outcome:* Increased regional commute carpooling will expand mobility and jobs access, shorten travel times, reduce VMT, increase public transit ridership, relieve crowding on regional transit, and generate revenue for drivers and carpooling matching service providers. Initial modeling by SFMTA demonstrates that the connected carpool lanes would reduce regional commute travel times by over 30,000 hours per day, reduce VMT by 350,000 miles per day, raise $30 million in revenue for carpool matching companies and $75 million for carpool drivers per year, and generate total value to the region of $200 million per year, including driver and company revenues accrued, GHGs precluded, and time saved.
   - *Timeline:* In Year 1, First, Battery, and Bryant Street will have: 1) HOV lanes installed, including lane striping, queue jumps to Bay Bridge onramps, designated carpool pickup zones at public plazas at Filbert, Sacramento, and Howard streets; 2) driver and passenger marketing by carpool matching partners and 3) roadside automated enforcement infrastructure at First and Harrison Streets. Year 2 will expand the HOV lanes to the Sterling onramp, US 101, and I-80. In Year 3, pilot adaptations will continue, as appropriate,

based on research feedback.

- *Lead:* The City will lead the implementation in partnership with California PATH at UC Berkeley. The City will provide HOV-lane infrastructure assistance. Potential partners for carpool matching services and marketing include Carma, Lyft, Scoop, Uber, etc. Potential partners for carpool lane enforcement technology include Kapsch, Transcore, Xerox, etc.

2. **Safe Driving On-Board Unit for Users** (Pilot R6)**:** This willbe for users of the regional carpool lane (private vehicles, peer-to-peer goods delivery) and will be deployed and analyzed similarly to that of the TaaS platform.

- *Desired Outcome:* On-board safe driving units will reduce unsafe driving behaviors, reducing collisions, injuries, and fatalities.
- *Timeline:* In Year 1, the city team will select the industry partner and develop the on-board unit. In Year 2, a cohort of drivers will be recruited, and the units will be installed in vehicles to be deployed and tested. In Year 3, the data collected from Year 2 will be analyzed, evaluated, and reported.
- *Lead:* The City will lead the implementation with the private sector.

3. **Dynamic Carpool Pick Up Curbs** (Pilot R7)**:** Carpool and ridesourcing services (e.g., Uber, Lyft) are growing in popularity. While pooled ridesourcing vehicles require little parking infrastructure, they need curb space for picking up and dropping off passengers. In the City, such curb space is limited, so drivers often use bus stops, loading zones, and parking spots reserved for persons with disabilities. This demonstration component will reserve curb space for picking up and dropping off passengers of carpooling and pooled ridesourcing services. Currently, several on-street parking spaces are reserved for passenger drop off for participants of casual carpooling near the Bay Bridge off-ramp in the Financial District. This pilot will be similar to this casual carpooling site, reserving spaces dependent on a common origin/destination in the City and popular times of day.

- *Desired Outcome:* Carpool pick up curbs will provide safe and convenient locations for carpoolers to pick up and drop off passengers, reducing travel times, idling, and conflicts

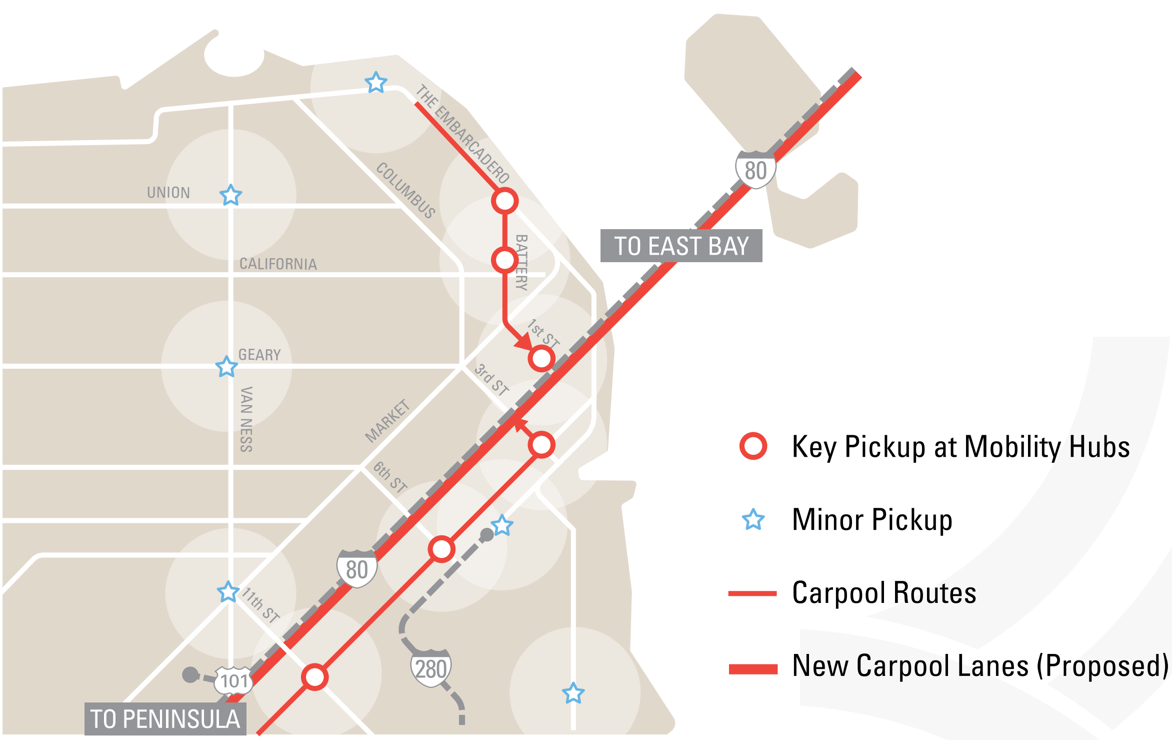


Figure 1.7 Connected Carpool Lane Pilot

with public transit, pedestrians, and cyclists.

- *Timeline:* In Year 1, key locations in San Francisco will be identified and installed for pickup/dropoff curb space in popular neighborhoods (e.g., Financial District, SoMa, Mission, Marina). In Years 2 and 3, more intersections and destinations will be selected and curb spaces will be expanded. Year 1 data and analysis will guide this expansion.
- *Lead:* The City will lead the implementation of this project, identifying curb space and industry partners.

1.2.3 City Network Demonstration Pilots

Three proposals include 1) Vision Zero corridors: smart traffic signals; 2) a municipal mesh network; and 3) a shared van shuttle service, all described below. The city-level demonstrations also advance our SECA vision by enabling a connected and optimized environment for encouraging multi-modal behavior (collective transportation) and shifts away from SOV reliance.

1.2.3.1 Vision Zero Corridors: Smart Traffic Signals (Pilot C1)

The smart traffic signals proposal will deploy and evaluate Multi-Modal Intelligent Traffic Signal Systems (MMITSS), including Dedicated Short Range Communication (DSRC) technology, across two distinct San Francisco contexts that are both within underserved communities.

1. **Tenderloin:** Within the Tenderloin neighborhood upgrade, approximately 40 signalized intersections have been identified as high-priority Vision Zero (VZ) pedestrian collision locations, which experience high public transit and emergency vehicle volumes and currently lack MMITSS technology. Pedestrian signal enhancements include traditional treatments such as Leading Pedestrian Intervals [LPIs], Accessible Pedestrian Signals [APS], exclusive pedestrian phases ("scrambles" and/or protected phasing), and the testing of Mobile Accessible Pedestrian Signals (MAPS). Public transit and emergency vehicle signal enhancements include Transit Signal Priority (TSP) and Emergency Vehicle Preemption (EVP) via the testing of DSRC technology, enabling a performance comparison against nearby intersections that currently use GPS technology for these functions where "urban canyon" and intersecting public transit route effects can be challenging to overcome. These signals will be interconnected into San Francisco's Transportation Management Center (TMC) via new wireless infrastructure.

2. **T-Third Corridor:** Along the T-Third light rail corridor, approximately 60 signalized intersections have been identified as high-priority VZ traffic collision locations, especially for vehicle collisions with trains. This route serves industrial zones that are transitioning into dense mixed-use communities via multiple major land use projects currently under construction. High-frequency trains run in semi-exclusive public transit lanes, while multiple electric and hybrid bus routes intersect the alignment. At present, TSP is provided for the LRVs via wayside detectors but not for the intersecting bus routes or emergency vehicles. Truck volumes for existing industrial uses are high, and construction vehicle traffic is growing as nearby development intensifies. Similar to the Tenderloin pilot, signal enhancements will include testing of DSRC technology for TSP and EPV functions. Also, construction trucks will be outfitted with DSRC units to evaluate the potential for Freight Signal Priority (FSP) at these intersections to reduce truck signal delay and reduce truck speeding through sensitive residential neighborhoods. For the LRVs, performance of TSP using DSRC can be tested against the current wayside detector technology. Signal enhancements will also include saturation deployment of next-generation Flashing Train Coming (FTC) roadside warning signs, as well as testing of Connected Vehicle dashboard and smartphone augmentation of FTCs to reduce vehicle/train collisions. Finally, pedestrian signal improvements will include LPIs, pedestrian recalls, and the testing of MAPS. These signals are already interconnected into the TMC via SFMTA's fiber network.

- *Desired Outcome:* Smart traffic signals aim to increase public transit speeds, reduce pedestrian collisions, decrease emergency vehicle response times, reduce truck signal delay, and lower truck speeds through sensitive neighborhoods.
- *Timeline:* In Year 1, the City team will deploy traffic signal enhancements and outfit buses and trucks with DSRC units. In Years 2 and 3, signal timing will be adjusted on an ongoing basis.
- *Lead:* SFMTA will lead this pilot implementation.

1.2.3.2 Municipal Mesh Network

The municipal mesh network demonstration proposal consists of three components: 1) collision avoidance technology; 2) Wi-Fi for public transit, taxis, and large municipal vehicles; and 3) connected Vision Zero corridors. These have been chosen because they are synergistic. By leveraging the City's municipal fleets, they can provide vulnerable users safety and equity in the streets with collision avoidance technology, digital equity through free Wi-Fi for patrons on-board, and at stops and real-time operational insights through the mesh networks.

1. **Collision Avoidance Technology on Large Fleet Vehicles:** Pilot C2 will install connected and collision avoidance technology, such as machine learning, computer vision, and robotics, in the context of autonomous perception and action systems for intelligent sensor systems. The technology will be installed in large fleet vehicles, such as MUNI buses, municipal construction and non-revenue vehicles to prevent collisions with other vehicles, people bicycling, and walking, reducing injuries and fatalities. Large vehicles have excessive blind spots and their interaction with vulnerable road users is often fatal. This pilot demonstration will test the efficacy of these connected systems to see how they reduce collisions and fatalities with people walking and cycling.

- *Desired Outcome:* Collision avoidance technology aims to reduce collisions and improve safety.
- *Timeline:* In Year 1, the City team will identify the most effective corridor and best available sensors and technology for the test fleet (engaging USDOT Partners Mobileye and NXP), install the technology on the vehicle fleet, begin data collection, and establish initial baseline performance. In Years 2 and 3, learned models will be deployed and technology performance will be evaluated.
- *Lead:* The City will lead the implementation.

2. **Wi-Fi for Public Transit, Taxis, and Large Municipal Vehicles** (Pilot C3)**:** Public transit vehicles, taxis, and other city fleet vehicles will be equipped with Wi-Fi access points ("hotspots"), enabling the creation of a vehicle mesh network that provides free City Wi-Fi both inside and outside vehicles, increasing digital equity among residents. Research will be performed focusing on both technical aspects of Wi-Fi availability based on vehicle density and on behavioral changes due to the service.

- *Desired Outcome:* Wi-Fi on vehicles will increase digital equity among residents by providing a critical communications linkage free of charge.
- *Timeline:* In Year 1, the City partners will select the technology partner and install the Wi-Fi access points (SFMTA public transit's are already installed) and supporting technology on city vehicle fleets. Year 2 will continue operations, which will be modified based on initial feedback. Outreach efforts will increase. In Year 3, technology operations will continue to improve and expand to more fleet vehicles.
- *Leads:* The City will lead the pilot implementation.

3. **Connected Vision Zero Corridors** (Pilot C4)**:** Connected Vision Zero corridors will have connected, signalized intersections with MMITSS priority. MMITSS will reduce idling and offer safety enhancements for pedestrians and cyclists. This will be deployed by installing DSRC roadside equipment and integrating with signal controllers along the corridor. DSRC radios will be installed on public transit vehicles serving that corridor as well.

- *Desired Outcome:* Our goal in connecting the corridor intersections is to garner travel time savings for public transit vehicles, increase satisfaction and safety for pedestrians and cyclists (to achieve Vision Zero objectives), and reduce energy use and GHG emissions.

- *Timeline:* In Year 1, the City will select the study corridor, install roadside, and in-vehicle equipment, and refine the software. Year 2 pilot testing will begin to verify functionality. In Year 3, implementation will continue and be adapted, as appropriate.
- *Lead:* The City will lead the implementation.

1.2.3.3 Shared Van Shuttle Service

The shared van shuttle service demonstration proposal consists of two components: 1) late night worker van shuttles and 2) after school van shuttles. They are described below.

1. **Late Night Van Shuttle** (Pilot C5)**:** A late night worker commute vanpool/shuttle service will be established between late night worker hotspots in San Francisco and dense neighborhoods in the outer parts of the City and then in the South and East Bay as demand dictates. A partnership between a late night workers group and vanpool/shuttle providers will be established (currently in development), and research on pickup/dropoff areas will be performed with data visualizations. A longitudinal impacts study (including a before-and-after user survey) will be performed to determine the equity and environmental impacts of the service, observing and documenting any reduction in cost commute, travel time savings, modal shift, and safety.

- *Desired Outcome:* A late night worker service will provide job access and safe, equitable transportation to workers who have shifts outside the typical workday.
- *Timeline:* In Year 1, the City team will partner with a worker's group and shuttle operator to determine the initial pickup/dropoff zones and begin the longitudinal survey with researchers. Year 2 will continue operations with modifications based on initial data analysis and user feedback. The longitudinal study with interim surveys and feedback, including focus groups, will continue. Year 3 will conclude by solidifying operating practices and potentially expanding service areas. The longitudinal survey will be completed in Year 3 including final data collection, analysis, and reporting.

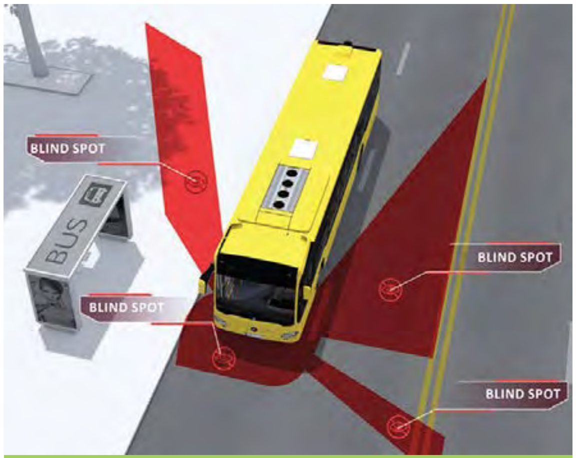


Figure 1.8 Blind Spots on Large Transit/Fleet Vehicles

- *Lead:* The City will lead the implementation.

2. **After School Van Shuttle:** An after school van shuttle will provide rides for elementary and middle schools in San Francisco to after school programs. To be differentiated from a typical school bus, this shuttle will employ dynamic technology to optimize routing and travel time. It will operate similarly to a vanpool service or as a flexible microtransit system. Several microtransit services are being tested by transportation startups in San Francisco and other U.S. cities. Similar to the late night van shuttle, a study of longitudinal impacts will be performed to determine the equity and environmental impacts of the service, observing and documenting any reduction in cost commute, travel time savings, modal shift, and safety.

- *Desired Outcome:* An after school shuttle service hopes to provide safe, efficient transportation to young students, decreasing the need for private vehicles for pickup.
- *Timeline:* In Year 1, the City will partner with a school and shuttle operator, determine initial pickup/dropoff zones, and begin the longitudinal survey. All minors who participate will first obtain signed permission from a guardian. Year 2 will continue operations with modifications based on initial data analysis and user feedback. The longitudinal study will continue with interim survey and feedback (i.e., focus groups). Year 3 will conclude by documenting operating practices and by

potentially expanding service areas. The longitudinal survey will be completed including data collection, analysis, and reporting.

- *Lead:* The City will lead the project implementation.

1.2.4 Neighborhood Network Demonstration Pilots through Community Challenge

The neighborhood-scale projects aim to deploy smaller pilot projects specific to neighborhood needs and context. In addition to what the winning neighborhood determines among the selection of choices, the City will study two demonstration proposals at the neighborhood scale. These include shared mobility hubs and automated vehicle (AV) pilots as presented below. The Neighborhood locations and the demonstration projects will be finalized using the Smart City Community Challenge described in Section 1.1. The neighborhood pilots further our SECA vision by deploying a shared vision in clustered hubs, as well as automated vehicles in a shared environment.

1.2.4.1 Shared Mobility Hubs

The shared mobility hub demonstration proposal consists of three components: 1) shared mobility hubs; 2) electric vehicle (EV) charging; and 3) Wi-Fi and parklets with community design.

- **Shared Mobility Hubs** (Pilot N1)**:** Up to 50 small shared mobility hubs in selected neighborhoods, linked to Wi-Fi hotspots, will contain carsharing, bikesharing, and scooter sharing vehicles, as well as carpool/taxi/ridesourcing service and delivery curb space zones. Research to understand optimal hub size, scale, and placement will emphasize locations near public transit to provide a first/last-mile solution. A longitudinal impacts study will be conducted to determine the travel behavior and environmental impacts on hub users.
- *Desired Outcome:* Provide a dense and reliable network of shared mobility services to reduce SOV trips, parking needs, and auto ownership, as well as reduce user travel costs through shared modes.

Figure 1.9 Late Night Shuttle

- *Timeline:* In Year 1, the City will develop industry partnerships with shared mobility operators who will provide vehicles, operations, and equipment. They will determine initial hub locations, and researchers will begin the longitudinal impact study. In Year 2, operations will continue and be modified based on initial data analysis and user feedback (e.g., surveys, focus groups). Depending on program success and feedback, the hubs will be expanded to other locations in the city. In Year 3, the longitudinal study will be completed, including analysis and reporting of the data collected.
- *Lead:* The City will lead the implementation with private sector partners.

- **EV Charging** (Pilot N1)**:** San Francisco has the top ranking in the nation for charger availability on a per capita basis. To date, over 490 publicly available charging stations have been deployed throughout San Francisco, each powered by 100 percent renewable hydroelectricity. Much more remains to be done as the widespread use of zero emission vehicles (ZEVs) relies on adequate infrastructure for vehicles to ensure consumer confidence. San Francisco aims to accelerate the transition to ZEVs and electrified shared transportation modes through careful planning and the development of new charging and fueling infrastructure that addresses consumer needs, provides equitable access, facilitates technological innovation, and contributes to the reliable management of the power grid. Our detailed EV plan is provided in the companion Vulcan proposal.

- **Wi-Fi and Parklets with Community Design** (Pilot N2)**:** Already located throughout San Francisco, parklets are public spaces built on top of on-street parking spaces, typically providing seating and other pedestrian amenities. This pilot will expand parklets throughout the City, obtaining community input on design elements, installing Wi-Fi kiosk access points (in conjunction with USDOT partner Sidewalk Labs), and documenting impacts on its users. The research seeks to understand potential impacts on modal choice (e.g., increased walking and bicycling), economic impact to parklet users and neighboring merchants, and digital equity in neighborhoods.
- *Desired Outcome:* Wi-Fi-enabled parklets aim to increase pedestrian and cyclist amenities, and increase digital equity in their proximity.
- *Timeline:* In Year 1, city planners will reach out to the community to site parklets, and the City will partner with technology providers to install Wi-Fi hotspots. Researchers will also begin longitudinal impacts study. In Year 2, operations will continue and be modified based on initial data analysis and user feedback (i.e., surveys, focus groups). Depending on program success and feedback, Wi-Fi parklets will be expanded to other locations in the City. In Year 3, the longitudinal study will be completed, with analysis and reporting of the data collected.
- *Lead:* The City will lead the implementation.

1.2.4.2 Automated Vehicle (AV) Pilot

The AV demonstration proposal has two components: 1) delivery or municipal service and 2) first-and last-mile public transit connected service. Both elements will work closely with citizens to develop and test. They are described below.

- **Delivery or Municipal Service** (Pilot N3)**:** Vehicles will be equipped with AV technology. This technology will include machine learning for smart city automation and intelligent sensors, as well as false positive detection. An AV pilot will acquire and test AVs in a low-speed urban environment.
- *Desired Outcome:* AVs for delivery or municipal service aim to reduce travel cost and increase safety.

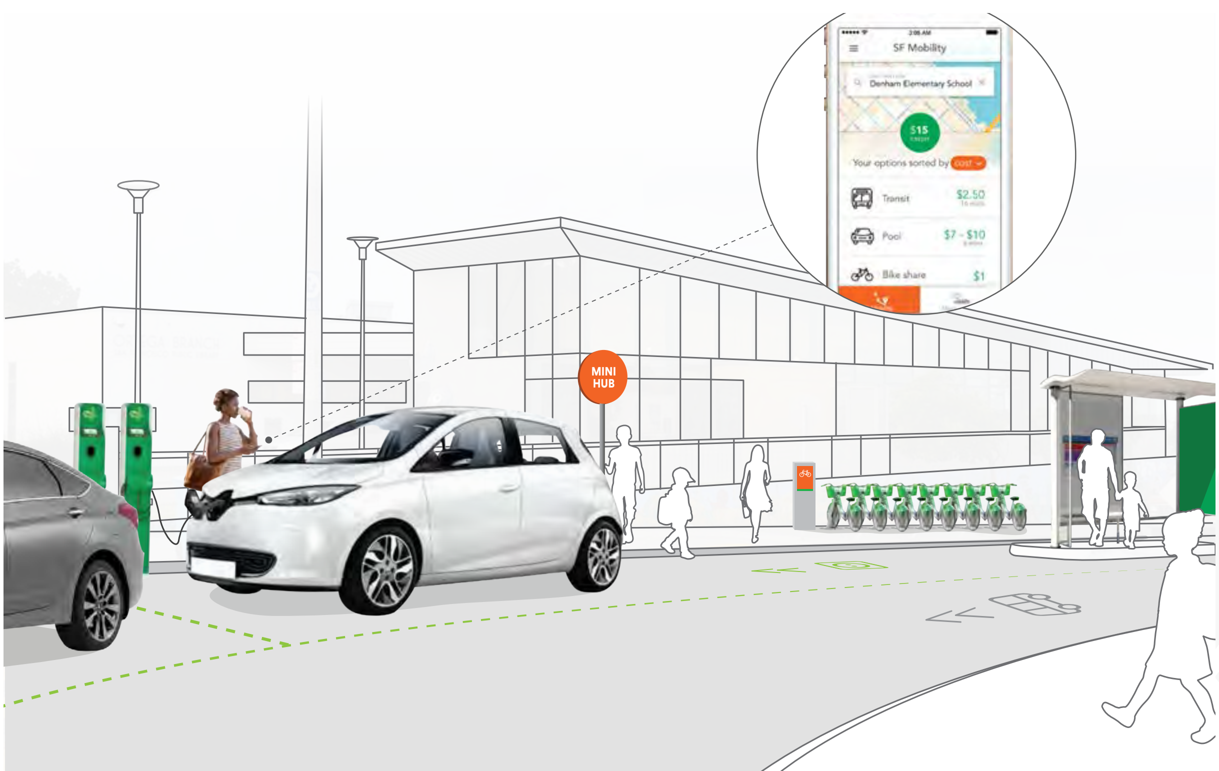


Figure 1.10 Shared Mobility Hub

- *Timeline:* In Year 1, the City will develop the route and detailed design, choose a vehicle supplier (three have been identified at present), design the data acquisition system, and define safety assurance requirements. In Year 2, the fleet will be installed for testing, create a route, install a data acquisition system, begin pilot testing to identify and debug problems, and develop operating procedures. Finally, Year 3 will complete the demonstration.
- *Leads:* The City will lead the implementation with private sector partners (e.g., Zoox, GoogleX).

- **First-and-Last Mile Public Transit Connected Service** (Pilot N4)**:** Similar to the delivery/municipal service above, a vehicle fleet (three companies have thus far expressed interest) will be equipped with AV technology and tested in the urban environment to serve as a first- and last-mile connection to regional public transit. Locations may include: Park Merced and Hunters Point Shipyard, Townsend St from 4th to 8th; Twin Peaks Blvd eastern segment; Yerba Buena Island to Treasure Island; Fisherman's Wharf to Fort Mason; and Fort Mason to Golden Gate Bridge.
- *Desired Outcome:* A first- and last-mile connected service aims to reduce travel costs, encourage public transit use, and reduce parking needs at transit stations.
- *Timeline:* Deployment will be similar to that of the delivery/municipal service (please see timeline above).
- *Leads:* The City will lead the implementation with private sector partners (e.g., Zoox, GoogleX).

In the next section, we discuss the connected vehicle and automated vehicles that will be deployed in these demonstrations to a more detailed extent, and the extensive experience of the City team.

1.2.5 Connected Vehicle and Automated Vehicle Deployment and Testing

With PATH's assistance, our team is uniquely equipped to deploy and study our groundbreaking Connected Vehicle (CV) and Automated Vehicle

Figure 1.11 Parklet

(AV) pilot projects. Indeed, California PATH was the first research program on Intelligent Transportation Systems (ITS) in the U.S. when it was founded 30 years ago. PATH has both developed and evaluated a wide range of CV/AV systems. Assessing the performance and safety of these systems requires in-depth understanding of sensor and communication technologies, software engineering, vehicle dynamics and control, and ergonomics and human factors, in addition to the more typical transportation systems engineering and planning skills mix. PATH has this expertise.

PATH's experience with CV and AV systems will be particularly valuable for several of the applications to be implemented in the San Francisco Smart City Challenge project:

- Collision warning for public transit buses, combining evaluation of the Mobileye Shield+ system and enhancements in pedestrian recognition based on new deep learning methods being developed by the Berkeley Deep Drive (BDD) consortium;
- Intelligent traffic signal control based on connected vehicle technology and applications that PATH has developed on behalf of the USDOT under the Multi-Modal Integrated Traffic Signal Systems (MMITSS) program;
- Automated low-speed shuttle vehicles for first-mile/last-mile public transit access, which PATH will evaluate based on experience acquired with this class of vehicles through participation in the CityMobil2 project in Europe; and

- Automated on-demand service vehicles, which PATH will evaluate based on its extensive prior experience in developing highly automated vehicle systems.

PATH researchers will collaborate with the City to address the traffic safety concerns of pedestrians and bicyclists. PATH will adopt the USDOT approved Mobileye Shield+TM systems to install on the city's bus fleet, which empowers drivers to avoid and mitigate imminent collisions, protecting the most vulnerable and difficult to observe road users: bicyclists and pedestrians. We will apply the advanced methodologies and research outcomes from BDD in autonomous perception, which will further improve the capability, reliability, and robustness of pedestrian and bicyclist recognition, as well as their interactions with other road users. The project will employ a route through the Tenderloin neighborhood that would significantly benefit from improved pedestrian and bicycle safety and is coincident to the route identified for the MMITSS effort and discussed in detail below.

PATH was one of the partners in developing the MMITSS system and testing and demonstrating it in the California Connected Vehicle Test Bed in Palo Alto. Through this work, the PATH staff understand the DSRC communications and traffic signal control elements that need to be combined to enable CV technology to enhance urban traffic in corridors. Based on the MMITSS experience, PATH can implement freight signal priority in coordination with existing public transit and emergency vehicle priority schemes and can also implement pedestrian mobility applications to allow pedestrians with mobility impairments to request extra crossing time in the pedestrian cycle through a mobile phone app. These vehicles and pedestrians will be communicating with the intersection signal controllers using DSRC. Integration of the pedestrian application with public transit and emergency signal priority will be implemented at approximately 40 intersections in the Tenderloin, a disadvantaged community. The Third Street light rail corridor has substantial truck traffic associated with local construction projects, so this will be used for freight signal priority at approximately 60 intersections.

Figure 1.12 Shared Electric Connected Automated Vehicle

Although low-speed urban shuttle vehicles are likely to be one of the earliest implementations of highly automated vehicles to become practical, there has been virtually no experience to date with public use of this class of vehicles in the U.S. The pioneering efforts on testing these vehicles in public operation have been made by the CityMobil2 project in Europe. Dr. Steven Shladover of PATH is a member of the Technical Advisory Board of CityMobil2 and can provide a unique understanding of the experience gained through that large project and how it can be applied in San Francisco. The initial route near the Caltrain terminal provides for partial segregation of the AVs from other road users. The vehicle route will be clearly delineated and separated using a temporary low-profile curb to discourage other road users from straying into the path of the vehicle. On the second route, providing access between the Twin Peaks parking area and vista point, the automated shuttle vehicles will operate on a route segregated from other vehicle traffic to minimize risks.

The team has experience not only with AVs and CVs but all the demonstration concepts described herein. The most advanced AV applications under current development are the automated on-demand service vehicles, which are proposed to operate within a limited geo-fenced neighborhood to be selected. For these vehicles, PATH will independently evaluate the data collected by the AVs, focusing on the near-miss and crash situations and the situations in which the on-board supervisor is needed to intervene, so that these potentially safety-critical limitations can be understood well enough to determine if and when the second-generation vehicles could be authorized to operate without supervision. In this case, the first stage of testing and public service will always include an in-vehicle supervisor for safety oversight, and operation of the second-generation vehicles without human operators will not be authorized until after the first-generation vehicles have demonstrated their ability to safely manage all the hazards that they encounter on the streets of the designated neighborhoods in San Francisco. Next, we discuss how each demonstration concept fulfills the USDOT vision elements.

1.2.6 Demonstration Concept Linkage to USDOT Vision Elements

In Table 1.2, we provide an overview of how each of the 16 pilot projects map to the 12 USDOT vision elements.

1.2.7 Integrated Research, Deployment and Development Approach

In this section, we outline our vision for our research and development approach to provide critical feedback and understanding of the efficacy of the 16 pilot projects described above. Our research methodology is designed to systematically inform what works and what does not, the benefits and impacts of these pilots, and it provides the documentation of this know how for technology transfer. We have enlisted a team of multidisciplinary scientists to lead this evaluation. The research component of our Smart City Challenge grant application is essential to understanding and documenting how our demonstration pilot projects collectively: 1) impact travel behavior, accessibility/equity, and safety; 2) reduce VMT, GHGs, and vehicle ownership and use; and 3) increase modal shift away from SOVs. In this section, we discuss the overarching methodological approaches that underpin our vision and how they apply to the pilot projects. There are five key methodological areas included in this plan: 1) Behavioral and Equity Impacts, 2) Connected Vehicle/ Automated Vehicle Analysis, 3) Safety Impacts Analysis, 4) the Data Analytics and

Figure 1.13 Connected Signal with AV and CV (1)

Mobility Data Commons (MDC) Architecture and 5) Data Privacy Analysis. We conclude this overview with Table 1.3, which outlines our key study hypotheses with respect to the 16 pilot projects, associated data metrics, and the data sources needed. These data will provide supply- and demand-side feedback to inform pilot operations and travelers, as well as to assess impacts. The massive understanding amassed through this research plan will be critical to providing iterative feedback throughout the pilots to optimize benefits and documenting lessons learned.

1.2.7.1 Behavioral and Equity Impacts

Behavioral impacts will be captured through two key approaches: 1) a panel survey to assess the Transportation as a Service (TaaS platform) and 2) a before-and-after pilot project assessment to evaluate micro-level projects deployed at the city and neighborhood scale. The value of this research is threefold. First, it provides invaluable feedback on user responses to the pilot projects and the operations. Second, it documents the impacts on society, the environment and our transportation system. Third, this provides unprecedented market insights to how people behave and respond to incentives and other interventions. Each is described below.

Panel Survey Approach to Understand Travel Behavior: TaaS Platform Evaluation

In social science survey research, using well-established panels is the gold standard for collecting high quality data. Companies maintain a pool of carefully selected and retained people available for hire to conduct surveys. The panels are maintained over time so researchers can ask follow-up questions. We propose to develop a 500-person experimental panel to cover the regional TaaS Platform, as well as a 500-person control group (i.e., individuals who do not use the TaaS platform but have access to it through the two-year evaluation period). Key steps in this methodological approach include: 1) institutional review board (IRB) approval. The IRB protects the safety and privacy of human subjects; 2) Participant recruitment; 3) Deployment of the demonstration concept across the population; 4) Periodic surveys of panel participants and feedback; and 5) final analysis. The timeline for this project is six months of preparation time at the beginning and two years of data collection with user surveys, activity data, and focus groups during the 24-month assessment. This includes surveys every two months to gauge feedback to pricing and nudging experiments, which will be conducted between

Figure 1.14 Connected Signal with AV and CV (2)

the before-and-after surveys at the start and end of the data collection period. The final six months of the project are dedicated to final analysis. We will provide feedback to the project implementation team throughout to inform incentives/nudging to optimize the social and environmental benefits of the TaaS platform applications. The Transportation

PILOT PROJECTS	Urban Automation	Connected Vehicles	Intelligent, Sensor-Based Infrastructure	Urban Analytics	User-focused Mobility Services and Choices	Urban Delivery and Logistics	Strategic Business Models and Partnering	Smart Grid, Roadway Electrification, and EVs	Connected, Involved Residents	Architecture and Standards	Low-Cost, Efficient, Secure, and Resilient Information & Communications Technology	Smart land Use
Integrated multi-modal mobility app platform					X	X	X		X		X	
Safe driving feature in the multi-modal app platform				X			X		X			
Freight delivery service and smart parking features in the multi-modal app platform			X			X	X		X			
Smart parking features in the multi-modal app platform			X				X		X			
Regional connected carpool (HOV) lanes			X	X			X					X

Table 1.2 Smart City Proposals and Vision Elements

PILOT PROJECTS	Urban Automation	Connected Vehicles	Intelligent, Sensor-Based Infrastructure	Urban Analytics	User-focused Mobility Services and Choices	Urban Delivery and Logistics	Strategic Business Models and Partnering	Smart Grid, Roadway Electrification, and EVs	Connected, Involved Residents	Architecture and Standards	Low-Cost, Efficient, Secure, and Resilient Information & Communications Technology	Smart land Use
Safe driving on-board unit for carpool users				X			X		X			
Dynamic carpool pick up curbs												X
Smart traffic signals (Vision Zero)			X				X				X	
A connected vehicle Wi-Fi for public transit/taxis/ municipal vehicles (mesh network)		X					X		X		X	X
Collision avoidance technology on large fleet vehicles (mesh network)		X		X			X					
Connected vehicle vision zero corridors (mesh network)		X	X	X			X	X			X	
Late-night commuter shuttle and after-school van shuttle					X		X		X			
Shared mobility hubs					X	X	X					X
Wi-Fi enabled parklets and community design							X		X			X
Automated Vehicles (AVs) serving as a delivery or municipal service	X					X	X					
AVs serving as a first-/last-mile transit connection	X						X					

Table 1.2 (continued) Smart City Proposals and Vision Elements

Sustainability Research Center (TSRC) at UC Berkeley will lead this effort. Key staff include Professors Susan Shaheen and Joan Walker and Dr. Elliot Martin.

Behavioral and Equity Impact Analysis of Pilot Deployment Projects

TSRC will also lead the evaluation of numerous smart city pilot project efforts using a frame of behavioral economics. We will assess the pilot projects on a number of dimensions including impacts on travel, the environment (e.g., emissions), and equity/accessibility. We will also collect socio-demographic and attitudinal data as appropriate. For each, researchers will survey a control group (n=200) and experimental group of participants (n=200) at the start (before any intervention), at the end of two years, and approximately three times in between. There are five key steps to each pilot evaluation. At the start of the project, we will develop the survey instruments (first six months). After the surveys are conducted (months 7-30), the last six months of the study will entail final data analysis i.e., surveys, activity data as appropriate, and focus groups. We will provide feedback to the project implementation team at the City throughout the pilot assessment periods to guide and optimize deployments. Surveys and behavioral tracking will provide the feedback into the pilot programs to enable adjustments throughout, as appropriate. There are five key steps including: 1) IRB approval; 2) Participant recruitment; 3) Deployment of the demonstration concept across the population; 4) Periodic surveys of participants and feedback (across the five survey total); and 5) Final analysis. TSRC is the lead on the following use case analyses: 1) regional connected carpool lanes, 2) Wi-Fi for transit/taxi/large municipal fleets, 3) shared van services (late night and school vans), 4) shared mobility hubs, 5) WiFi parklet, and 6) the automated vehicle pilot (freight delivery, municipal, and first-mile and last mile). Key staff include Professor Susan Shaheen, Dr. Elliot Martin, and Rachel Finson of TSRC.

1.2.7.2 Connected and Automated Vehicle Analysis

This research area is critical to the pilot effort and includes several projects: 1) low-speed vehicle

Figure 1.15 Smart Cities Methodologies

applications and automated first- and last-mile mobility service; 2) evaluation of advanced collision avoidance systems and development of machine learning perception in urban environments for pedestrian and bicyclist safety; 3) provision of Wi-Fi services on the public transit fleet to encourage modal shifts and to close the gap in the digital and income divide; 4) coordinated signals and DSRC: implementation of the Multi-Modal Intelligent Traffic Signal System; and 5) connected carpool lanes.

Automated Low-Speed Vehicle Shuttle and Automated First-Mile and Last-Mile Mobility Service

The automated vehicle (AV) applications are the most technologically challenging elements in the Smart City Challenge grant, with the least mature technology and the most important need to ensure public safety throughout the development, testing, and evaluation process. The PATH UC Berkeley team's evaluation approach for these systems will begin by developing a solid understanding of the capabilities and maturity of the technology, its vulnerabilities to the complexities of the urban environment, and the enhancements that will be needed to enable it to advance from the current state of development, which requires continuous supervision by an on-board human operator/safety driver to the state in which it can operate in some urban neighborhood(s) without continuous human supervision. The later stages of the evaluation can then also address user perceptions of AV applications, their desires and concerns, and the perceptions of the other road users who are sharing the street space with the AVs. This approach applies to the low-speed urban application and to the automated on-demand transportation service in the pilot deployment.

The vehicles will be instrumented with an independent data acquisition system to record detailed real-time data about the external operating environment of the vehicles (movements of other vehicles, pedestrians, bicyclists and animals and objects in the path of the vehicles) and the movements of the vehicles within that environment, as well as all interventions that the supervisor had to take. The data acquisition system is expected to be more comprehensive for the low-speed application than for the automated on-demand service vehicles because the former vehicles have less sophisticated built-in sensory capabilities. The data acquisition is expected to include video cameras to record the complete driving scene, as well as laser scanners and radars to track all stationary and moving objects in the vehicle path. These detailed data will be recorded in onboard computers with sufficient storage capacity to capture a full day of operational data that can be downloaded from the vehicles nightly. Software will be developed to record and label all the data for subsequent off-line analysis and assessment of the hazards that were handled successfully and unsuccessfully by the vehicle system to identify the causes of all unplanned stops by the vehicles, all collisions and near-collisions with other objects, and all human supervisor interventions. These data will be analyzed to determine which situations are troublesome for the vehicle automation systems and to develop recommendations for how their developers can enhance their capabilities.

The operational records of the vehicles will be tracked from month-to-month of the testing period to identify trends in the frequency and severity of incidents involving the vehicles, particularly as their developers make changes to their systems. Evaluation criteria (based on frequency and severity of crashes, near misses, and operator interventions) will be defined to determine when the vehicles are performing at a level that would justify relaxation of the requirement for continuous supervision by the onboard operator, and after careful review with the relevant local stakeholders and regulatory authorities, a recommendation will be made for when the on-board supervisor role can be eliminated.

The timeline for this project includes 6-12 months of vehicle instrumentation development and installation as well as software development coincident with the infrastructure improvements necessary to accommodate shuttle/mobility service operation. Data collection will occur over a 24-month period, and operational records of the vehicles will be tracked from month to month during the testing period. User surveys will be completed at the beginning and end of the effort, and in the case that the requirement for continuous supervision is relaxed, a new surveying instrument will be developed. The project team will provide feedback to the project implementation team throughout the duration of the project. California PATH at UC Berkeley will lead this effort. Key staff include Dr. Steven Shladover, Dr. Xiao-Yun Lu, and technical support staff.

Evaluation of Advanced Collision Avoidance Systems and Development of Machine Learning Perception in Urban Environments for Pedestrian and Bicyclist Safety

In this project, PATH researchers will collaborate with San Francisco to address the traffic safety concerns of pedestrians and bicyclists. PATH will adopt the USDOT approved Mobileye Shield+TM systems to install on the city's bus fleet, which empowers drivers to avoid and mitigate imminent collisions, protecting the most vulnerable and difficult to observe road users: bicyclists and pedestrians. Furthermore, researchers plan to leverage the research activities from the Berkeley Deep Drive (BDD) Center at UC Berkeley. We will apply the advanced methodologies and research outcomes from BDD in autonomous perception to further improve the capability, reliability, and robustness of pedestrian and bicyclist recognition as well as their interactions with other road users. We expect the following outcomes: 1) Field deployment evaluation of Mobileye Shield+ units on up to 200 public transit vehicles to observe how the deployed systems perform; 2) Aggregate operational data from telematics services of all Mobileye Shield+ units to enable the safety assessment of SF city streets, including actual incidents and near-miss scenarios encountered by equipped buses; 3) Collection of field driving video data for algorithm training to advance developments and validation of advanced deep learning technologies; and 4) Field demonstration of deep learning research prototypes on 15 public transit vehicles in the most challenging urban environment. In Year 1, we will perform experimental design and plan for the deployment of Mobileye units onto the public transit fleet and also to begin data collection. In Year 2, data collection will continue with training and validation of deep learning algorithms. In Year 3, evaluation of Mobileye deployment data and the frequency of incidents along deployment routes will allow assessment of safety improvement, and also the implementation of deep learning technologies will be demonstrated in field testing. The project team will provide feedback to the project implementation team throughout the duration of the project. PATH at UC Berkeley will lead this effort. Key staff include Dr. Ching-Yao Chan and technical support staff.

Provision of Wi-Fi Services on the Public Transit Fleet to Encourage Modal Shifts and to Close the Gap in the Digital and Income Divide

In this project, PATH researchers will collaborate with San Francisco to provide Wi-Fi services on the city fleet of 200+ SF public transit vehicles, with the goal to offer enhanced mobility to visitors and residents, as well as to provide equity in assessing the digital space. We will adopt the vehicle to infrastructure (V2X) solutions offered by one of a select number of connectivity solution providers from Silicon Valley, by using V2X networks and high-bandwidth backhaul communication links. The Wi-Fi services will be made available at no cost to passengers on public transit vehicles. We expect the following outcomes: 1) The availability of Wi-Fi services will promote the ridership on public transit systems in San Francisco and offer an alternative modal choice for tourists and residents alike; 2) The services will allow disadvantaged groups to use the free Wi-Fi services when they take public transit as part of their daily routines, which can help to advance digital equity, societal creativity and productivity; 3) Collection of deployment data through this service will enable the observation of transportation modal shift through a before-and-after study to assess the effectiveness of a transit ridership increase; and 4) Reduction in private vehicle use and reliance due to a shift to public transit modes, particularly along the transit bus routes and the associated neighborhoods. These changes will be evaluated by tracking the public transit vehicle trajectories and the travel patterns in adjacent districts. In Year 1, researchers will perform experimental design and plan for the deployment of the proposed solution to the transit fleet. In Year 2, data collection will be carried out to assess the ridership increase and the effects on modal shift. In Year 3, analysis of operational data and city traffic data will allow evaluation of the travel time and operational efficiency of the public transit fleet on selective routes and its impact on city-wide traffic. In addition, user surveys will be conducted to solicit feedback from riders about their experience in using the services for future enhancements. The project team will provide feedback to the project implementation team throughout the duration of the project. California PATH at UC Berkeley will lead this effort. Key staff includes Professor Trevor Darrel, Professor Pieter Abbeel, Dr. Ching-Yao Chan and technical support staff.

Coordinated Signals and DSRC: Implementation of the Multi-Modal Traffic Signal System (MMITSS)

This proposed study, led by PATH, will evaluate and provide design guidance for the implementation of the Multi Modal Intelligent Traffic Signal System (MMITSS) at signalized intersections as part of the connected Vision Zero corridors pilot. The MMITSS system will be implemented along an arterial corridor with frequent public transit service, significant pedestrian crossing, and occasional construction trucks along with heavy traffic volume (e.g., Third Street/Bayshore, Embarcadero/ King Street) to provide priority to public transit, heavy construction vehicles, and applications for pedestrian and bicycles including travelers with mobility limitations. As MMITSS has the ability to accommodate multiple priority levels for various traveler types while minimizing delays to traffic flow, the PATH research team will work closely with SFMTA to design specific MMITSS strategies through a systems engineering process employed in the design phase. As part of the design, data type and collection methods for before-and-after evaluation will be specified. The assessment of the system effectiveness will be conducted using field data, such as travel times and delays per vehicle class, and pedestrian delays and conflicts. Data on travel times will be collected from the public transit onboard devices and data providers. Signal status data obtained in real time from the controller conflict monitor will provide data on the frequency and the amount of additional green time for pedestrians and various vehicle types.

The timeline for this project includes six months of vehicle and infrastructure instrumentation in order to capture necessary data before and after the implementation of the DSRC/MMITSS applications. Data collection will occur over a 24 to 30-month period, and operational records of the vehicles will be tracked continuously during the testing period. System user surveys will be used at the beginning and end of the effort, and the project team will provide feedback to the project implementation team throughout the duration of the project. PATH at UC Berkeley will lead this effort. Key staff include Professor Alex Skabardonis, Wei-Bin Zhang, Dr. Kun Zhou, and technical support staff.

Connected Carpool Lanes

This proposed research will provide a technical evaluation of the implementation of a network of Connected Carpool Lanes along key arterials and freeways within San Francisco to evaluate their effectiveness. Carpool lanes will be created through restriping of existing travel lanes, and their usage will be maximized based on innovative carpooling services (e.g., Lyft Carpool, Carma, Scoop) and enforcement approaches. The effectiveness of the proposed carpool lanes will be evaluated based on several metrics for the travelers (travel time, delay, travel time reliability); system (i.e., VMT; vehicle hours traveled, person miles traveled) and environment (i.e., impacts on fuel use and emissions). Travel time data on the selected corridors will be obtained from commercial data providers. HOV specific travel times will be obtained from the casual carpool travel providers, such as Lyft, Carma, etc. VMT estimates will require information on the quantity of travel that would be obtained by selective detection at key points in the corridor.

The timeline for this project includes six months to develop the data stream from various data aggregators, including casual carpooling application providers. Data collection will occur over a 24 to 30-month period, and operational aspects will be tracked continuously during the testing period. System user surveys will be administered at the beginning and end of the effort, and system parameters will be measured before and during the study. The project team will provide feedback to the project implementation team throughout the duration of the project. PATH will lead this effort. Key staff include Professor Alex Skabardonis and technical support staff.

1.2.7.3 Safety Impacts Analysis

The safety impact analysis research plan consists of two key areas: 1) the safe driving platform app to detect and reduce unsafe driving patterns and subsequent collision/injuries/fatalities and 2) safety analyses for surveillance/monitoring.

Safe Driving Platform App to Detect and Reduce Unsafe Driving Patterns and Subsequent Collision/Injuries/Fatalities

A safe driving platform app will be used to detect unsafe driving patterns in a sample group of San Francisco drivers. The app will provide driver feedback, potentially reducing unsafe driving behavior, such as speeding and hard braking. The driver behaviors targeted account for a substantial portion of injury collisions in San Francisco. In addition to direct driver feedback, the project will compile input for safe-driving media campaigns and driver education programs in the city. Data from the app can be overlapped with collision history, infrastructure and other information, and it can be analyzed along various dimensions, including spatial and temporal variables. Additional data collected via infrastructure sensors and other means through the Smart City Challenge can also be included in the analyses. SFMTA will conduct deployment of the app, with the following key steps: 1) Identify apps through discussions with companies currently providing such technology (Year 1); 2) In consultation with SafeTREC of UC

Berkeley, develop an appropriate study design (e.g., baseline driving behavior, implement feedback phase, follow-up phase for driver behavior and, to the extent possible, long-term traffic incidents (Year 1); and 3) Recruit drivers for the study and collect data following the study protocol (Years 2 and 3). The role of SafeTREC will include the following key steps: 1) Advising on research design, app selection, data collection (Year 1); Analyzing results and preparing reports (Years 2 and 3); Identifying ways to incorporate study insights into the safe driving media campaigns (Years 2 and 3); and 4) If the demonstration is successful, develop recommendations for extension/expansion of the program (Year 3). Potential private sector partners include a company or companies that are developing apps for safe driving, such as Zendrive and Mobileye, which would later be contracted with San Francisco. Key staff include Professor David Ragland and Research Associate Offer Grembek, both Co-Directors at SafeTREC.

Safety Analyses for Surveillance/Monitoring

To help guide and then evaluate the impact of the Smart City Challenge program, SafeTREC will conduct systematic analyses of data relying on existing or emerging data systems, such as the robust Transbase Data Base (www.TransBASEsf.org), which San Francisco is developing. In these analyses, we will employ injury/fatality, exposure, and infrastructure data. Because use of collision data as the only barometer of traffic safety is a reactive approach, we also propose to identify data that can be used to evaluate surrogate safety measures—those based on non-crash events that are associated with increased crash frequency/severity—driver yielding, deceleration rates, stopping distances, etc. This will include sensors, video data, etc., which already are in place or that may be implemented as part of the Smart City Challenge grant. The four key steps are: 1) Identify data sources (e.g., Transbase, emergency medical data, mode-specific volume data, video, and sensor data (first six months of Year 1); 2) Conduct analyses to guide development and implementation of the Smart City Challenge projects (Years 1-2); 3) Conduct analyses to evaluate changes in mode-specific injuries or volumes over the three-year grant period at specific locations and at the neighborhood and regional levels (Years 2-3); and 4) Prepare reports and presentations describing results of the analyses (Years 1-3). SafeTREC has conducted numerous analyses of the type proposed over the past 15 years. Key staff include: Professor David Ragland and Research Associate Offer Grembek.

1.2.7.4 Data Analytics and Mobility Data Commons (MDC) Architecture

As part of the proposed project, UC Berkeley researchers will develop a modular architecture to support a data commons that will allow management, discovery, sharing, use/re-use, and general consumption of mobility data from a range of sources (public, research, and private); frequencies (real-time streaming, historic); sources (sensors, operational databases, third-party APIs); and structures (structured, semi-structured, and unstructured) to support research and deployment of key vision elements. The architecture will enable both real-time data flow and operations and a multi-tenant repository for post-hoc data access and use. MDC will support experimental and deployment protocols, document the findings, and ensure that the results are transparent and reproducible. Data will adhere to standards ensuring interoperability within the MDC, city infrastructure, as well as with external systems and USDOT programs. There are three key components to this research: 1) data analytics and machine learning enabled decision making, 2) data warehouse and real-time processing; and 3) dashboards and visualization.

Data Analytics and Machine Learning Enabled Decision Making

The UC Berkeley research team will lead members of the Smart City Challenge partnership to collaboratively develop a dashboard displaying the vital parameters of the city related to this project at the regional, city, and neighborhood scales. Four key steps are envisioned to support this effort. 1) Develop new data collection paradigms employing multiple industry sources (integrating near real-time locational data collected by the telecom industry (e.g., AT&T and Verizon) and IT services (Waze, Twitter, Sidewalk labs) (months 1-12). 2) Develop next generation of data-intensive (sample size of n=1 to 5M travelers) activity-based demand models. These models will include trip purpose, mode, destination, and departure times, which will inform a mobility micro-simulation for scenario evaluation, building off of the pilot deployment data of the city and Bay Area region and behavioral insights from the longitudinal panel research mentioned earlier (months 3-18). 3) Develop traffic flow models (micro-, meso-, and macro-) with flow harmonization and congestion reduction capabilities that leverage the automated and connected vehicle pilots (months 12-24). Optimize schemes capable of performing a collection of simulations and behavioral intervention strategies (e.g., incentives/nudging) and robust model predictive control (months 18-36). Key staff include UC Berkeley Professors Alexandre Bayen and Alexei Pozdnukhov and several postdoctoral scholars and PhD students.

Data Warehouse and Real-Time Processing

A centerpiece of this grant is the data commons. Commons data will be shared and preserved in data warehouse repositories and shared with different audiences throughout the project and well beyond the three-year effort. The repositories will link data, data models, and workflows from both the city and the private and research sectors (months 1-12). Data abstraction layers will be developed to handle the diversity of distributed data sources, satisfying the low latency and multi-tenancy requirements that ensure data harmonization and interoperability, both in batch and streaming processing on Berkeley's native Spark/Spark Streaming cluster computing technology (months 6-18). Data in the warehouse will be accessible to users through APIs and the open data commons using industry standards. We envision that the data warehouse will be housed and archived at the ITS Berkeley library at UC Berkeley. The SFMTA is exploring the use of the USDOT partner Amazon Web Services offer for the three-year period . Privacy-preserving data access layer will implement data access protocols based on provable differential privacy guarantees (months 18-36). Key staff include Research Librarian Kendra Levine, a data architect, and two programmers.

Dashboards and Visualization

Data processing algorithms will support computation of TaaS performance metrics (described below) to evaluate the outcomes of demand management and a range of policy intervention strategies (e.g., pricing) toward the City and region's environmental and equity goals. This will result in various visualization components (months 6-18) and modular dashboards (months 12-24) supporting the pilot project use cases and personalized travel advisories. Visualization and data access components will be integrated (months 24-36) with Berkeley's Data Science education program on-site, as well as with newly offered Massive Open Online Courses (MOOC), supporting community engagement, technology transfer, and digital equity through resident science. Key staff include a data scientist and research engineer, and two software engineers and consultation with USDOT Partner Sidewalk Labs' Flow service.

1.2.7.5 Data Privacy Analysis

We will develop best practices for transparency and accountability regarding data privacy and security choices. For Smart Transportation Networks. San Francisco's implementation of the Smart City Challenge will function as a test case for what privacy and data security policies best facilitate the creation of smart transportation networks consistent with public preferences. These networks require the collection, retention, and sharing of data on individuals' movements. Public concern over data privacy and security has forestalled similar efforts in the past. As the Smart City Challenge's pilot projects are implemented, legal scholars will determine and document what approaches to public transparency, democratic accountability, and community involvement are most likely to ensure long-term project success and public acceptance. Underlying our approach is the hypothesis that a porous and iterative approach to community engagement is most likely to achieve public buy-in and, therefore, long-term project success. As part of this effort, UC Berkeley Law School faculty and researchers will collaborate with the UC Berkeley research teams (i.e., TSRC, PATH, ITS Berkeley Library, SafeTREC, Tech Transfer, and City officials to: 1) Apply core privacy by design concepts to project implementation (Year 1); 2) Monitor data collection, retention, use, and sharing (Year 2); 3) Monitor community outreach and engagement (Years 1 to 3); 4) evaluate what approaches to data privacy and security most effectively achieve public support (year 3); and 5) develop a suite of model policies and protocols that other cities can rely on in addressing transparency and accountability issues that arise as a result of city data collection, retention, use, and sharing to facilitate smart transportation networks (year 3). We envision that one set of policies will provide substantive recommendations for data privacy and security. A second set will advise on the processes to ensure transparency and accountability adequate to achieve public buy-in. Berkeley Law School faculty and researchers will lead this effort. Key staff include Professor Catherine Crump and Jim Dempsey.

The team has developed several hypotheses and potential data sources to apply to these methodological approaches, discussed in the next section.

1.2.8 Hypothesis, Performance Goals/ Metrics and Proposed Data Sources

San Francisco will develop a performance measurement plan that describes the data types and collection process to support ongoing performance of the Smart City demonstration, including its impact on mobility, safety, ladders of opportunity, sustainability, and climate change. The performance management plan will document methodologies for collecting: 1) pre-demonstration data that can be used as a performance baseline, 2) continuous data during the life of the demonstration to support performance monitoring and evaluation, 3) cost data including unit costs and operations and maintenance costs, and 4) information on the timeframe that applications or other technology solutions are deployed during the course of the demonstration period.

Based on the proposed pilot projects and deployment plan, we have developed Table 1.3, which provides an overview of key hypotheses linked to our demonstration projects. In addition to the key hypotheses are metrics and proposed data sources. If we are awarded the grant, the hypotheses would be revisited, along with metrics and data sources, as appropriate.

1.2.9 Use Case Problem Statements

The deployment concepts explained in the previous section address a number of use cases described below that are replicable across the nation. These were chosen because they can be met in a number of ways and modes:

- **Multi-Modal Travel:** Enhancing opportunities for multi-modal travel, including last mile public transit connections and encouraging the right mode/size for the trip/task at hand, including grocery shopping, errands, social, etc.
- **Late Night Travel:** Safely traveling in San Francisco and throughout the Bay Area at night when regular public transit service is limited or non-existent, including late-night workers and social/recreation.
- **Commute:** Commuting to and from San Francisco conveniently and efficiently, with the ability to adapt to last minute changes in schedule.
- **Family Travel:** Travel with/for children, including travel to school, doctor's office, after school recreation, and family outings.
- **Greater Bay Area:** Travel throughout the greater Bay Area for day and multi-day trips, including social, recreation, family, business trips.
- **Persons with Disabilities:** Convenient and safe travel for persons with disabilities.
- **Planning and Payment:** Convenient one-stop travel planning and payment.
- **Digital Divide:** Ability to access convenient one stop travel planning and payment without the use of a smartphone.
- **Reducing Congestion:** Improving safety and reducing congestion among all modes.
- **Freight Movement:** More efficient goods movement in and out of the city, including home package delivery.
- **Health-Based Criteria Emissions:** Reducing/ eliminating tailpipe health-based criteria emissions.
- **Greenhouse Gas Emissions:** Reducing/eliminating GHG emissions from transportation, including

upstream life-cycle emissions.

- **Large Data:** Securely collecting and managing large data that informs travelers and transportation managers, and protects personally identifiable information and proprietary considerations of the private sector.
- **Connected Vehicles:** Connected vehicles and communication network that contribute to increased mobility, reduced congestion, and reduced emissions.

1.3 High-Level Schedule, Milestones and Deliverables

San Francisco will develop a detailed schedule along with the milestones and deliverables within the first two weeks of the award and make changes based on USDOT feedback. We will produce all the deliverables listed in NOFO. Table 1.4 provides a high-level schedule/plan.

1.4 Annotated Map

See Page 38 for annotated site map.

1.5 Partnership Framework and Engagement: The Technology Partners Challenge

Two years ago, San Francisco Mayor Ed Lee's successful Entrepreneurship-in-Residence pilot initiative paired a startup with a major international airport for 16 weeks. Within that short time something amazing happened—the development of a groundbreaking indoor navigation system for the visually impaired and blind community. San

Key Hypotheses	Metrics	Data Sources
Providing an integrated multi-modal mobility app platform will improve overall accessibility, promote multi-modal trips, reduce dependence on private automobiles, and address the first-mile/last-mile problem	• Increased public transit ridership • Reduced VMT, emissions, SOV trips, travel times, and travel costs • Increased quality of life and bikeshare use • Number of users on the mobility platform • Number of service providers who join the app platform • Time savings due to smart parking app (private drivers and freight delivery)	• BART, Caltrain, Muni, AC Transit • Bay Area Bikeshare • Before-and-after user surveys (and mobile app data) with longituindal (control/experimental) panel • Focus groups with longitudinal panel particpants • Community Mobility Challenge focus groups • Mobile app
A "safe driving" feature in the multi-modal app platform or in-vehicle device, which incentivizes/nudges drivers, encourages safer driving habits	• Observed safety driving behavior • Reduced collisions/fatalities • Increased equity for vulnerable users	• Police reports of traffic collisions • Before-and-after user longitudinal survey (control/experimental) panel • Community Mobility Challenge focus groups
Delivery service and smart parking features in the multi-modal app platform can improve logistics and parking situations, with reduced cycling of goods movement and vehicle parking	• Reduced VMT and emissions Reduced circling time (reduced VMT) • Reduced freight delivery time and costs (reduced truck VMT) • Reduced collisions	• Multi-modal app data • Delivery logistics data • Parking data • Before-and-after user surveys (and mobile app data) with longitudinal (control/experimental) panel • Focus groups with panel participants

Table 1.3 Demonstration Component Hypotheses, Metrics and Data Sources

Key Hypotheses	Metrics	Data Sources
Regional connected carpool (HOV) lanes will reduce travel times, stimulating more driver and passenger carpool participation, which in turn will reduce waiting times, walking distances, and detour lengths. This cycle will dramatically expand carpooling among regional commuters	• Increased number of vehicles in HOV lanes, casual carpooling participation, person throughput, and quality of life • Reduced SOV trips, travel time, and travel costs	• Caltrans PeMS data •Before-and-after user surveys (and mobile app data) with longitudinal (control/ experimental) panel • Focus groups with before and after study participants • Measurement of casual carpooling usage • Carpooling mobile app data
Dynamic carpool pick up curbs will provide safe locations for carpools linked to the multi-modal mobility app to pick up and drop off passengers curb side	• Reduced collisions, SOV trips, travel time and costs, VMT, and emissions • Increased person throughput, equity (ladders of opportunity), and quality of life • Improved accessibility	• Before-and-after carpool user survey (including demographic data) • Focus groups with before-and-after study participants • Carpooling mobile app data • Police collision report data • Community Mobility Challenge focus groups
A connected vehicle Wi-Fi mesh network will increase digital equity on-board and around the city, increase public transit ridership, and improve residents' quality of life	• Increase in shared mobility and public transit use by low-income and non•smartphone users (e.g., older adults) • Reduce SOV reliance • Reduced travel time and costs • Increased quality of life	• BART, Caltrain, Muni, AC Transit peak-period data • Bay Area Bikeshare peak-period data • Before-and-after user survey data • Focus groups with before-and-after study participants • Community Mobility Challenge focus groups
Collision avoidance technology, through vehicle mounted sensors and accompanying technology, can alert drivers about pending pedestrian and bicycle conflicts, improving safety	• Reduced collisions/fatalities • Increased equity for vulnerable users	• Police reports of traffic collisions • Sensor data
Connected Vision Zero corridors—real-time information exchange between intersection signal controllers and vehicles increases pedestrian and cyclists enhances traffic system performance, improves safety, and save energy	• Reduction of collision/fatalities Increased equity for vulnerable users • Energy saved (kWh)	• Connected corridor data (volume data) • Transit volume data • Police reports of collisions • Emergency medical data • Sensor data • Video data
An on-demand, late-night commuter shuttle and after-school van shuttle will increase jobs access, equity, and after-school program access and lower the commute cost and/or travel time of late-night workers who use the service	• Reduction in reported crime • Traveler perception of safety • Reduced travel cost in time and money (late night) • Jobs access (ladders of opportunity) • Increased quality of life • Modal shift • Reduced SOV use	•SF Police data (before and after) • Before and after user survey data • Focus groups with before•and•after study participants • Community Mobility Challenge focus groups

Table 1.3 (contined) Demonstration Component Hypotheses, Metrics and Data Sources

Key Hypotheses	Metrics	Data Sources
The strategic placement of shared mobility hubs will provide more transportation options for underserved populations and enable users to shift to more sustainable modes and decrease driving and ownership of personal vehicles, therefore reducing VMT and GHG emissions	• Increase in shared mobility and public transit use • Reduced SOV use • Reduced travel time and cost (travelers), improving accessibility • Decrease in vehicle ownership • Increase in digital equity in neighborhoods (ladders of opportunity) • Increased quality of life • Travel time savings for freight delivery due to curb space drop off (e.g., p2p deliveries)	• Public transit data • Shared mobility data • Before and after user survey data • Community Mobility Challenge focus groups
Wi-Fi enabled parklets will promote digital equity/access in a neighborhood, spur economic development, and promote modal shift away from SOV toward shared mobility and active transportation	• Increase in business patronage and revenue nearby parklets • Jobs access (ladders of opportunity) • Modal shift • Reduced SOV use • Increased quality of life	• Public transit data • Shared mobility data • Before and after user survey data • Focus groups with before and after study participants • Community Mobility Challenge focus groups
Automated Vehicles (AVs) serving as a first-/last-mile transit connection, delivery service, or municipal service can provide safe and dependable service to city neighborhoods	• Proof of concept of AVs in city neighborhoods • Reduce travel time and costs • Increase quality of life • Reduce SOV use • Job access (ladders of opportunity) and overall accessibility (reduced travel time and cost)	• AV onboard data • Before and after user survey • Focus groups with before and after study participants • Community Mobility Challenge focus groups

Table 1.3 (continued) Demonstration Component Hypotheses, Metrics and Data Sources

1.4 Annotated Map San Francisco Smart City Challenge Demonstration Proposals

This map shows the proposed locations of the key San Francisco Smart City Challenge demonstration proposals. The proposals included are at the regional, city-wide and neighborhood scale as indicated in each explanatory box along the side of the map. More information on each proposal can be found throughout Section One in the application document.

- Rail Stations
- Highway
- Automated Vehicle Route
- Railway
- Carpool Routes
- Rapid Networks
- Key Pickup at Mobility Hubs
- AV Carpool First/Last Mile Hub
- Late Night Employment Van Route
- Minor Pickup Late Night Employment Hub

Connected Carpool Lane — REGIONAL

- Ridesourcing/carpool matching app
- New highway HOV lanes for transit/carpools

Desired Outcomes:

- Increased ride sharing, mobility (especially job access) and public transit ridership
- Reduced commute travel times, regional rail crowding, congestion, VMT, and GHG emissions

Dynamic Carpool Pick Up Curbs — REGIONAL

Dedicated curb space for pick-up/drop-off by carpools and ridesourcing services

Desired Outcomes:

- Incentives for sharing rides
- Improved safety
- Reduced congestion, double parking, modal conflicts, idling, and travel times

SF Bay Area

Municipal Mesh Network — CITY

Create vehicle mesh network by installing Wi-Fi access points ("hotspots") in public transit vehicles, taxis and other City vehicles that provide publicly accessible Internet access inside and outside of the vehicles

Desired Outcomes:

- Increase digital equity

Late Night Van Shuttle — CITY

Vanpool or shuttle service between late night worker hotspots

Desired Outcomes:

- Increased job access and safety
- Equitable and convenient transportation options for evening workers

Smart Traffic Signals — CITY

Deploy Multi-Modal Intelligent Traffic Signal Systems in the form of Transit Signal Priority and Emergency Vehicle Preemption

Desired Outcomes:

- Increased safety and public transit speeds
- Reduced truck signal delays

Connected Vision Zero Corridor — CITY

Multi-Modal Intelligent Traffic Signal Systems located roadside and in-vehicle

Desired Outcomes:

- Reduced public transit travel times, idling and GHG emissions
- Improved safety and satisfaction for pedestrians and cyclists

Shared Mobility Hubs/Wifi Parklets — NEIGHBORHOOD

50 mobility hubs near public transit stations equipped with WiFi kiosks, car/bike/scooter-share, curb space for carpool/taxi/ridesourcing services, and delivery

Desired Outcomes:

- Better transit access and connections
- Increased use of sustainable modes
- Increase digital equity

AV First-Last Mile — NEIGHBORHOOD

Automated vehicle fleet to provide first and last mile shuttle service to major transportation hubs

Desired Outcomes:

- Reduced travel costs and parking demand at transit stations
- Increased public transit use

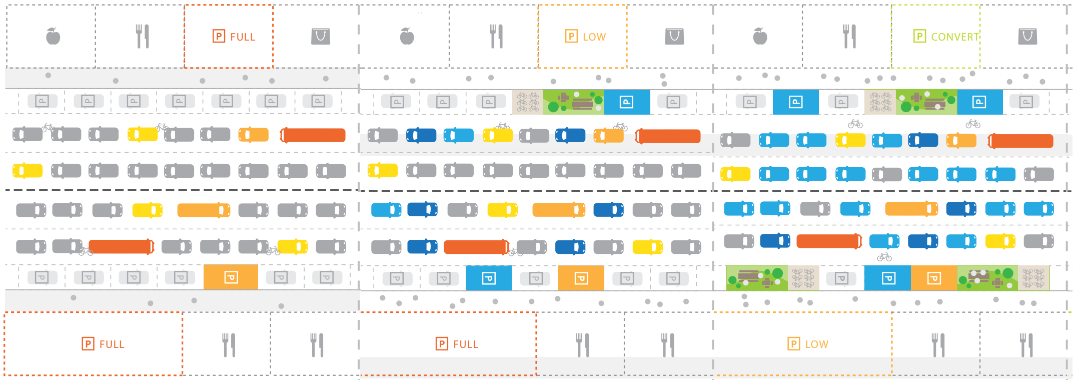
AV Freight Delivery — NEIGHBORHOOD

Freight delivery via automated vehicles in low-speed urban environments

Desired Outcomes:

- Increased safety for all road users
- Reduced travel cost
- Enhanced efficiency

Ownership: Current Model



OWNERSHIP/
CURRENT MODEL

All modes operate independently with little prioritization. Congestion, pollution, collisions, waste, noise. Public space sacrificed for parking and roads. Lack of funding to maintain system. Lack of supply means long wait times and high prices for on-demand services.

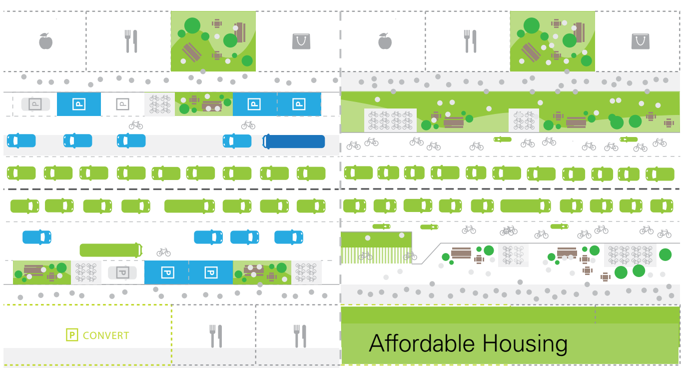
ON-DEMAND
SERVICES

Supply greatly increased for on-demand services. Sharing becomes viable. Car, bicycle and pool services emerge. Shared delivery services emerge reducing costs for suppliers and receivers. Late night service layer with micro-transit emerges.

SHARED
ON-DEMAND

Most vehicles are now shared vehicles, modes are integrated, trips costs are low enough for all users to participate. Supply is satiated with shared services and parking demand peaks. TaaS is preferred way of navigating city.

Shared & Connected: Future Model



SHARED &
CONNECTED

Connected technology optimizes shared services. Collision avoidance technology, signal optimization and speed reduction[jcg2] . Parking and street use demand reduces to repurpose some space to temporary uses. Build out bicycle network.

SHARED ELECTRIC CONNECTED
AUTOMATED MODEL

Shared Electric Connected and Autonomous services are fully optimized. Fatalities eliminated Vision Zero goal met with faster travel. Pollution, noise minimized. Parking structures repurposed for affordable housing, streets become shared spaces.

San Francisco's bold smart city vision culminates with our Transportation as a Service (TaaS) platform and Shared Electric Connected and Automated (SECA) vehicles. With USDOT's support we will propel this vision forward working in close partnership withour citizens, community groups, technology partners, and research collaborators at UC Berkeley and Lawrence Berkeley National Laboratory.

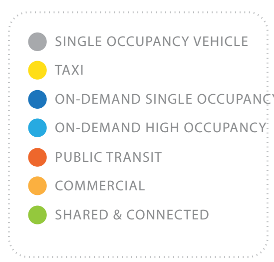


Figure 1.16 Ownership Model vs. Shared & Connected Model

Francisco International Airport (SFO) and Indoo.rs, a leader in indoor navigation technology, worked together to develop a prototype smartphone application that helps visually impaired travelers navigate through the airport terminal. This incredible solution is a testament to the power of collaboration—of working across sectors (in this case, government, industry, and the non-profit community) to spur technology solutions. It also embodies the values of San Francisco—ensuring ubiquitous access to essential services regardless of abilities or income.

The challenges cities face today require the best and brightest inside and outside of City Hall. San Francisco understands the importance of forging powerful collaborations and has programs in place to support them. The successful SFO and Indoo.rs team was part of an innovative public-private partnership now known as Startup in Residence (STIR) that has received Federal funding from the Economic Development Administration. Through the STIR program, we are experimenting with removing the friction associated with RFPs for both government staff and startups—one of the key issues voiced by the private industry. For government staff, that means publishing an RFP in days, not months. For startups, it means responding to an RFP in hours, not weeks.

We cannot do this alone. We need ideas and expertise to develop the roadmap for making a smarter San Francisco. We need the expertise of companies to: 1) bridge the physical and digital world; 2) build digital and data platforms at a city scale; and 3) ensure integration of security and privacy into every solution. That is why San Francisco is excited to announce a new partnership with UC Berkeley, the General Services Administration, and the City Innovate Foundation to address the challenges and needs of urban centers, starting with San Francisco. The first activity of this public-private consortium, the Smart City Institute, will support San Francisco's bid in the USDOT Smart City Challenge. As a founding member of the Smart City Institute, we are committed to realizing our vision and furthering the goals of the Smart City Challenge.

The Smart City Institute creates a safe space for industry members to collaborate with each other, academia, and government in real-world projects. The Institute will support the entire challenge lifecycle from identification and scoping to demonstration of innovative solutions in San Francisco. As part of our process for identifying and securing commitments from partners, we hosted an industry event with San Francisco Mayor Lee that brought over 200 business leaders from nearly 150 organizations to learn more about the Smart City Institute and how they might contribute to the Smart City Challenge. We encouraged interested parties to express their interest in joining the Smart City Institute via an online application that identified how they might contribute staff expertise, products, or data.

The home page of the online application is ***SmartCitySF.com***. We received over 100 applications from startups to large multinational corporations. A committee reviewed the proposals to identify those that make a firm commitment to helping San Francisco realize its vision and further the goals of the Smart City Challenge. The selected organizations were engaged to integrate their contributions into our plan. San Francisco is ready to join our partners in making our city smarter—intelligent roads, public transit, airports, ports, and high-speed rail that will propel San Francisco, the region, and California into the future.

1.6 Energy and Electric Vehicle Commitment and Deployment

California has been at the forefront of national efforts to reduce GHG emissions for a decade, since the Global Warming Solutions Act (AB 32) of 2006 and the Governor's Executive Order S-3-05 established the goal of reducing statewide GHG emissions to 90 percent below 1990 levels (baseline) by 2050 ("80x50"). Last year, the State set new, aggressive targets for decreasing GHG emissions to 40 percent below baseline by 2030, which will make it possible to reach the 80x50 goal. San Francisco's Climate Action Strategy mirrors AB 32 and has set near-term emission reduction goals by 25 percent and 40 percent below baseline by 2017 and 2025, respectively. To date, the City has achieved a 24 percent reduction in GHG emissions

Work Activity	Responsible Party	Start Date*	End Date*	FY 2016	FY 2017	FY 2018	FY 2019	Deliverables
Development of Concept of Operations								
Smart City Institute Partnership	T. Papandreou (SFMTA) S. Shaheen (UCB)	Jul-16	Jul-16					SFMTA/UCB Memorandum of Understanding (MOU)
Launch Tech Partners Portal	Program Mgr (SFMTA)	Jul-16	Aug-16					Online portal
Identify Contributors	Program Mgr (SFMTA)	Jul-16	Aug-16					List of local project contributors
Develop Memoranda of Understanding	J. Goldberg (SFMTA)	Jul-16	Aug-16					Execute MOUs with local project contributors
Launch Community Challenge	T. Papandreou (SFMTA)	Jul-16	Aug-16					Community feedback
Identify Neighborhoods	T. Papandreou (SFMTA)	Jul-16	Aug-16					Community adoption
Bid and Award	Program Mgr (SFMTA)	Sep-16	Feb-18					Contracts with vendors
Deployment - Year One								
Institute Demonstrations	Program Mgr (SFMTA)	Sep-16	Aug-17					
Regional								
Multi-Modal App (Taas)	G. Riessen (SFMTA)	Sep-16	Aug-17					Multi-Modal App, Backend App Support
Safe-Driving Feature (Taas)	G. Riessen (SFMTA)	Sep-16	Aug-17					Feature in TaaS platform to detect unsafe driving
Delivery Service Feature (Taas)	G. Riessen (SFMTA)	Sep-16	Aug-17					Feature in Taas platform to improve delivery efficiencey
Smart Parking Feature	G. Riessen (SFMTA)	Sep-16	Aug-17					Feature in Taas platform to intelligently manage parking demand
Connected Carpool Lane Pilot	G. Riessen (SFMTA)	Sep-16	Aug-17					HOV lanes, striping, queue jumps, pickup zones, enforcement infrastruct
Safe Driving On-Board Unit for Users	G. Riessen (SFMTA)	Sep-16	Feb-18					On-board safe driving units to reduce unsafe driving behaviors
Dynamic Carpool Pick Up Curbs	G. Riessen (SFMTA)	Sep-16	Aug-17					Carpool pick-up curbs to provide safe pick up and drop off
City								
Smart Traffic Signals	C. Paine (SFMTA)	Sep-16	Aug-17					Smart traffic signals to increase public transit speed, reduce ped collisions
Collision Avoidance Technology (Municipal Mesh Network)	C. Paine (SFMTA)	Sep-16	Aug-17					Collision avoidance tech to reduce collisions and improve safety
Transit & Taxi Vehicles with Wifi (Municipal Mesh Network)	C. Paine (SFMTA)	Sep-16	Aug-17					Wifi on city vehicle fleets
Connected Vision Zero Corridors	C. Paine (SFMTA)	Sep-16	Aug-17					Connected, signalized intersections for MMITSS, idling reduction, safety
Late Night Van Shuttle (Shared Van Shuttle Service)	C. Paine (SFMTA)	Sep-16	Aug-17					Late night worker commute van pool/shuttle service
After School Van Shuttle (Shared Van Shuttle Service)	C. Paine (SFMTA)	Sep-16	Aug-17					After school van shuttle with dynamic tech to optimize travel
Neighborhood								
Shared Mobility Hubs	A. Thornley (SFMTA)	Sep-16	Aug-17					Shared mobility hubs to reduce SOV trips, parking, auto ownership
EV Charging (Shared Mobility Hubs)	A. Thornley (SFMTA)	Sep-16	Aug-17					EV charging stations
Wi-Fi and Parklets (Shared Mobility Hubs)	A. Thornley (SFMTA)	Sep-16	Aug-17					Public spaces built on on-street parking, Wifi kiosks
Delivery or Municipal Service (Automated Vehicle Pilot)	A. Thornley (SFMTA)	Sep-16	Feb-18					Delivery and/or muni vehicles equipped with AV technology
First- and Last-Mile Public Transit Connected Service (Automated Vehicle Pilot)	A. Thornley (SFMTA)	Sep-16	Feb-18					Vehicle fleet with AV technology for first- and last-mile connection to regional public transit
Deployment - Year Two								
Evaluate Year One Deployment	Program Mgr (SFMTA)	Sep-17	Sep-17					Data and metrics
Refine Year One Deployment	Program Mgr (SFMTA)	Sep-17	Sep-17					Modify and bolster effective proposals based on analysis and feedback
Institute Refined Year Two Demonstrations	G. Riessen, C. Paine, A. Thornley (SFMTA)	Sep-17	Aug-18					Year two demonstrations and applications
Deployment - Year Three								
Evaluate Year Two Deployment	Program Mgr (SFMTA)	Sep-18	Oct-18					Data and Metrics
Refine Year Two	Program Mgr (SFMTA)	Sep-18	Sep-18					Modify and bolster effective proposals based on analysis and feedback
Institute Refined Year Three Demonstrations	G. Riessen, C. Paine, A. Thornley (SFMTA)	Sep-18	Aug-19					Year three demonstrations and applications
Evaluation								
Evaluate Replicability	Program Mgr (SFMTA)	Sep-19	Oct-19					
Implement Long-Range Changes	Program Mgr (SFMTA)	Sep-19	Oct-19					
Administration								
Kick-Off Meeting	T. Papandreou (SFMTA)	Jul-16	Jul-16					
Invoicing	J. Goldberg (SFMTA)	Quarterly	Quarterly					Invoice Packages
Meetings, Webinars, Workshops	Program Mgr (SFMTA)	Ongoing	Ongoing					
Quarterly Reports and Briefings	J. Goldberg (SFMTA)	Ongoing	Ongoing					Quarterly Reports
Interim Reports (Annual)	J. Goldberg (SFMTA)	Oct-17	Oct-19					Interim Reports
Final Report	J. Goldberg (SFMTA)	Feb-19	Feb-19					Smart City Demonstration Final Report
*Dates are subject to change								

Table 1.4 Proposed Three Year Smart City Challenge Summary Schedule

from baseline despite an increase in economic development.

In 2012, Governor Brown issued an Executive Order directing state government to help accelerate the market for zero-emission vehicles (ZEVs) in California. This executive order established several milestones on a path toward 1.5 million ZEVs in the state by 2025. ZEVs include hydrogen fuel cell electric vehicles (FCEVs) and plug-in electric vehicles (PEVs), or both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Additionally, in 2014, Senate Bill 1275 established the Charge Ahead California Initiative, setting a goal of 1 million ZEVs and near-ZEVs in service by 2023, as well as increased access to these vehicles by disadvantaged, low-, and moderate-income communities and consumers.

To help achieve these goals, the Mayor's Electric Vehicle (EV) Working Group formed in 2015. The group directed staff to develop recommendations that would facilitate ZEV market expansion, ensure ZEVs were broadly available to the community, and accelerate ZEV market growth throughout the Bay Area. The EV Working Group aims to have 15 percent of the vehicles driven in San Francisco (approximately 90,000) be ZEVs by 2025. This ambitious goal reflects the City's focus on the reduction of GHGs from the transportation system. CleanDriveSF includes five key goals that enhance stakeholder coordination moving forward to ensure broad ZEV access for everyone, as follows:

1. Decarbonize electricity supply.
2. Enable necessary infrastructure.
3. Transform vehicle fleets.
4. Build consumer awareness and demand.
5. Promote broad access to ZEVs and capture economic development opportunities.

1.6.1 Decarbonize Electricity Supply

San Francisco has two utility providers. The San Francisco Public Utilities Commission (SFPUC) currently serves 17 percent of the City's electrical load. Pacific Gas and Electric (PG&E) is the investor owned utility (IOU) in Northern California and currently serves 75 percent of San Francisco commercial and residential customer load.

Figure 1.17 Potential Workspace for Smart City Institute

Figure 1.18 50 UN Plaza—Home of the Smart City Institute

Between the two utility providers, San Francisco's energy mix is more than 40 percent renewables. In addition to electricity supply, there is over 30 megawatts (MW) of distributed solar photovoltaic (PV) capacity interconnected across 6,200 sites in San Francisco and 7MW of solar PV installed at 16 municipal sites in and outside of the city. The City will continue its path to 100-percent renewable energy with the launch of CleanPowerSF, San Francisco's new Community Choice Aggregation program.

Launched in May 2016, CleanPowerSF, which was authorized under State law (AB 117 2002 and SB 790 in 2011), allows the City to partner with local IOUs to provide an additional choice in the sources of energy generated and delivered to residents and businesses. Under CleanPowerSF, PG&E will continue to maintain the power grid, respond to outages, and collect payment. CleanPowerSF will replace the generation component of the bill with a new charge that represents cleaner sources of energy. Under CleanPowerSF, PG&E will continue to maintain the power grid, respond to outages, and collect payment from customers. CleanPowerSF will replace the generation component of the bill with a new charge that represents cleaner sources of energy. Under CleanPowerSF, PG&E will continue to maintain the power grid, respond to outages, and collect payment from customers. CleanPowerSF will replace the generation component of the bill with a new charge that represents cleaner sources of energy. Through the Smart City Challenge, we will expand CleanPowerSF and strategically integrate ZEV infrastructure that optimizes the use of the energy grid.

San Francisco has made considerable progress in deploying ZEV infrastructure for freight, delivery fleets, and private vehicles and has the top ranking in the nation for charger availability per capita basis. To date, over 490 publicly available charging stations have been deployed throughout San Francisco including more than 70 at 23 municipal locations, each powered by 100-percent renewable hydroelectricity. San Francisco aims to accelerate the transition to ZEVs and electrified shared transportation modes through careful planning and the development of new charging and fueling infrastructure that addresses consumer needs, provides equitable access, facilitates technological innovation, and contributes to the reliable management of the power grid. Through the Smart City Challenge we will:

- Support light duty ZEV infrastructure planning and investment by public and private entities by collaborating with Lawrence Berkeley National Laboratory, UCB, and PG&E to develop a San Francisco ZEV Grid Integration roadmap.
- Make home charging easy to install and use, with special focus on multi-unit dwellings and workplaces: The City's CleanPowerSF program will collaborate with private sector partners to explore new business models for bringing PEVs and carbon free energy to Municipal Affordability Units (MUDs) and using new PEV charging and storage infrastructure to provide grid services.

1.6.2 Enable Necessary Infrastructure

1.6.3 Transform Vehicle Fleets

Figure 1.19 EV Charging Infrastructure

San Francisco's fleet represents a visible area for ZEV expansion, as growing the use of ZEVs in municipal operations demonstrates these technologies at a large scale and expands community awareness. Using ZEVs in the City's fleet also helps decision makers better understand the opportunities and constraints of integrating ZEVs into San Francisco's high-density urban environment. San Francisco's goal in transforming vehicle fleets is to achieve economies of scale in ZEV procurement by aggregating the purchasing power of state and municipal fleets around the country to lower vehicle costs, increase access to a wider range of vehicles, and improve access to charging stations. Through the Smart City Challenge, we will improve the process by which the city acquires ZEVs for fleet use by evaluating internal procurement processes for fleet vehicles and making modification recommendations that support San Francisco's ZEV annual procurement goals.

1.6.4 Build Consumer Awareness and Demand and Promote Broad Access to ZEVs

Consumer education is critical to building interest in ZEVs, which includes demonstrating the benefits of ZEVs and equipping consumers with information before they reach the auto dealership. Furthering partnerships with automakers, dealers, and other local stakeholders is important to broaden consumer awareness and establish a ZEV buying or leasing experience that is appealing to the broader community. Through the Smart City Challenge, we will reduce upfront costs of owning or leasing ZEVs and promote consumer awareness of ZEVs through public education, outreach, and direct driving experiences.

1.6.5 Promote Broad Access to ZEVs and Capture Economic Development Opportunities

Expanding the use of ZEVs in San Francisco yields economic benefits—every community member who transitions to ZEVs saves money in fuel costs over the life of the vehicle, which they can reinvest into the City's economy through consumer spending. San Francisco has target actions to ensure that ZEV businesses grow, economic and workforce development opportunities are accessible to a broad range of community members, and there are new opportunities for investors to remove barriers to market transformation. Through the Smart City Challenge, we will work directly with the California Clean Energy Fund (CalCEF) to document and build understanding of the investment landscape to:

1. Understand the current equity landscape and identify barriers to participation, needs of entrepreneurs, and limitations to success.
2. Build an understanding of how the clean energy ecosystem is (or is not) addressing the needs of disadvantaged (DAC) and low-income communities as ZEV expansion programs are developed.
3. Map the health and environmental impacts that ZEVs can have on DACs in San Francisco.

San Francisco's Smart City Challenge ZEV Plan is a comprehensive roadmap that contains ambitious municipal and private sector fleet emissions reduction strategies, calls for significant infrastructure investment by our local utilities, identifies opportunities for public-private partnerships, pilots innovative projects to use our electrical assets to move San Francisco, and overall accelerates transportation electrification throughout the Bay Area.

1.7 Standards, Architectures, and Certification Approach

San Francisco endorses and embraces the challenges and rewards of using a standards-based reference architecture as the foundation for the Smart City solutions, providing interoperability with other deployments and a consistent, reliable transportation experience for all users. As part of deploying the Smart City concepts, San Francisco and partners are committed to developing interfaces using the Connected Vehicle Reference Implementation Architecture (CVRIA) as the foundation. We will develop new interfaces to the extent feasible, using existing networking, data, or other standards. We will specify all interfaces through the Systems Engineering Tool for Intelligent Transportation (SET-IT) tool and provide relevant feedback to USDOT for incorporation into the CVRIA. Where gaps in functionality, necessary changes to existing standards, or the need for new standards are identified, we will specify and provide these requirements to USDOT for possible coordination and remediation with relevant standards developing organizations (SDOs).

While the initial applications of CVRIA and SET-IT have focused on CV and AV applications, San Francisco will leverage its experience with these USDOT assets and extend the "platform" to integrate new and innovative Smart City solutions for the City. This includes both within the ITS domain and for new use cases leveraging existing or emerging transportation domains such as smart grid integration and urban automation, logistics, and delivery. San Francisco is committed to supporting the USDOT National Architecture team as they integrate the CVRIA into the National Architecture and expand it to incorporate these and similar Smart City solutions.

1.8 Systems Engineering Approach

The project team has significant experience in the application of systems engineering principles. Project team members from UC Berkeley have developed and written the Systems Engineering Management Plan (SEMP), Concept of Operations (ConOps), and Systems Requirements documents for the ongoing Caltrans-led I-210 Pilot Integrated Corridor Management system in Los Angeles County, as well as the SEMP and ConOps for San Diego's proposed Smart Parking initiative. Project team members have also contributed to the development of the ConOps for the Dynamic Ride prototype application within the USDOT.

Systems engineering is an interdisciplinary approach to help ensure success in the planning and development of complex systems. This approach focuses on defining customer needs and required functionality early in the product development cycle, as well as adequately documenting requirements, before proceeding with the design, development, and validation of a proposed system. It also attempts to take into account all elements that may affect the development of a solution, such as cost constraints, operational support and training needs, and system testing and validation processes. The objective is to minimize risks to budget, scope, and schedule by planning for project activities upfront and answering questions about how to deliver a quality product or solution to a specific problem.

As illustrated in Figure 1.21, design of the system will follow an iterative process in which design and testing of system components occur in phases. Each cycle includes design, build, and evaluation focusing on a specific aspect of the project. Such an iterative process will allow dividing the project into more manageable and predictable cycles, in addition to providing project stakeholders with visibility and decision points throughout the project.

The following are key documents that will be developed throughout the process, with their occurrence within the systems engineering process mapped by the numbered bullets shown in Figure 1.21:

1. **ConOps:** Document identifying presenting a summary vision for the system to be developed based on the identified user needs. Development of the Concept Operations (ConOps) will be based on IEEE Standard 1262-1998 and will involve extensive interaction with project stakeholders. This will include a workshop to identify user needs, one-on-one discussions with stakeholders to develop system concepts, and one or more final workshops to formally present and refine the concepts. A central element of the ConOps will be scenarios illustrating how the proposed system may operate under various conditions and how its users will interact with it. The document will also present a preliminary list of metrics to be considered for assessing system performance.

2. **Demonstration Site Map and Installation Schedule:** This step documents identifying the geographic area of the deployment project, the specific locations for deployment, the schedule according to which deployments are to occur, the organization or individual responsible for each installation, the milestones identifying when a specific installation is to be considered complete, and planned dates for unit testing. These will be updated as the project progresses

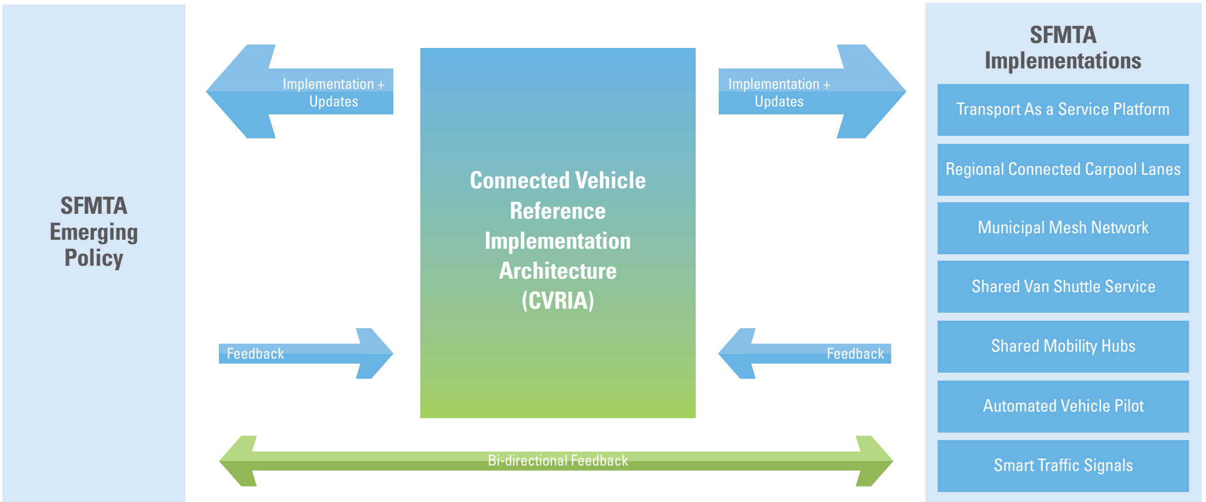


Figure 1.20 Framework for Standards, Architecture, and Certifications

to reflect changes.

3. **Systems Requirements Specification:** Document describing what the proposed system will do, the conditions under which it will operate, the input data it will use, the performance metrics it will calculate, and how well it performs its envisioned tasks. Development of this document will be based on IEEE Standard 1233-1998 and will involve significant interaction with project stakeholders through an initial requirement identification workshop, one-on-one meetings, and requirement review and consensus-building workshops.

4. **System Architecture and Standards Plan:** Documents detailing how the proposed system is to be built and integrated with other systems. This will include descriptions of processes and data flows to be developed, physical elements to be built or integrated with the system, communication protocols to be used or fostered and relationships to be developed among the various organizations supporting system operations. It will also describe how the system will integrate with the National ITS Architecture, the Bay Area ITS Architecture, and the CVRIA and how existing architecture(s) may be modified to fill identified gaps or outdated components where relevant.

5. **System Design Documents (SDDs):** These documents detail the various subsystems and components to be built. IEEE Standard 1016-1998, as well as the agreed-upon systems requirement, system architecture, and standards plan, will guide the development of these documents.

6. **Interface Control Documents (ICDs):** Companion documents to the SDDs informing each organization tasked with building parts of the system how their components are to interact with other system components.

7. **System Test Plan:** Document detailing the methods and metrics to be used to demonstrate that the systems satisfy all of the identified requirements. This will include a validation plan describing how the user needs identified in the ConOps are to be verified, a verification plan identifying how the agreed-upon system requirements are to be verified, and various unit test plans identifying how individual system components are to be tested.

8. **Testing Documentation:** Document detailing the specific verification and validation processes, as well as metric thresholds, that will be used to ensure that the system was built correctly and satisfies the user needs. Prior to executing the tests, the documentation will include the test cases, procedures, and data for use as part of the testing activities. As testing progresses, the existing documentation will be updated to include the test results.

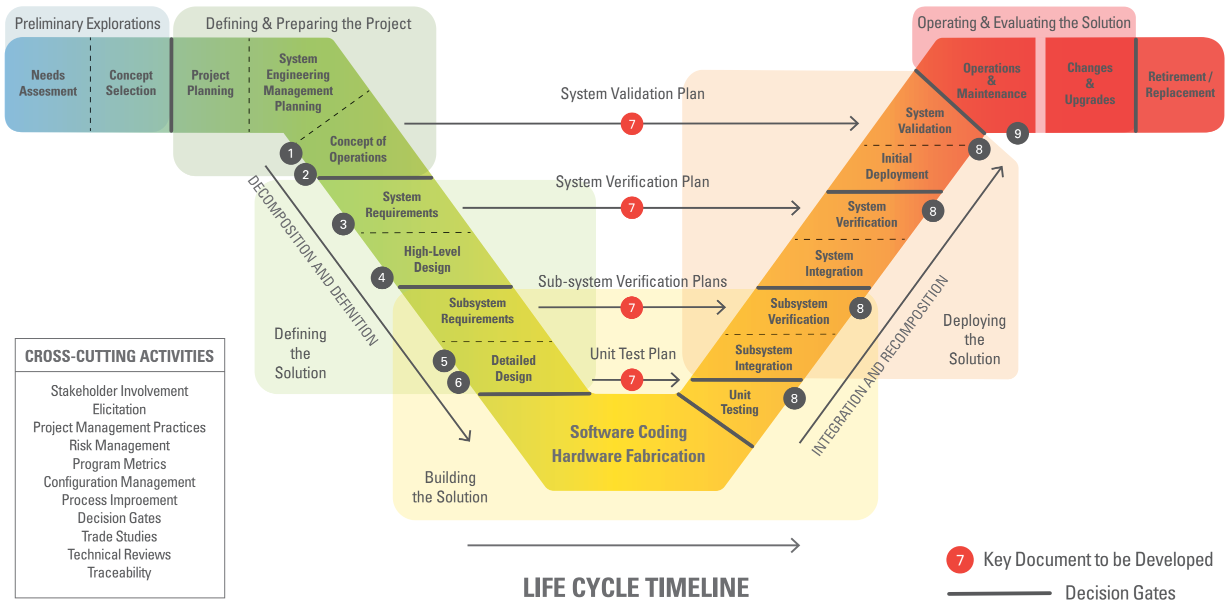


Figure 1.21 Systems Engineering

9. **Operations and Maintenance (O&M) Plan:** Document describing how the finished system will be operated and maintained.

To support knowledge and technology transfer efforts, all systems engineering documentation will be developed with the intent to share publically and be formatted for Section 508 compliance.

1.9 Safety Management Approach

San Francisco places priority on safety for all projects. Implementation of connected and automated vehicles involves unique challenges in regards to public safety, liability, and public acceptance. We will develop a detailed safety management plan as a part of the planning process and closely monitor the safety aspects as we design, test, implement, and evaluate the systems. This document will be critical to the pilot's success, and we will get inputs from key partners who bring extensive experience with safety considerations on roadway and public transit projects and in the connected and automated vehicle environment. San Francisco will work closely with USDOT on lessons learned from other CV and AV pilot deployments, specifically with the ongoing Connected Vehicle Pilots (Tampa, New York, and Wyoming) as we develop and implement a robust safety management plan.

As a part of the safety management plan, we will develop safety scenarios for the solutions and technologies during the design and testing phases. These scenarios will help identify safety needs and considerations. For each scenario, we will develop potential mitigating actions, taking into account likelihood and potential impacts.

The safety management plan will identify safety risks by adopting standard safety practices, such as ISO 26262 and Automotive Safety Integrity Level hazard analysis and risk assessment. In the safety management plan, San Francisco will establish and define the methods, processes, and organizational structure to meet safety goals. These processes will build on the procedures that we currently use for city operations and will consider how connected and automated vehicle strategies deployed as part of the Smart City demonstration may affect those processes. As the demonstration plan will use human participants, we will obtain Human Use Approval from an accredited Institutional Review Board.

San Francisco will prepare and submit a draft safety management plan to the USDOT for review upon award of the Smart City Challenge grant. We will implement the safety management plan during the deployment and continuously evaluate the effectiveness of implemented risk control strategies.

1.10 Communications and Outreach Approach

The Communications Plan encompasses both community engagement and a number of other critical activities.

1.10.1 Community Engagement Plan

The Community Engagement Plan seeks to bridge the gap between theoretical policy making and popular, community-driven solutions because average residents should define the changes they want. Giving all residents new forums will nurture the next generation of mobility advocates who will champion the Smart City approach beyond San Francisco. With this bottom-up approach to developing a Community Mobility Challenge, a user-friendly application process is a must. Private partners and SFMTA may be working behind the scenes to establish the infrastructure and develop the automotive technology, but in-depth experience is not required to identify a solution to a widely acknowledged community challenge.

The crowdsourcing platform and in-person meet-ups will help develop proposals in a democratic way to ensure the fullest ideas make it to the application stage—and only those with demonstrable community support.

The purpose of our Smart City communications plan is four-fold as described below:

- **Grow awareness and understanding**: Communications efforts will increase public awareness of the problems.
- **Build engagement:** Outreach efforts will help get residents to express how to transform the way we get around. Our work will only succeed if San Franciscans believe it is in their and the City's best interest.
- **Improve operations:** The Smart City implementation will introduce many new technologies. Educating residents and ensuring they know what the changes are and how to incorporate them into their daily lives will be necessary. Careful consideration will be given to how we will notify people about developments in their neighborhood. Because these are pilot programs, we will always have contingency plans for unlikely but potential scenarios.
- **Share lessons learned:** Knowledge transfer among professionals will ensure that the investment in San Francisco does not just improve one city but will also improve many cities. We will share what we learn to improve cities and prepare the workforce of the future.

Community engagement will target the general public, including monolingual, non-English speaking communities; advocates; merchants and local businesses; media; and labor and delivery companies.

1.10.2 Communication Plan Support Activities

The Communications Plan is essential to informing and engaging the public, monitoring public opinion, and ensuring documentation and sharing of lessons learned. UC Berkeley will perform the following elements: 1) Public Outreach and Opinion, 2) Climate and Equity Stakeholder Engagement, and 3) Knowledge Transfer.

1.10.2.1 Public Outreach and Opinion

The public relations and outreach needs for the grant are immense. UC Berkeley will provide portions of the outreach activities, working in consultation with the City to engage the public and understand public opinion. The data for hypothesis testing related to the Community Mobility Challenge will initially come from focus groups and the Community Mobility Challenge website itself. Focus groups will inform the website, which will collect data from participating residents. Public opinion surveys conducted three times per year will test the name recognition of the Community Mobility Challenge and the approval rating of the Community Mobility Challenge citywide and in the particular neighborhood that submitted the winning application. In Years One and Two, public opinion surveys will test the recognition and approval ratings of the pilots/demonstration projects themselves.

These activities will occur throughout the grant period, with emphasis on outreach activities in Year One, and additional polling in Years Two and Three.

1.10.2.2 Climate and Equity Stakeholder Engagement

UC Berkeley's Technology Transfer Program, in partnership with the National Resources Defense Council (NRDC), will convene stakeholder engagement on climate and equity via an advisory group. The rise of the tech economy has undeniably altered the social equity landscape in San Francisco and the surrounding region. This effort will directly tackle the social equity and climate impacts of Smart City Challenge outcomes. Doing so would break away from traditional planning approaches that silo transportation from its impacts—typically to the detriment of our environment and disadvantaged communities, including low-income communities, communities of colors, and those with disabilities. We will establish an Advisory Group comprised of community-based organizations, groups focused on social equity, and environmental organizations that would convene on a quarterly basis. NRDC has successfully used this approach in its ongoing study with Uber and Lyft examining the climate impacts of ridesourcing and with a state-funded pilot focused on electric vehicle car-sharing in low-income communities of central Los Angeles. The Advisory Board would be established in Year One and meet quarterly for the duration of the grant. The culmination of the Climate and Equity Advisory Group's work would be the promulgation of a series of environmental and equity performance metrics and policy recommendations that could inform the development of San Francisco's transportation-as-a-service platform and framework with publication not later than Year Three of the grant.

1.10.2.3 Knowledge Transfer

Technology transfer communication efforts aim to accelerate deployment and widespread adoption of the innovations and lessons learned through outreach, communications, and training. Activities will include development and dissemination of print and electronic communications; delivery of webinars, workshops, conferences, and other training programs; hosted demonstrations for other city representatives visiting San Francisco; marketing and outreach activities; representation at and participation in national forums; and site visits to cities considering implementation. A key aspect of the San Francisco Knowledge and Technology transfer will also be sharing lessons learned on strategic partnership and business models for accelerating innovation and bringing transformational change to how transportation is provided.

Written communications, in print and electronic formats, remains a mainstay of the technology transfer process. Publications will be produced jointly by subject matter experts and communications and graphic design professionals. Communications and marketing specialists will ensure that those publications reach their target audiences. Information specialists (research librarians) will ensure that all reports and publications are electronically archived and accessible internationally. Deliverables will include quarterly updates and topical briefs produced on an ad hoc basis reporting on the various implementation and research outcomes.

Training, workshops and conferences are an effective way to share the latest research results; incubate new ideas; and encourage collaboration among researchers and government, industry, and academia. We will host demonstration events so other cities may learn from city staff, partners, and stakeholders, through presentations, walking tours, and other on-site activities. Outreach efforts at events hosted by other organizations provide opportunities for presentations, exhibiting and one-to-one contact with potential adopters. We will conduct webinars on a quarterly basis, and release video updates as project milestones are reached. Tech Transfer will host one large-scale conference at the end of the project with cities invited from around the nation and world to demonstrate and disseminate lessons learned, foster collaboration among government, industry, and researchers and encourage implementation elsewhere.

High tech skills, such as data science, information management (collection, intellectual property, privacy, security), and analysis and visualization of big data for decision-making, will be important to the workforce of the future. Beyond skills, smart cities also require smart organizations. Siloed

POETS Public Participation Spectrum

INCREASE IMPACT ON THE DECISION →

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision. We will seek your feedback on drafts and proposals.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will work together with you to formulate solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 1.22 Public Outreach & Engagement Process (POETS) Public Participation Spectrum

organizations are a barrier to truly smart cities that need to integrate systems, people, and processes to make and implement data-driven decisions. Training will build skills and help workers not only work collaboratively within their organizations, but also across organizations, including public- and private-sector agencies and groups. Tech Transfer will support the City in development and delivery of training modules based on lessons learned in Year Three. One key component of UC Berkeley's knowledge transfer efforts will be conducted in partnership with the NRDC through a Smart Cities Exchange.

Smart Cities Exchange: By initiating the Smart Cities Challenge, USDOT and Vulcan Philanthropy have uncovered latent demand for resources to create innovative public-private partnerships to solve urban mobility challenges. USDOT/Vulcan's key challenge is how to leverage the momentum generated after July 2016 when only one city is announced as winner and dozens still lack resources. The significant $50 million investment deserves maximum leverage. By investing in the City of San Francisco, the USDOT would initiate a concerted effort to build off of the momentum initiated by the Smart City Challenge.

The Exchange would be a central component of San Francisco's project as a vehicle to glean best practices and transmit shared learning to the other six Smart City Challenge finalists with a vision and intent to scale up to the other 71 applicant cities. The Exchange will be established in year one and would convene twice annually in San Francisco. The Exchange will create issue-specific working groups, a real-time information exchange, and publish white papers throughout the term of the grant. The Exchange's final deliverable will be the development of a policy guide based on San Francisco's learning throughout the Challenge to be created in concert with the needs of other cities.

The Technology Transfer Program at the University of California, Berkeley's Institute of Transportation Studies is uniquely positioned to conduct this outreach; they have already established their program as a premier source for technology transfer publications, professional training, expert assistance, and resources for public agencies. Topics of expertise include the transportation-related areas of planning and policy, project development, infrastructure design and maintenance, safety, and environmental issues for motorized and non-motorized roadway traffic.

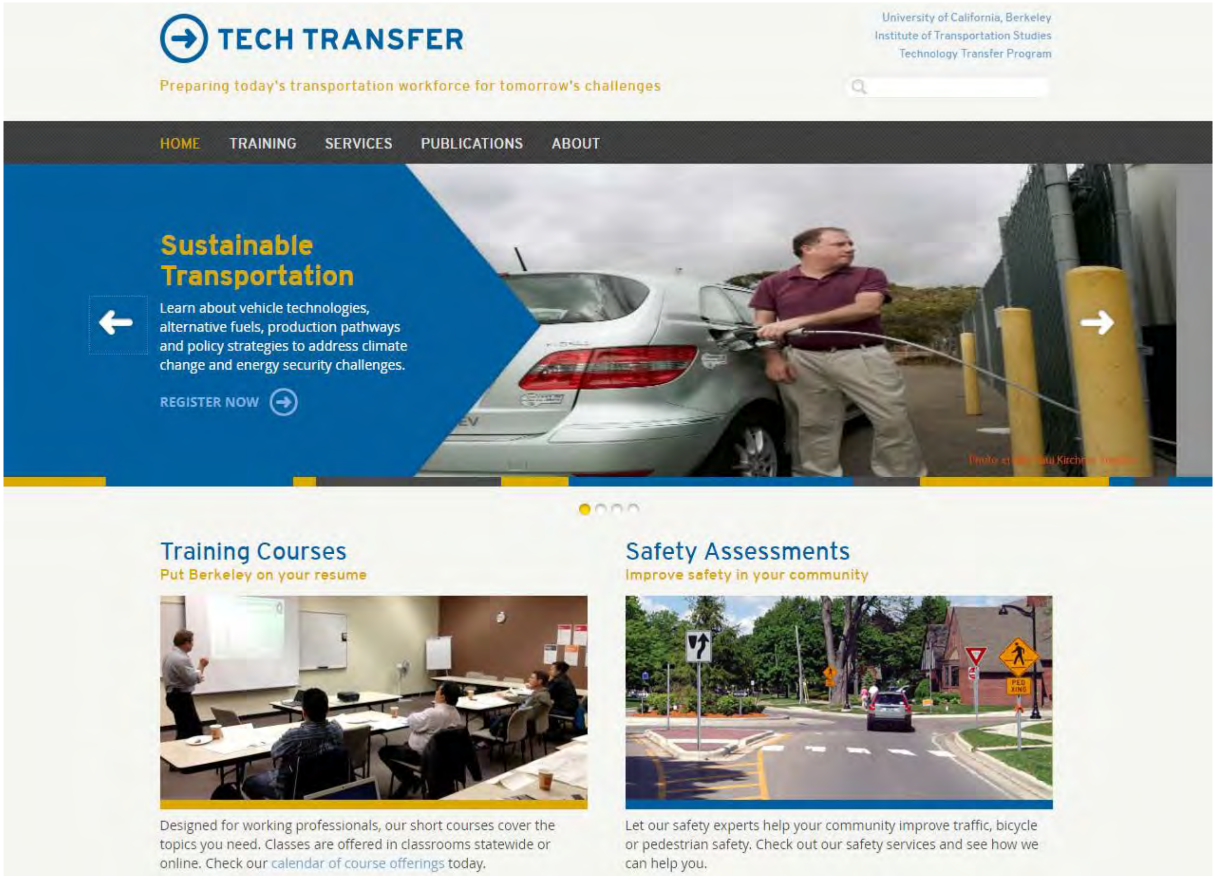


Figure 1.23 Tech Transfer Program

SECTION 2: DATA MANAGEMENT APPROACH

The Smart City Challenge deployment will usher in a new mobility era for San Francisco. The City will be empowered with an unprecedented amount of data from public and private sources. To capitalize on the power of data, we propose a Mobility Data Commons ("Commons") to reside at the heart of our project.

The Commons will be a partnership with the University of California, Berkeley, private companies and San Francisco to provide computational power, data and analytical tools. The data associated with this project will be voluminous, complex, and sensitive. Data will arrive in continuous streams. These factors, plus low latency and multi-tenancy requirements, means that the platform must provide scalable computing resources that ensure data harmonization and interoperability by adhering to master data standards. The Commons will meet these requirements by providing an ecosystem of loosely coupled complementary technologies consisting of data repositories, computing engines and analytical tools laying atop a highly performing operational data store. These technologies will allow users to manage and access data, computational resources, and software.

Data: At the heart of this ecosystem will be data repositories holding linked and unlinked data, data models (algorithms and parameters), along with data pipelines and workflows from both city-generated sources, as well as the private and research sector. A key requirement for this project is producing research grade data. This means that

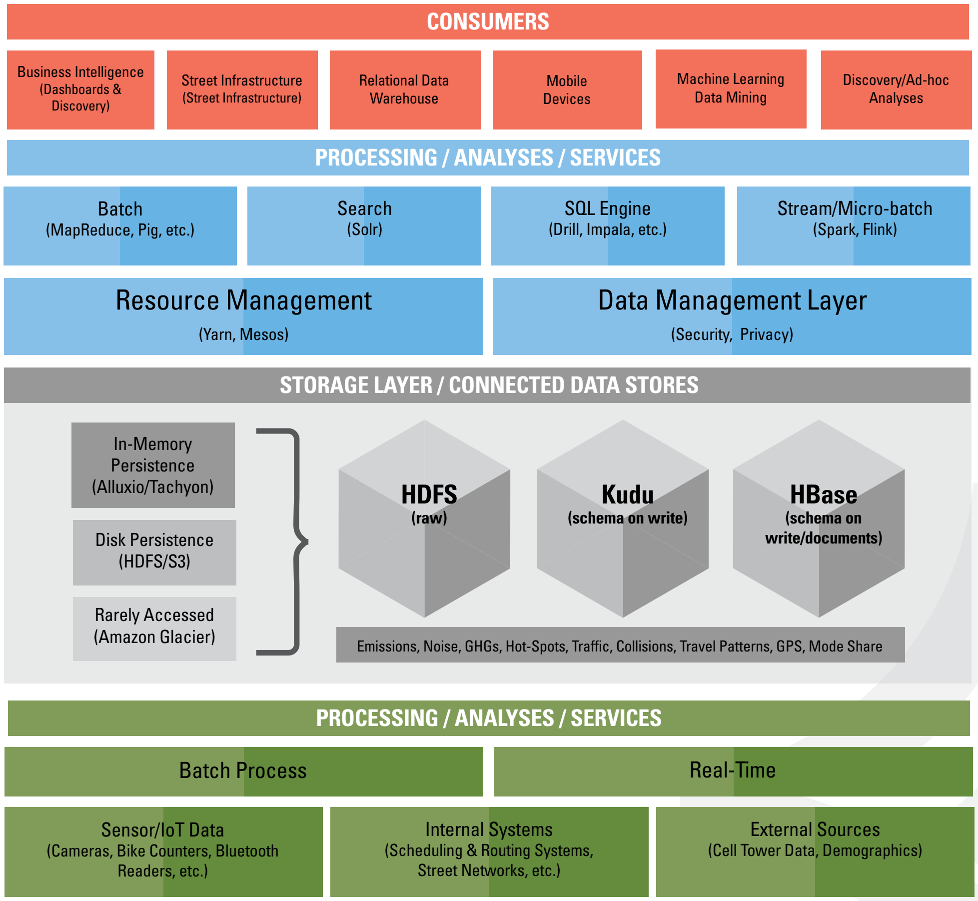


Figure 2.1 Data Platform

Data Category	Examples
Infrastructure	Street Network, Bike Network, Sidewalk, LiDAR, GPS, Parking, Signal Network, Fiber Conduit
Baseline	Pedestrian Deaths, Collisions, Congestion, Density, Travel Patterns, Noise, Parking Metrics, On-Time Performance, Road Conditions, Travel-Time, Origin-Destination Pairs
DSRC V2I and V2D	Signal Information, Road Work Zones, Safety Advisories, Weather, Recommended Speed Rates, Road Conditions, Driving Patterns
V2V	Routes, Passenger, Proximity, Interactions, Vehicle Events
Raw	GPS, Bike Lane Counters, Bike Share Kiosks
Transactional	Taxi, Bike, CAV Specific, Farebox, Parking Meter, Regional Agencies, Payment Systems (Clipper, Mobile Pay, TVM, etc.)
Processed/Semi-Raw/Computed	Origin-Destination Pairs, GPS Pairs, Cell Tower, Corridor Density, Counts Along Corridor, Parking Occupancy, SRCs/AVL/Radio (SFMTA)
Models	Parking Demand, Adjustable GeoFencing, V2I, Predictive Algorithms

Table 2.1 Examples of Expected Specific Data Categories

data from the Commons must support findings and results that are reproducible, and that the Commons itself must be capable of reproducing data. Additionally, data must adhere to standards ensuring interoperability within the Commons, as well as with external systems and programs, such as the USDOT's Dynamic Mobility Applications research program.

Computational Resources: USDOT's computational and memory demands by those accessing this ecosystem will vary. Some processes will require only desktop level power, while others will require multiple computer nodes for extended periods. The Commons must be capable of delivering scalable computing power against both in-memory and disk-bound datasets to suit various needs including real-time operational activities related to Vehicle to Infrastructure (V2I), vehicle to vehicle (V2V), and cars to devices, cars to infrastructure, and cars to vehicles (collectively, C2x), as well as research with lenient latency requirements.

Software includes both custom and vendor tools for facilitating the management, discovery, sharing, use/re-use of linked and unlinked data, data models (algorithms and parameters), and software, along with data pipelines and workflows. Software will also serve a critical role in ensuring interoperability with platforms adhering to DOT standards by harmonizing data and components within the Commons system.

2.1 Types of Data Produced and Expected Use Cases

Data in the Commons will include continuous real-time and event data from a variety of sensors, batch data from cell towers, traffic surveys, bike counters, INRIX travel times, Waze reports, and research or compiled data from analysis and modeling. Examples of the expected specific data categories can be found in Table 2.1 (above).

This data, as well as data from other non-transit sources, including surveys, will support a variety of use cases, including:

- Assess performance against outcomes and goals for the grant, including mobility, safety, affordability and access (e.g. coverage by type)
- Demand forecasting and validation
- Analyze various patterns of use: shared, delivery and multi-modal
- Support specific research proposals and pilots as part of the Smart City Challenge grant
- Support real-time operations management and measure the impact of real time system changes (e.g., changes to digital signage or DSRC beacons)

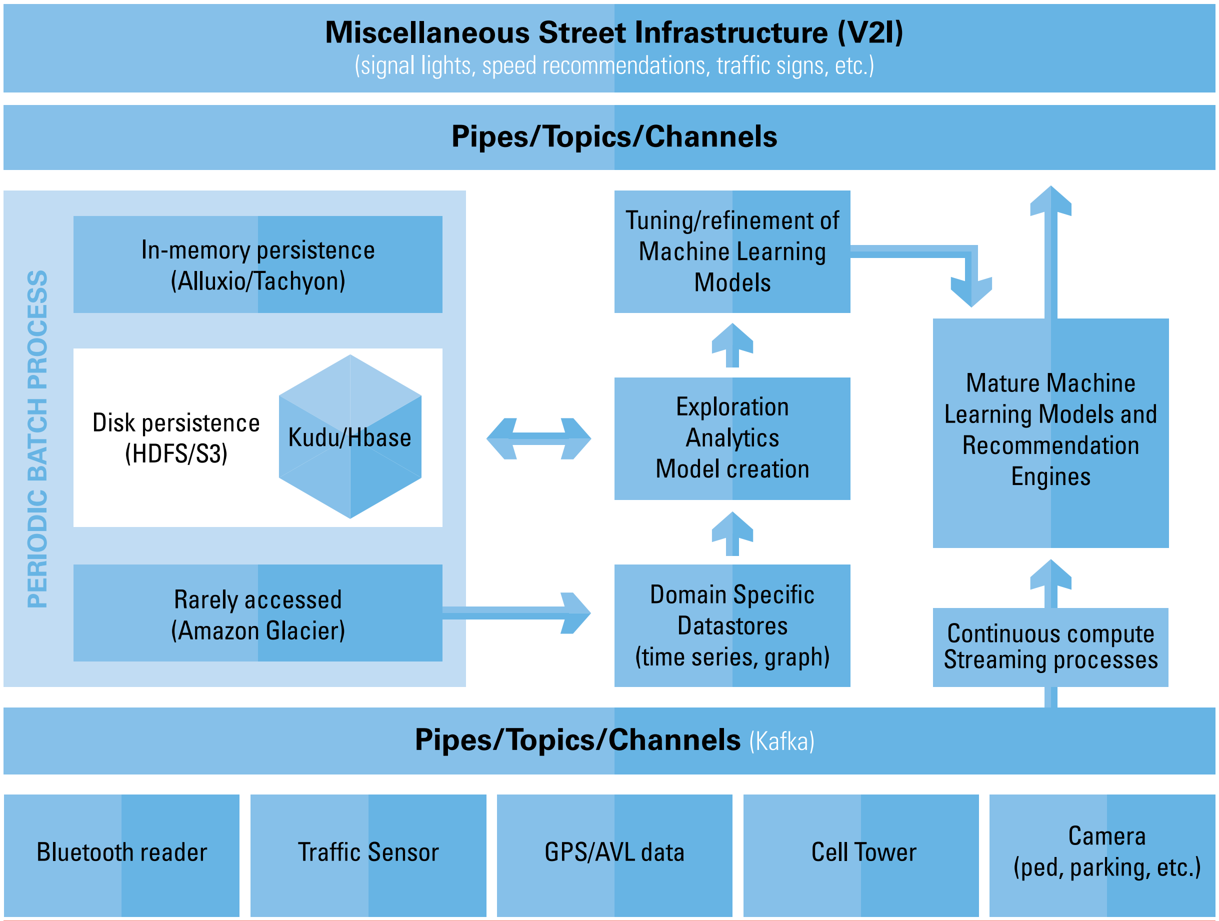


Figure 2.2 Data Flow for Monitoring and Affecting Surface Movement

- Support assessment of structural changes (e.g. bulb-outs) to surface movement
- Integrate with other city operations or analysis (e.g. ambulance and police deployment, street repair, and environmental monitoring)

2.2 Architecture and Policies for Re-Use, Re-Distribute, and Derivative Products

The architecture of the Commons allows for the management, discovery, sharing, use/re-use and general consumption of data and derivative products from a range of industries, frequencies, sources, and structures. The architecture also provides for real-time data flow, operations and a multi-tenant repository for post hoc data access and use.

We will create a framework for ensuring that new data collection methods do not create unnecessary threats to privacy, i.e. the individual's ability to move throughout the City without being centrally tracked. Ensuring this approach requires both strong governance and community input. Our existing drone policy can serve as the foundation for this work. The basic data flow consists of:

- Sensor data pushed to a receiving area
- Sensor data processed and pushed in one of two paths:
  - Path A – data fed to existing recommendation engines/models. Recommendation results are fed to surface infrastructure (e.g., signs, V2I/C2x equipment)
  - Path B – data fed to a persistent storage layer for tuning/model creation/hypothesis testing
- Batch data are received and fed to a persistent storage layer for tuning/model creation/hypothesis testing
- Results from all paths are fed to the persistent storage layer for re-use

After ingress, data are stored in a cloud-based data repository and made accessible to multi-node computation engines and an array of analytical and data management software. However, data access will be standardized via an Application Program Interface (API) and a streaming gateway. Both the API and gateway will be well-documented and open for public use. The repository is fed through an extraction, load and transformation layer that consumes, standardizes, and links data in the repository. This will also allow for the provision of data from data sources not traditionally combined with transit. Data standardization will allow us to more easily integrate data and simplify use of data in the Commons without necessarily having to make costly changes to source, often legacy, systems.

A mix of data tools for mapping, visualization, and query generation will make the repository more accessible to a wider, less technical audience. For the Commons to reach its full potential, policy makers, community groups and advocacy groups must be able to leverage the data. User-friendly data tools, supported by UC Berkeley's Massive Open Online Courses education program in Data Science will help expand the number and type of users.

Ultimately, the Mobility Data Commons will foster a range of data-driven products from user facing consumer apps to research papers to operational management and insights. New companies will leverage both the insights from the research and the unprecedented combination of data to incubate and build new business models.

2.3 Privacy and Security Framework

To manage the volume of data in the Commons we will develop a principle and risk-based approach. For each lifecycle phase, we will define a set of principles, related requirements and implementation procedures. A risk-based approach will help us consistently balance the privacy risks with the benefits expected from collecting and using the data. A principle and risk-based approach will allow us to accommodate a wide range of requirements governing data in the Commons.

2.3.1 Overview of the Data Lifecycle

Defining a data lifecycle helps us consistently manage data in the Commons. Below is the basic dataset lifecycle that we will use.

- **Plan:** Identify business needs and anticipated uses to define the dataset requirements and supporting specifications.
- **Produce:** Ensure the dataset is collected, created or procured per enterprise and dataset requirements, including data quality specifications.
- **Manage:** Ensure the dataset is stored in an appropriate environment, is maintained per requirements and is backed up as appropriate.
- **Access and Use:** Make the dataset available via appropriate channels, including enterprise data systems and publication, where appropriate. Establish feedback cycle to further support user needs.
- **Archive and Dispose:** Archive the dataset as needed and dispose of properly when no longer in use or as specified by retention schedules

2.3.2 Privacy throughout the Lifecycle

Table 2.2 outlines sample privacy principles and requirements for each phase. Upon award, this framework will be developed into a full plan as specified in the Smart City Challenge NOFO.

2.3.3 Privacy Risk Model

Underlying the lifecycle framework is a risk-based approach to assessing, selecting, and implementing privacy controls. Given the range of expected pilots, we will follow a basic process to develop a privacy and security plan for each project: assess risk, select and implement controls, then continuously monitor and assess. In each case, we will assess three primary privacy risks posed by the Mobility Data Commons:

- The unauthorized access or disclosure of private information collected and stored in the Commons
- The use of public data to re-identify individuals when the data is intended to be anonymous
- The reduction in autonomy privacy posed by sensor based data collection methods

Phase(s)	Privacy Principle(s)	Sample Requirement(s)
Plan and Produce	• Collect only what is necessary or authorized • Be transparent about the data collected and intended use and disclosure (data agreements and human subjects processes) • Design for quality and collect directly from the subject when possible • Incorporate privacy risk into the design	• Define the purpose for collecting the data • Identify and develop any notice, consent, and authorities needed • Develop a process or identify a POC to address privacy related questions/concerns • Develop a privacy assessment and plan
Manage	• Take reasonable steps to check accuracy of data, including identifying errors and omissions • Ensure data are protected at rest and in transit	• Develop a process for data to be corrected on an ongoing basis • Encrypt at rest and in transit where feasible
Access and Use	• Provide access to only those who require access to perform their job duties • Use the data in a way that is consistent with what the subject would expect • Each subject should have access to their own data and the opportunity to correct it • Ensure that induced disclosure is legally necessary	• Collect use cases during the design stage • Develop a process to assess new use cases • Provide access to subject data only if required for use case • Develop a process for subjects to request, access and correct their data • Develop a process to assess and respond to legal requests
Archive and Dispose	• Retain subject data only as long as required • Ensure subject data is protected during archiving and disposal	• Develop and implement retention schedules • Securely archive and dispose of data

Table 2.2 Sample Privacy Principles and Requirements

Information Security: The City will work with UC Berkeley to ensure that the information security framework is consistent with University of California Information Security policies as well as City policy. By leveraging a principle-based framework, we can incorporate diverse information security frameworks, including NIST, ISO and UC policy and the foundational objectives of confidentiality, integrity and availability.

Open Data Privacy Framework: In the case of open data derived from individual information, risk is primarily a function of likelihood of re-identification and impact.

Privacy Risk = *Likelihood of re-identification X Impact.* Likelihood in this risk equation is inherently uncertain given the volume of both public and private data, changes in computing power and statistical techniques as well as motivation and ability. Impact is also uncertain given shifting social values related to privacy and data disclosure. The City is already in the midst of developing a comprehensive framework for evaluating and mitigating open data privacy risk, with input from Harvard and UC Berkeley Law Schools.

Autonomy Privacy: The collection of new forms of data via sensors poses policy questions around the shrinking scope of private behavior and action. We will create a framework for ensuring that new data collection methods do not create unnecessary threats to the ability of individuals to move throughout the city without being centrally tracked.

2.3.4 Privacy Governance and Community Engagement

To implement and govern the privacy process, we will leverage our existing open data privacy review processes, as discussed above. However, we recognize that the unprecedented level of data as well as the new sensor-based sources we expect in the Commons requires an additional level of oversight. We propose a Privacy Board to sit within and report to our overall governance structure. This Privacy Board will:

- Oversee the development of a detailed privacy framework
- Recommend to the overall governance board approval of the privacy framework
- Oversee ongoing implementation of the privacy framework

Establishing clear authority and governance via the Privacy Board demonstrates that privacy concerns have primacy in the design and operations of the Mobility Data Commons. The Privacy Board will be comprised of high-level representatives from the City and research and private partners with direct access to executive level decision-makers.

2.3.5 Privacy Governance and Community Engagement

As part of the creation of new data sources and sensors we will establish a community engagement process to communicate the proposed data collection, the benefits and the intended protections. Stakeholders will come from neighborhoods, advocacy groups, planners and representatives. An active community engagement process will both address concerns and mitigate unexpected delays up front due to backlash.

Licensing of data in the Mobility Data Commons is key to realizing the full potential of the data partnership. Lack of clarity in licensing or overly strict license practices can constrain the ability to leverage data for broader use, including derivative works and services. A patchwork licensing approach can result in: 1) interoperability between licenses, limiting the ability to blend and leverage data under different licenses, 2) attribution stacking (the need to cite multiple attributions) which can become burdensome to manage and practically challenging to implement, and 3) share-alike provisions that impose extra burden, limiting the ability for smaller organizations to participate.

For City generated data, we have already adopted a citywide licensing standard—Open Data Commons Public Domain Dedication License. This license optimizes use of City data by limiting common licensing issues as discussed above.

For private and research data, our licensing framework will seek to openly distribute data consistent with our city licensing standard. For the balance of data, whether due to concerns over privacy, intellectual property or rights in data, we will develop a framework using the following principles:

- Foster use of the data in the Commons
- Encourage reuse and derivative works
- Limit compliance complexity and support ease of use
- Account for the specifics of licensing data versus other forms of content
- Protect private rights while balancing public benefit

In practice, we will likely implement this through a process requiring non-City contributors to the Mobility Data Commons to select from a limited set of licenses consistent with our principles.

2.4 Current Data Collection Effort

The City's data infrastructure is ready to support the different deployment applications. A suite of sensors currently provides real-time information to several sub-systems including California's Performance Measurement System and Bay Area 511. The City intends to expand its current sensor deployments to more roadways citywide. San Francisco recently announced creating a large Internet-of-Things platform that aims to bring in data from a variety of urban sensors including energy and transportation sensors to the open data platform. We will build off this initiative for the Smart City vision. "DataSF" will eventually be an integrated data clearinghouse that serves as:

- A one-stop place where all the data is accessible to users without registration and in a machine-readable format
- A developer portal that provides real-time, searchable methods to build applications. The system will also expand the scope of analytic tools to anything that the developer community can think of.
- A portal for assessment and evaluation logs for interested residents to conduct independent analyses.

The open data hub (depicted in table 2.3) will be devoid of any personally identifiable information. The data hub will also only hold aggregate data from certain sensors to improve privacy and security.

The SFMTA collects a multi-modal data set to create a total picture of travel with the City's right-of-way, including transit and parking demand, vehicle velocity, and multi-modal travel origin and destinations, as well as safety measures including

City Data Informs Transportation Operations: Land Use, Development, Demographics, Economic Development			
Public Safety	Human Services	Public Transit	Public Works
• Vision Zero High Injury Network • Transbase Public Health Database	• SF General Data SFPD Collisions Data	• Routing • Passenger Counts • Transit Signal Priority • Waze Traffic Data • Routing of Services	• Pavement Database • Construction Updates • Street Closures
Transportation data integrates with city data: SFPark parking management system (including meters and parking garages), transit fare systems, transit passenger counting, bicycle and traffic counters, incident management and a variety of GPS vehicle tracking including transit vehicles, non-revenue vehicles, taxis, and commuter shuttles.			

Table 2.3 Open Data Hub

collision analysis. These datasets form the basis of a citywide and public sharing data network including partnerships with the Mayor's Office of Civic Innovation's public data sharing platform and the Department of Public Health's TransBase system, which offers analysis of health and safety impacts of transportation in an open geospatial data portal.

An integrated intelligent transportation system could improve transit and traffic operations through real-time dynamic scheduling and real-time incident routing. The data system and platforms can leverage and further the goals of the SFMTA's Transportation Management Center, a state of the art facility poised for dynamic monitoring and management of the transportation network. SFPark's public datasets and evaluation forms a template for the way municipal data can further academic research and empower development of private sector applications. The program followed the City's lead as one of the first to pass an open data law, which continues to serve both academic research and the City as a hotbed of civic innovation.

2.5 Data Policies and Partnerships

San Francisco will employ a data classification policy and system compliant with standards. Data will be classified based on its level of sensitivity and potential impact. This will apply to both data that is collected directly by the City as well as data that is shared with the city from third parties, such as private sector companies sharing their proprietary data with the City for research and operational purposes.

The data platform has the potential to handle personally identifiable information from a variety of city and private data sources. We will establish a framework that categorizes identified people and objects related to stored data, and maps them to public and private spaces. This framework will be used to guide the collection and management of data as either default open, available for limited access, or default closed.

Our partnership with UC Berkeley will allow us to add private data to the Commons. UC Berkeley's history of working with mobility providers, and preparing data procurements for the California Department of Transportation positions us well to develop the trust required to encourage private data sources to contribute. To codify private participation, we will develop a data contribution scheme to define levels of data access.

Developing comprehensive mobility data will fuel a more holistic discussion and analysis of travel patterns for shared modal and multi-modal trips. It will also help us achieve our ultimate goals of improving safety, enhancing mobility and opportunity, and addressing greenhouse gas emissions.

SECTION 3: MANAGEMENT APPROACH

3.1 Program Management and Team Organization

The Smart City Challenge will be implemented through an organization administered by the SFMTA, in partnership with UC Berkeley, and a to be determined program manager.

Our management and staffing approach, represented in Figure 3.1, will establish and maintain clear communication with the USDOT and all project participants. The SFMTA will work in close collaboration with UC Berkeley and other partners to ensure timely and accurate completion of all project tasks and delivery of all required deliverables and reports. A primary tenet of our approach is a flat organizational structure with clearly established roles.

Many administrative, fiscal, and contracting responsibilities will be centered at SFMTA, as the Consortium's Operating Agent and prime awardee, with subawards to UC Berkeley and other partners for various roles. SFMTA and UC

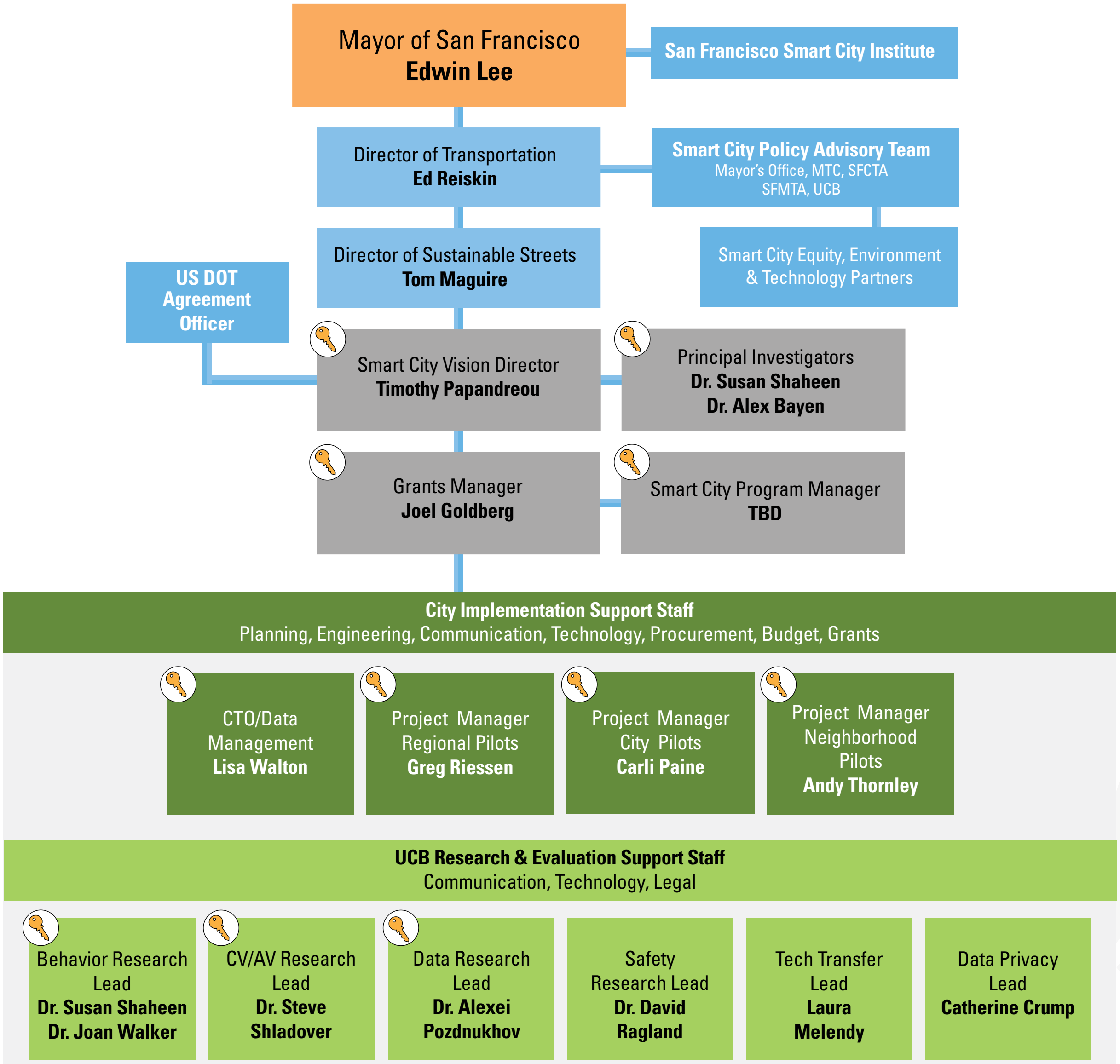


Figure 3.1 Management and Staffing Approach

Berkeley each have an extensive track record in organizing, leading, and managing large, complex transportation projects with many participants (see Section 5 for more information).

As shown in the organizational chart, the team will be led by SFMTA's Tim Papandreou, who will serve as the Smart City Vision Director, and Professor Susan Shaheen, who will serve as the Co-Principal Investigator (lead) along with Co-PI Professor Alex Bayen. Mr. Papandreou will work closely with the SFMTA Grant Manager (Mr. Joel Goldberg) and a "to be selected" Smart City Program Manager from a General Management/Consultant firm (within two weeks after the grant award). Provided below is a brief description of the key roles.

Smart City Vision Director: Mr. Papandreou of SFMTA will serve as the Smart City Vision Director and provide strategic vision for the execution of the Smart City Challenge grant. Specifically, he will work closely with the technical and management teams to ensure that deployment projects are designed and deployed in an integrated way to meet the Challenge's safety, mobility, climate change, equity, and the ladders of opportunity goals. He will also lead the external Technology Partner's engagement and will work closely with the Mayor's office to commit the resources needed for the successful execution of the project activities. Mr. Papandreou will provide thought leadership in shared mobility, complete street pilots, and integrating connected and automated vehicles into City transportation networks. He will also play a lead role in the Smart City Institute on behalf of SFMTA. The Smart City Vision Director will coordinate with the communication and public outreach team that will be led by the City's Director of Communications and will include representatives from the Mayor's Office, Office of Innovation, and supporting contractors and non-profits as they are integrated into the program.

Grant Manager: As the Grant Manager, Mr. Goldberg will lead all the procurement activities (including capital procurement) and subcontractor management. He and the SFMTA Capital Finance Section will be responsible for reviewing and sending invoices to USDOT and submitting the monthly and quarterly progress reports. He will work closely with USDOT on all contractual issues in a proactive manner and resolve them quickly. He will identify and commit the internal resources needed to execute the grant. Mr. Goldberg will be directly accessible to USDOT to provide any updates, as needed. He will work closely with the Smart City Program Manager (see below) to monitor project risks and to support the overall management and execution of the grant. The Grant Manager will work closely with San Francisco Public Works and the Mayor's Office of Innovation and manage the grant funds through the City Manager's office.

Smart City Program Manager: The City will appoint a single Program Manager (PM) with strong project management credentials (e.g., PMP certified) from an outside firm to be responsible for executing day-to-day activities of the deployment. The PM will work very closely with the Grant Manager to manage resources. The PM will ensure that tasks are completed on time, will be responsible for oversight, and will have the authority to make changes to the pilot project activities in consultation with SFMTA, UC Berkeley and other partners. The PM will also have decision-making authority over major operational and administrative issues. The PM will work closely with the Smart City Vision Director to provide formal updates at monthly Smart City Policy Advisory Board meetings. The PM will work closely with the technical leads to assess, identify, assign, and mitigate the project risks. The PM will be also responsible to maintain quality control, using a Quality Control Plan to be integral to the Project Management Plan.

Co-Principal Investigator (Lead): Professor Susan Shaheen will serve as the Technical Lead/Co-Principal Investigator and provide overall technical guidance for the project. She will work closely with Professor Alex Bayen who will serve as the Co-Principal Investigator. Overall UCB project oversight, contract management, reporting requirements, invoicing, and cost management will be conducted by Professor Shaheen's team at the Transportation Sustainability Research Center (TSRC). The behavioral and equity impacts design and evaluation will be conducted and managed by her with support from Professor Joan Walker. TSRC will also oversee the Tech Transfer team's activities. The Co-PI will work closely with the PM to ensure quality control for all the deliverables, as well as the Smart City Vision Director. She will also play a lead role in the Smart City Institute on behalf of UC Berkeley, as a founding partner in the laboratory. The Smart City Institute will manage the technology partners that have committed support for the pilot projects.

Co-Principal Investigator: Professor Alex Bayen will serve as the Co-Principal Investigator and will work closely with Professor Shaheen (lead Co-PI) in overseeing the technical delivery of the deployment projects, contract management, reporting requirements, invoicing, and cost management. Professor Bayen also will assist Professor Alexei Pozdnukhov in managing and providing oversight for the data analytics and Mobility Data Commons architecture. Finally, he will play a lead role in the Smart City Institute on behalf of UC Berkeley.

Technical Leads: Professors Susan Shaheen and Alex Bayen will be supported by a strong group of technical leads. The connected and automated vehicles design and analysis will be managed by Dr. Steve Shladover of California Partners for Advanced Transit and Highways (PATH). Dr. David Ragland at SafeTREC will design and manage the safety impacts research and analysis. Catherine Crump of the Berkeley Law School will manage the data privacy analysis. Ms. Laura Melendy will lead the Tech Transfer components of the project, including a subcontract to the Natural Resources Defense Council (NRDC). Ms. Amanda Eaken will lead NRDC's role in climate and equity stakeholder engagement and knowledge transfer. Numerous postdoctoral researchers, graduate student researchers (GSR) and undergraduate students will provide support throughout the project.

Pilot Leads: As previously discussed, the Smart City deployment proposal consists of three main Pilot Scales (Regional, City and Neighborhood). Given the number of deployment activities that will occur across the three pilot scales (there are 16 pilot projects in the proposal), we will have individual pilots leads for the regional, city, and neighborhood-focused deployments. The three leads, all SFMTA employees, will work closely with the overall Program Manager and the Grant Manager. Having separate project leads for the three deployment scales will be more effective in managing the stakeholder community across the three deployment scales. Mr. Greg Riessen will serve as the Regional Pilots Lead (seven pilot projects). Ms. Carli Paine will serve as the City Pilots Lead (five pilot projects), and Mr. Andy Thornley will serve as the Neighborhood Pilots Lead (four pilot projects). The Pilot Leads' primary role will be to manage the pilot deployments using an integrated portfolio management approach, so that the synergies among the different pilot projects are maximized and schedules are properly managed.

In addition to the Pilot leads, the team will be led by industry experts for each of the key technical areas including: 1) Data Management (Lisa Walton); 2) Behavioral and Equity Analysis (Professor Susan Shaheen, with support from Dr. Joan Walker); 3) Connected and Automated Vehicles (Dr. Steve Shladover); Data Research (Professor Alexei Pozdnukhov, with support from Professor Alex Bayen); Safety Analysis (Professor David Raglan); and Data Privacy Analysis (Professor Catherine Crump). Pilot and Technical leads will ensure that work in their respective projects is progressing at a sufficient pace to meet or exceed the management plan. They will be expected to challenge their teams as they report the results of the Smart City Challenge projects.

Policy Advisory Board (PAB): A Policy Advisory Board (PAB) will meet throughout the duration of the project to provide any needed support and recommendations related to policy and regulations to execute and deploy our proposed vision. This board will consist of the San Francisco Mayor's Office representative, the UC Berkeley Chancellor's Office representative, and SFTMA representative. The function of the PAB is to review and make recommendations to the Smart City Institute Director, research leaders at UC Berkeley, and the USDOT. The PAB will pay particular attention to the integration of the pilot projects funded directly by the Smart City Institute via the technology partners. The primary duties of the PAB are to provide policy and regulatory guidance to the PMO Lead, Smart City Vision Chief, and the technical team, as necessary.

Climate and Equity Stakeholder Advisory Group: UC Berkeley's Technology Transfer Program, in partnership with the Natural Resources Defense Council (NRDC), will convene a Climate and Equity Stakeholder Advisory Group to provide support to the pilot projects and the evaluation. This effort will directly tackle the social equity and climate impacts of the grant to address the full spectrum of its impacts. We will establish an Advisory Group, led by Amanda Eaken of NRDC, made of community-based organizations, groups focused on social equity, and environmental organizations that will hold quarterly meetings. The Advisory Group will be reflective of San Francisco's rich cultural diversity and history of environmental activism. The culmination of the Climate and Equity Advisory Group's work will be key environmental and equity performance metrics and policy recommendations as a result of the pilot projects, as well as the publication of a best practices guide.

3.2 Project Management Processes

San Francisco's management approach is based on the Project Management Institutes' Project Management Body of Knowledge. This approach enables us to provide the USDOT team with timely delivery of innovative, flexible and compliant services. Most importantly, our approach allows the Agreement Officer Representative (AOR) to easily work with the San Francisco team to modify the statement of work, resources, budget and schedule at any time.

The overall management of the project involves several key functions: monitoring daily progress, conducting interim performance reviews, and reviewing deliverables. The Smart City Program manager and other technical leads will interact periodically with staff to ensure proper and timely execution of tasks and review all deliverables. Best practices and procedures will be applied to efficiently monitor and evaluate work deliverables.

After execution of the cooperative agreement, the program manager and key technical team will conduct a kickoff meeting in Washington, DC with the USDOT's AOR to ensure that all parties have a common understanding of the AOR's requirements and expectations. By the kickoff meeting, we will have obtained consensus on our proposed work plan and detailed approach to accomplishing the key project deliverables. Our proposed work plan will include project scope and task descriptions, deliverables and schedule, management and staffing plan, and other relevant information. We will submit the meeting minutes within a week of the kickoff meeting.

The program manager and the team partners will prepare a Program Management Plan that describes the activities required to perform the work, per current guidance. The purpose of this plan is to detail the management and technical approaches to executing the project.

The Program Management Plan is the primary planning document for the project. It establishes the structure and controls for making management and technical decisions in the project, prioritizing project resources to meet project goals and objectives, and maximizing stakeholder buy-in for project deliverables. The plan will also describe in detail the objectives and methods to execute the scope of work on schedule. Specifically, this plan will contain sections describing a Scope Management Plan, a Schedule Management Plan, a Communications Management Plan, a Cost Management Plan, a Quality Management Plan, Configuration Management Plan, and a Risk Management Plan.

Scope Management: To make sure all required actives are fulfilled, the project plan will be shared, reviewed with, and approved by the AOR regularly to obtain concurrence on the scope of all scheduled project activities. Changes to the project will be brought to the regularly scheduled meetings with the project team and AOR, to confirm and achieve consensus on any impact to the project scope.

Schedule Management: The Program Management Plan organizes project activities, milestones and deliverables into a comprehensive plan and detailed schedule. There may be several challenges in executing this project. Thus, as the plan is finalized, specific key dependences within the plan and critical paths will be identified. Those elements will be discussed with the AOR and the technical staff to ensure they are aware of these dependences and that they are on track to meet key milestones.

A delivery schedule will guide project execution. The schedule will be refined in consultation with the USDOT and submitted with the final Program Management Plan. Upon finalizing the schedule, the final schedule will be provided in Microsoft Project and PDF format.

Project expenses will be tracked at a task level and the actual expenses will be constantly checked against the planned expenses for that task. Any significant variation will be discussed with the AOR and a corrective action will be implemented in a proactive manner.
Microsoft Project will be used to plan the project schedule, and Microsoft Excel to plan project budget allocation. The team has the tools for tracking project schedule, technical progress, and spending, These tools include formal, automated program manager reports that itemize all labor and costs by subtask; program manager access to monitor electronic time sheets at any time; and formal, required, bi-weekly project reviews that include the program manager, principal and contracts staff. These reviews require program managers to discuss project progress, deliverables, schedule, and cost in an organized manner that reduces the chance to overlook anything.

Communications Management: Transparent communication mechanisms will be used to openly communicate and monitor integrated cost, schedule, and technical performance, and to detect and proactively address any issues. Daily communication and formal weekly meetings will ensure that technical leads are fully aware of progress, potential risks and technical issues. Similarly, regular communication between the program manager and partners' contracts and financial leads ensures all contractual requirements are followed while periodic contacts with partner organizations' leadership ensure their continuing commitment.

The San Francisco team will submit progress reports to the USDOT, summarizing the team's progress toward completing each task within the task order, and which include the following components:

- Updated task progress summary, for each project task, including the status of each task deliverable,along with the major accomplishments completed and upcoming activities and milestones for the task. The summary includes any identified variance from the current work plan and planned corrective actions.
- Concise list of outstanding issues requiring USDOT attention and issues resolved.

Each Progress Report will be accompanied by the following:

- Updated version of the Project Schedule, tracking the progress of each of the six major tasks and subtasks against the baseline, clearly identifying actual start and end dates for all activities that have been initiated and/or completed.
- Updated Risk Log containing a comprehensive list of identified and assessed risks to the successful completion of this task order. Each newly identified risk is recorded into the Risk Log, with the action to develop a mitigation strategy by the next scheduled Progress Meeting.

The San Francisco team will conduct these quarterly progress briefings in person at the USDOT headquarters in Washington, DC.

Cost Management: The San Francisco team will take a proactive approach to identify hours charged and dollars spent supporting projects to ensure we stay within budget. The team will submit the reports where the cost and remaining budget are documented to ensure a controlled budget for the Smart City demonstration and spot any issues before cost overruns can occur. Project management costs will be kept low, while still providing the strong and effective leadership required for the highly complex set of proposed activities.

Quality Management: The San Francisco team will provide quality assurance and reviews for our work products under the scope of the task order. The team will perform quality planning, control and assurance activities across all areas and tasks as follows:

- Monitoring internal process compliance using established processes

- Regularly monitoring and objectively evaluating performed processes, work products, and services against applicable process descriptions, standards, and procedures
- Identifying and documenting non-compliance issues and recording and reporting the issues to applicable stakeholders to ensure that noncompliance issues are addressed
- Providing feedback to project staff and management on the results of quality assurance and control activities
- Maintaining quality records and lessons learned

All contract deliverables will have version control, with unique version numbers assigned to each document. Approved final versions of each deliverable (including the Project Schedule) will be placed under configuration control.

Configuration Management: This includes managing how items will be placed under configuration control are identified, when they are identified, and when they are placed into a configuration control process or system. Configuration management may include establishing a Configuration Control Board and include procedures for handling proposed changes to items under configuration control, and the role of the USDOT in configuration control.

Staff/SME Assignment: Successful project execution will depend on a strong team that meets the key needs for quality on this project. It will also require the participation of technical staff with a solid understanding of the technical areas and technologies relevant to this project. The staff members already on the team meet these criteria based on their many years of relevant experience.

Organizational Conflict of Interest Avoidance: Although there are no known issues at this time, we will proactively work with USDOT to identify any potential issues and take the necessary steps to ensure an independent evaluation and impact estimation. If necessary, we will introduce additional staff or subcontractors to validate this independence.

3.3 Existing and Future Public and Private Partnerships

San Francisco is already working with Smart City technology partners for its current Smart City initiative and vision. Indeed, the City has also been engaging potential partners since the release of the Smart City Challenge Phase 1 NOFO to better understand various smart city technologies and solutions currently available and developing. The City has worked to vet potential partners based on their expertise, experience, and what they can provide to the overall Smart City Challenge.

San Francisco plans to use the services of the USDOT sponsored partners to the fullest extent possible. At a high level, the San Francisco Smart City team discussed the potential partnerships:

- Regional Deployment Scope: High Occupancy Lane Network – Potentially use NXP on-board units for connected vehicle communications, sensors and beacons long carpool lanes in the City.
- Citywide Deployment Scope: Municipal Mesh – Use "Mobileye" technology for collision avoidance on municipal vehicles.
- Neighborhood Deployment Scope: Shared Mobility Hubs – Leverage Sidewalk Labs' WiFi kiosks in the neighborhood co-located and integrated with car/bike/scooter share and parklets.
- Data Management: We will use AWS for its cloud services. We will also use Sidewalk Labs Flow dashboard.

Engagement approach for start-ups, small businesses, local technologists

The San Francisco Smart City concept will incorporate multiple entities ranging from startup companies to local businesses. Local and small businesses will be able to benefit by using or adding to City data (e.g., promoting business through ads on kiosks, or using City data to track the travel patterns of potential customers).

As part of our Communication Plan, the team will develop and implement an engagement approach. We will develop a comprehensive list of business types that will have different uses for the Smart City technologies. The comprehensive list will be the foundation for developing protocols when interacting with a particular type of business. As engagements progress and business interactions increase, the approach will be reevaluated through surveys and feedback sessions to understand the needs of businesses and to ensure the approach is effective and can continue to accommodate all types of businesses. Consistent and regular communications throughout the project will ensure that we maintain strong relationships that will create a more connected community.

For startups, there are two ways to engage: (1) as members of the Smart City Institute; and (2) as participants in our federally-funded Startup in Residence program. The Smart City Institute will be a space for industry, academic, and government collaboration on policies, architecture and standards, projects, and demonstrations. Startups are not required to make direct contributions to become members but are encouraged to make in-kind contributions. We expect a large number of startups to become members of the Smart City Institute. A large number of the 100 USDOT Smart City Challenge partnership proposals received were from startups. Startups can also apply to participate in the 16-week Startup in Residence program, which pairs technology companies with City departments to tackle specific challenges that can be addressed by technology. The program allows departments and startups to co-create solutions so that both parties can enter into a commercial contract without going through an additional procurement step.

San Francisco has a long history of engaging our community and we have been leaders in working with local technologists to create community-driven solutions. We have led a number of government sponsored hackathons starting in 2009 when we launched our open data initiative.

Data have been a new medium for engaging local technologists and we have been a leader in creating data standards, instituting robust data sharing policies, and creating the infrastructure to make a sustainable impact. We also have a number of partnerships with Code For America's Brigade, civic accelerators like Tumml, 1776, Y Combinator and many others where we share civic and social needs from government to the technology community. Our Smart City work will continue building on our history of open data, partnerships and civic tech experience.

3.4 Opportunities to Leverage Federal Resources

The SFMTA anticipates a broad portfolio of bond and grants revenues worth $2.8 billion dedicated to

sustaining and expanding its entire transportation network: transit and accessible transit services, pedestrian and bicycle improvements, traffic signals, and parking infrastructure. Using these funds we have partnered often and effectively with public and private entities to achieve the Agency's Strategic Plan goals. With regard to the USDOT, two recent examples of SFMTA's partnering are worth highlighting.

The SFPark program, staffed and managed by SFMTA, is an award-winning dynamic parking management system that received substantial start up funding ($20 million) from the USDOT's Urban Partnership Program. It helped achieve behavioral change through pricing experimentation. It has been highly successful in managing on-street and off-street parking in the City. The program tested new technologies and policies and resulted in lasting improvements to parking in the City and serves as a model across the U.S. and 12 nations around the world.

Our Value Pilot Pricing Program grant for Linked Priced Electric Bikesharing ("e-Bike") for $1.5 million was also a success. This innovative project is a partnership between the SFMTA, City CarShare of San Francisco and UC Berkeley's Transportation Sustainability Research Center. Funds will be used to buy electric bicycles and storage pods, and their usage, distribution and impacts will be monitored and analyzed by the Transportation Sustainability Research Center.

Similarly, but on a larger scale, the federal funds that SFMTA is poised to receive from the Smart City Challenge will leverage other complementary and enhancing investments with an array of potential partners. Relationships with partners will be codified during the development of the full grant application, and will be memorialized and made compliant with USDOT provisions upon grant award. A number of vendors and consultants are quite aware of the SFMTA's work and we are confident our grant application is stronger as a result.

Our communities believe in our vision for a better transportation system as well. Recently, San Francisco residents voted for a $500 million streets bond, improved the city's funding formula for transportation based on population, and approved a $2.4 billion budget to improve transportation citywide. Simultaneously, the SFMTA's credit rating of AA and Aa2 are the highest ratings for a transit agency in the nation.

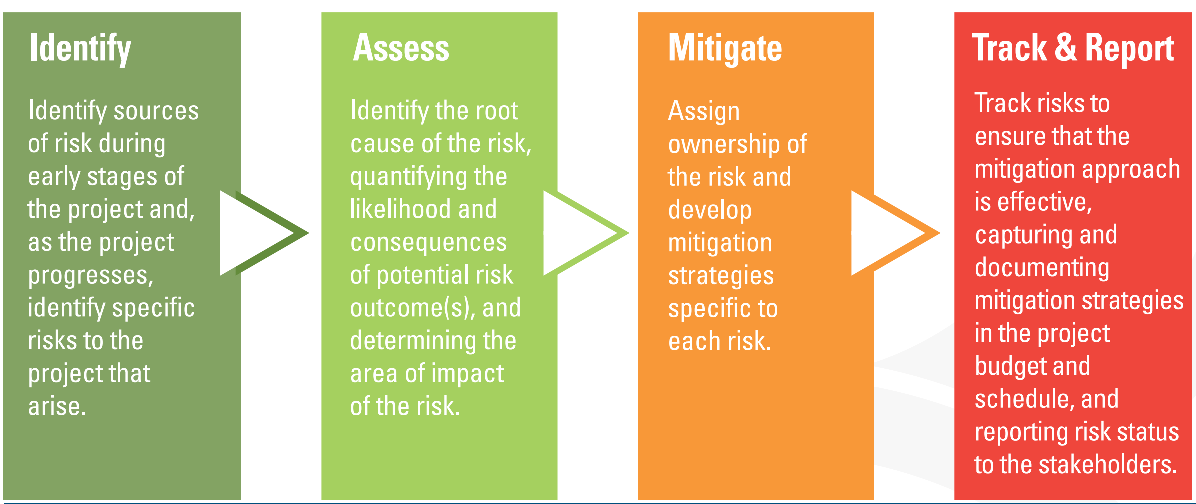


Figure 3.2 San Francisco's Risk Management Approach

	Potential Risks	Mitigation
Community	Public opinion may not support technology and city streets to be used for deployment.	Define Community Engagement Plan to cohere community groups, Mayor's Office and City Departments.
Technical	Passenger data from connected traveler and connected vehicles to be used for decision making and operations.	Work with federal government and companies to develop framework.
Policy	State operation policies for automated vehicles.	Work with state and federal partners to guide effort.
	Technical and policy issues related to cybersecurity and software bugs for connected and automated vehicles.	Work with policy makers to ensure security policies are adequate and current.
	CV/AV may have uncertain impacts on land use, either resulting in more sprawl or reinforcing compact growth patterns.	Create policy preference for shared model over the ownership model with incentives to enable densification.
Institutional	Intergovernmental coordination may not fully integrate approaches at local and regional scales.	Continue building upon working relationships with neighborhood, local and regional partners via Smart City Institute and Policy Advisory Board.

Table 3.1 Potential Risks and Mitigation

3.5 Risk Management Approach

Our risk management approach follows industry best practices. To mitigate factors that could jeopardize the ability to achieve project or task objectives, we will take the following steps to manage risk:

The risk management approach will be closely knit with the SCC Management and Staffing Structure in Section 3.1, with the UC Berkeley team managing the technical risks and SFMTA managing the policy, community, and institutional risks. Assigning ownership of risks will help in track progress and mitigate risks. The Program Manager will track risks from the various projects and will ensure timely action. To mitigate non-technical risks, the Program Manager will work with the pilot leads (Regional, City, and Neighborhood Pilots) to develop achievable approaches, as well as their impact(s) on schedule, scope, or costs. Risks will be prioritized based on their potential impact on the individual project and the program itself.

USDOT will have access to the updated risk log and mitigation approach(es) to assess soundness and feasibility. San Francisco is well aware of the cultural and technological complexities of this effort, and we are committed to collaborate and work with our partners and stakeholders to solve each of these issues to work toward the path of an inclusive and livable city and region. Table 3.1 shows examples of certain risks for different categories and how they can be mitigated effectively. The City has a strong, collaborative track record in managing complex grant-funded projects. Within the new Smart City Institute framework, risk will be further reduced because of a high level of public participation and partnership.

A full staffing plan including the non-key staff will be provided as a part of the Project Management Plan.

Resumes are included as an Appendix to Volume 1 with page numbering not counting towards the Volume's page count limitations.

4.2 Contingency Plan

We will retain the same Program Manager and Project Leads throughout the performance period of the grant as much as practically possible. However, if changes occur due to uncontrollable events, we will follow a prescribed contingency approach documented in the Project Management Plan for staff replacement. As we finalize the team post-award, we will ensure that we have strong replacement candidates for all of the key positions should the need arise. If replacement of the Program Manager is needed, we will work closely with USDOT and offer the resumes of several candidates for review and concurrence.

SECTION 5: CAPACITY AND CAPABILITY

5.1 Capacity and Capability

San Francisco has a strong track record of delivering innovative and high profile projects that have not only improved the lives many, but have also added to the national body of transportation knowledge.

The City is at the leading edge of the sharing economy that began here. Thanks to our shared mobility partners, we have crossed over the cultural trust barrier of getting into a shared ride with a stranger. We will now expand the spirit of sharing by linking all the modes together to work as one transportation system and test people's openness to use shared electric connected automated (SECA) vehicles. With over 5,000 employees, the SFMTA has the technical capacity to direct, plan, and implement the Smart City Challenge project. With assigned project managers, engineering staff, and technical support from a myriad of enthusiastic partners, we have the rich background and deep expertise required to successfully deliver San Francisco's Smart City Challenge pilot projects.

The SFMTA is well-versed in the procurement processes and rules associated with local, state and federal law. To ensure compliance, the SFMTA has developed a set of procedures and checklists to guide procurement. These checks are used from the start of the procurement process through the term of the contract. Contract requirements are reviewed by a dedicated Capital Program Management staff and discussed with project managers during the grant kickoff meeting, after the grant is awarded, and before grant work begins. Project managers receive ongoing support from fully-staffed contracts, accounting and procurement teams.

The most notable SFMTA project with a similar flavor and scale was the SFPark program. At the end of the day the SFMTA had expended some $42 million in FHWA funds on SFPark. By all accounts the project was a success. SFPark shifted how we manage, operate and provide parking, including travel behavior, reduced vehicle miles traveled and greenhouse gas emissions by 30 percent (less driving around looking for parking), changed the SFMTA's view on parking, pivoting from limited access to customer focused.

In addition, our key research/deployment partner UC Berkeley has a proven track record of managing federal awards both large and small, including many cooperative agreements. Federal funding to the UC Berkeley campus ranges from $400 million to $500 million each year including approximately 20 active awards. UC Berkeley is used to being subawardee on large awards. Its Institute of Transportation Studies has several active awards from the USDOT including two with a total worth of $14 million.

UC Berkeley is completely engaged in supporting this effort. Specifically, many of the centers at the Institute of Transportation Studies (ITS) at Berkeley will commit faculty, staff, and student resources to support the effort including the Transportation Sustainability Research Center, California PATH, SafeTREC, the Smart Cities Center, Tech Transfer, and others. They will engage faculty, students, and researchers from Haas School of Business, the Goldman School of Public Policy, the School of Law, the Department of City and Regional Planning, the Department of Civil and Environmental Engineering, and beyond. With a long history in managing sensitive data, Professors Shaheen and Bayen will work closely with the ITS Berkeley Library to develop a data warehouse and a data commons along with replicable data protocols.

5.2 Committment to Maintain and Operate the Deployment

For Fiscal Year 2016-17 the SFMTA adopted an operating budget of $1,173,800,000. The agency additionally receives between $350 to $400 million per year in capital grants supporting an array of projects, such as:

1. Timely state of good repair investments;
2. Safety and modernization upgrades;
3. Street (bicycling and pedestrian) and public transit system enhancements and expansion,
4. Cutting-edge and innovative pilot programs.

With grant funding, when the projects are completed and entered into service, the investments become capitalized assets. The SFMTA typically maintains its assets for their proscribed useful lives. For example, buses funded by the Federal Transit Administration are operated and maintained for at least 12 years, and FTA-funded light rail vehicles are anticipated to last at least 25 years with proper maintenance.

It would be imprudent, though, to make a commitment to unilaterally support every investment in the Smart City Challenge portfolio of projects. Rather, the SFMTA and its partners will constantly evaluate and refine the experiments and programs being delivered throughout the contract with USDOT. Those elements that the SFMTA and its partners determine will benefit the City and County of San Francisco beyond the pilot period will be integrated into the Agency's Long-Range Capital Plan and five-year Capital Improvement Program (CIP) as follows in Phase 3 below:

Phase 1: Define Vision Statement (completed)

Phase 2: Deployment of Pilots (Smart City Challenge grant pending)

- Codify concepts
- Test and refine
- Evaluate and bolster

Phase 3: Expand and Cultivate New Pilots

- Determine scope, scale and pace of expansion (toward the end of Year 3) based on:
  - Political will
  - Public acceptance and success of Phase II
  - Readiness of new technologies, particularly AV/CV
- Renew, reaffirm and bolster partnerships

As program implementer, the SFMTA will include Phase 3 in its agency-wide, multimodal capital prioritization process:

- Submit near- and long-range capital budgets and justifications into the Capital Improvement Program (CIP) process. Budgets include capital costs, including near-term delivery oversight costs, as well as long-term operations and maintenance costs for the project upon completion. The justifications will, like the present Smart City Challenge application, include full scope, schedule, and budget, and identification of project delivery teams.
- CIP projects and programs are reviewed by SFMTA's Transportation Capital Committee (TCC), a cross-divisional board of program managers and finance staff, as well as by the Director of Transportation's Executive Team.
- The most timely and high-priority projects will then be presented to the SFMTA Board of Directors in the context of a two-year Capital Budget for its approval, and then the approval of the San Francisco County Board of Supervisors.
- Upon approval of the Capital Budget, projects will secure funding via grants or local sources.

SECTION 6: CONCLUDING STATEMENT

San Francisco's vision for a smart city begins and ends with our community, its neighborhoods, and its citizens. It embraces equity and change in the best senses of the words. It also builds on our strong partnerships with the private sector, community organizations, and academia. Our proposal builds on our deep and long-standing commitment to people, equity, the environment, safety, and innovation. Further, it capitalizes on our many successes in deploying large-scale pilot projects, such as SFPark, and sharing this understanding with the nation and the world.

Our approach spans neighborhood, city, and regional scales. We believe this tiered method is essential for making connections across the system and to transform transportation. Our pilot project platforms will provide the ultimate laboratory for testing and growing large-scale change and creating a model platform that other cities can replicate and customize. Our philosophy toward "tech transfer" goes beyond other cities. It embraces education and training with a focus on infusing our curriculum with know-how in data management and analytics to inspire the next generation of "city scientists."

According to Mayor Ed Lee, "Transportation is the greatest equalizer of all." So it is not surprising that mobility is at the core of San Francisco's smart city initiative. Our approach is bold and ambitious. We want to usher in the future of transportation and leave no one behind. While our approach builds upon a strong supply-side focus in managing our rights-of-way and transportation system through sensors, cameras, and signals, it is matched with a bold demand-side approach that emphasizes our users and, at the grassroots level, their self-defined needs. Through our vision of the power of 10% reductions (fatalities, emissions, SOV trips, freight delays and collisions, and low-income household expenditures on transportation), we hope to calibrate and optimize our pilot projects and, ultimately, the transportation network through feedback control over the three year Smart City Challenge performance period. Feedback control aims to monitor the transportation system to provide critical feedback that can help us to meet our goals through dynamic response to changing conditions. This approach is central to our Smart City Institute pilot incubator, which we view almost as a living organism, that requires dynamic feedback to adapt and grow. In the past, several technological solutions have been developed to address challenging transportation problems, but they have failed to deliver on their promise. This is because they either focused too heavily on the supply-side and operations, failed to actively engage the community, or both. By melding new tools (supply-side) to a community challenge process (demand-side), we directly address these concerns in our Smart City Challenge proposal to ensure success and to develop a blueprint for the nation and the world.

Key predictions mentioned in USDOT's Beyond Traffic are population growth, including the number of older citizens, freight growth, and the shift of people to mega-regions. San Francisco, always at the cutting edge of social changes, is feeling these pressures now. Travel to, from and within the City is incredibly time consuming and expensive. Our problems will become more acute because of continued strong economic growth in the Bay Area. Freight demand is on the rise with increased deliveries in San Francisco contributing to congestion, pollution and safety conflicts. Our Smart City Vision addresses growing population, changing demographics, and coordinated freight movements now, to prepare for 2045 and beyond.

We acknowledge that our approach is ambitious. This is by design. It matches our aspirations and the scale of this challenge. It reflects the mindset needed to tackle serious transportation issues. We believe our application addresses Secretary Foxx's sense of "urgency" in tackling our nation's transportation problems, and it is infused with our collective creativity. It has inspired us, catalyzed our ideas, challenged us to already create new partnerships, dream big, and aspire to a new transportation future of shared electric automated and connected (SECA) vehicles. We are deeply grateful for the opportunity to respond to this challenge and the impacts it has had on our city.