APPENDIX C

Smart Communities Summary Document

OVERVIEW

Background

The Capital District Transportation Committee (CDTC) is the Metropolitan Planning Organization (MPO) for the Albany-Schenectady-Troy and Saratoga Springs metropolitan areas. New Visions 2040, the long range regional transportation plan developed by CDTC, was adopted in 2015 and is the basis for which CDTC allocates planning funds and programs federal transportation funds for capital projects in the Transportation Improvement Program (TIP). In other words, all federally-funded or federally-approved transportation actions, such as highway or transit projects, must derive from the priorities and principles in the regional plan.

New Visions 2040 includes a set of planning and investment principles as well as short- and long-term actions to help achieve the plan's goals. These investment principles are:

1. Investing in a quality region
2. Economic development
3. Regional equity
4. Bicycle and pedestrian transportation
5. Transit
6. Complete Streets
7. Infrastructure
8. Safety & security
9. Travel Reliability
10. Freight
11. Environment
12. Technology

Developing New Visions 2040 was a multi-year process and included several subcommittees and a series of public outreach events. The Environment and Technology Subcommittee collaborated to create a white paper which was released in September 2015. This paper proposes a planning and investment principle that supports the environment:

Technology – We must plan for new, smarter, better, and rapidly-changing transportation technology.

Advancements in technology, such as self-driving cars, self-adjusting traffic signals, smart phone apps, ridesharing, carsharing, and bikesharing will have tremendous and wide-reaching impacts on future transportation. These impacts include, but are not limited to, decreasing congestion, providing transportation to more seniors and people with disabilities, reducing traffic crashes, and more.

The paper goes on to outline a series of strategies and programs consistent with planning for new, smarter, better, and rapidly-changing transportation technology. These included the following:

1. Electrification
2. Automated Vehicles
3. Traffic Signal Technology
4. ITS Technologies
5. Travel Demand Management
6. Smart Growth and Land Use Planning
7. Protecting Environmental Systems

The full Environment and Technology Task Force White Paper, as well as other subcommittee reports, can be viewed at http://www.cdtcmpo.org/documents-reports/new-visions-regional-transportation-plan.

Shortly after New Visions 2040 was adopted by CDTC, the USDOT announced the Smart Cities Challenge. The Capital Region was one of the 78 applicants that submitted a proposal in late 2015. The vision elements outlined in the proposal are below:

1. Urban Automation
2. Connected Vehicles
3. Intelligent, Sensor-Based Infrastructure
4. Urban Analytics
5. User-Focused Mobility Services & Choices
6. Urban Delivery & Logistics
7. Strategic Business Models & Partnering Opportunities
8. Smart Grid, Roadway Electrification, & Electric Vehicles
9. Connected Transportation Services
10. ITS Architecture & Standards
11. Low-Cost, Efficient, Secure, & Resilient Information
12. Communications Technology
13. Smart Land Use

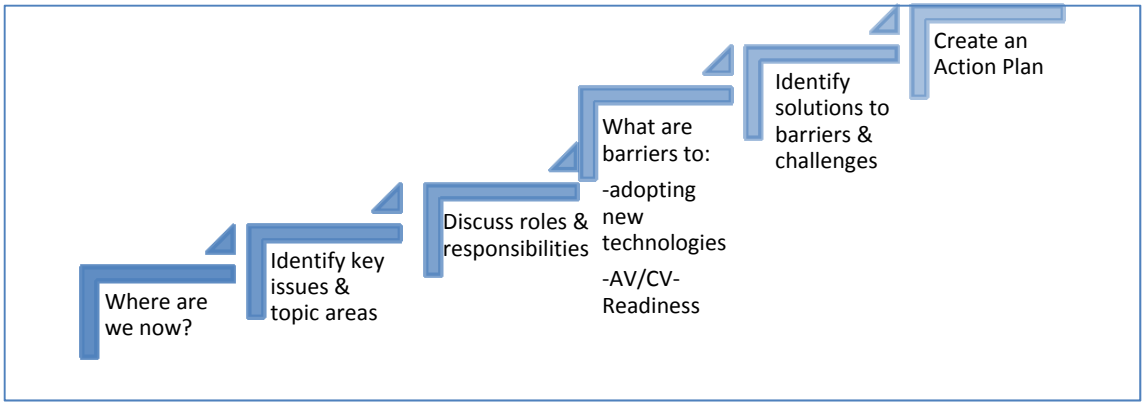
The Capital Region's proposal was not chosen but the vision of leveraging new technologies to improve mobility for all remains. Since then, Schenectady and Saratoga Springs have forged ahead in developing their own Smart Cities plans and convening local task forces. Mobility options continue to expand with the recent launch of a regional bike share system and legislation to allow the operation of transportation network companies (TNCs), like Uber and Lyft, in Upstate New York. CDTC continues to explore new transportation technologies and strategies and evaluate their potential impact on the Capital Region transportation network. To support this continued effort, CDTC has included a SMART Communities task in its 2018-20 Unified Planning Work Plan (UPWP), and budgeted $100,000 for the effort, including $75,000 for consultant services. To assist in the development of a regional SMART Cities "roadmap" and policy framework, CDTC has established the SMART Communities Task Force.

Goals

The CDTC SMART Communities Task Force will meet as needed to develop a regional "roadmap" that includes short-term action items. The first meeting was held on Wednesday, March 14th and focused on the status of ongoing SMART City and mobility projects in the region, and a discussion on what the key issues and topic areas. Future meetings will identify partners in the region and define the role and responsibility of CDTC, and MPOs in general, in implementing SMART City plans and policies; discuss barriers to autonomous vehicle readiness; recommend solutions to barriers and challenges to become a SMART and autonomous vehicle-ready region; and develop a plan that includes action items. The Task Force and its plan should aim to increase interest in SMART City concepts, emerging technologies and smart mobility services, among cities, towns, and villages, but also users of the transportation system.

The roadmap, or plan, should include:

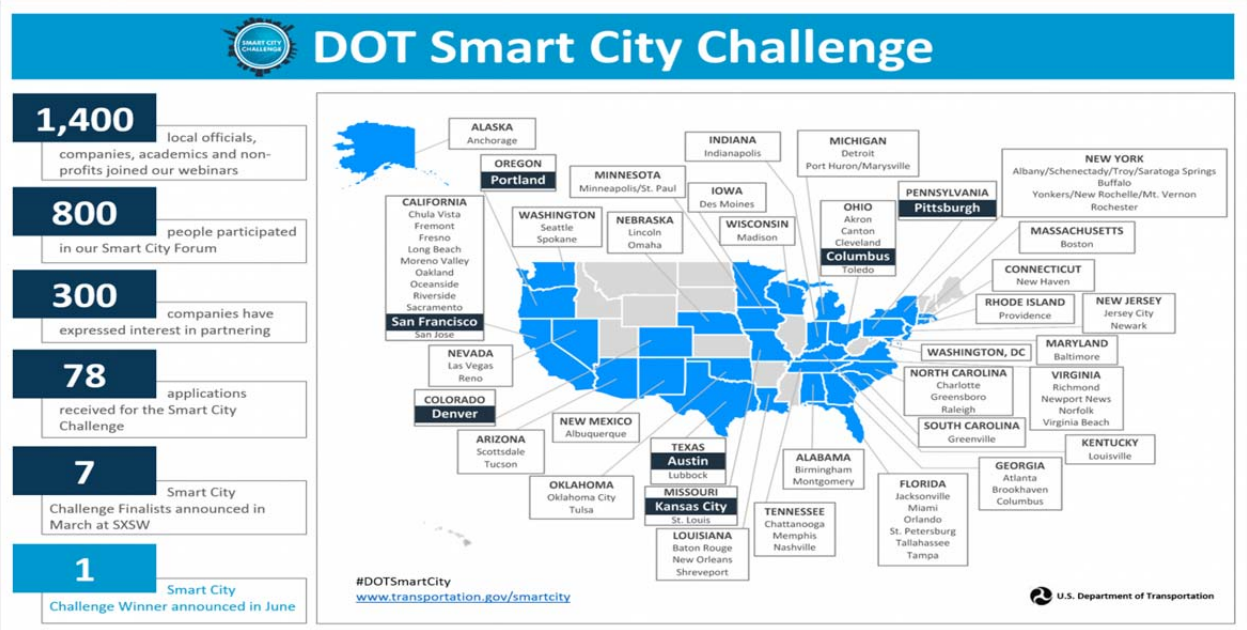
1. Regional vision for technology and transportation
2. Identify technology needs for transportation network
3. Identify project investment priorities, funding strategies
4. Identify private sector, university, and public agency partners



The anticipated timeline for developing the roadmap and action items is Summer 2018. At least one action item/project should be completed by April 2019.

USDOT Smart City Challenge

As previously mentioned, the Capital Region was one of 78 applicants that submitted proposals to the 2015 USDOT Smart City Challenge. Applicants competed for up to $40 million pledged by DOT to define what it means to be a "Smart City" and "become the first city to fully integrate innovative technologies – self-driving cars, connected vehicles, and smart sensors – into their transportation network."



USDOT named 7 finalists – Austin, Columbus, Denver, Kansas City, Pittsburgh, Portland, and San Francisco – and worked closely with them, their residents, and each other to develop detailed Smart City plans and visions. The finalists each received $100,000 for public outreach, production of pitch videos, and technical assistance from federal experts and private partners to further concept development.

Applicants faced similar mobility challenges:

1. Providing first-mile and last-mile service for transit users to connect underserved communities to jobs.
2. Facilitating the movement of goods into and within a city.
3. Coordinating data collection and analysis across systems and sectors.
4. Reducing inefficiency in parking systems and payment.
5. Limiting the impacts of climate change and reducing carbon emissions.
6. Optimizing traffic flow on congested freeways and arterial streets.

The following page shows the common strategies proposed by the 7 finalists to address their mobility challenges.

Strategies	Austin, TX	Columbus, OH	Denver, CO	Kansas City, MO	Pittsburgh, PA	Portland, OR	San Francisco, CA
Partnership with research institutions/universities	•	•	•	•	•	•	•
Crowdsourcing data from public, managing data by research institutions or organizations, and open access to all	•	•	•		•	•	•
Leveraging the data by research institutes and building apps according to the needs of the population	•	•	•	•	•	•	•
Develop smart corridor and transit services to demonstrate the capability of intelligent infrastructure to improve transit service and efficiency	•	•	•	•	•	•	•
Implementation of electric vehicles and charging stations	•	•	•	•	•	•	•
Connecting visitors and citizens by providing information using the available data	•	•	•	•	•	•	•
Technology friendly policies to be introduced and mitigated to facilitate testing, demonstration, and deployment of smart city technologies	•	•	•	•	•	•	•
Implementation of car share and bike share	•	•	•	•	•	•	•
Development of app for easy access to connecting people for car sharing	•	•	•	•	•	•	•
Intelligent Vehicles for smarter, safer and more environmentally friendly Autonomous Vehicles	•	•	•	•	•	•	•
Affordable public transportation (package mobility service) and multimodal connection	•	•	•	•	•	•	•
Connecting suburbs to the urban core or the city through car share, or Connected and automated vehicles from transit to home/work and vice versa	•	•	•	•	•	•	•
Development of apps or availability of information for ease in delivery process by terminal queue status and load matching and mobility on demand services for real time travel decision making for alternating routes		•	•	•	•	•	
Smart Land Use: Reduction of sprawl, or by dynamic pricing of parking space and garages, or corridor improvements through road diet, green design, walkable, bike-able, transit hub, etc.	•		•	•	•		•
Implementation of Mobileye Shield + to increase safety and reduce collisions		•	•				
Strategies focused on improving accessibility to job centers	•	•		•			•

The Capital Region shares other characteristics in addition to similar mobility challenges with the finalists. The finalists vary in size and population density and are larger than any single Capital Region City but similar in population size to the Capital Region as a whole. Many of the finalist cities are current or emerging megacities. The Capital Region is growing relative to Upstate New York but is not in the top tiers of growing metropolitan regions.

	Austin	Columbus	Denver	Kansas	Pittsburgh	Portland	San Francisco
Population	790,390	787,033	600,158	459,787	305,704	583,776	805,235
Density	2653/Sq. Mile	3384/Sq. Mile	3923/Sq. Mile	1,460/Sq. Mile	5522/Sq. Mile	4375/Sq. Mile	17,818/Sq. Mile

The Capital Region is unique from most metropolitan areas in that it lacks a central city. The four largest cities in the region, Albany, Schenectady, Troy and Saratoga Springs, are interconnected socially, culturally, and economically, but have distinctive characteristics as well as their own transportation challenges. Regionally, there are a large number of colleges and universities, a growing technology sector, strong transit ridership, growing electric vehicle ownership and a publicly-accessible charging network, existing and planned bus rapid transit corridors, and relatively new smart mobility services like car sharing, bike sharing, and ridehailing (i.e. Uber).

	Albany	Schenectady	Troy	Saratoga Springs	Total for 4 Cities	Region
Population	97,856	66,135	50,129	26,586	240,709	837,967
Density	4,468/Sq. Mile	6,012/Sq. Mile	4,516/Sq. Mile	920/Sq. Mile	3,979Sq. Mile	372/ Sq. Mile

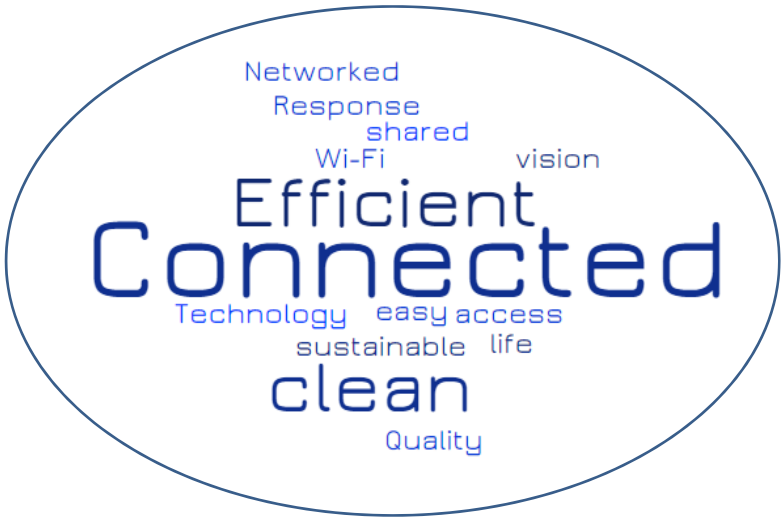
Source: 2010 U.S. Census

Columbus, Ohio was the winner of the USDOT Smart City Challenge. The City's proposal was characterized by USDOT as a "holistic vision for how technology can help all residents move better and access opportunity." Columbus received $40 million from USDOT and an additional $10 million from Vulcan Inc. specifically for electric vehicle deployment. A key part of the SMART Columbus project is providing better access to healthcare, through connected vehicles, multimodal trip planning and a common payment system, mobility assistance for people with cognitive disabilities, smart mobility hubs, and prenatal trip assistance. Project details can be found on the City of Columbus website.

WHERE ARE WE NOW?

Defining a "SMART City"

The USDOT described Smart Cities projects as strategies for "integrated, first-of-its-kind smart transportation systesm that uses data, applications, and technology to help people and goods move more quickly, cheaply, and efficiently." There are other suggested definitions of "Smart City," including a suggestion by The Atlantic that there is no such thing and its merely a "snazzy political label." For the purposes of the CDTC SMART Communities Task Force, "Smart City" includes strategies that improve *how* we move, how we move *things*, how we adapt, how we move *better*, how we grow opportunity for all, and align decisions and dollars in an efficient, connected, sustainable, and equitable manner. The Task Force will develop a roadmap that provides guidance and tools to Capital Region communities so that they can embrace technology and encourage innovation in a way that is consistent with New Visions 2040.



Above is a word bubble created through a poll questions: "What one word best describes a "Smart City" for you and your organization?" Task force members submitted their answer via text.

SMART Capital Region

CDTC has supported new smart mobility services since 2011 when it coordinated with the Capital District Transportation Authority (CDTA), to plan and host a Car Share Summit. Since then, new mobility services and programs have begun operating throughout the region. In 2014, Capital CarShare launched, with assistance from CDTC and CDTA, with a fleet of six vehicles in the City of Albany. Today it operates in Albany and Troy with a fleet of eight vehicles and plans to begin adding electric vehicles. Transportation Network Companies (TNCs) like Uber and Lyft hit the pavement of the Capital region in

June 2017. Shortly after, the Capital City Trolley and CDPHP Cycle! bike share also rolled out. This winter, CDTA phased out its old swiper cards and introduced smart cards called the Navigator. The Navigator can be replenished online, via the app, or in-person at several locations throughout the region. CDTA and its smart mobility partners are working to integrate the Navigator with other modes like bike share and taxis.

In addition to new mobility services, two Capital Region cities have released their own Smart City plans. In 2016 Saratoga Springs assembled a Smart City Commission and started the process of developing a roadmap. Their plan contains ideas for integrating technology into staff services and operations, tourism, and community services that benefit residents. The City of Schenectady also established a Smart City Advisory Commission and released a report in 2017 that outlines how the City is using technology and data throughout the city to save money, improve operations, and become more sustainable.

Smart Communities Task Force members were polled on what the key issues in the Capital Region are. The following issues were discussed:

Connectivity – not having a central city creates a sense of being disconnected from other parts of the region. For example, residents in Saratoga Springs feel disconnected from Albany, not just geographically.

Parking perceptions – most cities in the region are confronted with the perception that there isn't enough parking but the real problem might be a lack of information about where parking is available and when.

Lack of EV infrastructure – existing electric vehicle charging stations are publicly-accessible but not always visible, which may discourage residents from purchasing a plug-in vehicle.

Access – not all Capital Region residents have the same access to mobility choices.

Transit – fixed-route transit does not serve all residents and there is opportunity for enhanced or express transit services in some locations and along select corridors.

Isolation – an aging population that predominantly resides in the suburbs of the Capital Region is increasingly becoming isolated because of their lack of access to mobility. Older residents should be able to age in place, no matter what type of community they live in.

Priorities

The CDTC planning and investment principles can be compressed to energy and the environment, mobility, equity, health, safety, and the economy, or economic development. CDTC uses these principles to prioritize projects and investments in the programming of the Transportation Improvement Program (TIP) and in developing projects and programs included in the Unified Planning Work Program (UPWP) which functions as CDTC's annual budget and task list.

Below is a description of each principle:

Energy: CDTC should prioritize investments in transportation programs or projects that reduce energy use, are sustainable, and do not have adverse impacts on the environment, especially sensitive habitats or natural resources.

Economy: Investments in transportation programs or projects should create economic development – create jobs, support business innovation and/or improve the economic well-being and quality of life for a community by growing incomes and the tax base.

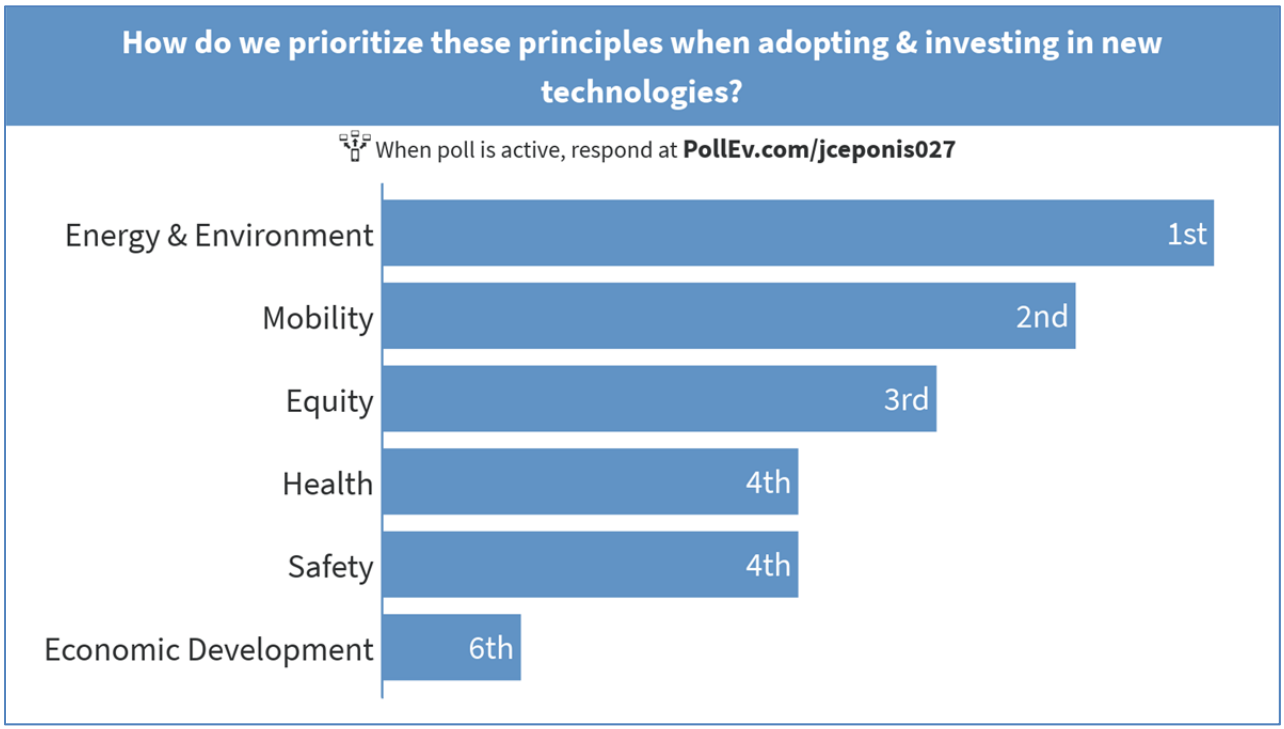
Mobility: Investments in transportation programs or projects should improve the ability to move between spaces, seamlessly and affordably. CDTC recognizes that access to mobility is essential to economic and social mobility, and is a priority in creating a transportation system that works for all.

Health: Health is always considered in the goals of CDTC's planning and programming policies, programs, and projects. Transportation projects and programs that help reduce air pollution; prevent traffic injuries and deaths; and lower obesity, diabetes, cardiovascular disease, and cancer rates and priority investments.

Safety: Safety is integrated into all surface transportation decision-making. It means investing in transportation programs and projects that reduce transportation fatalities and serious injuries, and improve safety within communities.

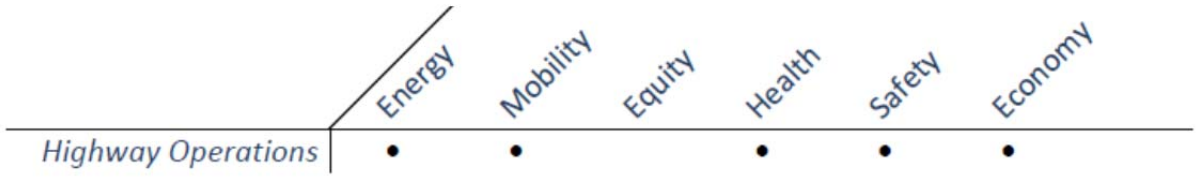
Equity: CDTC refers to equity as the fairness with which the impacts of transportation programs and projects (benefits and costs) are distributed. It is a priority of CDTC to avoid investments in programs or projects whose adverse impacts fall hardest on the most vulnerable communities.

The CDTC investment principles relate to different modes of transportation and investment areas in different ways. Task Force members were asked to rank the investment principles in order of importance. Those poll results are below. Task Force members indicated that energy and environment should be the most important investment principle guiding CDTC's planning. It was suggested that the investment principles would be prioritized different from community to community.



Modes

The Task Force then reviewed the different modes, or investment areas, how SMART City projects fit into them, and which of the New Visions investment principles the projects were related to.

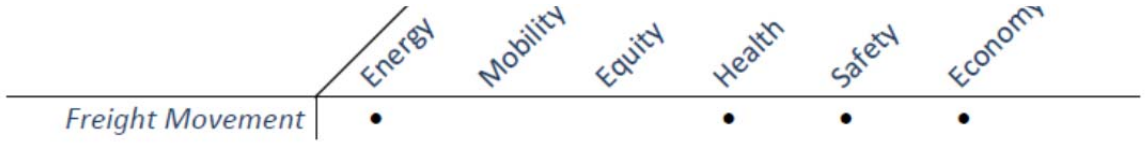


High-Occupancy Toll Lanes (or HOT lanes) is a lane on a roadway available to high-occupancy vehicles without charge while other vehicles that choose to use it would be required to pay a fee or toll, which could be adjusted in response to demand.

Congestion Pricing requires vehicles to pay a fee or toll, adjusted in response to demand, to enter and drive in a specific area of a city. New York City has proposed congestion pricing and London implemented congestion pricing in 2003.

Variable speed limits change based on road, traffic, and weather conditions and have the potential to improve safety and reducing congestion and travel times.

In the era of on-demand transportation services, like Uber and Lyft, how will highway operations and capacity be impacted? How can we **design for the Uberization of transportation**?



Automation will include freight vehicles, such as trucks.

GPS Fleet Management Systems can help truck fleets reduce operating expenses, save time, optimize operations, save money, increase the number of trips, improve safety and increase competition.

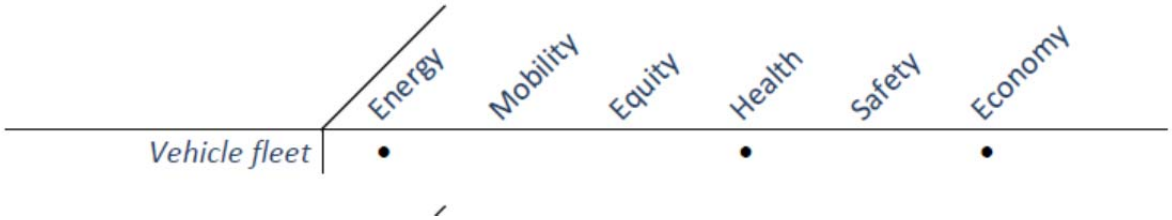
Truck **Platooning** is the linking of two or more trucks in a convoy using connectivity technology and automated driving support systems. These trucks can maintain a set, close distance between each other, reduce fuel consumption and emissions, and make vehicles drive at a constant speed with less braking and accelerating.

Delivery **Drones** are unmanned aerial vehicles utilized to transport packages, food, or other goods. Drones have the potential to reduce energy use in freight transport and the time it takes to receiving packages.

The **Electrification** of trucks can significantly reduce fuel use and emissions from freight transport. Electric trucks will require new charging infrastructure.

Urban freight delivery, or last mile freight transport, can utilize alternative modes, such as bicycles. An example of this operation is B-Line in Portland, Oregon. The company owns warehouse space which serve as small-scale distribution centers on the edge of urban areas which they use as staging areas to load cargo bicycles which deliver goods and packages to downtown businesses.

Container on Barge in the Capital Region would use the canal system and Mohawk and Hudson Rivers to transport freight via barge, moving products away from railways or roadways and onto waterways. This can potentially improve safety and reduce fuel use and emissions.



Automation, or driverless cars, is unmanned ground vehicles that are capable of sensing their environment and navigating without human input. Automated technology is currently being tested in various U.S. cities. The technology promises the potential to improve safety and reduce fuel consumption and greenhouse gas emissions (especially if it is also electrified). Automation can also change the vehicle ownership model, pushing towards a shared vehicle fleet, and unknown impacts to land use.

Electrification is encouraging the deployment of electric vehicles (EVs) in the vehicle fleet. This can be done by expanding the EV charging network through workplace charging, publicly accessible multi-family housing charging, and highway fast charging.

Telematics is a method of monitoring a vehicle by combining a GPS system with on-board diagnostics. This technology collects data that can improve safety, reduce emissions, and reduce transportation costs (insurance, maintenance, and fuel).

Alternative Fuels such as hydrogen, propane, natural gas and biofuels should be part of a diverse vehicle fleet, as part of a strategy for resiliency and energy independence. Alternative fuels are generally cleaner than petroleum fuels, some biofuels can be made from renewable resources, and advanced vehicle technologies like EVs can be powered by low-carbon and/or renewable resources. .

BusPlus Expansion will improve transit service and accessibility in the Capital Region. CDTA's "40 miles of bus rapid transit" (BRT) includes implementing express, limited stop service along the Washington and Western Avenue Corridors between downtown Albany and Crossgates Mall and the River Corridor from downtown Albany to downtown Troy. BRT amenities like transit signal prioritization, designated lanes, and real-time travel information create a high-quality and efficient service.

Electrification of transit can help reduce fuel use and emissions in the region. Electric buses will require new infrastructure to support the fleet.

A mobility trend is transit's **integration with other modes**. Not only meaning close proximity between transit and alternative modes like bike share and car share, but the ability to use a single media for the user's choice mode.

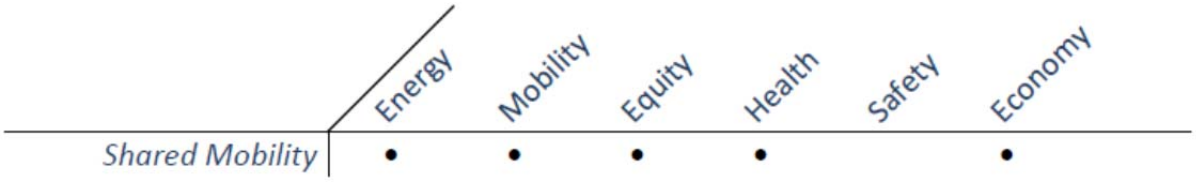
Multi-modal hubs are areas designed to allow for the easy transfer between modes. A commuter would be able to exit a bus and pick up a bike share bike, hail a cab, reserve a car share vehicle, or get into their personal vehicle nearby.

Real-time information provides customers the current status of vehicles, including approximate locations and predictive arrival times so they can use their time more efficiently.

Transit **signal prioritization** improves transit service and reduces delays for mass transit vehicles at intersections through controlled traffic signals. The traffic signal can communicate with arriving transit by holding green lights longer, shortening red lights, or giving a transit vehicle a leading green signal.

Human Services Transportation refers to enhanced mobility for people in need of specialized transportation. CDTC and CDTA's Access Transit work with local service providers, such as senior

centers, to coordinate public transit-human services, to improve efficiencies, save money, and enhance service.



Ridesharing is carpooling, or an arrangement where passengers agree to share a ride in a private vehicle driven by its owner for free or for a fee (cannot exceed the cost of the trip provided). CDTC works with 511NY at NYSDOT to manage iPool2 in the Capital Region, software that helps people find carpool matches.

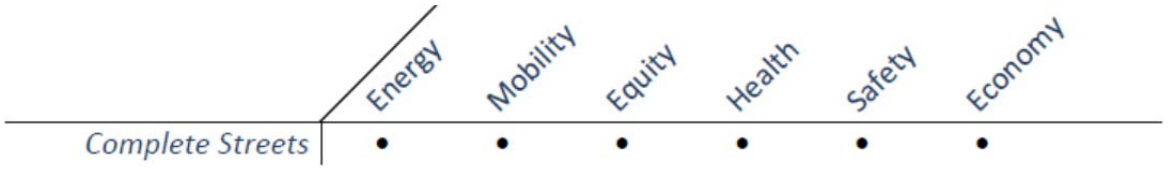
Carsharing is a short term model of car rental. Members of a carsharing organization can reserve vehicles for short periods of time, usually by the hour, and pick the vehicle up in their own neighborhood or close to an activity center. Currently, ZipCar holds agreements with most local colleges and universities to provide service on campuses and Capital CarShare, a nonprofit carsharing organization, operates in the Cities of Albany and Troy.

Peer-to-peer and **one-way carsharing** are types of services that have emerged in some cities as mobility services have evolved. Peer-to-peer allows private vehicle owners to rent out their personal vehicle by the hour and collect payment whereas one-way carsharing is the short-term rental of a vehicle that does not require the member to return the vehicle to the same spot they picked it up.

Bikesharing is a service that makes bicycles available for a very short term basis for a price. CDPHP *Cycle!*, a regional bikesharing service, launched in 2017 in the Capital Region and plans to double its system in 2018.

Integrated mobility refers to smartphone applications and other "smart" media that allows users to access a variety of mobility options for your route, including bikeshare, carshare, taxi, etc. It consolidates billing and payment.

Transportation Network Companies (TNCs) are mobility service providers that pair passengers via websites and smartphone applications with drivers who provide such services. TNCs in the Capital Region currently include Lyft and Uber.



Accommodation of all modes is the principle objective of Complete Streets. It's the design of a roadway to allow for safe access for all users.

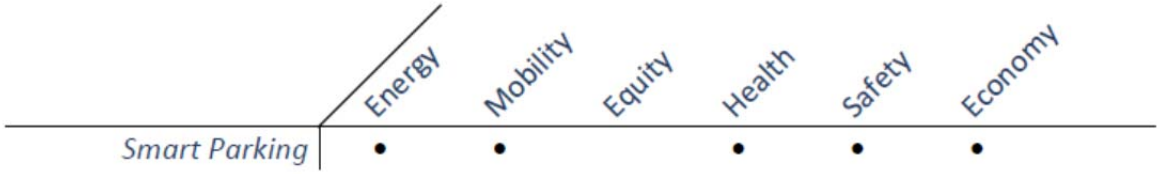
Mobility hubs, or **multi-modal hubs** are areas designed to allow for the easy transfer between modes. Here commuter can exit a bus and pick up a bike share bike, hail a cab, reserve a car share vehicle, or get into their personal vehicle nearby. Complete Streets design should be updated to include guidelines for how to integrate mobility hubs into landscape and roadways.

Greenway and trail connections are off-road, paved paths for non-motorized transportation. They are an integral part of developing a multi-modal network.

Traffic-calming slows vehicles, improving safety for pedestrians and bicyclists. Slowing vehicle speeds on local streets is essential to creating a safe, accessible, multi-modal network that encourages people to use alternative modes rather than driving alone.

Smart traffic signals are traffic control devices that use sensors and artificial intelligence to intelligently route vehicle and pedestrian traffic. They may communicate with road users and/or other nearby signals to optimize safe, traffic flow.

Smart Enhanced Multi-modal Arterials (SEMAs) take Complete Streets a step further by integrating connective technology.



Smart parking is a parking management strategy that uses technology to save fuel, time, and space and achieve faster, easier, and denser parking for vehicles. Smart parking can employ various technologies such as:

Occupancy sensors can be mounted on the pavement surface of individual parking spots to detect vehicle presence and send that information to a central server which can be used to guide motorists to available parking spaces, to increase traffic flow in cities and reduce emissions.

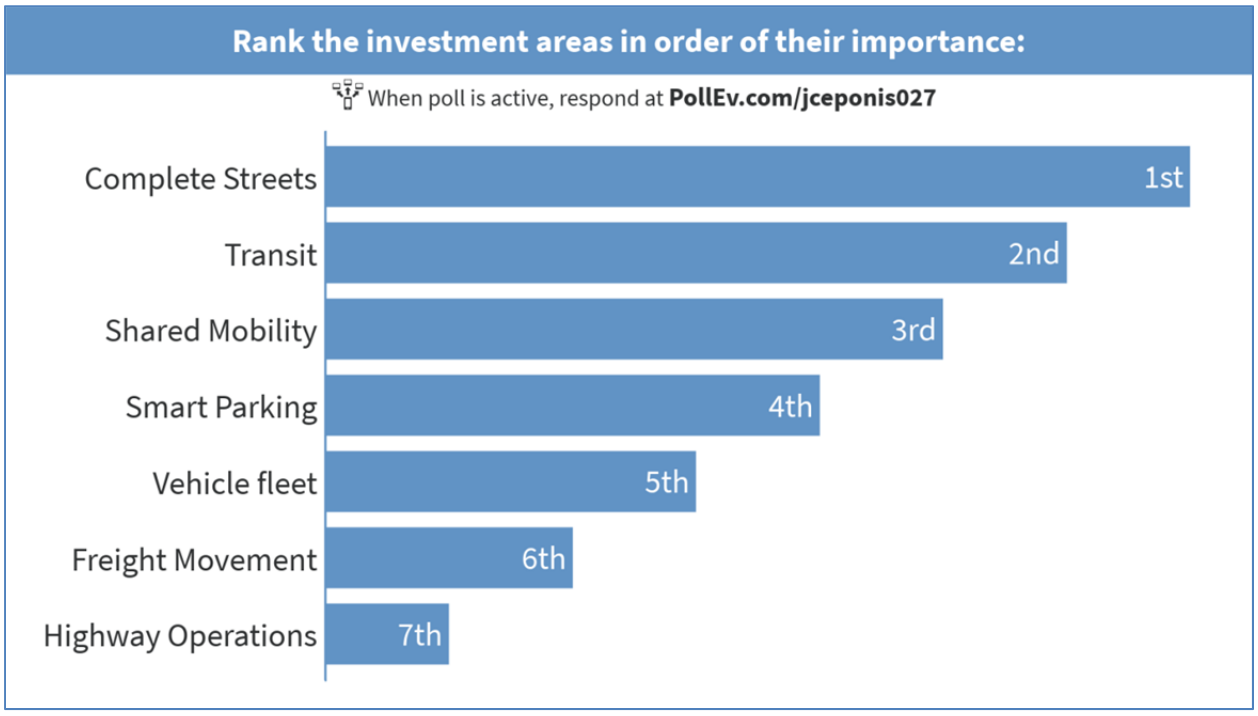
Smart meters allow parking customers to pay for parking using cash or credit cards. They can be solar-powered, have real-time communication and a web-based management system, and make parking rules and fees visible and easy to understand.

Parking reservations allow drivers to effectively find and reserve vacant parking spaces online or through a smartphone application. This reduces emissions and improves traffic flows in cities.

Wayfinding signage directs parking customers to available parking.

Parking management can help reduce emissions by installing and proving **electric vehicle (EV) parking**. EV parking provides plug-in vehicle owners with a space prioritized for their use where they can plug-in and recharge their vehicle.

After reviewing the modes or different investment areas, Task Force members were polled and asked to prioritize modes, and the SMART City projects that could fit into each mode, for investment. Below are the results from the poll.



These principles will help shape new policies and processes related to the investments and adoption of new technology and mobility in the Capital Region. As illustrated below, transportation has significant and profound impacts on energy use, health, and the economy. It is vital that as new technologies are

explored, piloted, and implemented, project sponsors be thoughtful of how they fit into the overall regional vision and what impact they have to individual communities and the region's transportation system as a whole.

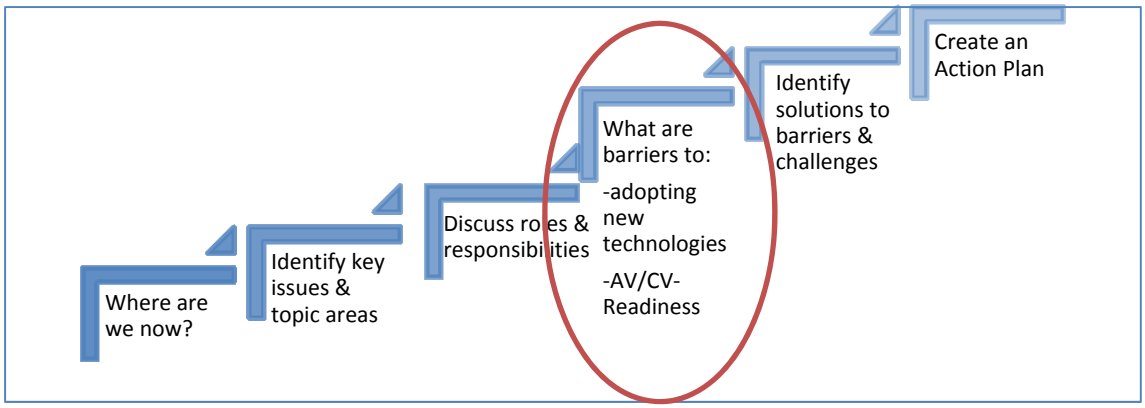
	Energy	Mobility	Equity	Health	Safety	Economy
Complete Streets	•	•	•	•	•	•
Transit	•	•	•	•		•
Shared Mobility	•	•	•	•		•
Smart Parking	•	•		•	•	•
Vehicle fleet	•			•		•
Freight Movement	•			•	•	•
Highway Operations	•	•		•	•	•

Discussion Items

The Task Force concluded the meeting discussing what, if anything, is missing from the areas of investment, or modes and available technologies that may fit into them. There was also discussion about how different modes relate to each other and often overlap, such as smart parking and complete streets, and transit and shared mobility. There was a lot of interest in complete streets and developing guidance on how to implement them successfully.

NEXT STEPS

Autonomous Vehicles (AV) and Connected Vehicles are an emerging issue that warrants its own meeting. The CDTC SMART Communities Task Force will schedule a meeting to focus on AV-Readiness. Questions like what infrastructure is needed for successful AV deployment, how to leverage the benefits of AVs and minimize negative impacts, and how the Capital Region can act as a living laboratory to autonomous and connected vehicle technologies? Who are our partners?



The next Task Force meeting will be scheduled for Wednesday, May 9th at 3:00pm at the CDTC office and will feature presentations and discussions on AV-Readiness.

CONNECTED & AUTONOMOUS VEHICLE READINESS

What are they?

Autonomous Vehicle (AV) technology can handle the whole task of driving so that the driver does not have to. A full AV does not require a driver and these vehicles will eventually integrate onto Capital Region roadways by progressing through the six levels of AV technology. The graphic on the right describes the six levels.

Six Levels of Driver Assistance Technology Advancements

Connected vehicles (CV) are different than AVs in that technology allows vehicles to communicate with each other and the world around them. An example of CV technology is vehicle navigation or GPS-based system that receives information on congestion in the road ahead through cellular signals and suggests an alternative route. Useful information is supplied to a driver or vehicle to help the driver make safer or more informed decisions. This type of technology is already very much part of our transportation system.

Potential benefits of AVs are:

- Potential for near zero crash fatalities, near zero crash injuries
- Reduction in incidents on the expressways, resulting in greatly reduced congestion
- Significantly higher capacity on existing pavement, reducing the need to widen roads
- Improved mobility for seniors and people with disabilities

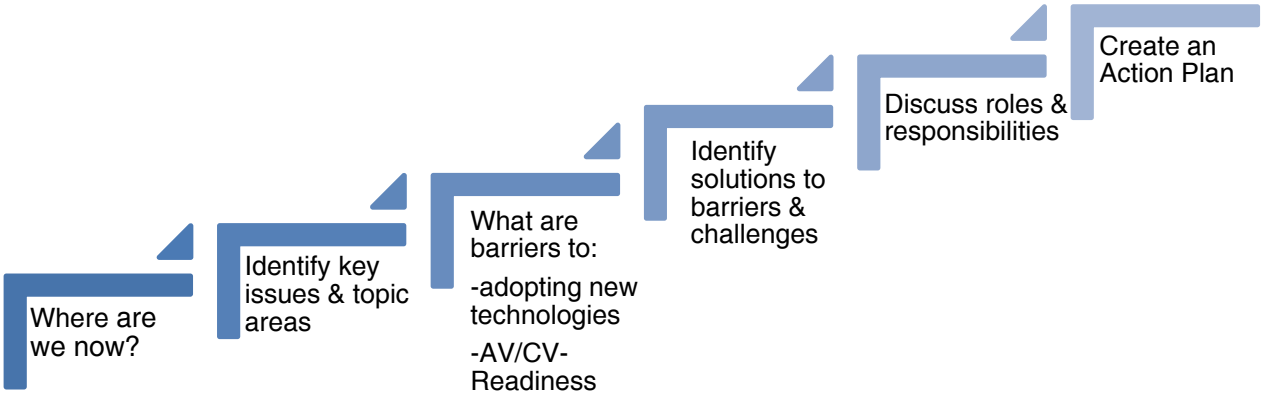
Potential Issues with Autonomous Vehicles:

- Access to AV mobility for lower income groups may not be equitable
- Increases in ride hailing, reduction in car ownership?
- Will streets need to be redesigned?
- Maintaining complete streets and walkability

- Transition period when only some cars are self-driving

Meeting Overview

The CDTC SMART Communities Task Force met on Wednesday, May 9, 2018. The previous meeting in March attempted to provide steps for developing a SMART Communities and AV-Readiness "Roadmap." The purpose of the Roadmap is to identify CDTC's role and stakeholders, suggest action items, and recommend policies for accommodating emerging technologies and mobility services while maintaining a high quality of life in the Capital Region. After the initial SMART Communities Task Force meeting, CDTC amended the steps and those changes are reflected below.



The meeting included an overview of what AVs are and what benefits & impacts are anticipated with their integration into the vehicle fleet. CDTC staff presented examples of ongoing AV tests and pilots in cities across the country and scenarios for AV deployment. Task Force members were given opportunities to provide their opinion and feedback on AV technology, how the Capital Region can leverage its benefits, and what concerns or issues should be mitigated. The questions were asked in the context of the investment principles and priorities discussed in the previous SMART Communities Task Force meeting.

Vehicle & Traffic Law

Currently, the use of AV technology is prohibited on public highways within New York State. A provision adopted on April 1, 2017 to the Vehicle and Traffic Law allowed the New York State Department of Motor Vehicles (DMV) Commissioner to approve "demonstrations and tests consisting of the operation of a motor vehicle equipped with autonomous vehicle technology while such motor vehicle is engaged in the use of such technology on public highways within this state for the purposes of demonstrating and assessing the current development of autonomous vehicle technology on public highways within

this state for the purposes of demonstrating and assessing the current development of autonomous vehicle technology and to begin identifying potential impacts of such technology on safety, traffic control, traffic enforcement, emergency services, and such other areas as may be identified by such commissioner." The provision also requires state police to supervise all tests and demonstrations.

The DMV solicited applications for AV tests and demonstrations in 2017. Audi was the first manufacturer to be approved for AV testing and completed a 6.1 mile demonstration in and around Albany in May 2017. A Chevy Bolt EV with AV technology was approved for testing in Manhattan in early 2018 but never moved forward. The AV provision to the Vehicle and Traffic Law expired April 1, 2018 and a report on the testing is expected from the DMV Commissioner on or before June 1, 2018.

AV Tests & Pilots

Despite the sunset on the AV testing provision, the University at Buffalo's Amherst campus received funding from the New York State Energy Research and Development Authority (NYSERDA), and will begin a demonstration of an autonomous electric bus called Olli. The demonstration is limited to private roads on the university campus and will assess the safety, efficiency and user acceptance of self-driving vehicles as well as the operability of the vehicle in Western New York's inclement weather. The University will also study what kind of laws and policies must be implemented to support self-driving shuttles on public roads.

A number of AV demonstrations are currently being tested on public roads across the U.S. Some examples include:

AAA's Hop On Project in Las Vegas offers free rides to its members on a self-driving shuttle bus in downtown. The shuttle only makes three tops on a 0.6-mile loop, but has been called "the largest self-driving pilot project in the U.S."

The **MCity Driverless Shuttle** research project on the **University of Michigan's North Campus** is expected to begin testing this spring. The shuttle is an all-electric, 11-passenger vehicle and will cover a one-mile circular route at no cost to riders. The University of Michigan will be the first college campus to deploy driverless shuttles on public roads to transport students, faculty, and staff. The test will study how passengers react to the vehicle as a way to gauge consumer acceptance of driverless technology.

Uber began testing self-driving cars on America roads in 2015. They have tested AV technology on various models of cars in multiple cities with mixed results. There have been collisions and traffic violations reported and Uber recently suspended AV testing after one of their vehicles and "safety drivers" was involved in a fatal crash in Arizona.

AV-Readiness: Task Force Feedback

What job do we need AVs to do?

- Deliver resources and goods to homebound populations (ex. medicine, food, etc.)
- Data and information must be collected and delivered to vehicles in real-time
- AVs must reduce crashes and improve safety
- Connect to larger transit system through scaled services (first/last mile/ shuttles)

How can AV technology expand access to healthcare, employment, education & recreation for all users of the transportation system and all ages, abilities, and incomes?

- Ambulatory services & connected passengers – mobile information hubs could deliver medical information and a diagnosis to hospital or medical facility before a patient arrives by AV
- Improve transportation reliability for low-wage workers to get to work and reduce turnover for employers.
- AV technology could be used to provide one-way car sharing

How will AVs impact the transportation ecosystem?

- Public roads could become privatized
- Insurance market impacts
- Access and sharing of data could become problematic – as services become privatized, data becomes a commodity that governments are required to purchase in order to provide high quality infrastructure and appropriate programming
- Privacy concerns and increased exposure to advertising and marketing
- Mobility and transportation could shift to a subscription service
- There will be new economic opportunities as companies develop products and services that can be offered while using an AV.

Other Benefits/Costs of widespread deployment of AVs for cities & metropolitan regions

- AVs could provide an opportunity for the acceleration of smart grid and EV charging technology (i.e. inductive charging) that can reduce the need for new power plants.
- Better information can improve government programs and services.
- Data sharing or an open data system can improve government transparency and cultivate an environment for innovation that could deliver improved or new products and services.

Next Steps

The CDTC SMART Communities Task Force is scheduled to meet next on June 13, 2018 at 3:00pm. The Task Force will discuss the role of the MPO in AV-Readiness, public policy considerations, how communities can plan for the coexistence of existing infrastructure and AVs, and how can communities take advantage of any new infrastructure investment.

A Few AV Resources

National League of Cities, *Autonomous Vehicles: A Policy Preparation Guide*

National Conference of State Legislatures, Autonomous Vehicles: Self-Driving Vehicles Enacted Legislation

USDOT, *Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety*

Rand Corporation, *Autonomous Vehicle Technology: How to Best Realize Its Social Benefits*

Seattle Department of Transportation, New Mobility Playbook

Pedestrian and Bicycle Information Center, Discussion Guide for Automated and Connected Vehicles, Pedestrians, and Bicyclists

Boston Transportation Department, Go Boston 2030 Imagining Our Transportation Future: Vision and Action Plan

Video: The Future of Autonomous Vehicles by Robin Chase

Meeting Overview

The CDTC SMART Communities Task Force met on Wednesday, June 13, 2018. This meeting was the second part of a two part AV-Readiness discussion. A summary of the previous meeting was presented along with a series of discussion questions and roles of government agencies/organizations.

Roles & Responsibilities

Policy Level	Traditional Roles	Example New Policy Needs
Federal	• Provide transportation funding • Regulate the safety of the vehicle – issue guidance to achieve national safety goals, enforce compliance with safety standards, and communicate/educate the public about safety issues	• Define jurisdictions. Support modernization of transit funding. • Regulate the "driver" when it is the vehicle.
State	• Set rules for operation, driver licensing, insurance, & liability • Enacting & enforcing traffic laws & regulations	• Testing, registration & use of automated vehicles • Set operation rules, incentives for pooling & efficient operation • Modernize insurance & liability rules
City & Regional (MPO)	• Build & maintain infrastructure • Manage transit systems • Planning & policy • Program funding • Collect & analyze data	• Price empty or single occupant miles & access to congested areas • Modernize transit • Set rules for data sharing & use

Discussion Questions

What is the definition of successful AV deployment? - When CDTC and Capital Region communities plan for AV deployment, what language or shared goals do we want to see?

- Due to the level of uncertainty, it should be goal-oriented and less prescriptive to allow for flexibility, experimentation, and innovation.
- CDTC could develop model language for communities to use in their plans.
- An autonomous fleet must be electrified
- Policies and programs that support AV-deployment must prioritize equity.

- CDTC should continue to prioritize Complete Streets, principles that will improve safety for all road users, including autonomous "driverless" cars.
- Parking and building requirements should be flexible and account for AVs
- Acceptance of AVs requires governments to communicate anticipated outcomes and impacts of AVs early to illustrate how things can change. Issues regarding the workforce, unions, etc. must be addressed.

What infrastructure is needed to support AVs? – the interstate system and public roads were built and maintained with public funds so it is reasonable to expect the public to fund infrastructure needed to support AV-deployment. Funding is uncertain and the Capital Region cannot invest in everything at once…

- Dedicated short range communications (DSRC) – a two-way short- to- medium-range wireless communications capability that permits very high data transmission critical in communications-based active safety applications.
- Streetlights
- 5G – the 5th generation wireless cellular technology engineered to greatly increase the speed and responsiveness of wireless networks.
- Wireless EV charging
- Roadbed sensors
- Broadband (maps of existing broadband coverage in the region are on the next 5 pages)

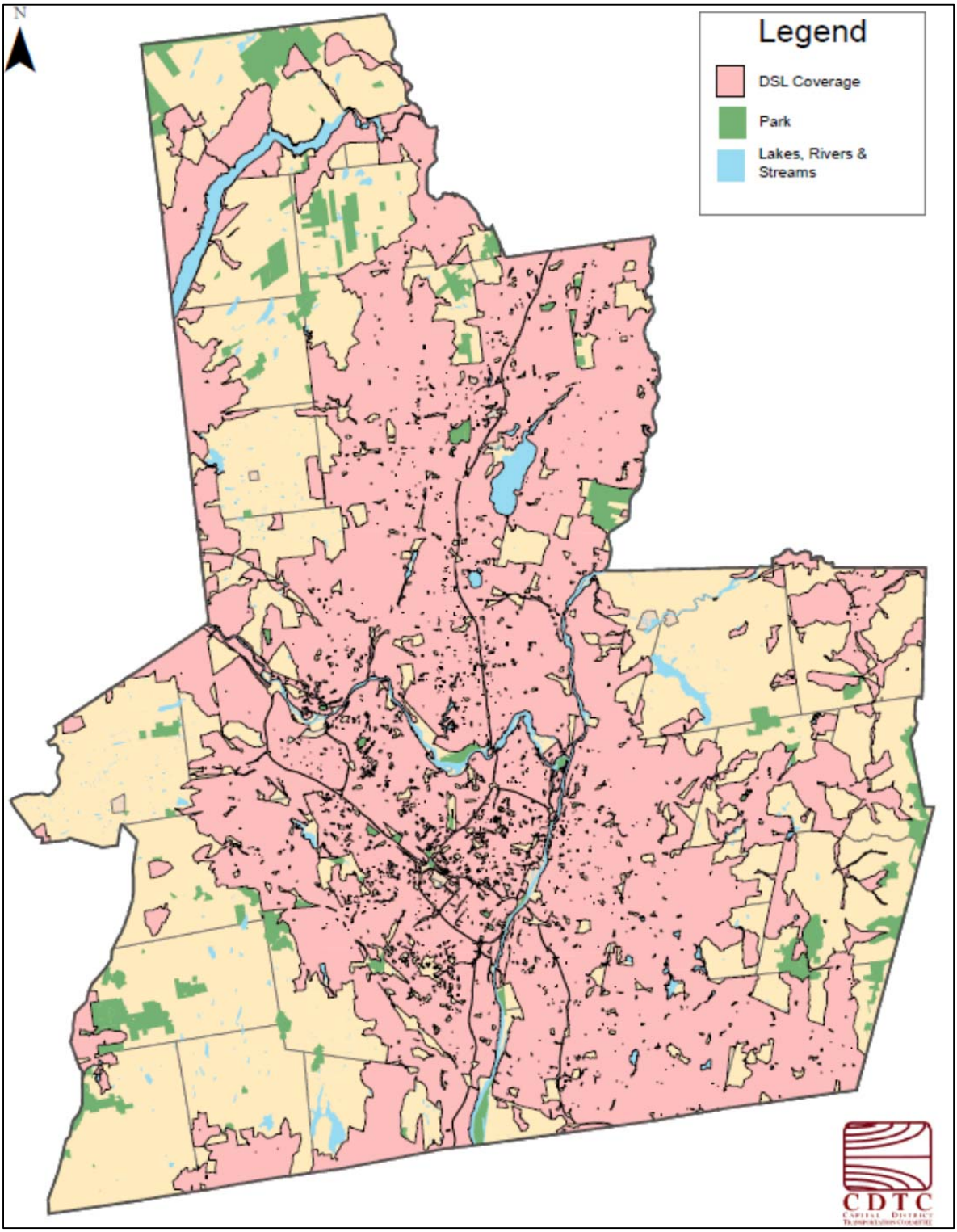
What are the barriers to AV deployment? – is there current policy or ordinance language that prohibits pilot projects? Prohibits flexible, experimental design for buildings and infrastructure? Acknowledges need to incorporate technology and innovation? Prohibits funding from being used for AV deployment?

- Is it too early to begin discussing this?
- Public perception/acceptance
- Need a process in place to handle incidents

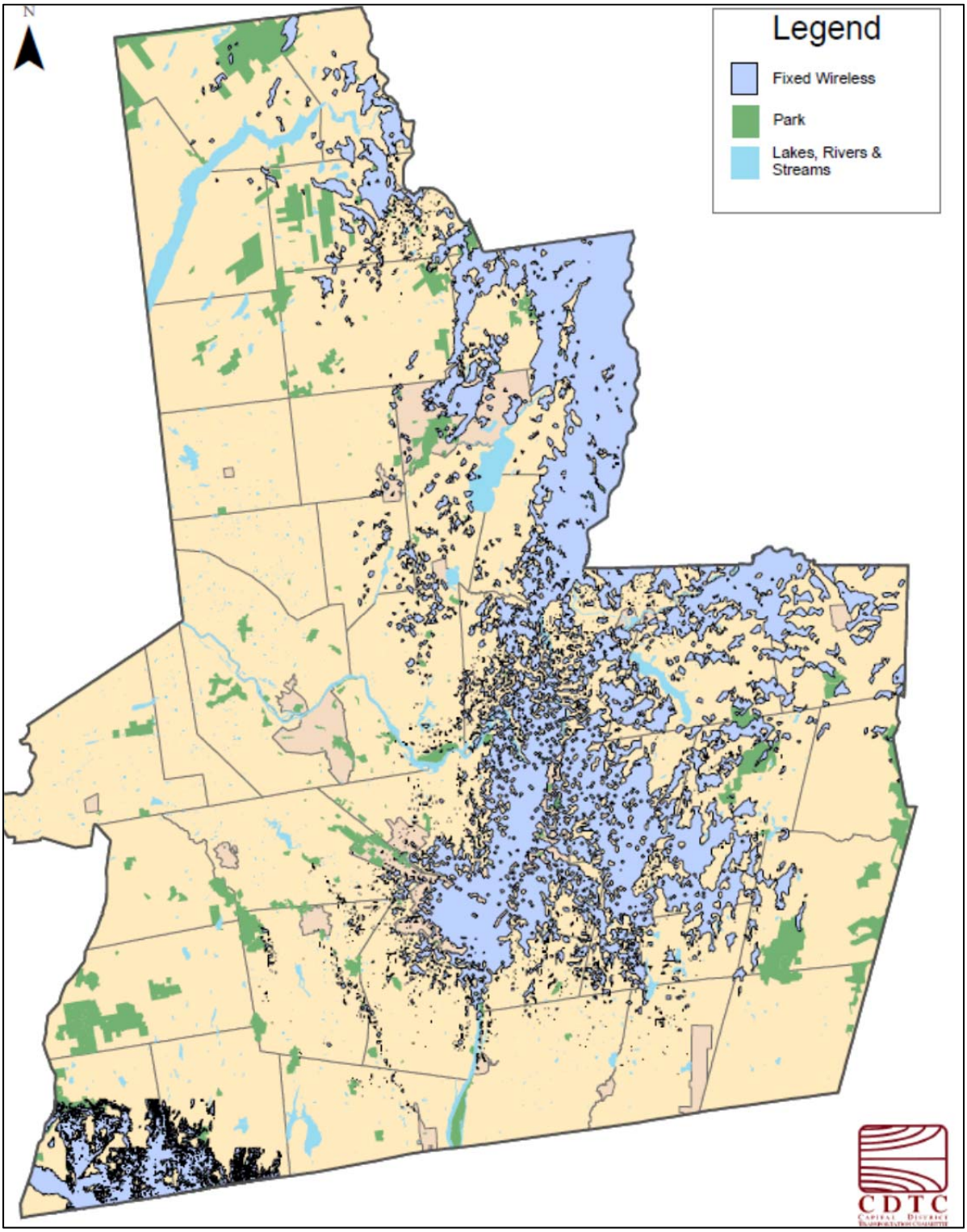
What planning tools are already available to communities/ How can they be adapted for AV-Readiness? – communities need to be able to address shifting land use patterns anticipated as a result of AVs, like reduced demand for parking. What strategies or tools can assist communities and be adapted specifically for AV-Readiness?

- Land trusts / land banking
- Transfer of development rights
- Zoning/ Transit-oriented-development (TOD) – should be more flexible so uses can change as market conditions shift, quickly.

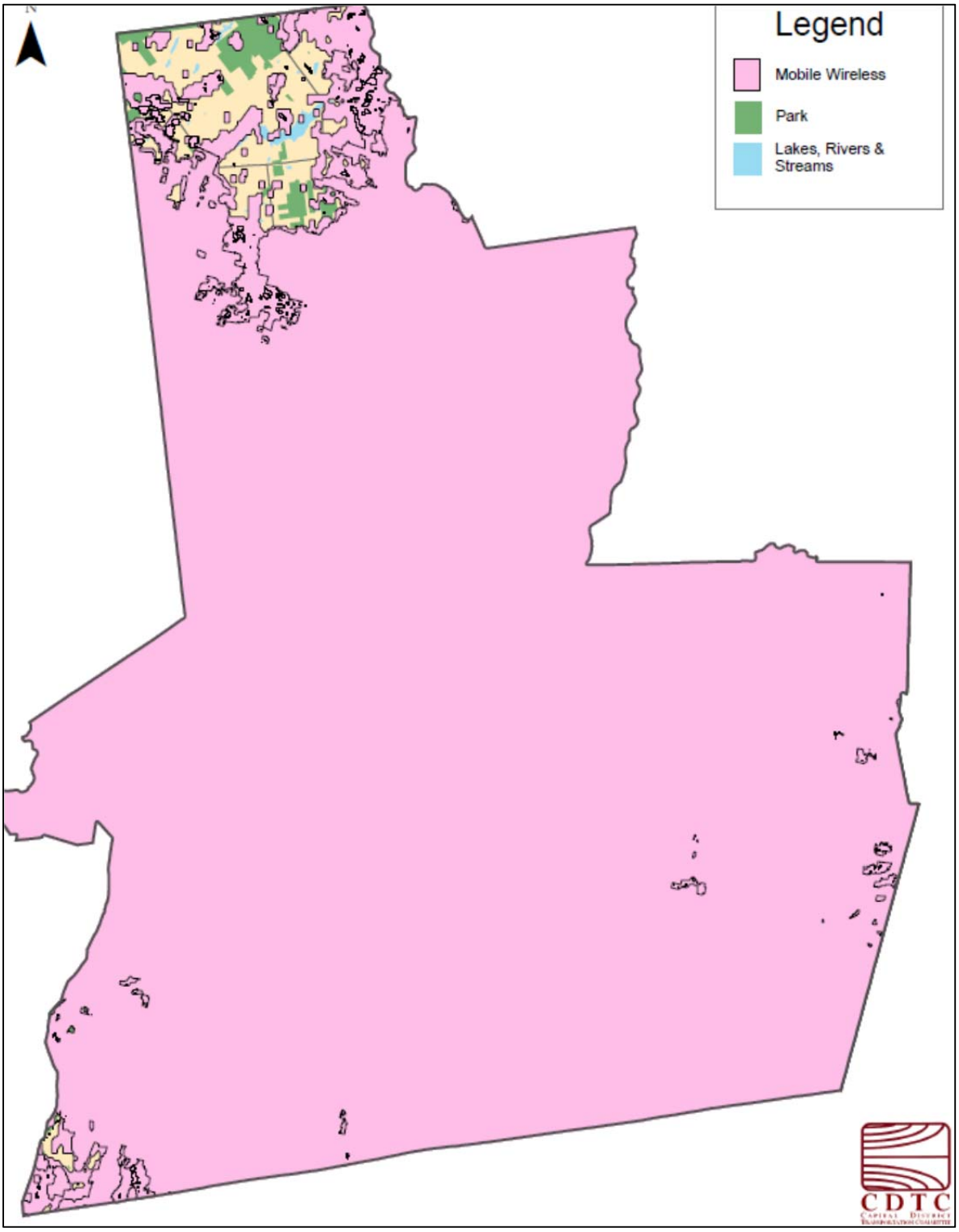
DSL Coverage



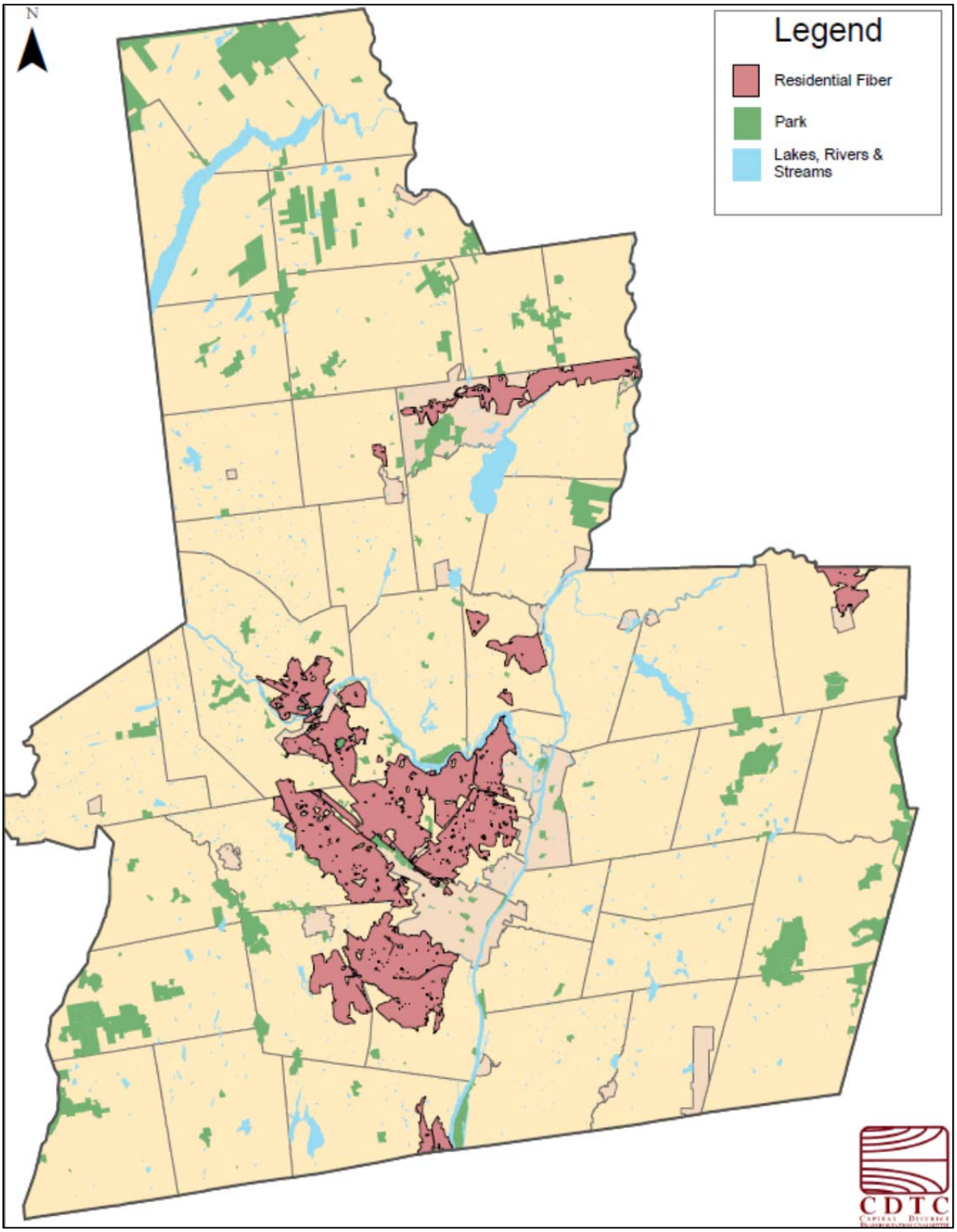
Fixed Wireless



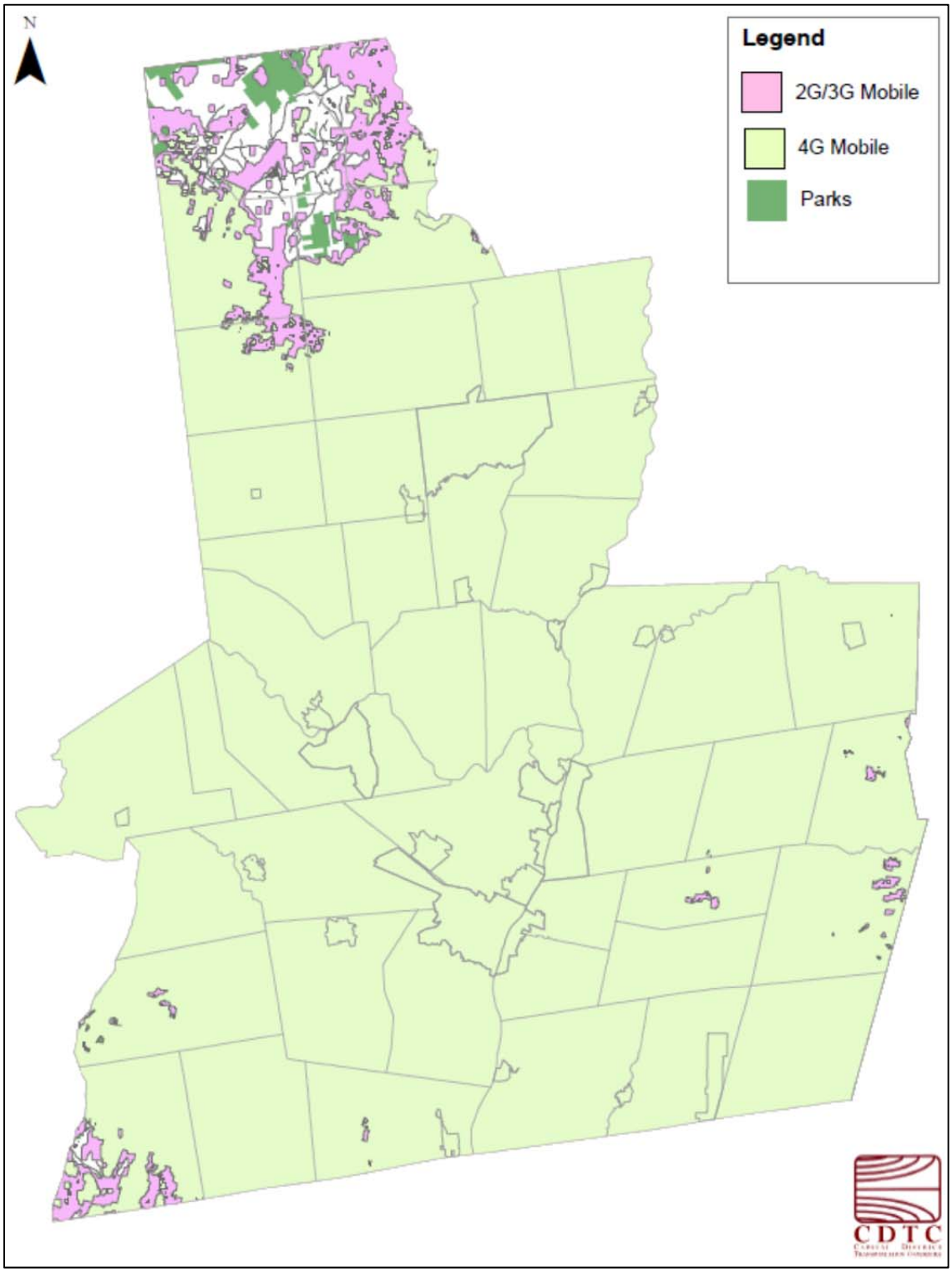
Mobile Wireless



Residential Fiber



Wireless 3G & 4G



How can communities use AV-Readiness to repair sprawl? To do-over cities? – is this an opportunity to be leveraged fix poor land use decisions in the past and improve connectivity?

- Could malls, office parks, and other land uses on the edges of cities and activity centers be identified for retrofitting as mobility hubs to aggregate and provide seamless transfer across a ground number of options and ownership models?

How does transit stay competitive?

- Continue to compete with private owned cars (80% of market)
- Partner and expand with shared mobility "rivals," rather than compete, to expand shared mobility

How do we educate local policy makers, planners, engineers, & user-consumers? – how do we nudge people from privately owned automobiles powered by fossil fuels to a predominantly shared use, electric vehicle model?

- Training & education for local officials
- Gather information & feedback from local governments right now

How do we support local AV-Readiness planning?

- Smart Corridor Plans
- Vision Zero plans
- Transportation Technology plans
- New Mobility planning

Do we need to identify new funding mechanisms? – Transportation revenues are on the decline and the highway trust fund has been insolvent since 2016, we don't have enough funding to fix what we have now, how do we fund the next transportation revolution?

- Integrate technology to improve efficiencies and save money.
- Implement local transportation taxes to fund transit and new mobility improvements
- Capture value created through transportation improvements and higher land values, like user fees, general taxes and fees or fees on mobility services

Examples of AV Policies

Seattle's New Mobility Playbook

Table 2. Preliminary Automated Mobility Policy Framework, Seattle

Topic	Example Policy
Equity and Accessibility	**EA1:** Ensure the benefits of automated mobility are equitably distributed across all segments of the community and that the negative impacts of automated mobility are not disproportionately borne by traditionally marginalized communities.
Pilots and Partnerships	**PP1:** Develop strategic pilot partnerships to test automated vehicle technology in Seattle's climate, hilly terrain, and urban traffic conditions.
Infrastructure and Street Design	**IS1:** As vehicle ownership decreases and reliance on shared automated vehicle fleets increases: • Capitalize on system efficiencies to implement our transit, bicycle, and pedestrian master plans. • Capitalize on opportunities to invest in placemaking features and expand the pedestrian realm. • Identify and phase in corridors and zones dedicated to transit, walking, and high-occupancy automated vehicles only.
Mobility Economics	**ME1:** Develop a tiered and dynamic per-mile road use pricing mechanism for automated vehicles operating in highly congested areas and corridors of Seattle: • Tier 1 (elevated surcharge): Zero-occupant automated vehicles • Tier 2 (base surcharge): Single-occupant automated vehicles • Tier 3 (reduced surcharge): Automated vehicles using smart lanes with less than three passengers • Tier 4 (no surcharge): Automated vehicles using smart lanes with three or more passengers • Tier 5 (additional surcharge on Tiers 1–3): Peak travel period surcharge for all nonpublic transit vehicles trips with less than three passengers, including freight
Land Use and Building Design	**LB1:** Ensure automated vehicles advance our land-use goals and capture the value of transit-oriented development.

Seattle's New Mobility Playbook Preliminary Automated Mobility Policy Framework which addresses equity and accessibility, pilots and partnerships, infrastructure and street design, mobility economics, and land use and building design. The table above provides examples of policies for each of these topics.

Shared Mobility Principles for Livable Cities

https://www.sharedmobilityprinciples.org

The American Planning Association's Policy Principles for Autonomous Vehicles

American Planning Association

Making Great Communities Happen

APA Policy Principles for Autonomous Vehicles

Autonomous vehicles (AVs) will be a disruptive, society-changing technology, not just for planning and placemaking, but for employment, social engagement, mobility, and a full range of physical, social, and economic factors. The AV has the potential to be the most transformative technology since the automobile. Mobility for all components of the nation's population can be improved.

Jobs will be lost even as other jobs are created; while the whole of society may break even, it is likely that the workers who lose jobs will be in different geographies and have different skill sets than the new jobs so there will be localized benefits or detriments which may exacerbate existing divides in the nation.

AVs are not only cars, but a wide range of applied technologies like smaller automated delivery vehicles that could use multi-use paths. As such, changes in the regulatory environment may be required as will a more complete understanding of the tort and liability issues surrounding ownership and use of autonomous vehicles. For planners and communities, it is important to note that AVs will impact land use, social structures, infrastructure and equity. The public policy developed in the near term around AVs has the potential to either reinforce or undermine local and regional planning goals.

The American Planning Association (APA) has developed this initial set of principles for integrating AVs within the fabric of our communities through planning, urban design, placemaking, and infrastructure investments. The mission of this paper is to provide a starting point for APA from which to enunciate some initial near-term policy recommendations.

Key Planning Principle

Principle 1: APA strongly encourages development of a shared mobility model instead of private ownership for AV travel to exploit the benefits of AV in a way that does not perpetuate existing conditions that have led to sprawl, inequitable access to mobility, excessive pavement with corresponding stormwater management challenges, energy waste, and environmental degradation. Regulatory and financial structures should be put into place that will facilitate shared mobility by not disadvantaging it as compared with private ownership.

Guiding Strategies

Mobility, Connectivity, Access

Principle 2: APA supports development and provision of mass transit or transportation utilizing automated and autonomous vehicle technologies, especially in managing first-mile and last-mile issues while improving safety, reliability and economic performance.

Principle 3: APA supports local planning efforts to reclaim public rights-of-way from the expected reduced space needed for AV travel (e.g., less parking, narrower lanes) for purposes within the public

realm to provide public benefits. Specific attention should be given to reintroducing bicycle and pedestrian-only public rights-of-way and spaces as a way of improving both placemaking opportunities and AV performance.

Principle 4: APA supports efforts to eliminate or sharply reduce municipal and off-street parking requirements with the growing incorporation of AVs into the national transportation system and permit the reuse of parking structures as active land uses.

Principle 5: APA calls on the professional design industry in concert with local communities to ensure the future built environment, including streetscapes, accounts for automated vehicles (less/reusable parking areas, more curb space for pickup/drop-off, self-activated charging stations, etc.).

Principle 6: APA supports the further use of ride-sharing, given the joint use of vehicles reduces environmental impacts including noise, emissions, impervious surfaces for streets and parking, etc.

Social and Environmental Equity

Principle 7: APA supports efforts to share autonomous mobility as a service rather than encourage ownership of each vehicle individually such that universal mobility is brought closer to reality and the potential for zero occupant vehicle miles is reduced.

Principle 8: APA supports the ongoing evolution and use of automated vehicle technology for passenger vehicles and freight, given the technology has the potential to improve economic welfare and safety and maintain or improve environmental conditions.

Principle 9: APA supports efforts to research and address equity issues created by AVs; equity concerns include the rural-urban divide and the increasing suburbanization of poverty and how these will be impacted or exacerbated by AV adoption.

Principle 10: APA supports the development of green technology (vehicle-to-infrastructure or V2I) for automated vehicle infrastructure, given the infrastructure is consistent with environmental protection and has minimal or no new impact on nearby development.

Principle 11: APA recognizes that significant adoption of automated and autonomous vehicles will occur over a time frame measured in decades and that adoption rate will be unevenly distributed geographically. However, the technologies and systems necessary to support such vehicles must be universally available as early as possible to support pioneers and early adopters.

Principle 12: APA recognizes that most urban transit agencies are operating in a failing—or failed—business model which needs to be dramatically revised because mass mobility remains the key to equity and access for substantial portions of the population, especially in urban and suburban areas.

Energy, Sustainability, and Research and Development

Principle 13: APA supports the development of automated and autonomous vehicles with a strong preference for using alternative energy and sustainable tire technology and materials such that there is an overall reduction in energy consumption even if projections positing an increase in Vehicle Miles Traveled are accurate.

Principle 14: APA supports the development of vehicle-to-infrastructure (V2I) technology for passenger and freight modes as well as the facilitated transfer of goods between modes for improved security, reduced costs, and other benefits.
Principle 15: APA supports research and development efforts focused on creating a more sustainable transportation network resulting from the possibility of more compact development, reduced pavement requirements, improved vehicle performance, modified roadway maintenance schedules and equipment, and any other factors that contribute to an overall more sustainable transportation system.

Safety and Security

Principle 16: APA supports the Vision Zero construct and encourages the development of policies and technologies, including Vehicle to Pedestrian (V2P) technologies, to reduce or eliminate fatal vehicle crashes for all users of the transportation systems, but especially pedestrians/cyclists.

Principle 17: APA supports efforts to secure infrastructure (technology and roadways) to ensure the safety of users as well as the reliability of systems. To this end, APA encourages the use of open source, non-proprietary technologies.

Principle 18: APA supports the further development of vehicle-to-vehicle and vehicle-to-infrastructure technology to improve safety; however, information technology for security of personal identification information (PII) must be prioritized within the data security of vehicle operating systems.

Data and Decision Making

Principle 19: APA is supportive of strategies that create a policy environment friendly to innovation while maintaining local control of public spaces and land use planning.

Principle 20: APA believes that having good and current data is crucial to decision making by federal, state, and local planning and transportation officials and encourages the development of a central data repository available to all.

Principle 21: APA supports a vibrant economy in part stimulated by research and technology and maintenance and operation of automated vehicle technology. Demand-responsive transportation networks are an example where "Big Data" can be used to promote personal mobility.

Principle 22: APA encourages the use of public-private partnerships (P3) for co-funding of technology and infrastructure to benefit the surface transportation system globally in ways that reduce or do not exacerbate the equity and affordability issues occasionally associated with P3.

Economics and Fiscal Planning

Principle 23: APA recommends a thorough analysis of the fiscal mechanisms used currently to finance vehicle-related infrastructure investments that may be impacted by widespread adoption of AVs—parking structures, high-occupancy toll lanes, congestion-pricing, gasoline taxes, and similar strategies—to ascertain both long-term effectiveness as well as whether changes will affect the ability to repay current revenue-based borrowing.

Principle 24: APA encourages governmental entities at all levels to consider the effect of loss of current revenues derived from vehicle sales, service, ownership, fines and forfeitures, fees, and similar sources will have on budgets and begin to plan now for that eventuality.

Principle 25: APA believes that AVs will create an ever-greater emphasis on the mobile economy where goods and services are delivered directly to the customer at the customer's place of choosing as well as while the customer is also mobile.

Principle 26: APA supports rethinking the role of public rights-of-way and considering them not so much as public space but as a public utility which is priced accordingly.

Policy Recommendations

APA recommends the following near-term actions:

1. Create a standards entity comprised of industry, technology, university and government partners to develop standards for interoperability and secure data communication.

2. Invest further in mass transportation and transit infrastructure to support a mobility sharing economy potentially centered on AV technology that provides access to all with respect to income, gender, race, and other unforeseen discriminators while reducing historically inequitable transportation decisions.

3. Adopt local ordinances that enable communities to be responsive to autonomous vehicles while providing flexibility to reclaim abandoned infrastructure for public use. APA, working with partners, should consider developing a model ordinance for states and localities.

4. Emphasis should be placed on creating model state enabling legislation to authorize localities to control public infrastructure for public benefits and fully implement sustainable land use policies that fully exploit the opportunities presented by the shared mobility model of AV adoption.

5. Actively advocate for maintaining local control over public spaces and planning processes, especially those public spaces that may no longer be dedicated to vehicular travel and parking.

6. Work with partner organizations to develop a common set of guidance for the design of future buildings, public spaces, facilities, roads, highways, bridges, and other infrastructure.

7. Develop flexible parking policies that can allow for the reduction or elimination of certain parking requirements as AV market penetration increases.

8. Continue as a profession to further policies that encourage ridesharing and shared mobility strategies which address first and last mile issues.

9. Engage with all stakeholders to develop for adoption legislative policies for AVs related to certification, licensing, training, and tort liability.

10. Support funding from public and private sectors as well as universities for ongoing research and analysis of the implications of AVs for urban placemaking and mobility planning.

11. Convene an expert panel to consider and promulgate standards applicable to AV systems and networks that protect the privacy of all AV users.

12. Study the fiscal implication to governments at all levels from the large-scale implementation of AV technology as it relates to the impacts on income streams currently derived from transportation taxes and fees, personal property taxation, parking fees and fines, and traffic violation fines, fees and forfeitures to ensure that the public services and infrastructure currently funded by such revenues can continue to be funded consistent with the needs and opportunities of AV mobility.

13. Support planning-focused research, professional development and education programs related to ongoing AV technology research and breakthroughs to help planners keep pace with the state of the practice in this rapidly evolving field.

14. Engage the architecture, real estate and residential building industries in discussions about the future of urban design and home construction when personal automobile ownership is no longer a major consideration for the arrangement and space utilization of residential dwellings.

15. Consider how the availability of AVs may encourage greater opportunity to age in place and develop long-term community plans accordingly.

February 2018

NACTO Blueprint for Autonomous Urbanism

BLUEPRINT FOR AUTONOMOUS URBANISM

Module 1 | Fall 2017
Designing Cities Edition

NACTO

National Association of City Transportation Officials
120 Park Avenue, 20th Floor
New York, NY 10017
www.nacto.org

ABOUT NACTO

NACTO's mission is to build cities as places for people, with safe, sustainable, accessible and equitable transportation choices that support a strong economy and vibrant quality of life.

The National Association of City Transportation Officials is a 501(c)(3) nonprofit association that represents large cities on transportation issues of local, regional, and national significance. The organization facilitates the exchange of transportation ideas, insights, and best practices among large cities, while fostering a cooperative approach to key issues facing cities and metropolitan areas. As a coalition of city transportation departments, NACTO is committed to raising the state of practice for street design and transportation by building a common vision, sharing data, peer-to-peer exchange in workshops and conferences, and regular communication among member cities.

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West Palm Beach, FL

Foreword

The autonomous revolution will be humanized.

One century ago, as the automotive age swept across the nation, cities responded not by adapting cars and trucks to the varied uses of the street, but with a relentless clearcutting of urban roads, removing all obstacles from curb to curb—including pedestrians—and all but eliminating street life. Subsequent generations of urban planners built upon this, hollowing out downtown urban cores with congestion and traffic danger, replacing housing with parking lots, and eviscerating urban economies.

Today, in the second decade of the 21st century, and as we anticipate the arrival of self-driving vehicles on city streets, we have a historic opportunity to reclaim the street and to correct the mistakes of a century of urban planning. This adaptation starts with a plan.

The Blueprint for Autonomous Urbanism is based on the principle of people, showing how to adapt new mobility technologies to our cities, and not the other way around. If we redesign streets to meet the needs of people, they begin to look very different. Curbsides become places for commerce and shared mobility, not parking. Vehicle travel lanes occupy only as much road space as they need to move people efficiently, and are not saturated with thousands of single-occupancy vehicles. And space is dedicated to the kinds of mobility that really make our cities move: public transit, walking, biking and shared rides.

The Blueprint looks to the autonomous future as a chance to revolutionize the street for the people, and not just a revolution in the technology running on it.

Janette Sadik-Khan

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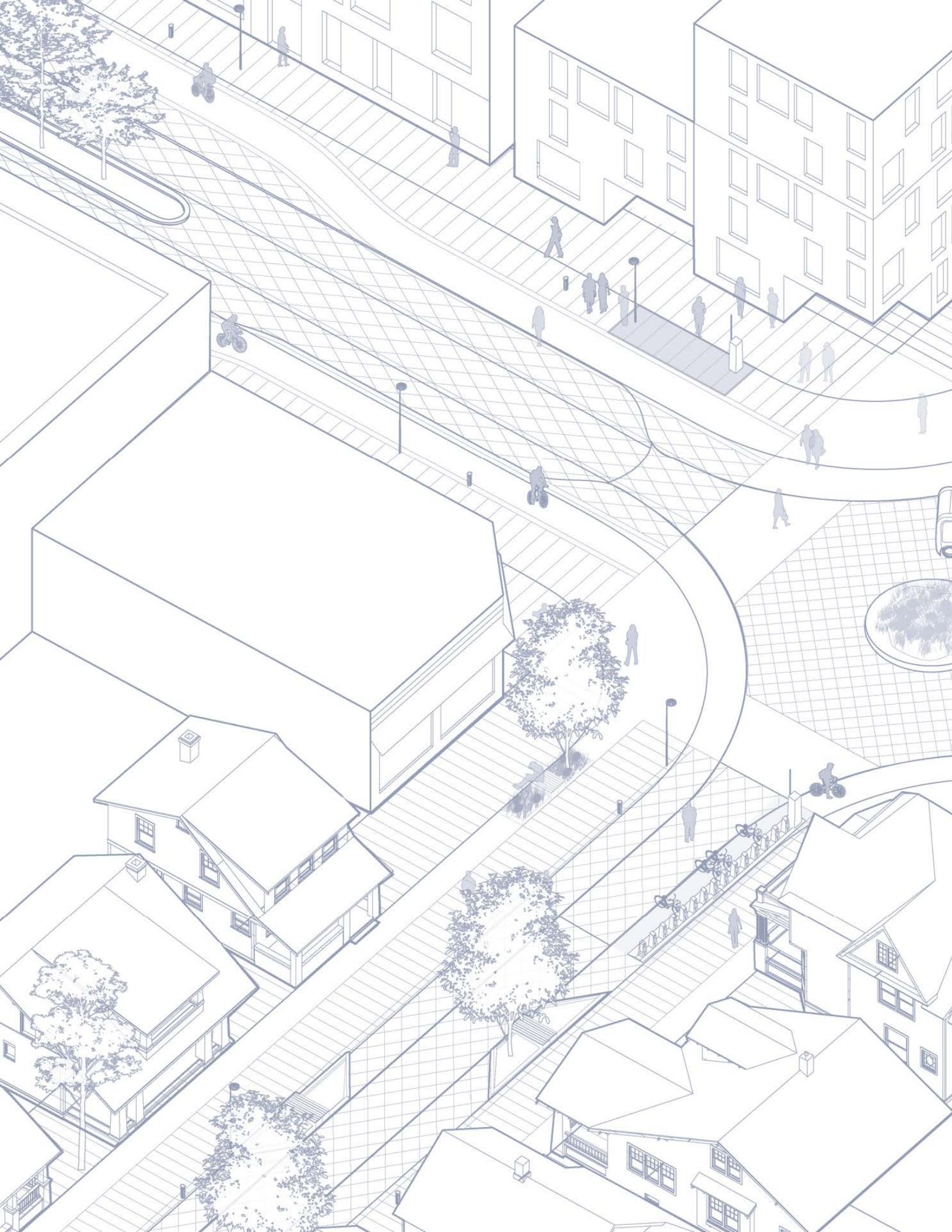


Blueprint for Autonomous Urbanism

Drastic advances in automated and connected vehicle technology will upend the way people move around cities, presenting sweeping opportunities as well as serious risks. This Blueprint envisions a future where cities and transit agencies leverage new technology as a tool to enhance the public realm and improve the lives of all urban residents. This is a future shaped by proactive urban policy, in which the footprint of vehicular travel is reduced, every transit vehicle supports high occupancy trips, and safe spaces for walking and cycling are abundant. With the right policies, automation can enable newfound dynamism in mobility and make it easier than ever to access quick, affordable, equitable and sustainable transportation options throughout cities.

Introduction

Transportation decisions have dramatically changed the face of cities over the last 100 years. From streetcars to traffic signals to highways and parking lots, transportation infrastructure has reshaped how humans engage with their surroundings. While many transportation innovations were optimistically intended to benefit society, the changes were not always for the better; from sprawling land uses, to highways that divide neighborhoods, to the public health burden of traffic crashes, to the sheer amount of space dedicated to parking cars, a century of automobile-oriented transportation policy has left an entrenched legacy in urban design.

Today, the advent of autonomous vehicles poses a similar risk—and presents an opportunity to learn from the mistakes of the past and ensure that cities and transportation systems become more efficient, sustainable, and equitable.

The prospect of a widespread shift to automated transportation comes on the heels of a decade of unprecedented progress in sustainable transportation. City leaders and practitioners have not only embraced biking, walking, and transit as essential to their city's attractiveness, but have experimented successfully with new, more nimble forms of project delivery and implementation. Automated vehicles must not negate this progress.

This Blueprint outlines a vision for cities in a future where automated transportation is both accepted and widespread as part of the built environment. It is a human-centered vision for the potential of city streets, intersections, and networks—one in which automation is harnessed to serve the goals of safety, equity, public health, and sustainability. As a vision, it sets out to inspire policymakers and practitioners to challenge basic assumptions of design, traffic operations, and engineering and to project a vision that builds on present progress, yet takes advantage of technological possibilities.

A Critical Turning Point

As with other visions of the not-too-distant future, the Blueprint charts a course amidst many open questions. Despite the recent enthusiasm for automated vehicles, much remains to be seen about how they will ultimately perform on streets and highways, how people will (or will not) integrate them into their lives, and how their evolution may impact the many people who rely on transportation services for their livelihood across the globe.

Speculating on these unknowns is not the purpose of this document. Nonetheless, waiting to see how events unfold is not a viable option. The onset of automated vehicles marks a critical and consequential turning point in the history of mobility—as important as the early 20th century rise of motordom. The policies contained here are a step towards building a policy agenda and aspirational framework for the deployment of automated vehicles. In the absence of such policies, transportation network companies and technology companies will shape urban transportation policy by default. Cities must restate and reiterate their goals and priorities now in order to proactively create cities that best serve the long-term needs of their residents—and other levels of government must heed their call.

For those working in cities and public officials, the Blueprint is intended to serve as a foundational and aspirational human-oriented vision for the city—a statement and visualization of core principles in an uncertain future shaped by technology.

For the private sector, the Blueprint is intended to communicate the urban vision that cities are working toward and the importance of partnership to achieve this vision.

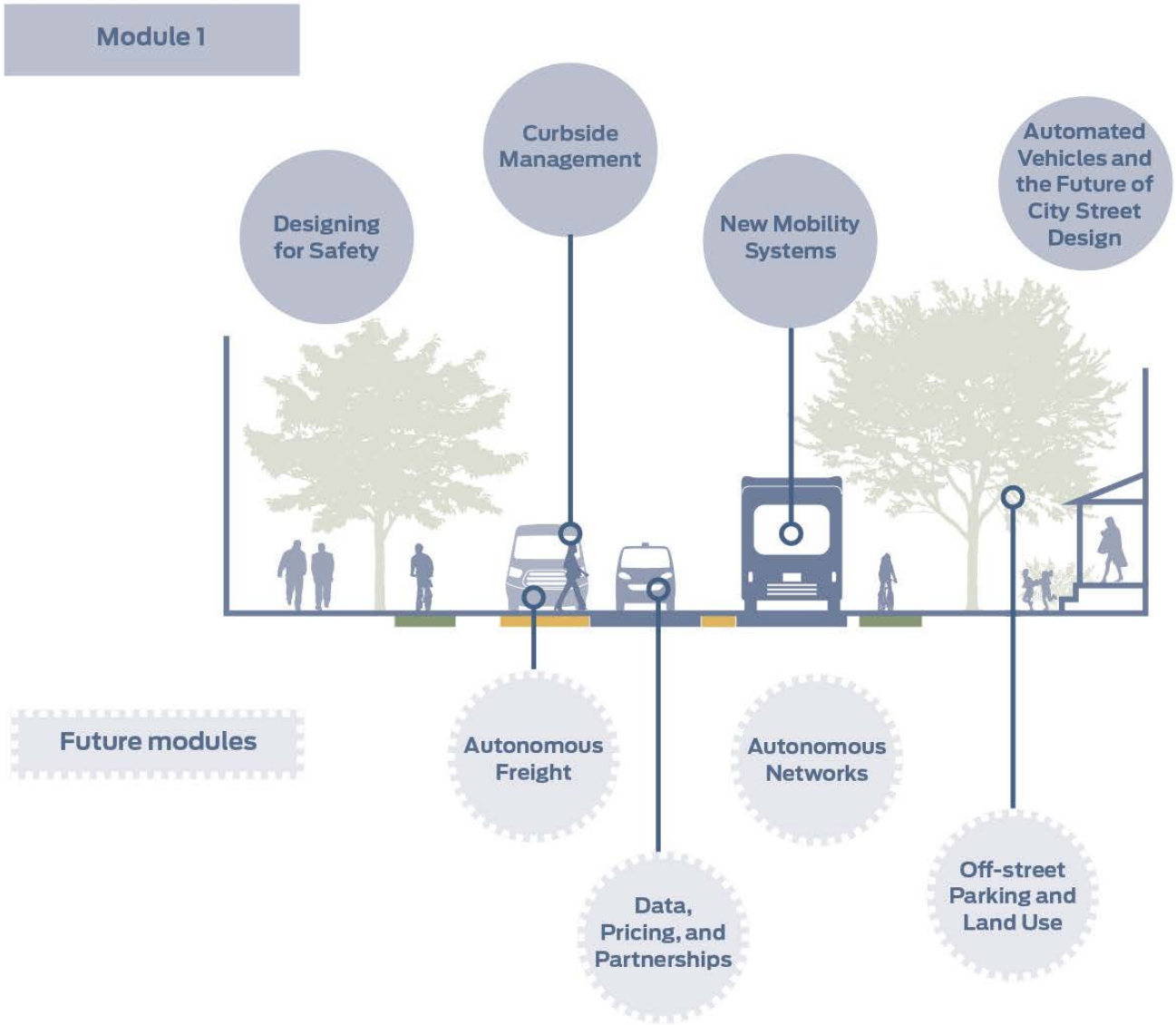
This Blueprint outlines a vision for cities in a future where automated transportation is both accepted and widespread as part of the built environment. It is a human-oriented vision for the potential of city streets, intersections, and networks—one in which automation can serve the goals of safety, equity, public health, and sustainability.

Structure of the Document

Unlike the NACTO Design Guides, the Blueprint does not focus on specific markings or measurements. It endeavors first and foremost to illustrate policy goals using renderings and diagrams, and to present an alternative vision of the future oriented around city streets as public spaces.

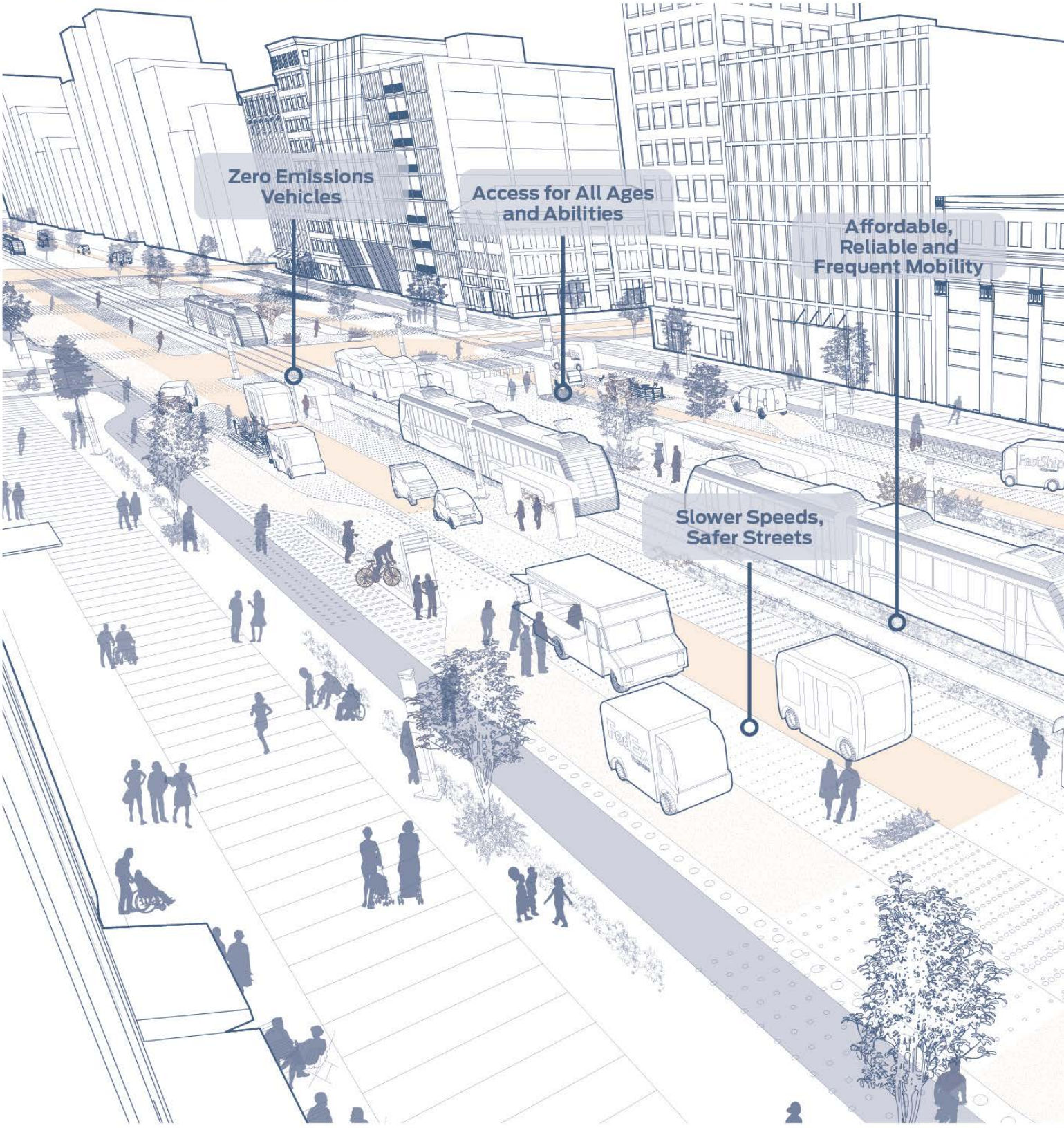
This is not a design guide. The Blueprint lays the groundwork and sets a vision for city streets in the automated future that are designed for people. It is rooted in our cities' goals for building safe, accessible and equitable communities with strong economies and vibrant communities. The ideas and vision presented in the Blueprint adapt NACTO's foundational principles to the rapidly changing technology and transportation realm.

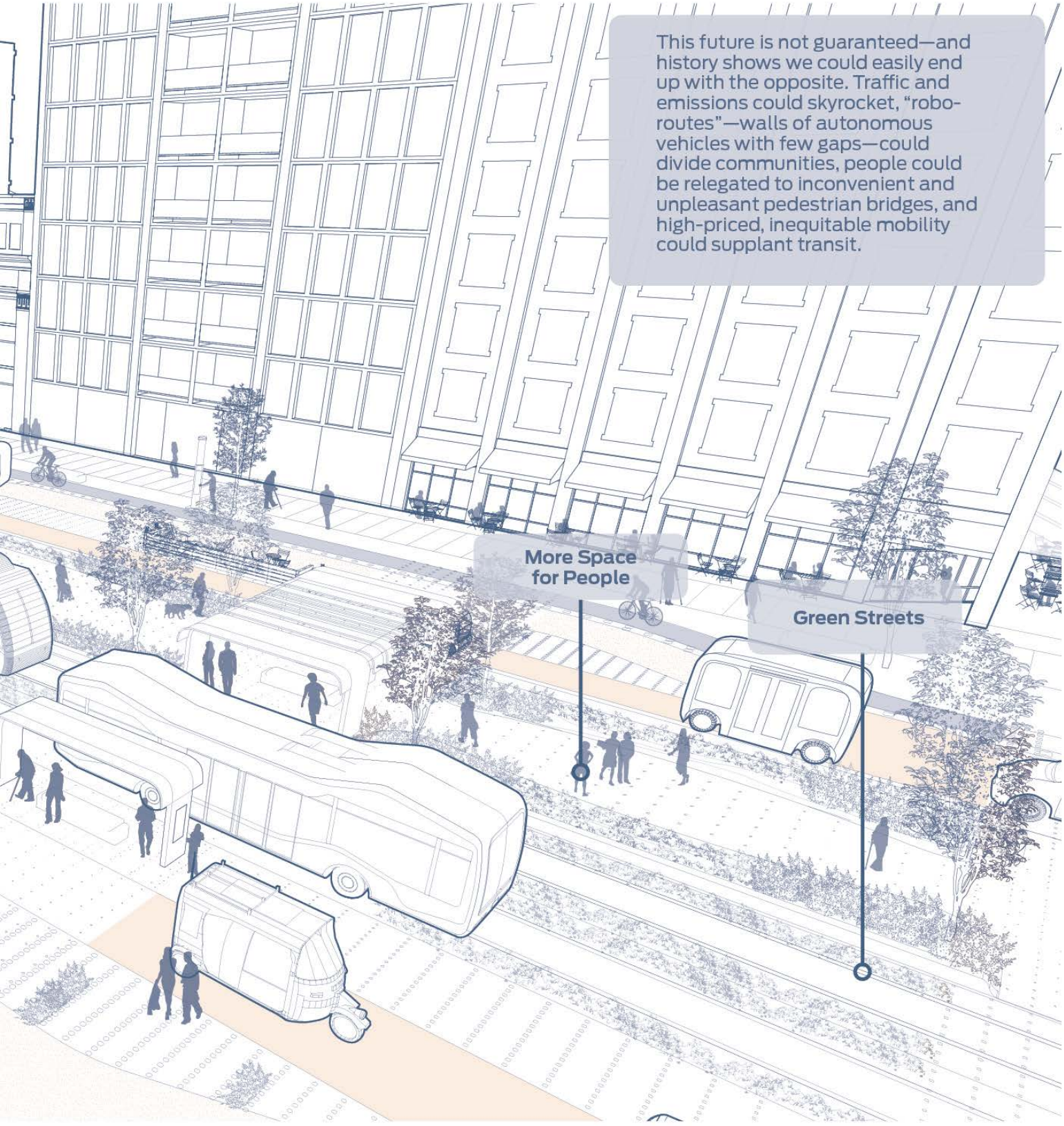
This module of the Blueprint addresses some of the most pressing issues city transportation agencies face today but acknowledges those issues will vary by city and over time. The modular approach is an attempt to lay the groundwork in a field that moves rapidly. We will be build on this vision as technology advances.



The Promises and Perils of Automation

Automated vehicle technology holds many promises for cities, but the potential benefits of automation are not guaranteed. City policies must proactively guide the technology to prioritize people-centric design.



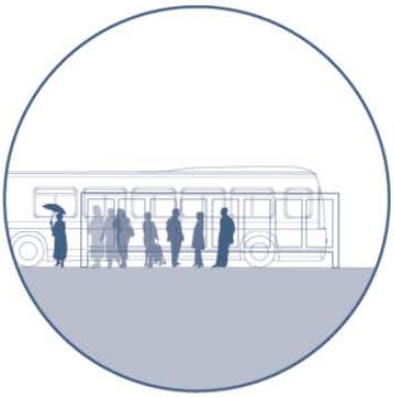


This future is not guaranteed—and history shows we could easily end up with the opposite. Traffic and emissions could skyrocket, "robo-routes"—walls of autonomous vehicles with few gaps—could divide communities, people could be relegated to inconvenient and unpleasant pedestrian bridges, and high-priced, inequitable mobility could supplant transit.

Principles for Autonomous Urbanism

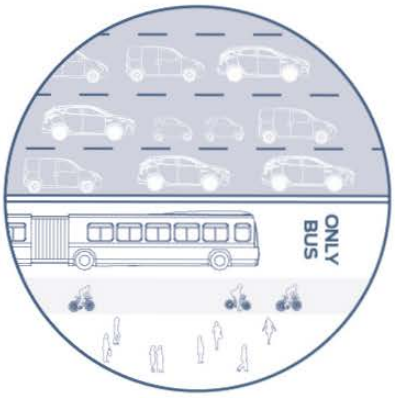
Safety is the Top Priority

Streets should be designed for the safety of all users, with special attention necessary for pedestrians and cyclists. Cities should require that highly automated vehicles be programmed for safe, slow speeds on city streets, with mandatory yielding to people outside of vehicles. Maximum vehicle operating speeds in city street environments should not exceed 20 mph, or 25 mph in very limited circumstances, with lower speeds in downtown and neighborhood zones.



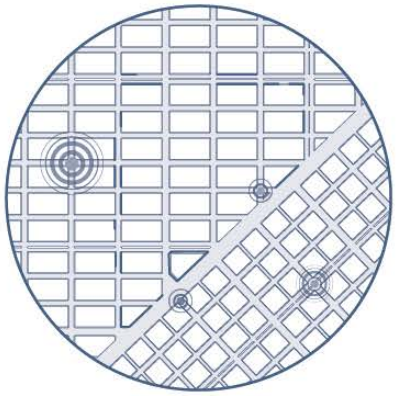
Provide Mobility for the Whole City

The benefits of autonomous urbanism can only be realized if mobility is made more accessible, convenient, and affordable for the entire city. Cities and their partners should offer flexible and affordable mobility options tailored to the needs of different communities, from walking and biking to fixed transit and ridesharing.



Rebalance the Right-of-Way

With the right policies, autonomous vehicles can move more people in fewer vehicles on less congested streets. That means that cities can use space more wisely. Instead of planning for roadway expansion, reallocate street space to active, sustainable modes and use technology to manage the public realm dynamically.



Manage Streets in Real Time

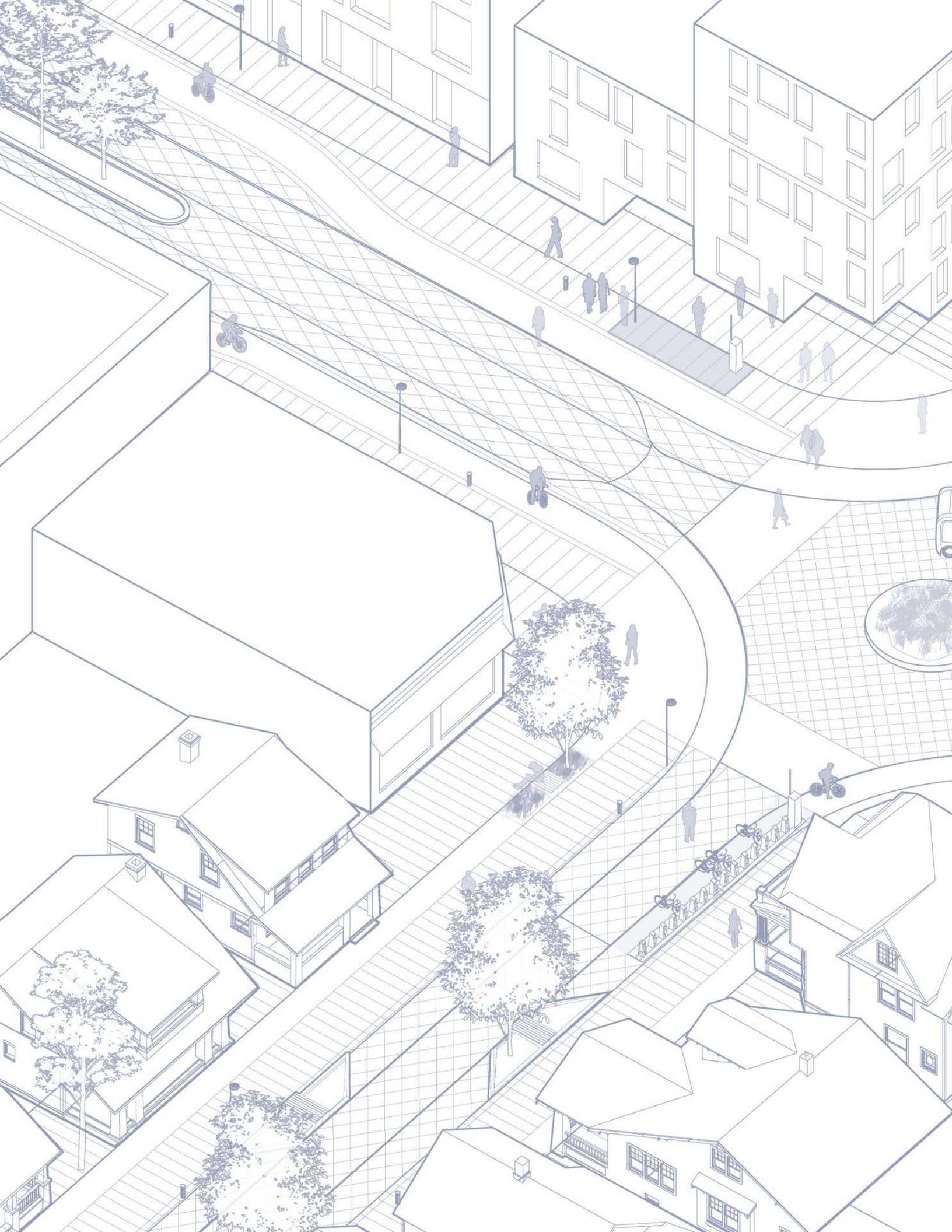
New technology makes real-time, proactive street management feasible. Cities must leverage this opportunity to revolutionize the services they provide and the ways they capture revenue. Real-time right-of-way management and vehicle occupancy pricing mechanisms will allow cities to incentivize shared and active modes over private automobile trips, while reapportioning vehicle space as public space.

Move More with Fewer Vehicles

As technology is embedded in urban transportation, vehicles can assume maximum rider occupancy, creating an interconnected network of mobility supply and demand whether for freight or passengers. Transit agencies will need to adapt to new consumer expectations and reshape their services to ensure seamless connections with other modes.

Public Benefit Guides Private Action

Autonomous urbanism should foster balanced collaboration with the private sector that maximizes public benefit. Smart governance ensures that these partnerships are neither unconditional endorsements nor punitive prohibitions, but are instead guided by set criteria and clear, measurable and adaptive policy goals.



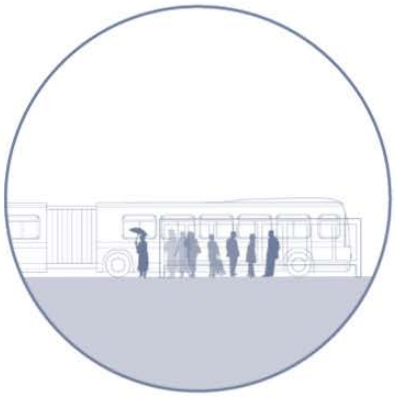
2 Policy Ideals and Actions

Cities need strong policies to guide the future of automation and to help communities shape powerful technologies around their goals, rather than the other way around. Clearly articulated policy goals represent a good first step for cities. Achieving these goals will require creative public-private partnerships, adaptive decision-making, and critical data-sharing agreements.

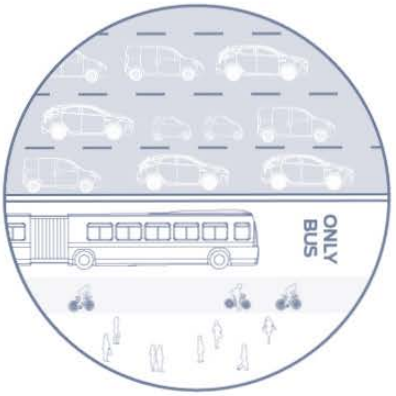
Setting up for Success

The right policies today will position cities for success in the autonomous era of tomorrow. The autonomous revolution can support cities as they work toward streets that prioritize pedestrians, dedicate more space to better bicycle infrastructure, and allow for reliable transit service-but only with smart, thoughtful, intentional policies. The following are critical steps that NACTO cities have already adopted and are implementing to prepare for the autonomous future.

Safety is the Top Priority



Mobility for the Whole City



Rebalance the Right-of-Way

20 is Plenty

Set speed limits for automated and human-driven vehicles that are safe for people walking, cycling and taking transit.

Create a Citywide AV Working Group

For automated vehicles to work for the whole city, all city departments must be involved in planning for the autonomous future.

Stop Expanding Roads

Update existing traffic models to reflect the reduced need for roadway due to future efficiencies through automation.

Collect Better Data for Safety

Use a third-party platform to anonymize and aggregate data from vehicles operating in the city to pinpoint hazardous locations and redesign streets for safer operation.

Invest in Active Modes

Build streets that prioritize sustainable and active modes like transit, walking and biking.

Take a Lane for Transit

Dedicate travel lanes for high-volume transit services to boost person-throughput in critical corridors.

Set Operating Principles that Prioritize People

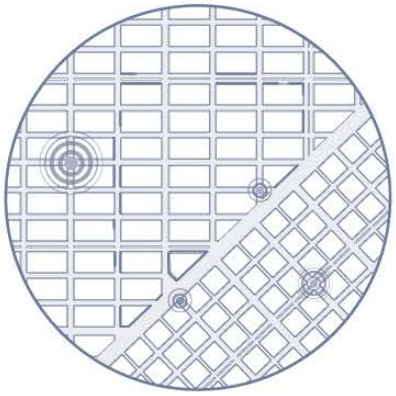
Establish principles for operation and geometry on city streets that ensure safe operation of both human-driven and automated vehicles.

Collaborate Regionally to Promote Interoperability

Support multiple modes to provide complete coverage to all areas of the city, integrating them all in a single platform to allow for easy customer use.

Pavement for the People

Repurpose underutilized travel lanes to ensure safety and comfort for people walking along the curbside, and create valuable public spaces in neighborhoods and downtowns alike.



Manage Streets in Real Time

Street Management with Data

Use third party data platforms to exchange data about the street securely and seamlessly, supporting street management in real time.

Price the Curb

Create delivery and pick-up and drop-off management plans that maximize customer experience while minimizing the fight for the curb that endangers people across modes.

Code the Curb to Optimize Access

Maintain a dynamic, digitally-visible curbside inventory to democratize curbside access while guarding safe function of the roadway.

Move More with Fewer Vehicles

Prepare for a Future without Parking

Reduce parking minimums in zoning codes to reflect lower overall parking needs. Develop prototypes for adaptable parking garages and infrastructure that could be retrofitted in the future.

Incentivize Electrification

Support shared, electric vehicle use by allocating space for charging stations and employing occupancy-based congestion pricing.

Invest Strategically in Transit

Modernize and strengthen public transit and its partners on high volume routes.

Public Benefit Guides Private Action

Clear Hurdles for Public-Private Partnerships

Create replicable requests for qualifications with 'piggy-backing clauses' so that companies can clear hurdles once to work across US cities, supporting local goals.

Engage the Public

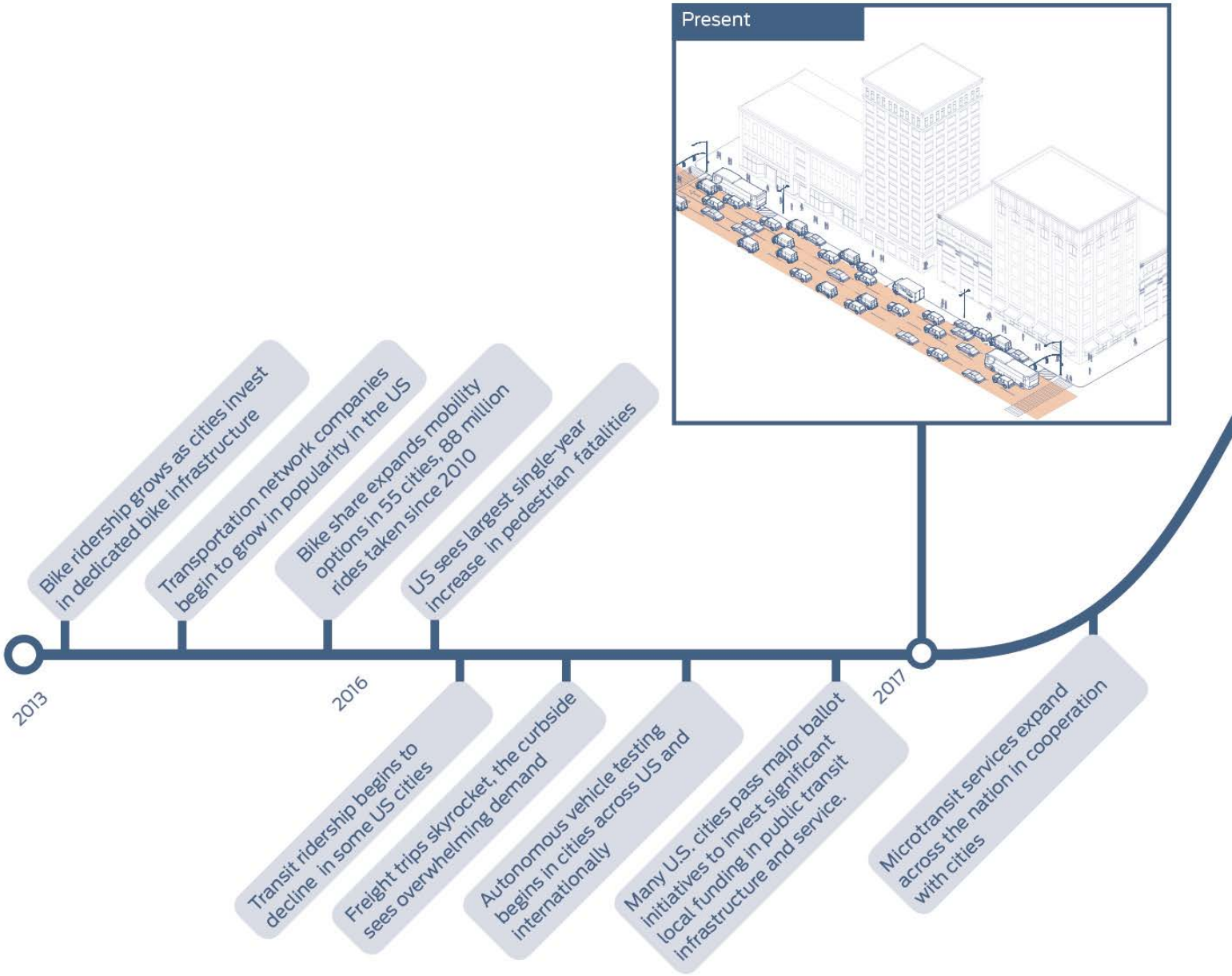
Make technology development and pilot projects transparent so that the public can engage in an informed discussion about how new technology can make their lives and communities better and stronger.

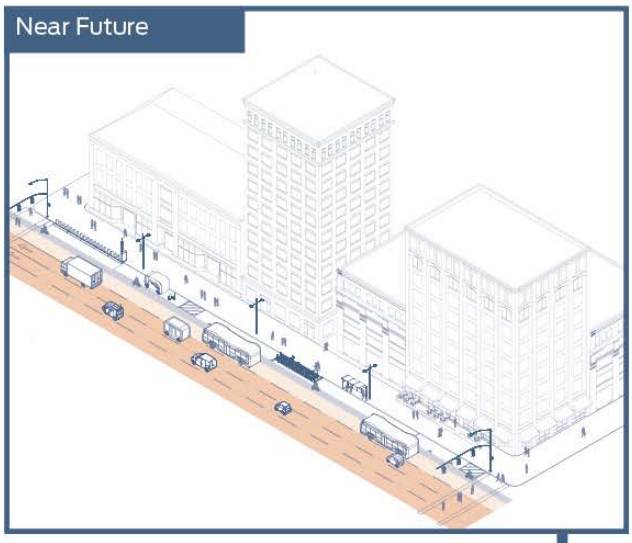
Cities are Integral to Autonomous Operations

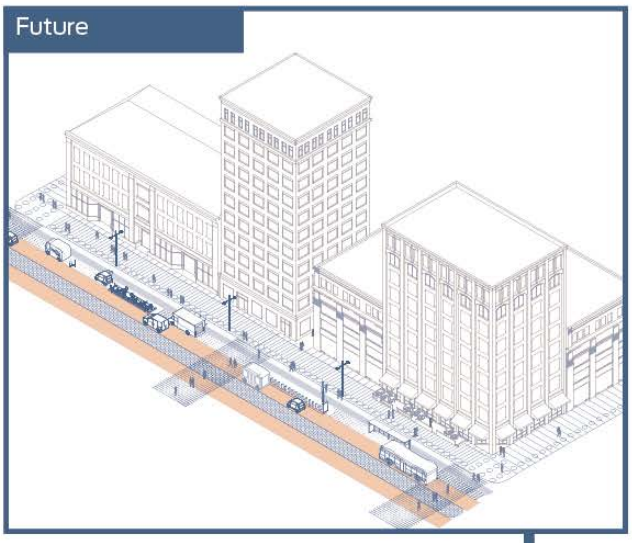
Cities already support and manage traffic. They must be integral partners in discussions about future technology operations.

Managing the Transition

Automated vehicles are on the horizon and cities are preparing for their arrival today. Though the pace of technological change is rapid, changes to urban infrastructure tend to be incremental. While much experimentation will take place on the vehicle side of automation, city streets and sidewalks can also serve as an important venue for testing new policies, technologies, materials, and street types.







Partial Automation

Full Automation

Cities invest strategically to simultaneously prepare for connected, autonomous technology and to make every street safe and welcoming for cycling and walking

Speed limits reduced to 20 mph, curbside lanes are dynamically priced and reclaimed for people

Mobility pricing enacted in the first US city, emissions and congestion reductions seen

Walking, cycling and core transit use surge, all vehicles in cities are shared

More cities begin to price VMT to reduce congestion as AVs proliferate

Fleet vehicles are fully automated, VMT decreases, cities densify

Data Foundations

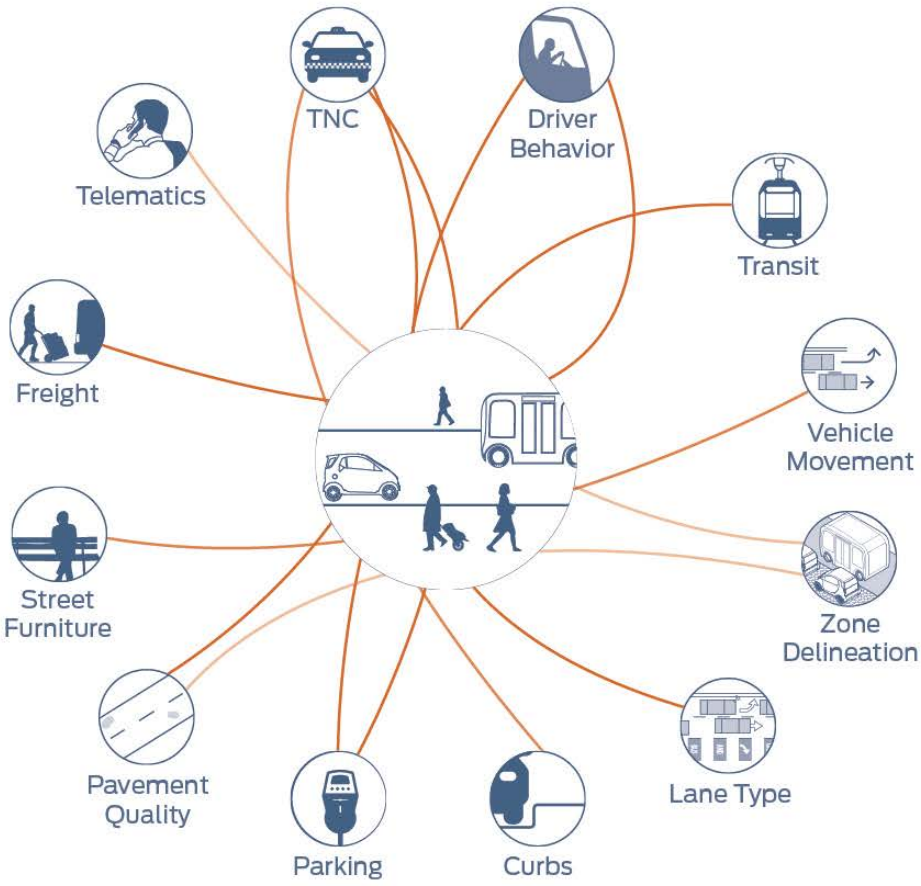
Data is replacing concrete, asphalt and steel as the foundation of 21st-century urban transportation planning and management. New technologies have the potential to radically improve the efficiency, cost, and inclusiveness of our transport system.

The World Wide Street

Billions of detailed, street-level data points are collected in real time daily on everything from traffic speeds and volumes to travel patterns and transit use. This data is vital to the operations and management of streets, regardless of the entity generating them. Cities need to establish partnerships that align private technologies with the public interest.

Street-level data points can be aggregated from a variety of different sources. The graphic at right depicts a selection of the diverse data streams that cities can use to better manage and inform transportation networks.

However, intricate information on people movement is laden with personally identifiable information that neither government nor private companies should have access to. Cities need access to this information in an anonymized and aggregated format so that they can effectively track trends and plan for the future.



Keeping Data Safe

In order to protect user data, an independant third-party company can sort and anonymize data collected before it is used for analysis, ensuring individual users are not identified. Once analyzed, this data can be used to direct city policy and prioritize projects.

Data Generation

Vast amounts of data are generated by users and vehicles of streets. This data is immensely useful for cities seeking to make data-driven policies based on real-time information, but it is frequently too big, includes sensitive information, or is not appropriate for the necessary analysis.

Curbside User Data

Transit Data

Vehicle & Driver Behavior

Third Party Data Platform

Third party data platforms aggregate and anonymize sensitive data in order to make information available to cities in a format they can use quickly and easily. For example, NACTO's partner, the Open Transport Partnership, collects, aggregates, anonymizes and provides analytical tools based on this data.

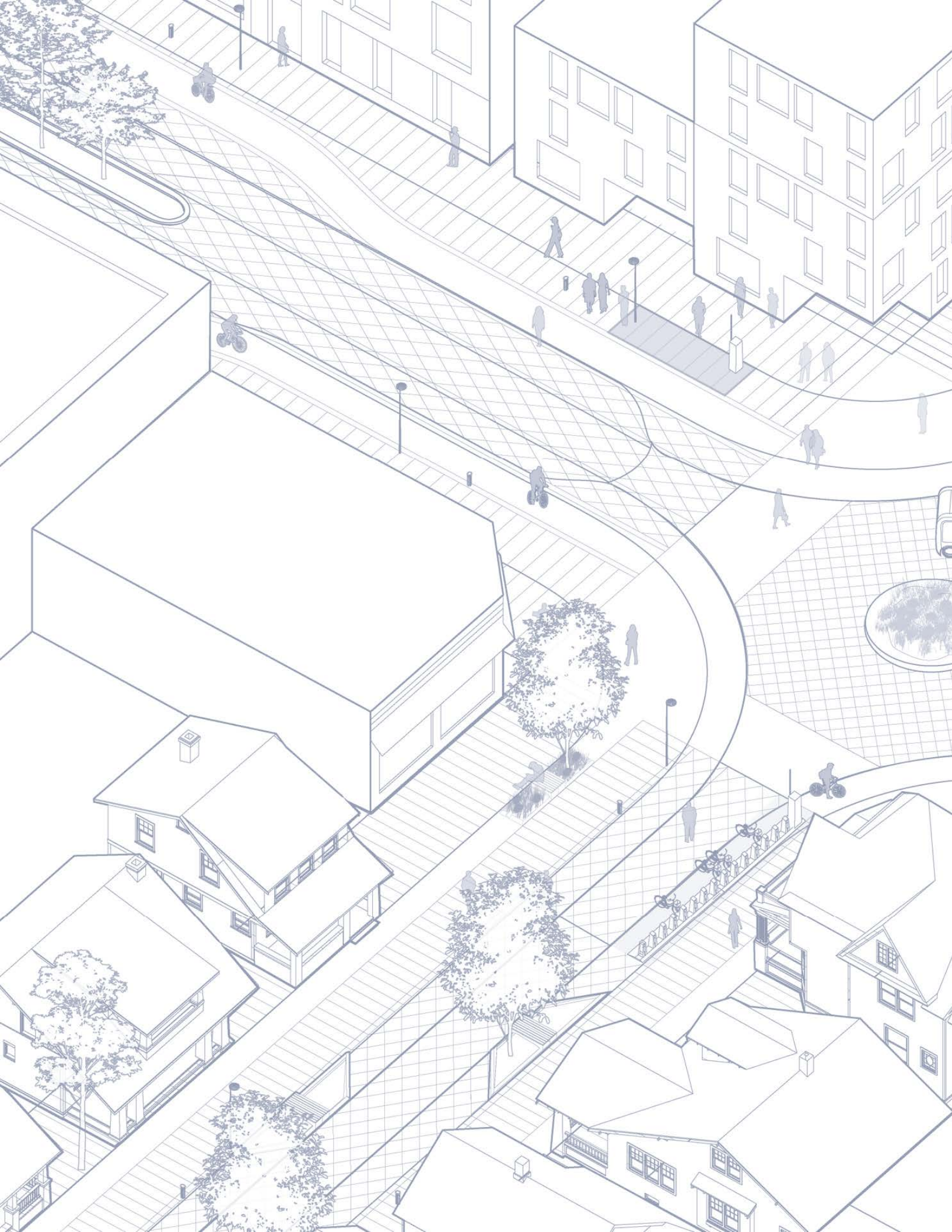
Data Driven Policies

Data platforms can show data in formats that are applicable for complex transportation issues. Cities can then use this accessible information to make the best decisions for their rights-of-way.

Curb Pricing

Lane Allocation

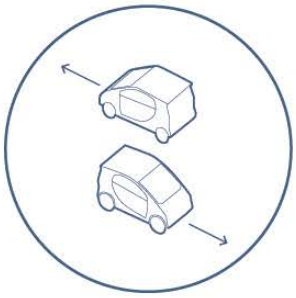
Safety Projects



3 Automated Vehicles and the Future of City Streets

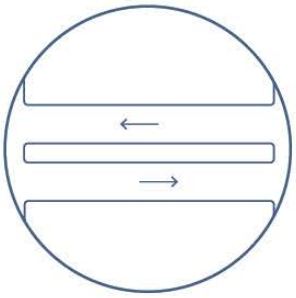
The vision for the future is one in which streets of all sizes are designed for people, not vehicles. Autonomous vehicles will require less space than traditional vehicles, affording cities the opportunity to dedicate more space to public amenities. These streets could move traffic more efficiently and safely for all users. From major urban streets that allow seamless transit access, to residential streets that become a place for neighbors to meet and children to play, the future street is a place for people.

Dynamics of the Future Street



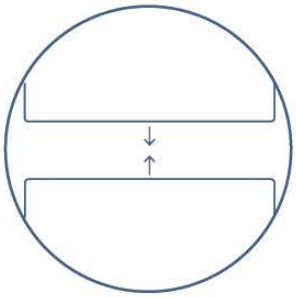
Two-way Operation

In a connected vehicle environment, streets can operate two-way, enhancing the overall flexibility of the network when properly managed. However, two-way operation should never be implemented at the cost of pedestrian movements, and medians or transit platforms would be needed to facilitate shorter crossings on major streets. In residential areas, limits on VMT and through-traffic can minimize conflicts.



One Lane Each Way

Outside of highways, streets could be limited to a single lane of vehicle traffic in each direction, excluding dedicated transit lanes. Residential streets can be designed as "yield" streets to limit through traffic. Major streets should provide high-capacity bus or rail service. AV-only lanes should be discouraged.

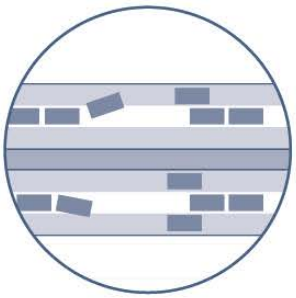


Lane Width

Lane widths can be kept to a minimum. In most urban environments, lanes of 10' or less suffice with controlled lane guidance, and streets without large transit vehicles can be even smaller if adjacent flexible space is available. In the long term, lanes should not be demarcated by markings, but instead be relatively flush with the sidewalk and median, with elements like bollards, accessible textured pavers, or other cues to demarcate uses.

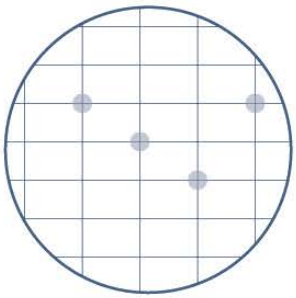
Integrate freight & deliveries

Vehicle design in the future could make use of constrained street space to accommodate both passengers and freight operations. Where possible, freight and electric charging infrastructure could be paired with peripheral dispatch points or be integrated into the street to minimize freight congestion.



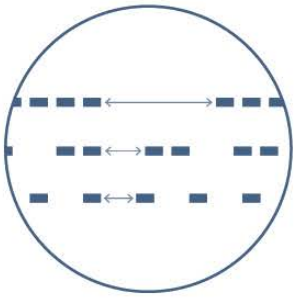
Manage Curbside Demand

Cities could dynamically manage curbside environments more easily in the future, allowing for curbs to serve a variety of different functions over the course of the day, ranging from public space to bike share stations, mobility hubs, information kiosks, and vendors. Detailed curbside inventories and management strategies will allow for the curb to be managed and priced in real-time.



Flexible Mobility Hubs

Passenger pick-ups and drop-offs can happen at designated hubs, encouraging both vehicles and people to coordinate trips. Curb space and flexible medians may provide this infrastructure, or sign posts may suffice to indicate key hubs. Both permanent infrastructure and flexible kiosks for pick-up points could exist in both transitional and future states.

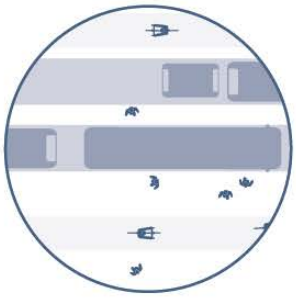


Manage Traffic Gaps

Cities should avoid creating robo-route arterials with endless platoons of traffic. With more passenger consolidation into multi-use vehicles and sufficient spacing between vehicles and platoons, pedestrians could have safer, more frequent crossing opportunities than traditional signalization can provide, achieving both safety and operational goals.

Street Tech

Wherever possible, sensor and other real-time mobility management technology should be embedded within the vehicle. For infrastructure that cannot be embedded, consolidation of on-street sensor technologies is critical for streetscape quality. In the transition period, inexpensive design elements could be considered as a retrofit for the ubiquitous 'unconnected' hardware of the street environment, such as regulatory signs and warning devices.

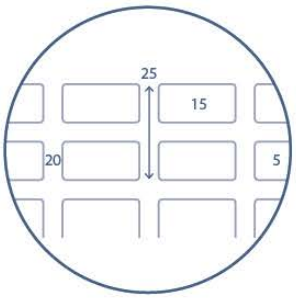


Manage Streets by Mode

Shared spaces, rather than separation, could define street operations in the future, especially on lower capacity streets. Motor vehicle traffic would be allowed at low speeds on many streets, diminishing some of the challenges of preserving freight access while dramatically expanding public space. As with truck routes today, some vehicle types could be forbidden from certain streets. An alignment between vehicle type and roadway role may be desirable.

Time of Day Management

Streets could be managed actively according to different demand during different times of day. Certain thresholds of pedestrian activity may trigger closures, temporary 10 mph operation, or ensure re-routing to other parts of the network.



Low, Steady Speeds

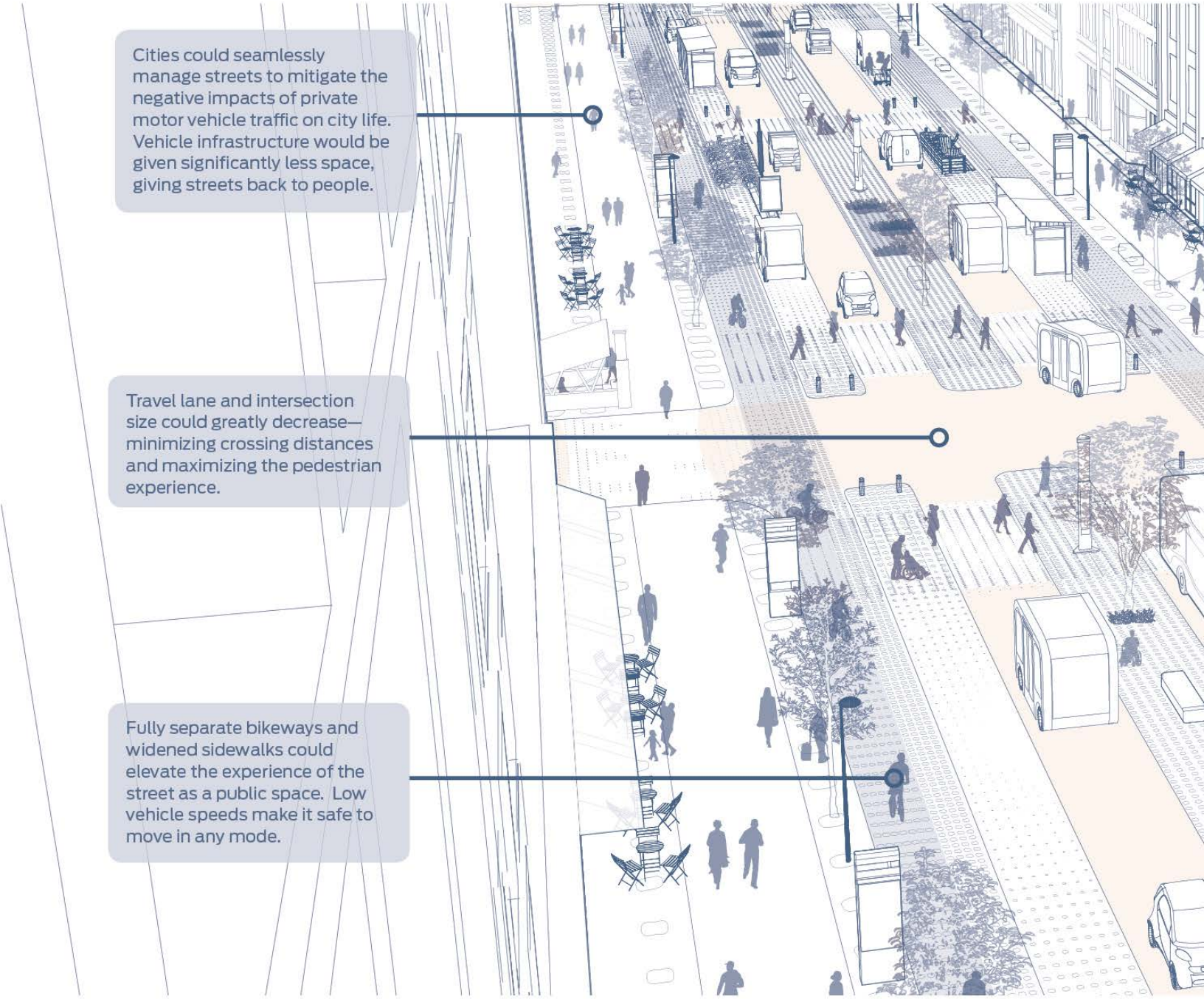
To ensure a safe environment for active transportation modes, speeds could be actively managed and programmed, and limited to 20 mph or less in city centers, especially where bicycling or transit are not fully separated from other motor vehicles. Lack of signal delay, vehicle coordination, and decreased traffic volumes would provide consistent, reliable movement—taking less time to go from place to place than in the existing hurry-up-and-wait system.

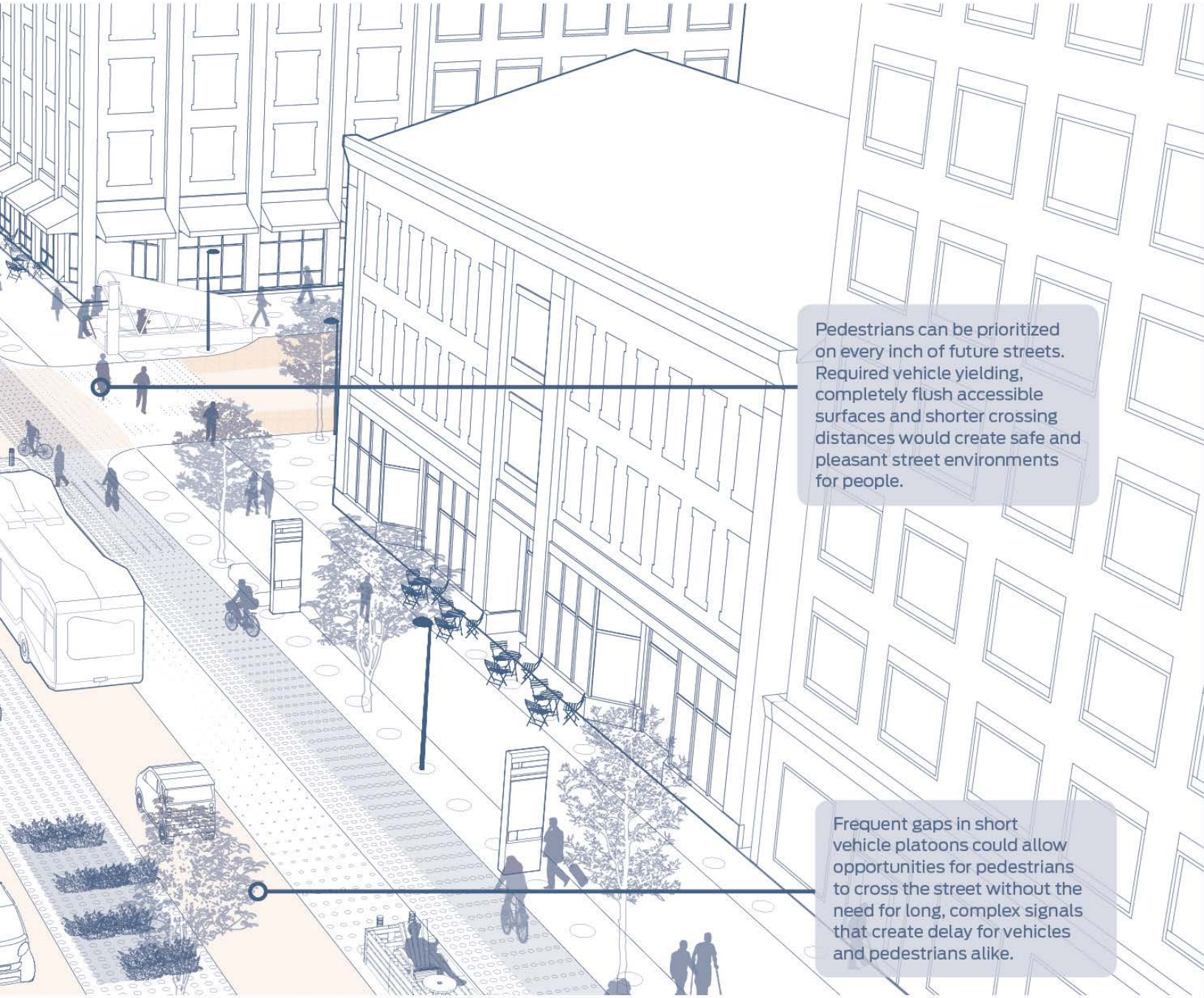
Pedestrians Detected, Not Connected

People walking and biking should not be required to carry sensors or signals to stay safe. Connected or individual vehicles should be able to detect and yield to pedestrians in all conditions, and retain full responsibility for not injuring people using the street.

Dynamics of the Future Street

Streets in the autonomous age should give ultimate priority to pedestrians, bicyclists and transit riders. Smaller and fewer lanes can minimize conflicts and crossing distances for pedestrians and allow space for robust bicycle infrastructure on all streets. Transit should have priority operation in dedicated lanes and be the backbone of the urban mobility system. Curbsides could be flexible and allow for a myriad of public and private uses—from loading zones to parklets. Speeds can be restricted to 20 mph and overall travel lanes for private vehicles can be drastically reduced. Travel times could remain unchanged due to the greater capacity of active travel, dedicated transit lanes and shared vehicles, as well as smoother intersection movement at low speeds. This street of the future would add value for everyone using it through sound design and smart policies.



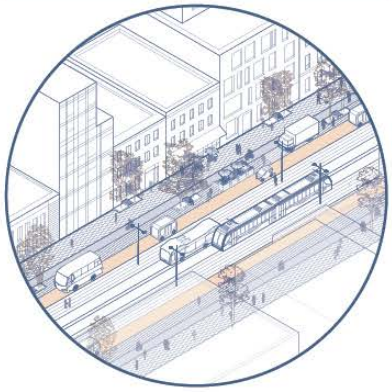

Pedestrians can be prioritized on every inch of future streets. Required vehicle yielding, completely flush accessible surfaces and shorter crossing distances would create safe and pleasant street environments for people.
Frequent gaps in short vehicle platoons could allow opportunities for pedestrians to cross the street without the need for long, complex signals that create delay for vehicles and pedestrians alike.

Street Types

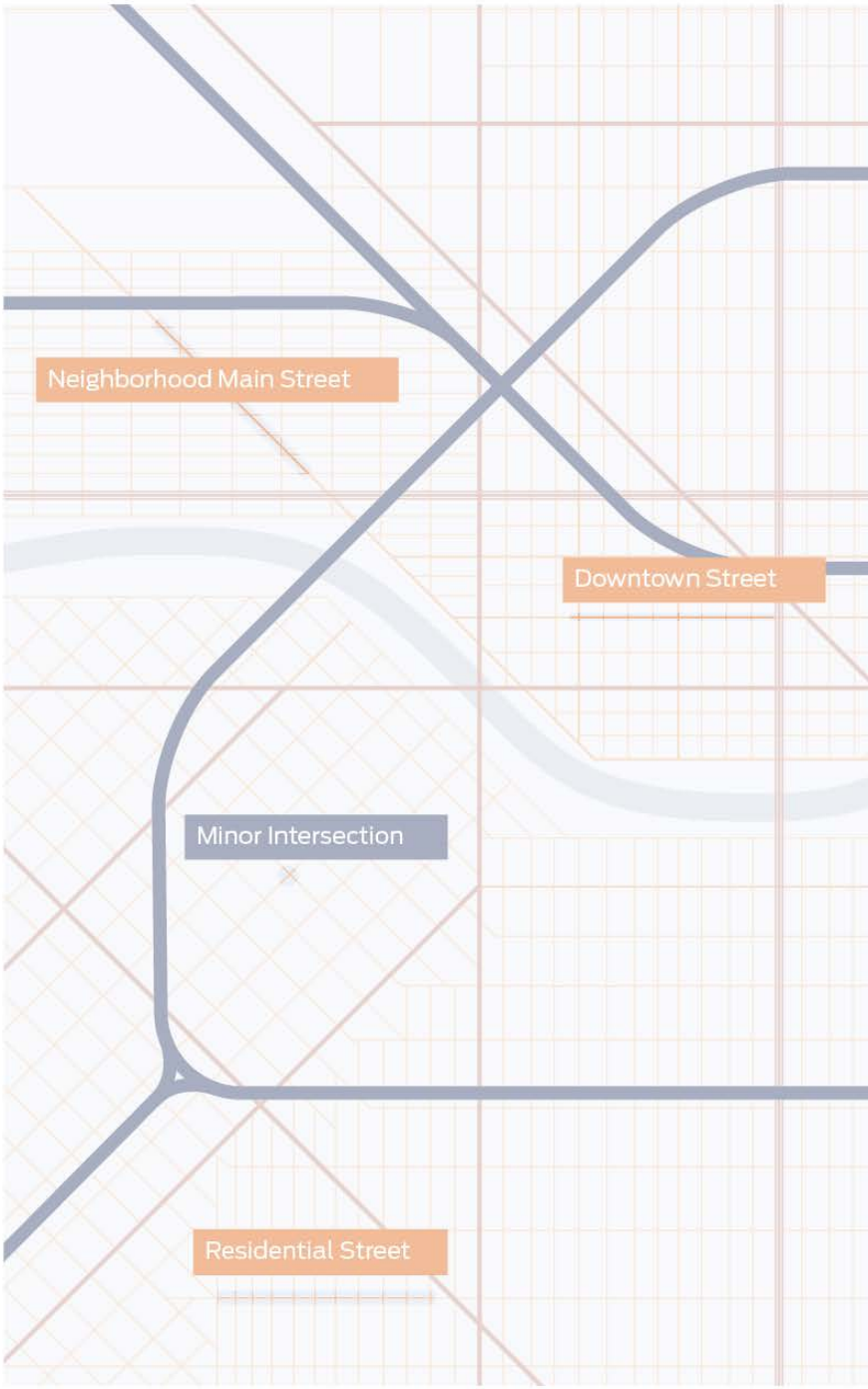
Streets and highways today reflect a century of investment in auto-oriented infrastructure that has failed to provide reliable or safe urban mobility. Much more efficient, humane streets are possible. Technological changes present a chance to remake our streets as cities adapt to, and shape, the new mobility system. The changes shown in the following pages are not dependent on vehicle automation. They complement and build upon the new dynamics of mobility, operational safety, and efficient use of space.

Multiway Boulevard

Major Transit Street



Downtown Street



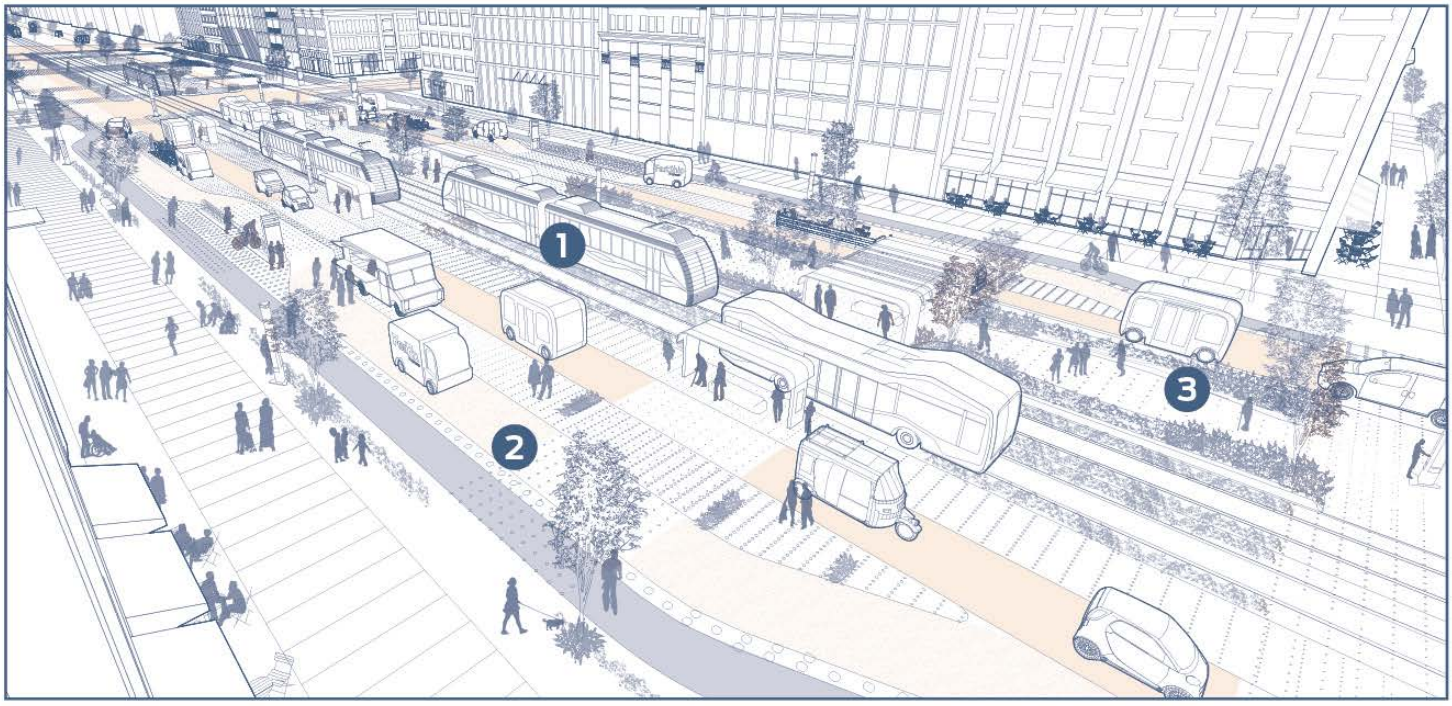
Neighborhood Main Street

Residential Street

Minor Intersection

Multiway Boulevard

Multiway boulevards represent an opportunity to reconnect neighborhoods and provide reliable transit. With only one lane for through traffic in each direction, these boulevards could recover a large amount of space for functional green infrastructure such as rain gardens. Managed curbsides can allow for seamless transit access, while dynamic pricing would discourage vehicles from blocking through traffic. By dividing the street into manageable parts and creating more opportunities for people to cross the street, boulevards can link, rather than sever neighborhoods.



Center Transitway

A transitway in the center lanes would afford a priority space for transit unimpeded by other vehicles.

Access Lanes

Access lanes would provide space for pick-ups, drop-offs, and deliveries. As pedestrian-priority space, the lanes would be fully traversable and could have restricted access at certain times of day.

Green Infrastructure

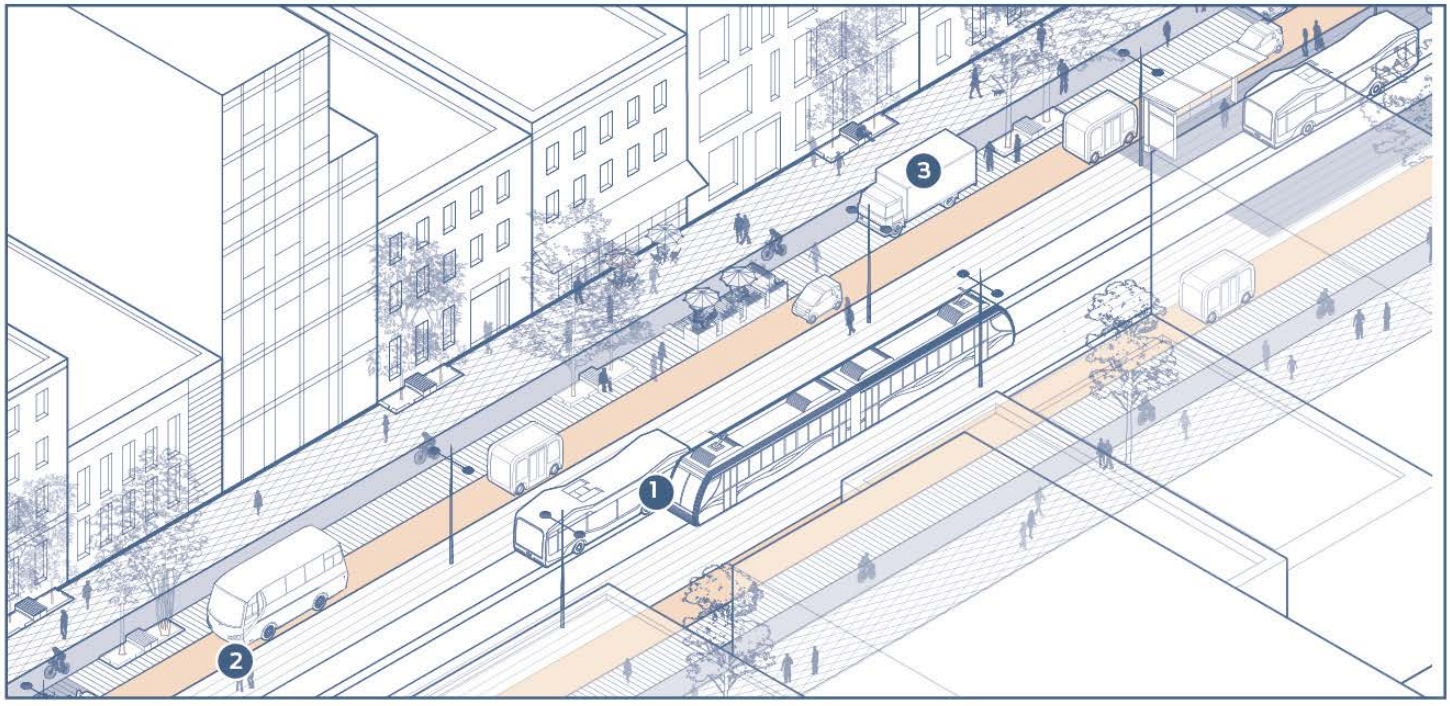
Green infrastructure helps absorb stormwater and keep the city cool, in addition to providing green space for people to enjoy.


Today


Tomorrow

Major Transit Street

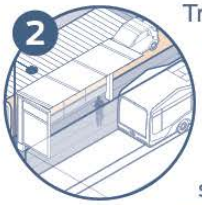
Major transit streets serve as critical aggregators in the transportation network, funneling people and activity onto central corridors. To prevent these corridors from turning into impassable robo-routes, public and private actors will have to closely monitor, actively manage, and ingrain modal hierarchies through design. With strong design and management, streets that are overburdened by car traffic today can become welcoming, high-performing public spaces in the future.



Dedicated Transit Lanes

Dedicated, central lanes could serve light rail, bus, and microtransit, while smaller vehicles could be permitted in narrow access lanes. System-wide reliability and capacity should be the touchstones of tomorrow's transit agencies and street operations.

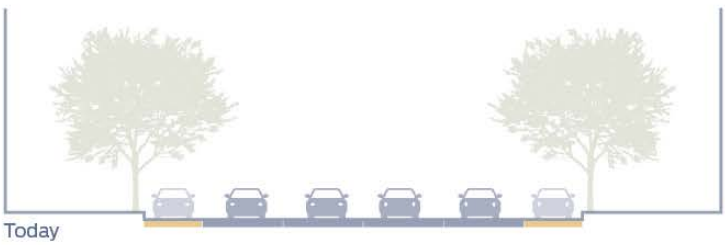
Mobility Hubs



Trunkline transit could integrate seamlessly with point-to-point options. Cities' proactive policies on data sharing would allow for integrated transit options, no matter the provider.

The Flex Zone

Freight and small vehicles are could be accommodated at low speeds. The former curbside could become a flex zone alternating between public spaces and loading without delaying or endangering transit users.



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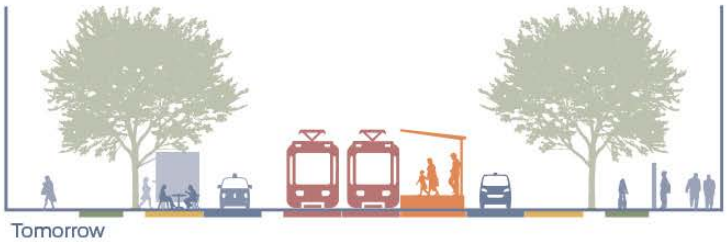


Tomorrow

Downtown Street

Downtown streets, perennially in high demand by many modes and as gathering spaces, are vital to the future of the city. Every element of the street, from sidewalks to loading zones, should allow a seamless walking experience for people, and high-capacity transit should be given the space it needs to operate reliably. Downtown streets should prioritize transit and freight access by disincentivizing low-occupancy vehicles.

Safe & Short Crossings

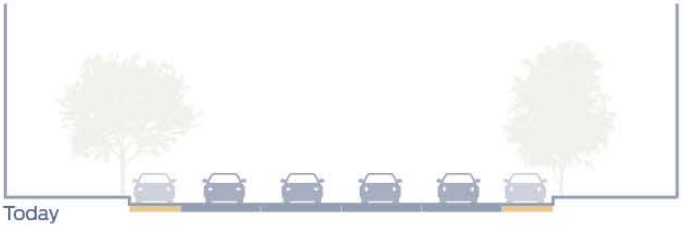
Crossing the street should no longer be a difficult or time consuming task. Traffic streams of few cars with frequent breaks and smaller lanes would allow safer crossing environments.

Parking to Public Spaces

The rebalanced right-of-way could allow for lively public spaces, leaving enough room for sidewalk cafes and expansive sidewalk areas. No vehicles would need to be stored on downtown streets.

Protected Bike Lanes

With motor vehicles still present, people bicycling will need protection from traffic in the form of fully separate infrastructure buffered from flex zones.



Today

Tomorrow

Neighborhood Main Street

Neighborhood main streets are active, lively places that attract people from across the area. They are also where residents pick up mobility services such as transit and bikeshare. Accessible mobility hubs can facilitate better corner-to-corner transit services, and dedicated bicycle infrastructure would prioritize non-auto modes.

Surfaces Over Striping

With vehicle speeds at a bicycle pace, bicyclists and vehicles could interact seamlessly by using separated but flush lanes. Street surfaces can indicate the rules of the road in place of striping.

Functional Medians

Permeable medians would manage stormwater and beautify neighborhoods while also providing a refuge for pedestrians crossing the street.

Freight and Loading

Freight and loading vehicles could be accommodated in a curb lane so as to not disrupt passing vehicles and bicyclists.


Today


Tomorrow

Residential Street

Residential streets are the heart of the city. The decreased need for vehicle storage means that streets can be an extension of the front yard. Flush curbs could create environments that are fully accessible and green infrastructure further beautifies the streets. These streets could become central meeting hubs for the community and encourage transit travel through bike share and nearby mobility hubs for corner-to-corner transportation options.

Play Streets

Residential streets should primarily be spaces for residents to enjoy—for people to recreate or meet neighbors.

Green Infrastructure

Trees, bioswales, and planters would reduce stormwater runoff, while providing shade and evaporative cooling effect for the neighborhood.

Vehicle Access

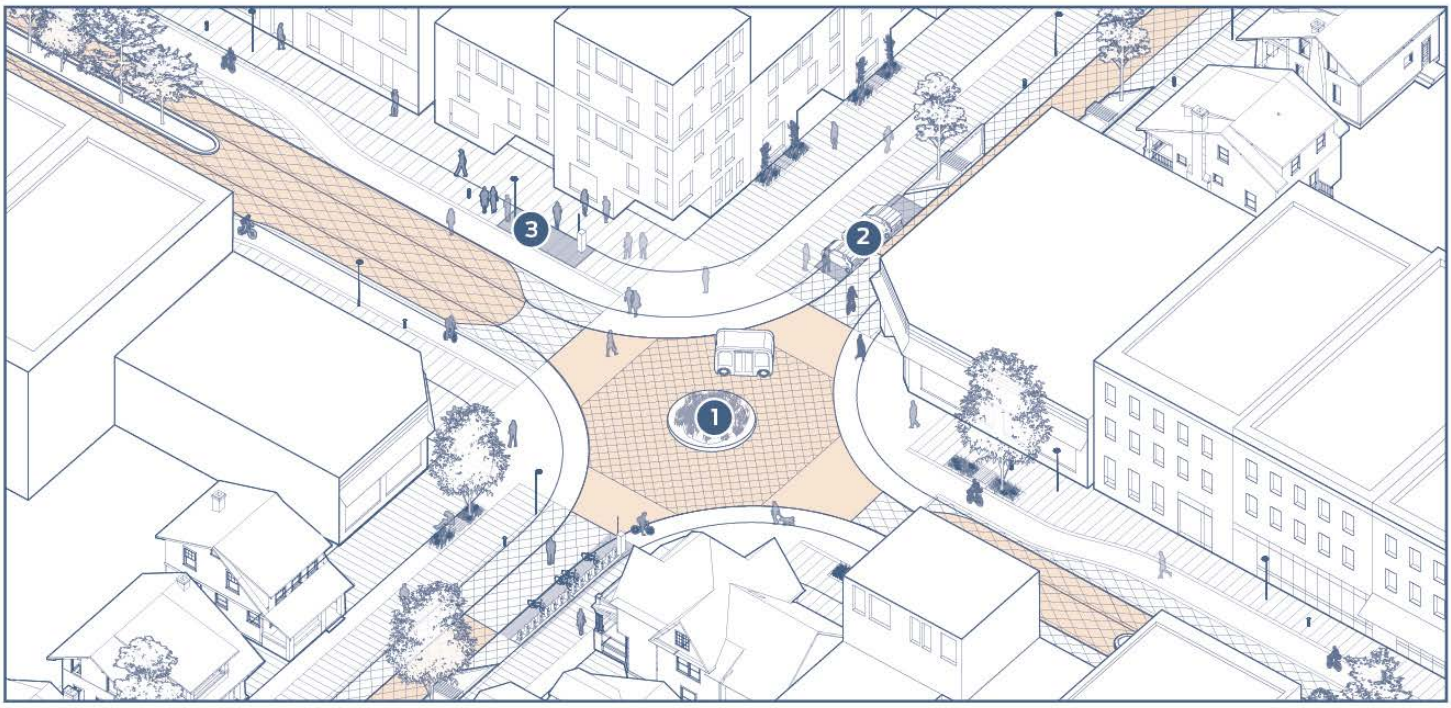
Most vehicles whould be restricted, permitting only local traffic and delivieres, and speeds limited to 10 mph.


Today

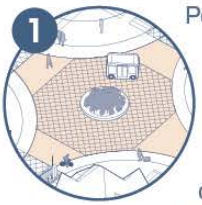

Tomorrow

Minor Intersection

Minor Intersections could serve as the core of residential neighborhoods, with dynamic mobility hubs, bike share, car share and other mobility services. Mini-roundabouts and flush curbs can communicate the residential, shared nature of the street, while active volume and speed management would ensure that these areas are protected from an onslaught of through traffic.

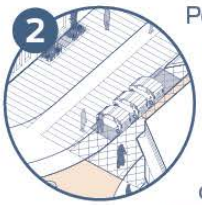


Mini-Roundabouts



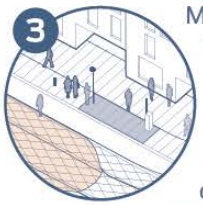
Pedestrian delay could be significantly decreased due to short platoons and shorter crossing distances. Mini-roundabouts would allow vehicles to travel at consistent, slow speeds.

Last Mile Connections

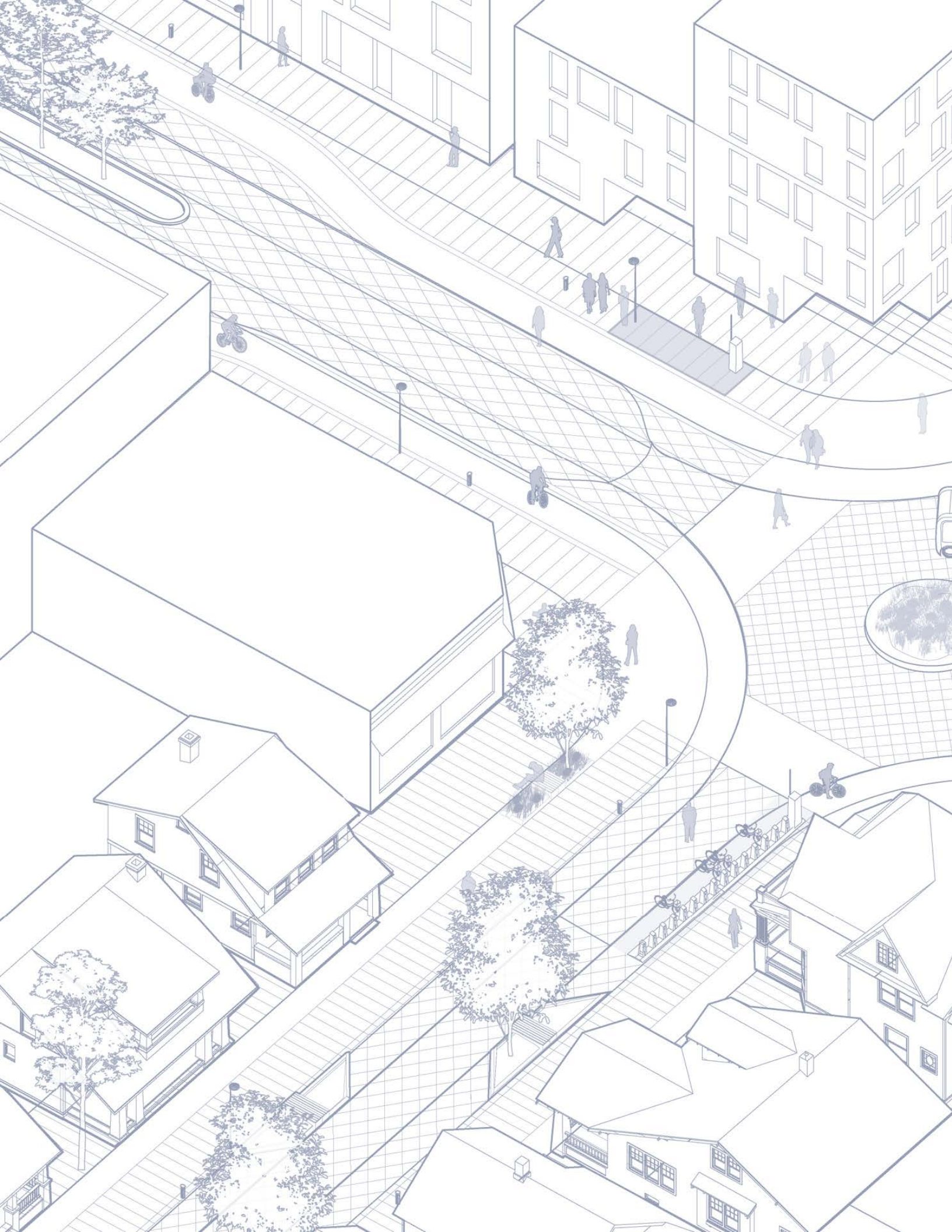


Point-to-point transit options could be abundant in residential neighborhoods, allowing multiple options to connect to core transit close by.

Mobility Hubs



Mobility hubs would provide clearly marked zones for pick-up and drop-off, necessary for the corner-to-corner transportation services in the new mobility network.



4 Design for Safety

The safest places in cities are those with the most walking, biking and transit. The evidence is clear that no investment or new technology can make it safe to mix high-speed traffic with people walking or cycling. Without a line of code or byte of data, livable street design and the growth of active modes have been proven to make cities safer.

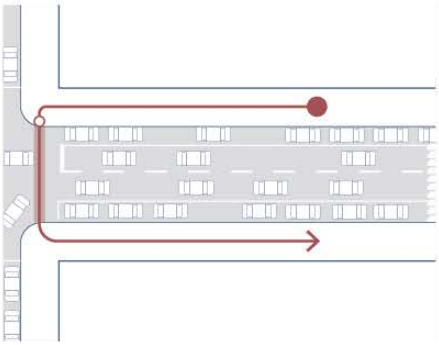
There is a growing recognition that eliminating motor vehicle-related deaths can only be achieved by decreasing vehicle speeds, using design and regulation to create a system in which it is safe to be human.

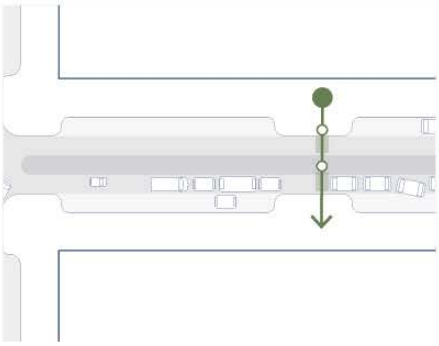
Setting safe speed limits is one critical part of the equation. Sensors have the potential to improve conflict-detection and reaction time over that of trained human drivers, but even the best detector cannot avoid a crash if vehicle speeds are too high to stop after an unexpected event. Lower speeds are the way out of the ethical dilemmas of driving: physical limits will still make the difference between life and death.

New Rules of the Road

A shift in transportation technology presents an opportunity to rethink long-held assumptions about how streets operate and how cities manage their traffic flows. Traffic signals, curbs and striping were products of the last revolution in mobility. They became widespread and standardized only after a period of flux and uncertainty. The advent of automated vehicles presents a chance to question the modern rules of the road and to consider new possibilities for street operations, infrastructure and design.

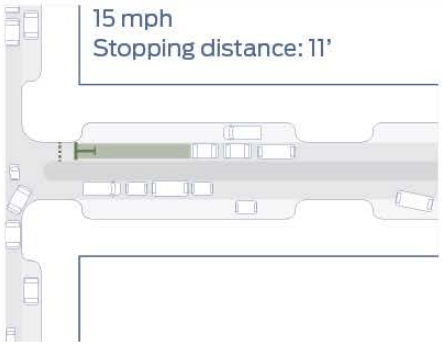
More Frequent Crossings





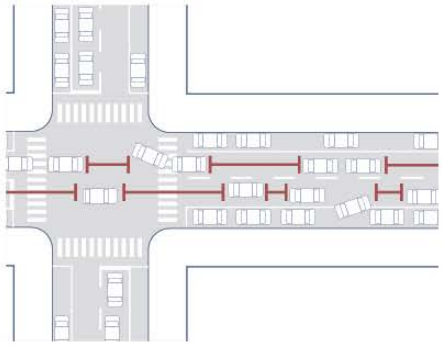
Present-day traffic operations focus primarily on conflict points at or near intersections. In the era of automation, the intuitive act of crossing directly to one's destination—known technically as mid-block crossing—could become normal once again. Frequent, formal midblock crossing points (every 50–100 feet), coupled with sufficient gaps in AV traffic, would relieve bottlenecks at intersections, while accommodating pedestrian desire lines more seamlessly.

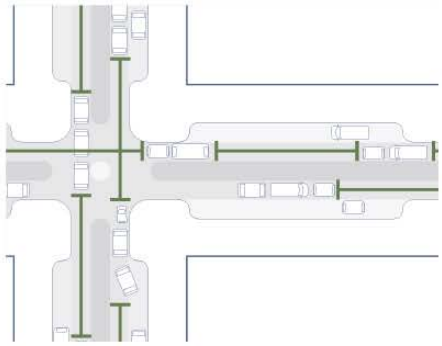
Stopping Distances



To ensure a safe street environment for all street users, speeds can be actively programmed, managed, and limited to 20 mph or less in city centers, especially where bicycling or transit are not fully separated from other motor vehicles. Vehicle coordination, decreased traffic volumes, and lack of signal delay would provide consistent, reliable movement.

Vehicle Spacing



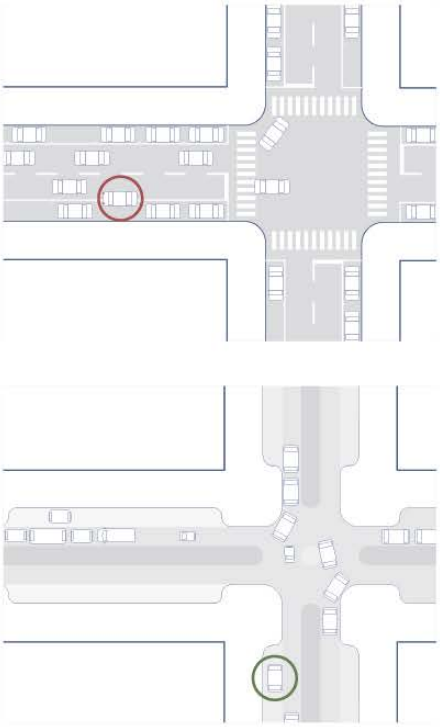


Cities can avoid creating impassable, highway-like arterials with endless platoons of traffic. With more passenger consolidation into multi-use vehicles and sufficient spacing between vehicles and platoons, pedestrians could have safer, more frequent crossing opportunities than traditional signalization can provide, achieving both safety and operational goals.

Intersections to Roundabouts

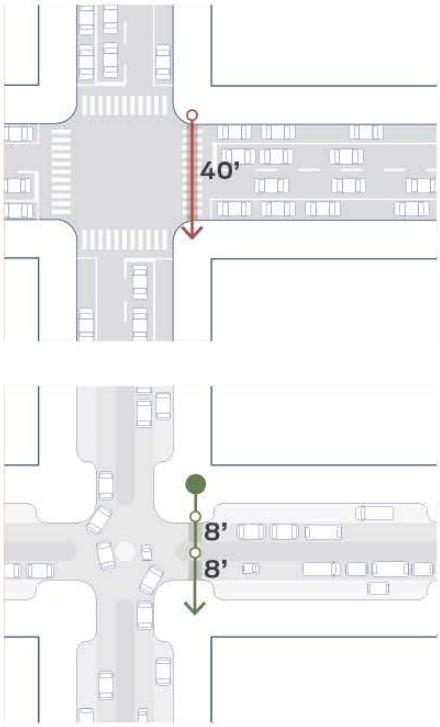
In a connected and automated vehicle environment, intersections could accommodate more fluid streams of traffic. Certain types of intersections, especially at minor crossings, could behave more like roundabouts with consistent, slow traffic as opposed to persistent stop-and-go movement.

Pick-up and Drop-off



To drop off passengers, vehicles on major streets should first turn right. Turning off of the main street stopping would reduce congestion on main corridors and allow more space along the curb to be dedicated to other uses. Where bicycle traffic is heaviest, right turn pick-ups and drop-offs may be less ideal.

Shorter Crossing Distances

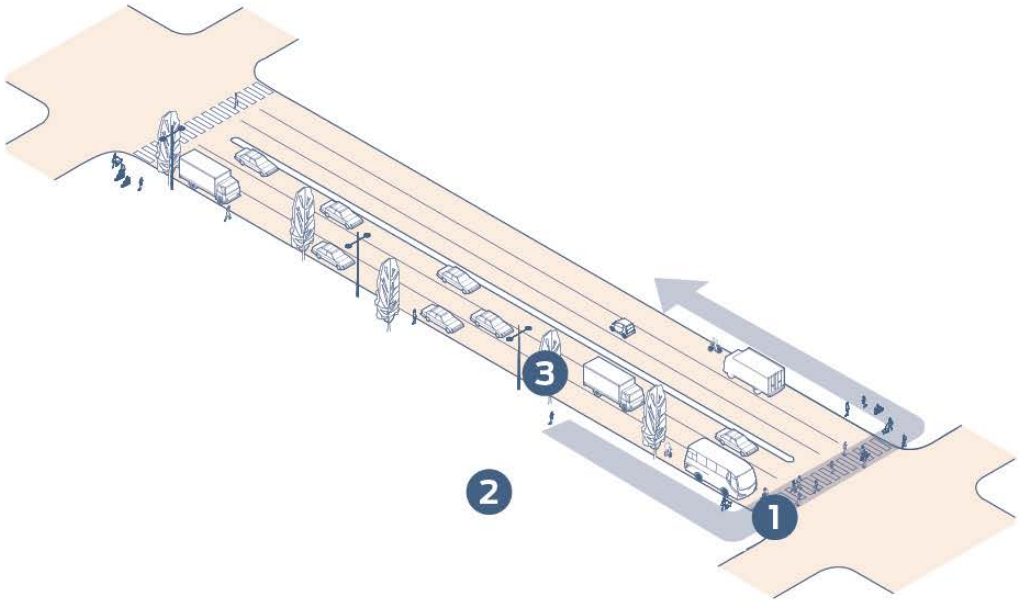


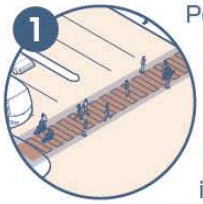
Streets with narrow lanes and medians allow for shorter crossing distances and frequent refuge. When paired with short platoons with gaps adequate for pedestrian crossing, pedestrian and vehicle delay is minimized.

Safe, Frequent Crossings

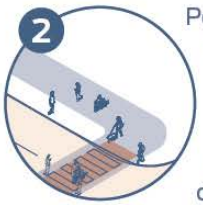
Today, pedestrians incur significant delay when traveling to their destinations. Long signal lengths and infrequent or poorly spaced crosswalks increase both the time and distance to cross the street, making walking undesirable in some places. In the future, streets could proritize pedestrians through software and infrastructure.

Today

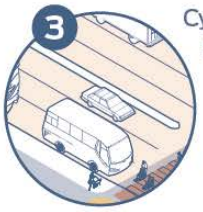




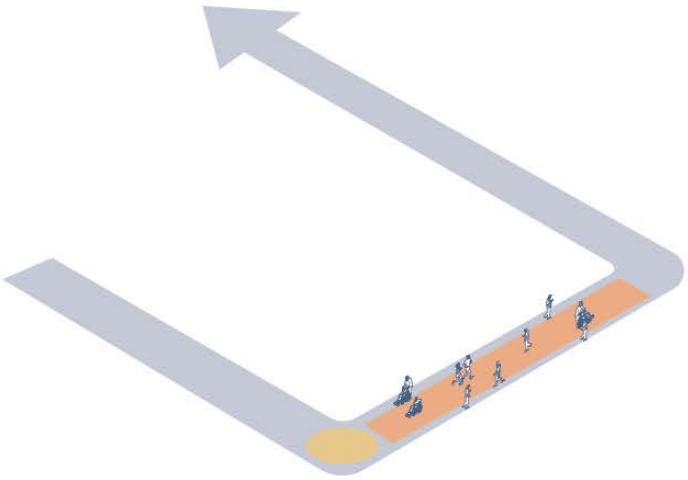
Pedestrians are only permitted to cross at intersections. Crossing may be difficult at unsignalized intersections, and pedestrian delay may be high due to long waits.



Pedestrians are limited to narrow sidewalks, and often must take long routes to reach mid-block destinations.



Cyclists often must share a lane with vehicles, resulting in stressful conditions and discouraging new cyclists.



Distance to cross

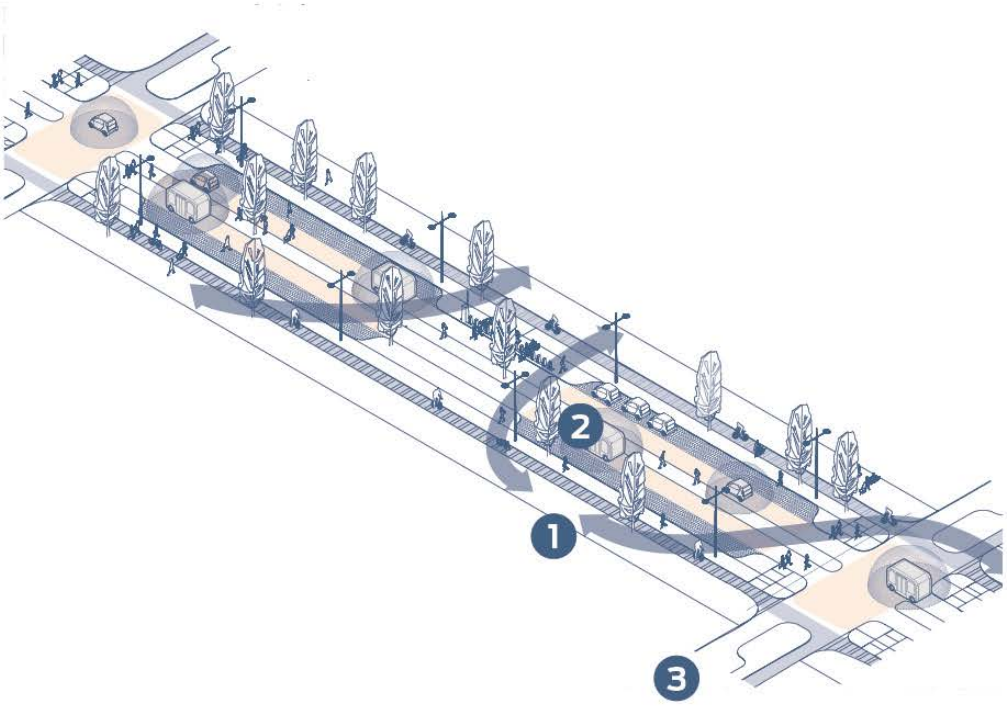
260 feet

Time to cross

100 seconds

On the streets of tomorrow, people rule the road. Vehicles should be optimized to travel at consistently slow speeds, allowing for pedestrians to safely cross streets at close intervals. Fewer lanes and crossing distances would make it more convienient and quicker to get to destinations on the other side of the street. The instinctive human act of walking straight to one's destination, pejoratively known as "jaywalking," becomes simply "walking."

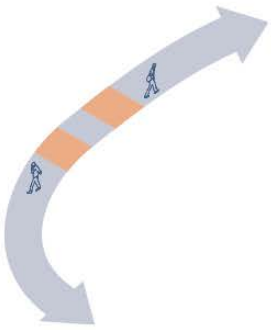
Tomorrow



Pedestrians would be able to cross almost anywhere along the street. Medians can provide space to wait between vehicles, and slow travel speeds would make crossing easy and safe.

More space could be dedicated to pedestrians, and additional amenities like seating and kiosks would enliven the streetscape.

Safe, protected bike lanes would make active transportation easy for many more people.

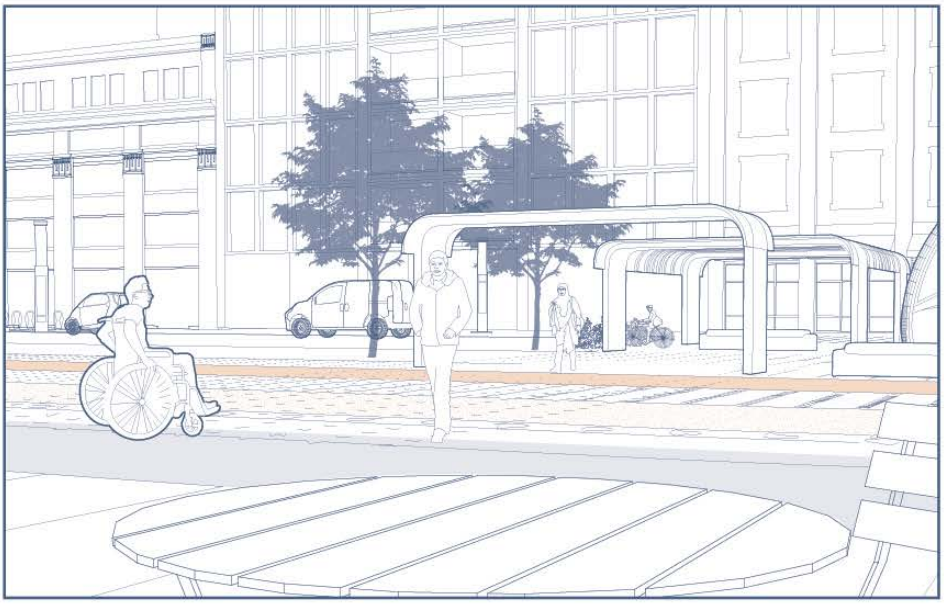


Distance to cross
80 feet

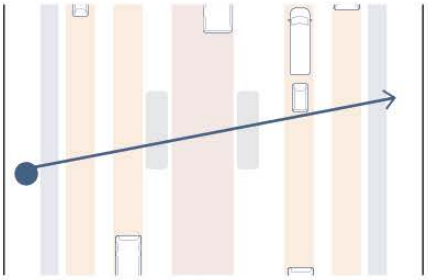
Time to cross
23 seconds

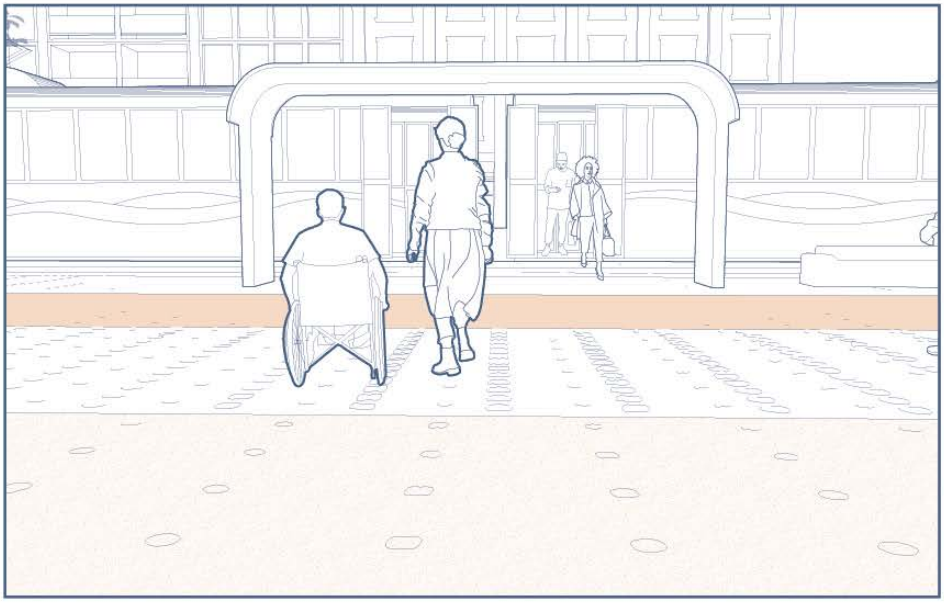
Crossing the Street

Today's streets are characterized by missing sidewalks or curb ramps and uneven surfaces, rendering many parts of the city completely inaccessible. By providing flush surfaces, regular gaps in platooning vehicles, and medians for refuge, future streets can be accessible for all street users.



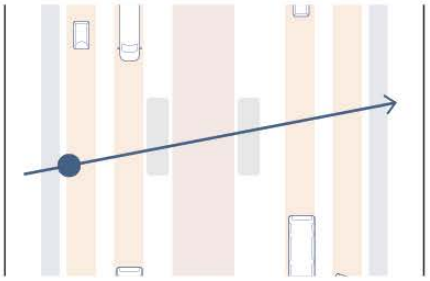
A person who uses a wheelchair is leaving a café table in the middle of the block, and wants to cross the street to meet a friend.

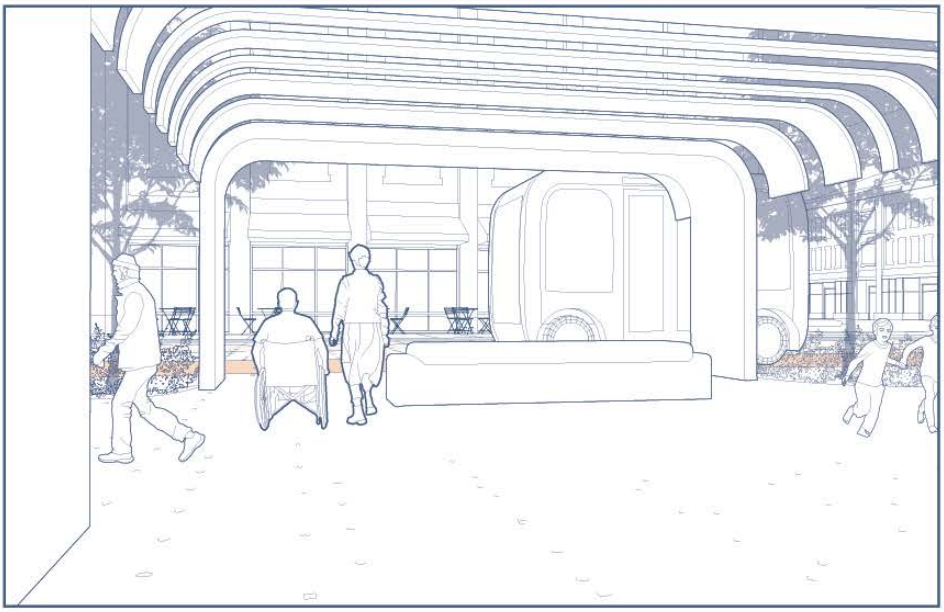




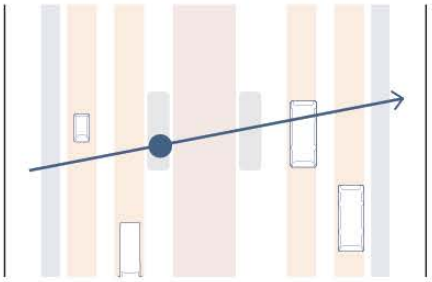
He looks left and crosses the bikeway, which is level with the sidewalk, feeling a slight rumble over the textured edge between the two.

He waits briefly before crossing the low-speed flex zone lane, while a vehicle carrying freight pulls away slowly from nearby. The truck has detected that people are moving toward the lane, and has slowed to 10 mph to stop quickly if needed.

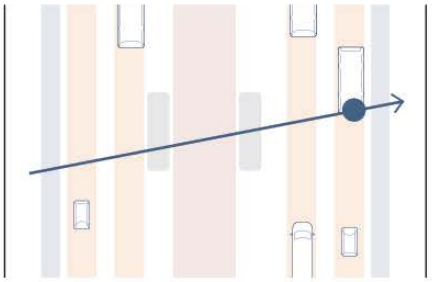




He crosses the flex zone and proceeds to cross the main vehicle lane. Seeing that approaching vehicles are still relatively far away, he begins crossing, but his wheels hit a piece of litter and he slows down. A vehicle approaching senses that he might still be in the lane if it continued at its current speed, and slows slightly from 15 to 10 mph to keep a longer distance between them.

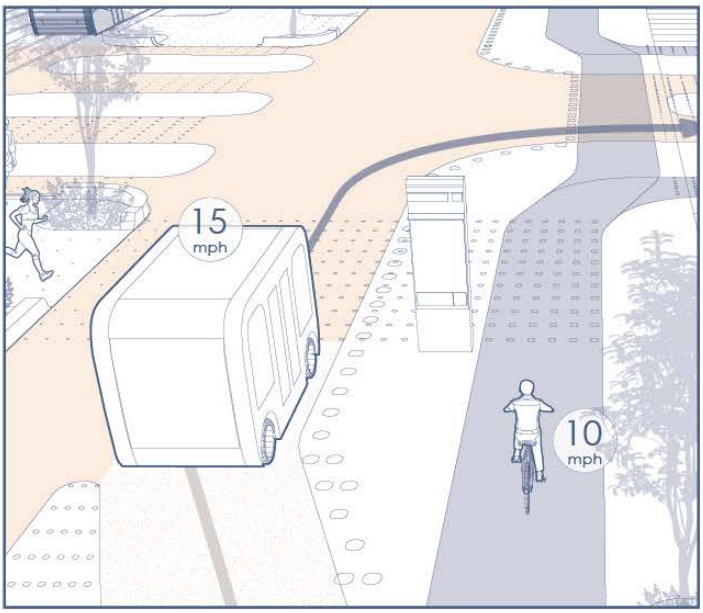


He proceeds through the transit lanes after waiting for the bus to pull away. He sees that there is a gap in the main vehicle lane and that all vehicles are stopped in the flex zone lane. He crosses the rest of the way at a normal speed, reaching the other side of the street to meet his friend.



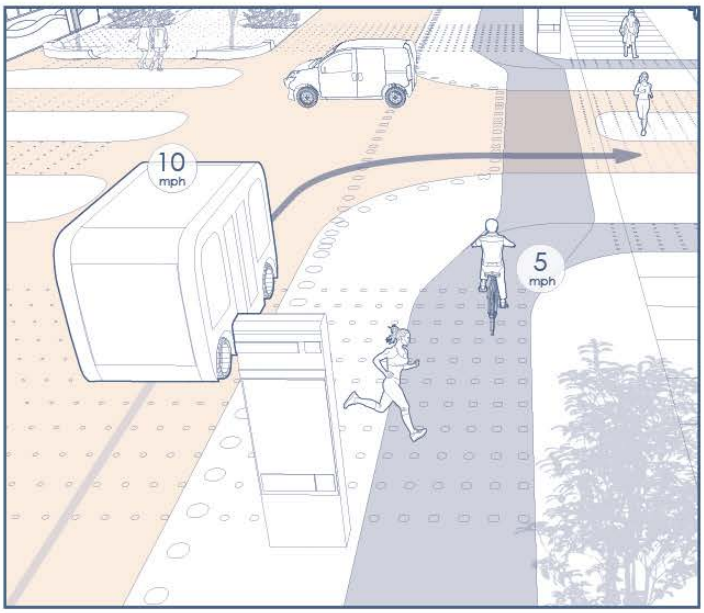
Cycling through Intersections

In the future, bicyclists and autonomous vehicles could interact seamlessly. Today, right hook collisions, when a right-turning vehicle hits a bicyclist continuing straight, are frequent and deadly. Automated vehicles would need to sense bicycles before the vehicle enters the intersection. To ensure safety for all, vehicles should be programmed to give bicyclists and pedestrians priority.

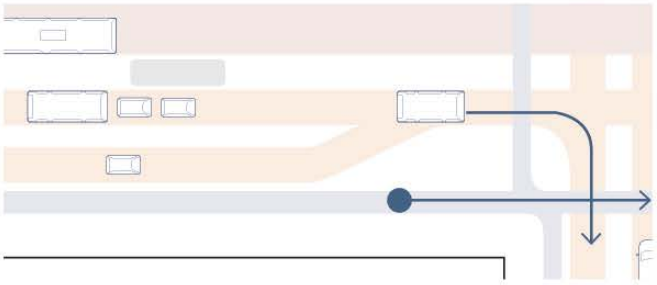


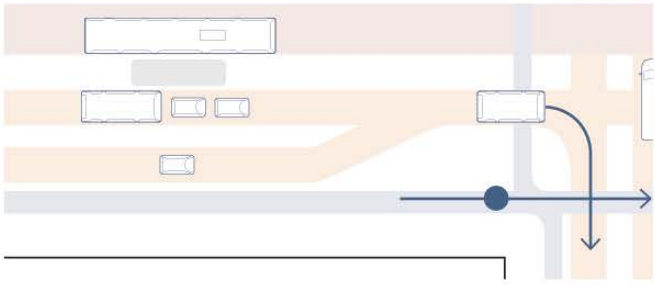
As the cyclist approaches the intersection, she is passed gradually by an automated shuttle that intends to turn right. The shuttle detects and tracks her movement, and slows as it approaches the intersection.

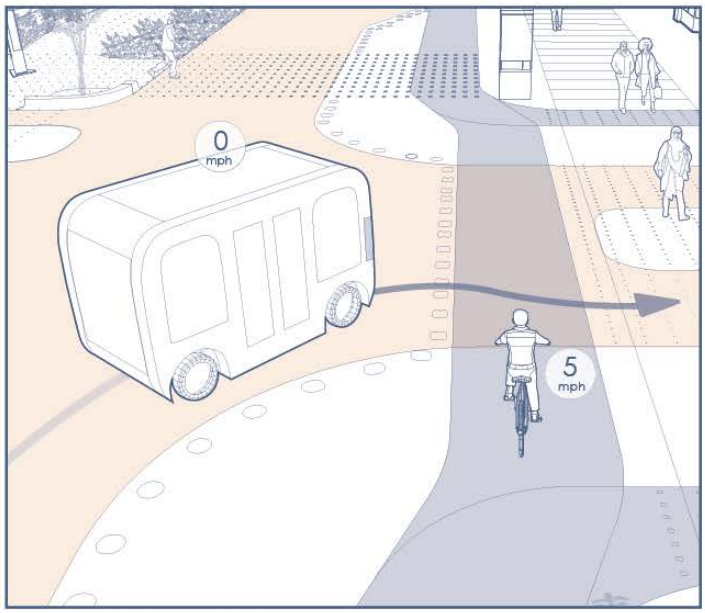
An audible signal is flashing yellow, giving the shuttle permission to continue with caution, which the bicyclist can see and hear. During this phase, vehicles are permitted but must yield to one another and to people. These intersection controls also have a pedestrian-and-bike-only phase.
The shuttle has been tracking a jogger on the left, but has calculated that she'll just be arriving at the crosswalk when the shuttle passes.



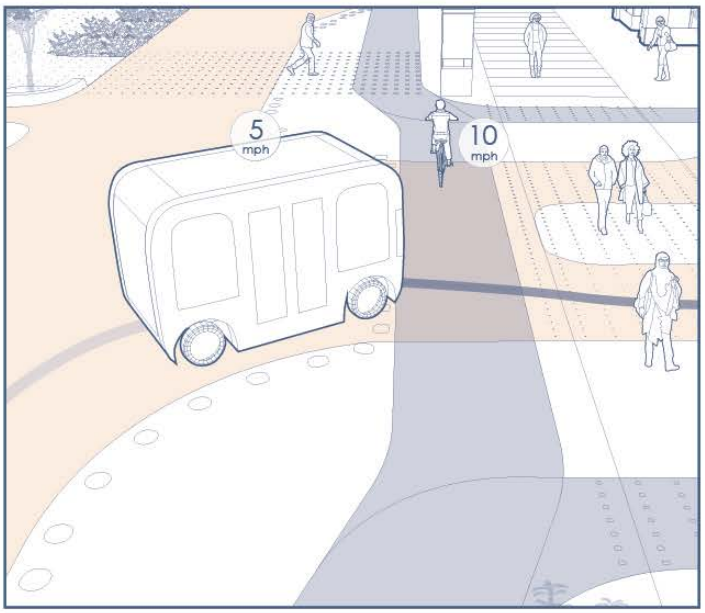
The bikeway curves to the right, creating space for a vehicle to wait as indicated by a yield line in the pavement. As the bicyclist gets close to the intersection, the shuttle slows to a crawl to be ready for an instant stop as it approaches the crosswalk—since the bicyclist might turn left, too. It anticipates that she will probably go straight, and sets its speed so it can stop within three feet (usually 7 mph).



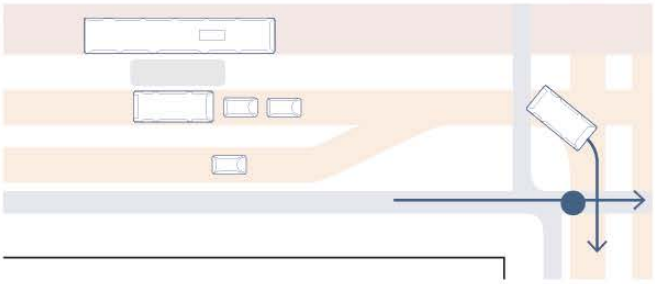


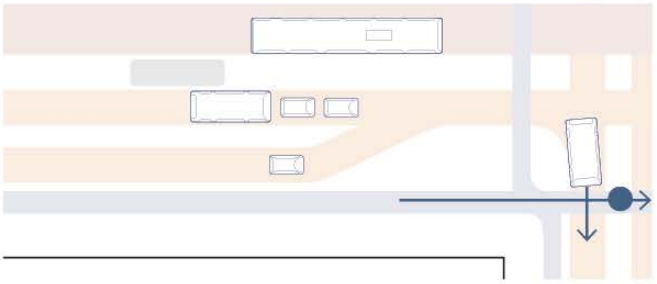


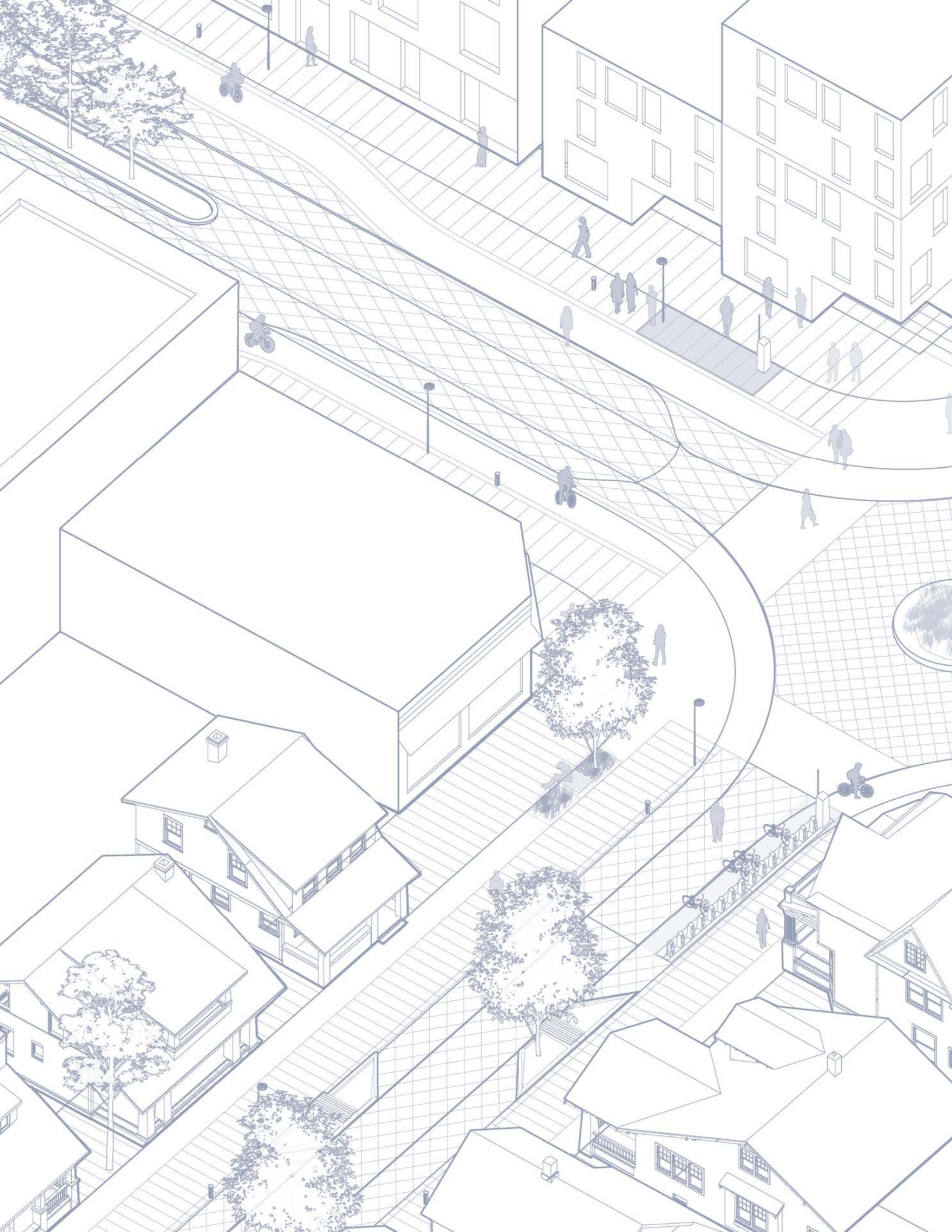
Seeing that there is no other cross-traffic, the bicyclist goes straight and the shuttle waits for her and the pedestrians in the crosswalk. The shuttle's routing algorithm anticipated that it will usually need to pause here.



The bicyclist proceeds, seeing as she crosses the median that vehicles coming from her right also slowed. The group of people in the crosswalk finish crossing the street, and the shuttle proceeds.







5 New Mobility Systems

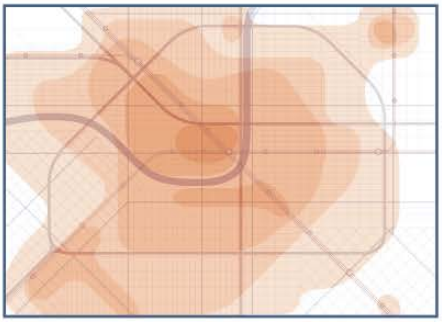
New mobility systems can offer a seamless passenger experience that integrates microtransit and shared on-demand service with traditional bus and rail lines.

Automated vehicles could make personal car ownership an ever more expensive proposition. Increasing numbers of vehicles could become part of shared networks of fleets and many routine trips served today by cars or ride-hail could evolve into more transit-like services. Transit, in turn, could deliver more reliable, frequent service as demand grows on main routes. New transit partnerships could match vehicles to travel demand in real time and be capable of managing and deploying services for both fixed routes as well as flexible, last-mile options. Cities can take a lead role in creating the policy basis and incentives for this system to work—as well as managing streets as a public right-of-way. People of every income level could benefit, with smart policy, from a greater diversity of mobility options, and a more integrated, seamless payment and information system.

Principles for New Mobility Systems

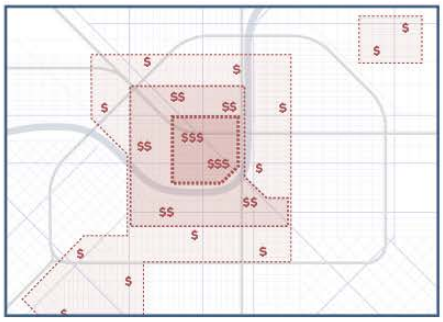
In the future, the city's role will include active management of street capacity as well as providing the regulatory structure for mobility service providers—transit companies and new service providers alike. New mobility systems must be designed to meet critical city goals: ease of use, efficient use of space, equitable mobility and reliable performance.

Build a network to match demand



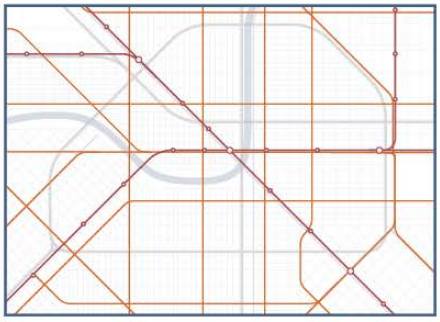
Even today, transit is best able to serve cities' densest and most vibrant areas, where driving and parking is impractical and takes up too much space that could be used for more productive activities. In the future, transit will function best if cities map demand between various neighborhoods, and connect the busiest and densest areas together with high-capacity transit.

Pricing creates a reliable network



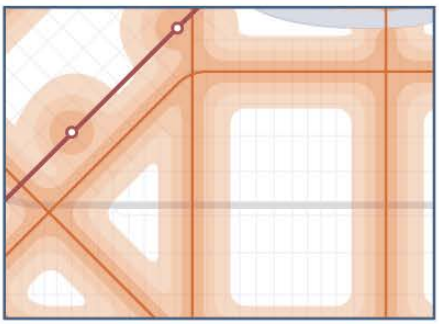
Pricing supports transit and for-hire providers by making travel times reliable across the day for each link in the network—no matter how high demand rises. Equitable allocation of the public right-of-way depends on the city's ability to incentivize aggregated trips to dense areas and prioritize critical travel, such as ambulances, police and other emergency services.

Create an interconnected grid network



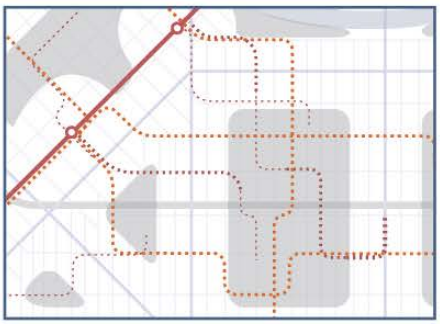
Service could be configured into a grid network to make the best use of transfers, allowing easier connections between neighborhoods, businesses, and activity centers, and helping transit capture the largest share of total trip-miles citywide. An all-purpose network can be relied on at all times of day and for all trips, a necessity for supporting car-free households.

Upgrade the transit backbone



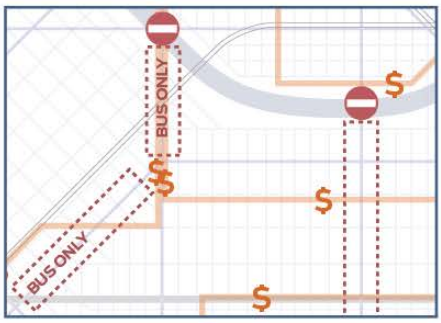
Busy bus routes can be upgraded into rapid lines with on-street priority provided by technology available today. These lines could be enhanced with active traffic management and AVs feeding more riders into the system. City experience shows that taking early action to insulate transit from changing vehicle traffic patterns can yield large benefits in ridership.

Fill in gaps in the network with flexible services



Dense demand in core neighborhoods supports a strong transit system, but after decades of car-based development, travel demand is spread thinly across city-regions. Cities should convene mobility providers to create a level playing field that provides reliable, affordable mobility for everyone. With regular routes and curbside management, private companies could thrive while consumers could have access to convenient mobility services.

Create conditions for reliable, affordable mobility



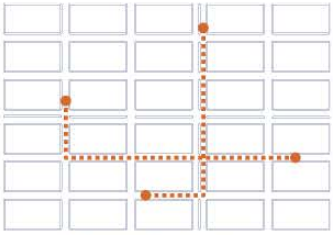
With multiple mobility providers, cities will likely need to use regulations to create viable service conditions: regular routes, curbside management, or even a passenger trip assignment system. Otherwise, competitors will send as many vehicles as possible onto the street to capture riders first—a self-defeating situation familiar in informal transport systems, and which might otherwise be exacerbated by the presence of zero-occupant vehicles.

Integrating Flexible Services

Automated, shared vehicle fleets can help fill last-mile gaps in the fixed transportation network, aggregating multiple trips and consolidating them along major corridors. Technology could allow vehicles to group trips and use streets more efficiently, reducing the amount of space used—and time wasted in congestion—while moving more people.

Flexible

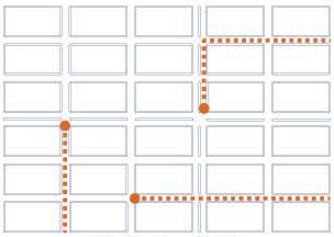
Personal Bike | Walking | For-Hire Vehicle | Point-to-Point Car Share



Door-to-Door

Walking is part of every door-to-door trip, and biking is fast, cheap and space-efficient. Expensive, higher impact motorized services, such as taxi-like vehicles and point-to-point car share, serve an important role for freight and some passenger trips, but left unregulated could overwhelm the rest of the street system. With price or occupancy incentives to use road space efficiently, cities can make sure the right size of vehicle is used for each trip.

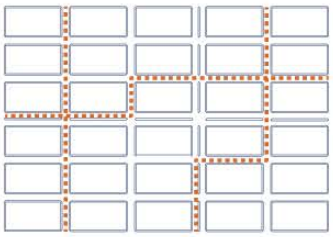
Bike Share | Microcar Share Scooter Share



Hub-to-Hub

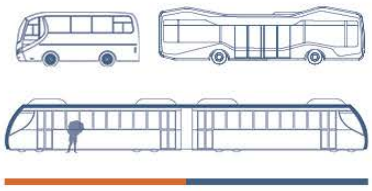
Mobility hubs are already emerging in cities. Bike share and car share allow users to check out and return vehicles at stations or spots spaced closely within a given service area so that they are only a short walk away. These services are already successful and can cover larger areas as bicycling infrastructure expands.

Micro-transit and Delivery

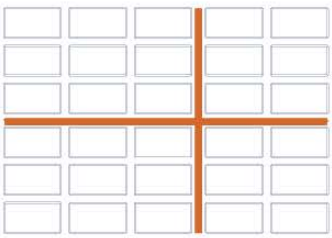


Flex Route

Dynamic and flexible services can maximize vehicle occupancy and route efficiency when there are not enough passengers to justify a full-scale fixed transit route. These services could connect customers with fixed route transit or serve as node-to-node transportation. The same vehicle can serve a "semi-on-demand" flex route in a low density area, and then act like a fixed route vehicle in a denser area.



Local Bus | Rapid Bus Metro or Subway | Light Rail | Regional Rail



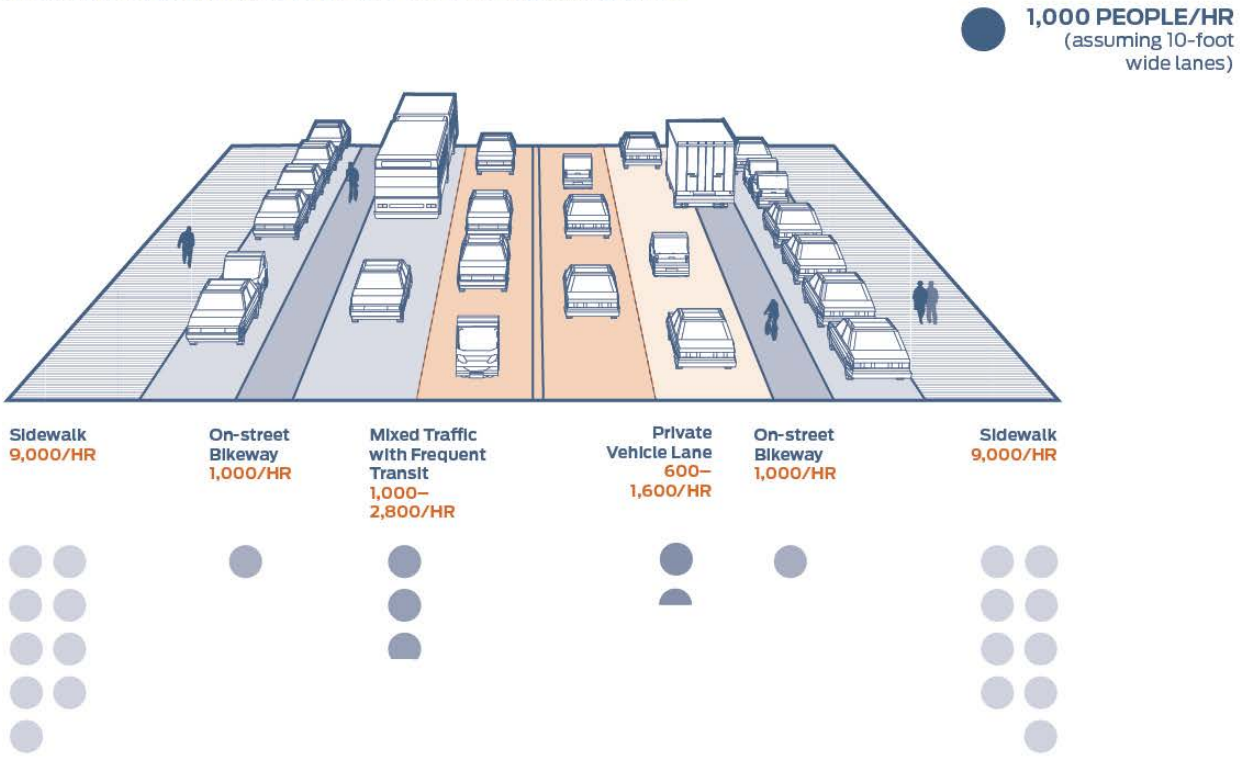
Fixed Route

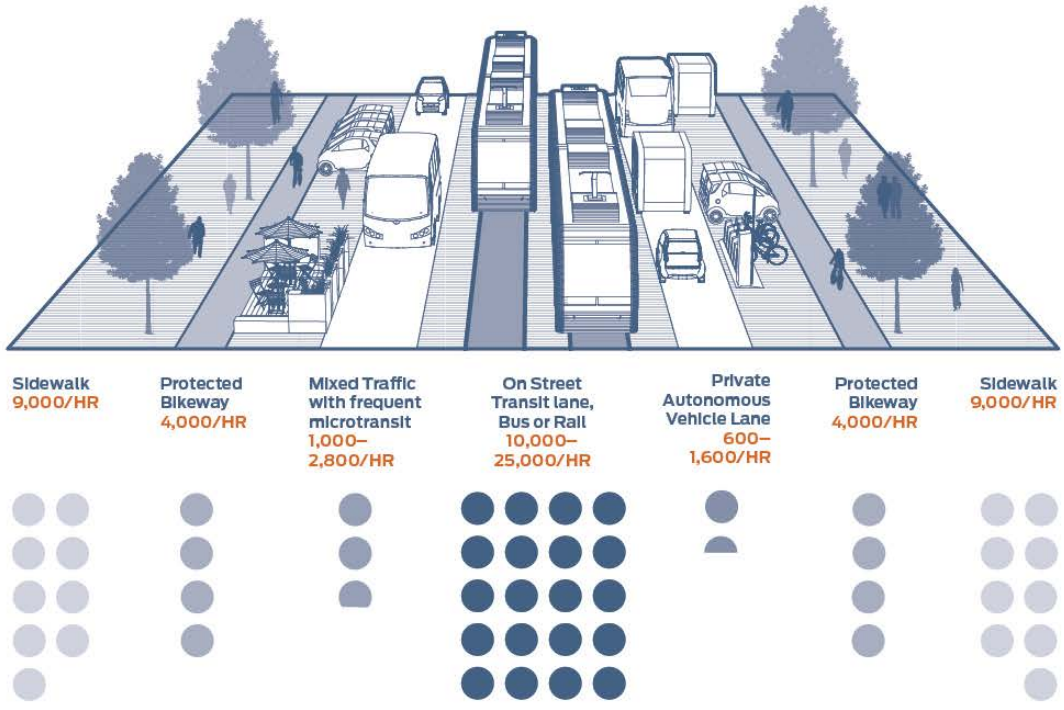
Fixed route service today ypically involves large vehicles that travel a set route with predetermined stops. These transit routes could expand as the backbone of the urban mobility system, accented by microtransit AVs, to serve more of the city. Vehicles could shrink on low-demand routes in order to maintain frequency, or even improve it. Transit agencies should focus on expanding service time span and frequency to grow ridership on core routes while cities should provide priority space for transit to increase reliability.

Fixed

Move More People With Fewer Vehicles

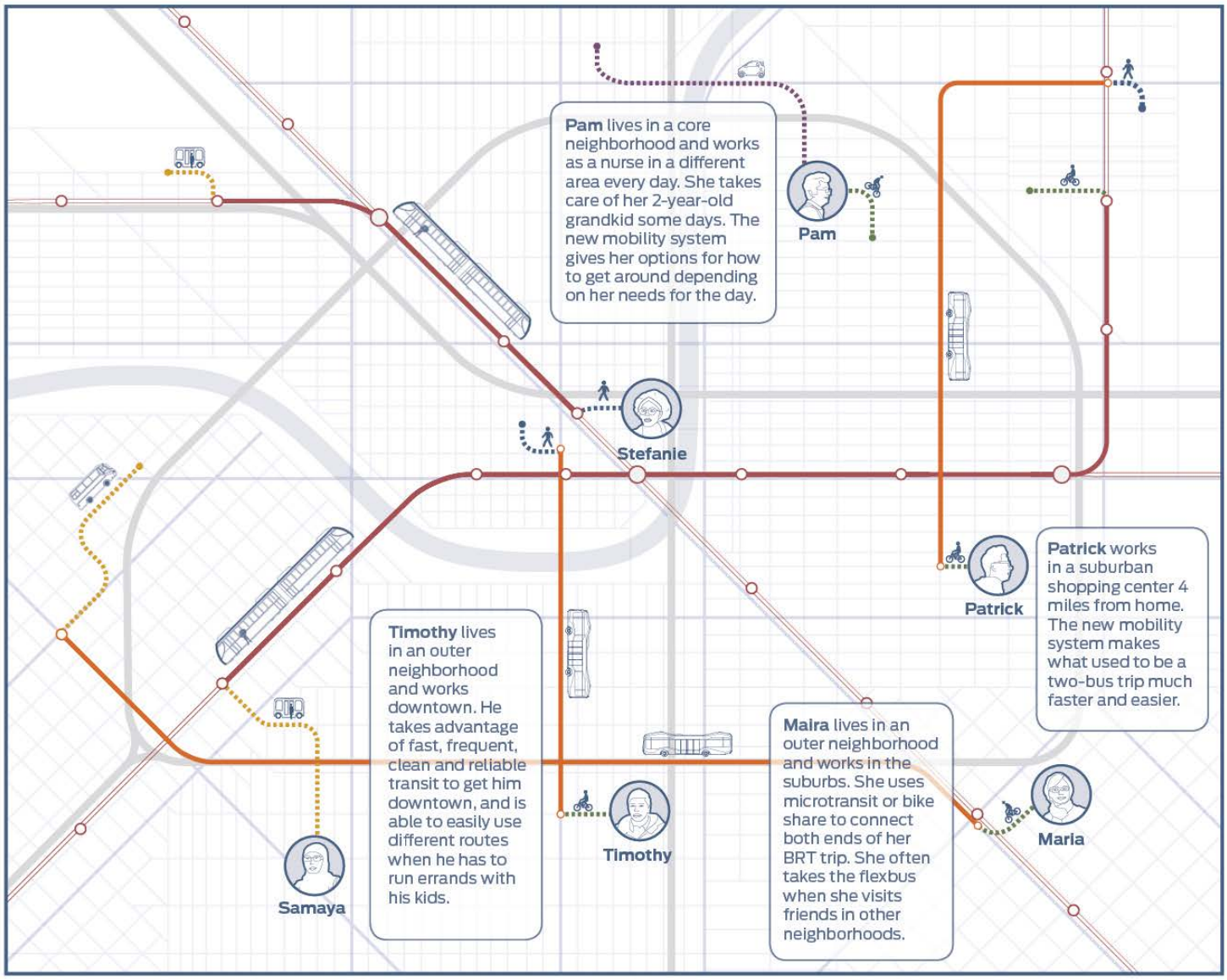
Cities can use technology to drastically increase the capacity of a travel lane, allowing more people to be moved in less space. However, the greatest capacity gains cannot be achieved if single occupancy vehicles predominate. Biking and high-capacity transit must remain a key component of streets, with dedicated space, in order to move the large numbers of people who live in growing cities.





The New Mobility Network

Mass transit should serve as the backbone of the transportation network, while autonomous vehicles, biking and walking complement the core parts of the network and provide service where mass transit is not as efficient. Public agencies and private companies could work in tandem to actively manage the network, with volume, mode and speed thresholds controlled through real-time pricing and curbside demand management.

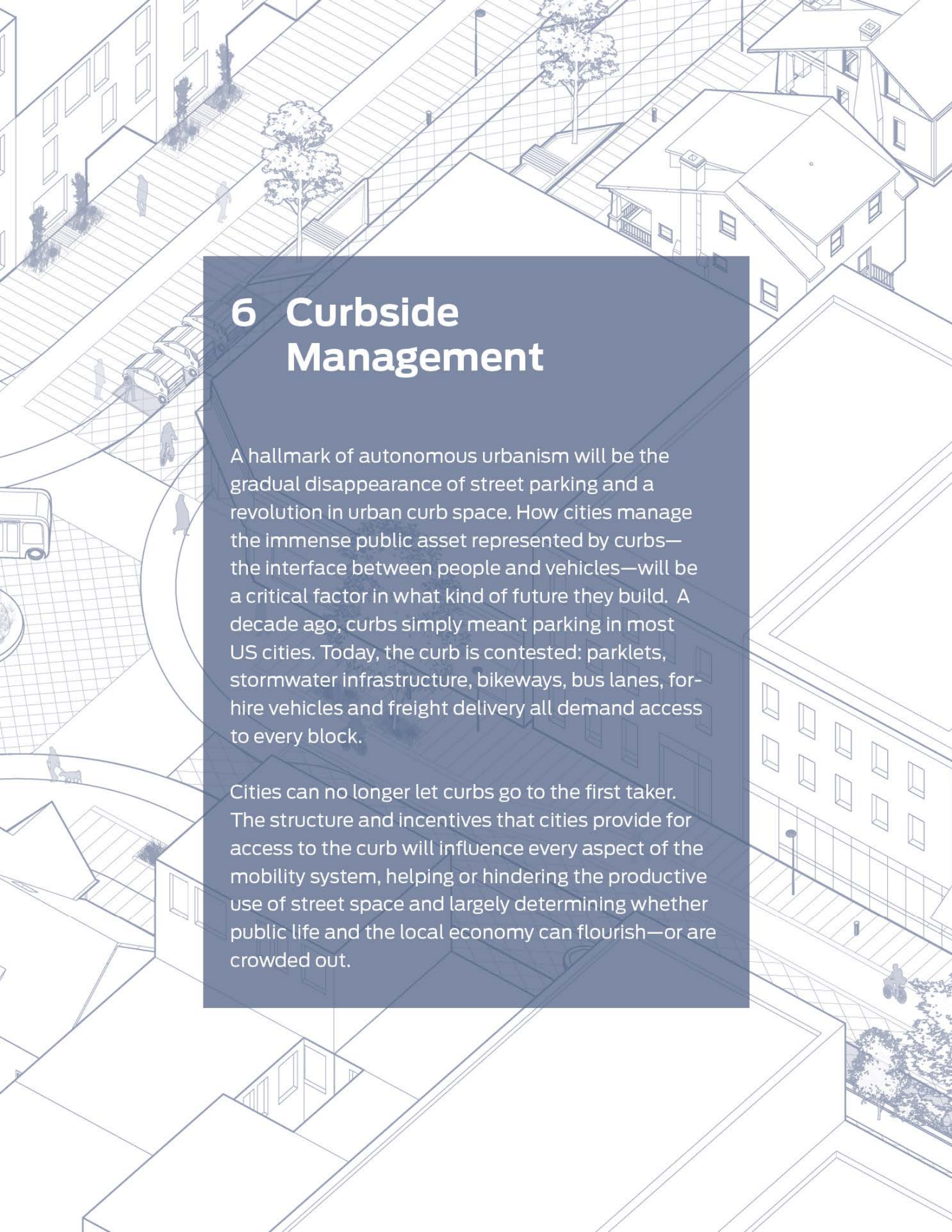


A Reassuring Rider Experience

The success of integrated transit systems around the world shows that consistent branding and easy-to-understand routing that can give riders confidence that they will arrive at their destination is much more important than who or what is driving each transit vehicle.

Changing Trip Types

Cities today are decentralized, making hub-and-spoke transit systems inconvenient for many types of trips. Along with realigning bus routes into a grid network, providing a larger range of services and travel options can help people get around conveniently and affordably.



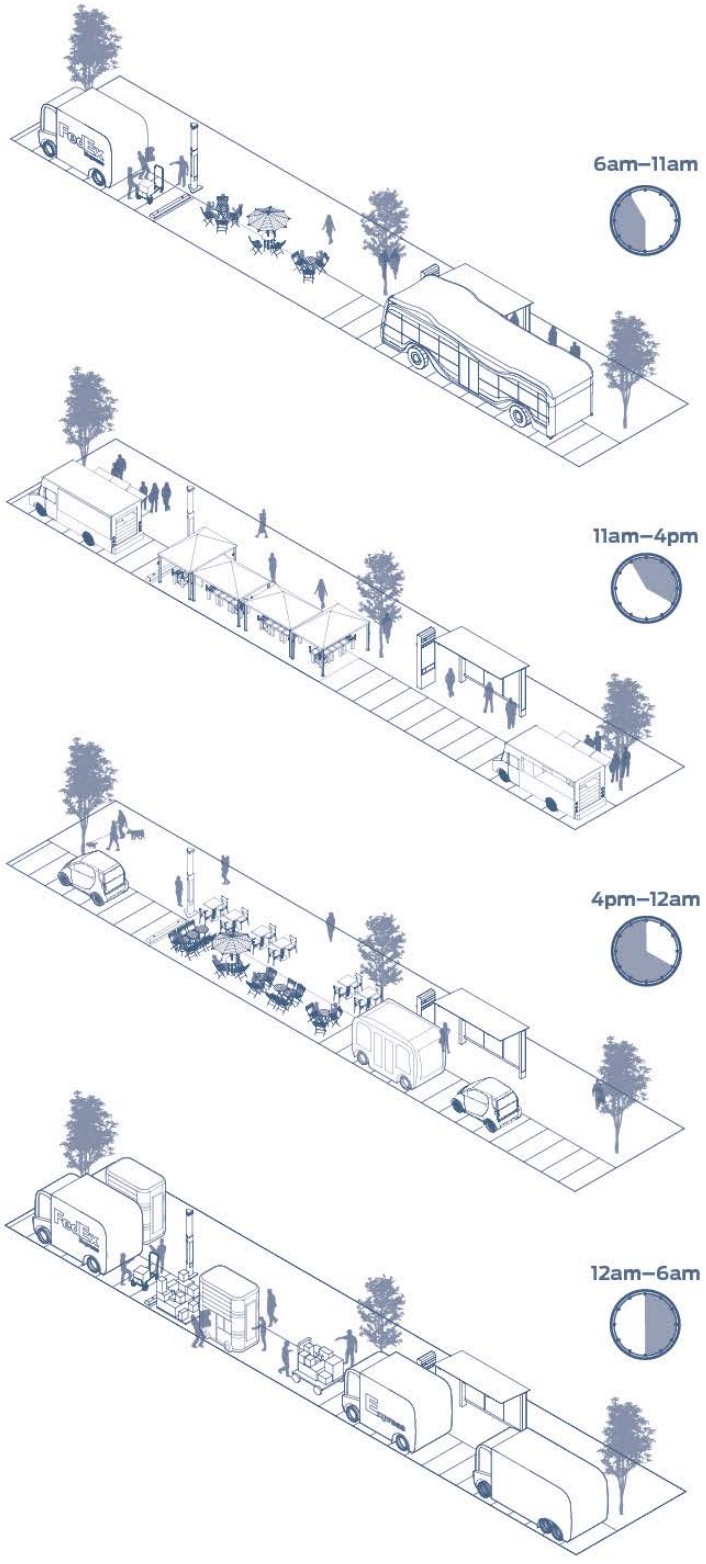
6 Curbside Management

A hallmark of autonomous urbanism will be the gradual disappearance of street parking and a revolution in urban curb space. How cities manage the immense public asset represented by curbs—the interface between people and vehicles—will be a critical factor in what kind of future they build. A decade ago, curbs simply meant parking in most US cities. Today, the curb is contested: parklets, stormwater infrastructure, bikeways, bus lanes, for-hire vehicles and freight delivery all demand access to every block.

Cities can no longer let curbs go to the first taker. The structure and incentives that cities provide for access to the curb will influence every aspect of the mobility system, helping or hindering the productive use of street space and largely determining whether public life and the local economy can flourish—or are crowded out.

Time of Day Management

Curbside flex zones can play many roles, from public space to loading zones. They could change use over the course of the year, week, or even the day.



Morning

Before the peak of the morning rush, freight deliveries arrive to stock stores with their goods for the day.

By 7:30, delivery vehicles give way to vehicles dropping off employees, many enjoying breakfast or coffee in a parklet on the way into work.

Mid-day

Late morning brings some deliveries of packages and mail to businesses and residents. At noon, the lunch rush begins bringing many people to street vendors to enjoy their mid-day meal.

By 2:00, most diners are back inside and light delivery activity continues until the evening rush.

Evening

The evening rush stops delivery activity as street and vehicle capacity is shifted to move people instead of goods. Passenger movement continues into the evening as people grab dinner or drinks, pick up children, or head to evening events.

Automated evening and late-night delivery activity allows for easy movement of large goods on underutilized streets.

Late night

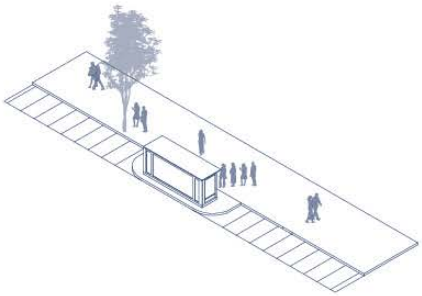
Late at night the curb prioritizes freight vehicles. Passenger movement is at a minimum through the early hours of the morning, leaving more space for increased delivery services in cities. Delivery ease is increased through the use of nearby storage lockers.

In the morning, freight makes way for transit vehicles.

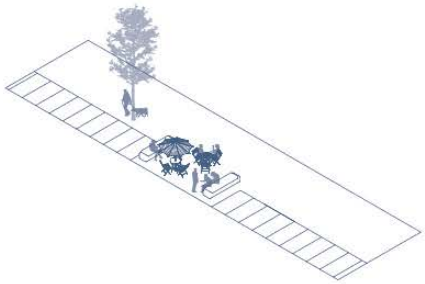
Flexible Curbside Uses

Curbsides have the potential to host a variety of different programs and activities— some permanent and others variable throughout the day or time of year. Cities can actively manage curbsides through pricing and make curbs feel more like an extension of the sidewalk than the edge of the roadway.

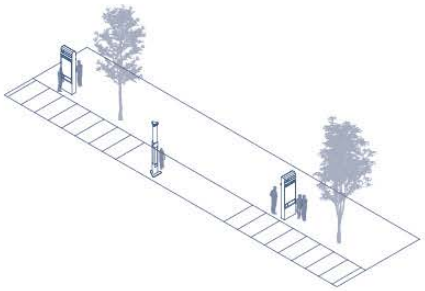
Vendors



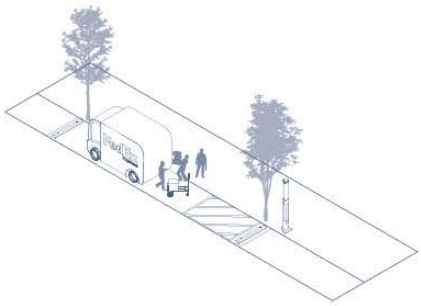
Public Seating



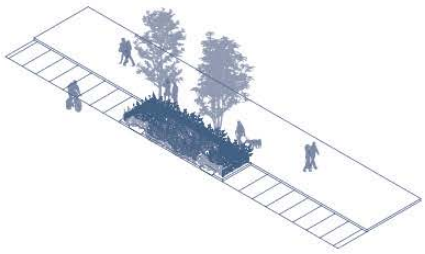
Digital Infrastructure



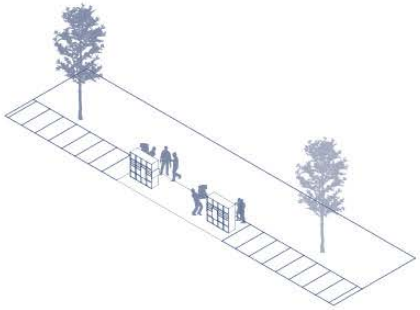
Freight Loading



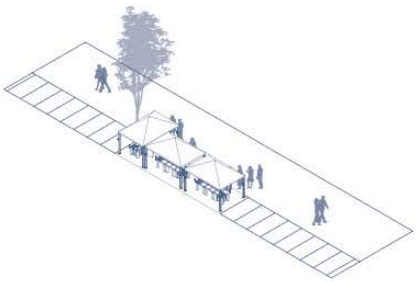
Green Infrastructure



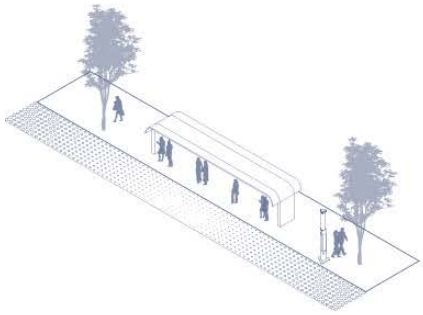
Delivery Lockers



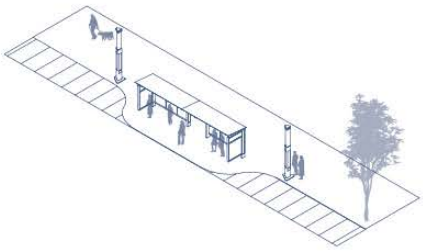
Market



Pick-up/Drop-off Zone



Transit Stop



Coding the Curb

Today

Cities today have to dedicate curb space either for loading or parking or transit or public space, but can only change use according to pre-set times. Conventional practice is to allocate spaces on the curb based on the adjacent land use, using only meters and time limits to create turnover in business areas, rather than to match curb demand to supply.

The city's typical role is to update curb regulations periodically based on changes to land use or in response to specific requests, such as for loading zones at supermarkets or bike corrals and parklets at small retailers. Usage data for planning purposes is in short supply, and real-time curb availability data is absent. Little attention is paid to curbs on residentially-oriented and industrial streets.

The Near Future

Cities are already updating curb uses based on demand and values. A portion of parking on high-demand curbs may be allocated to high-capacity transit and active modes, but these changes are flashpoints because on-street parking is under-regulated and over-used. With a combination of curbside inventories, pricing and permits for residential parking, and transparent, demand-based charging for the curb on highly used streets, cities could better manage the curbside.

With systematic implementation of existing technology, cities could charge for the amount of time a vehicle uses the curb, and account for and broadcast the availability of curbside spaces. These changes would quickly lead to better use and availability of curb space.

Today

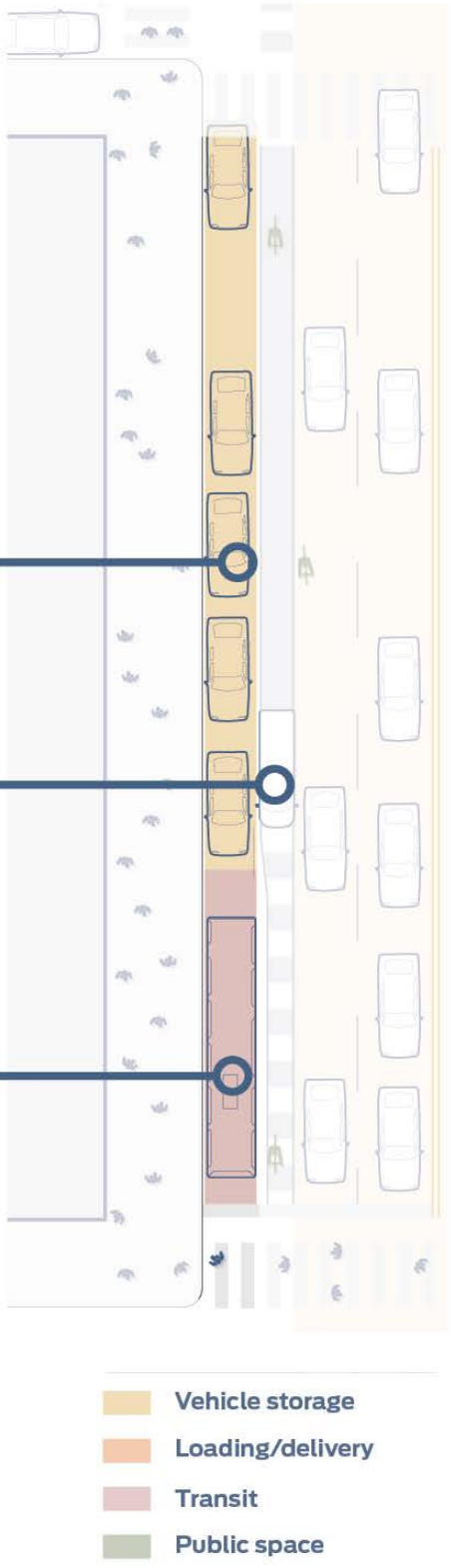
(Under)Pricing the Curb

The curbside today sees overflowing demand that varies by mode and time of day. However, in most cities, prices for curb use remain stagnant and curbs are inflexible to new short-term uses.

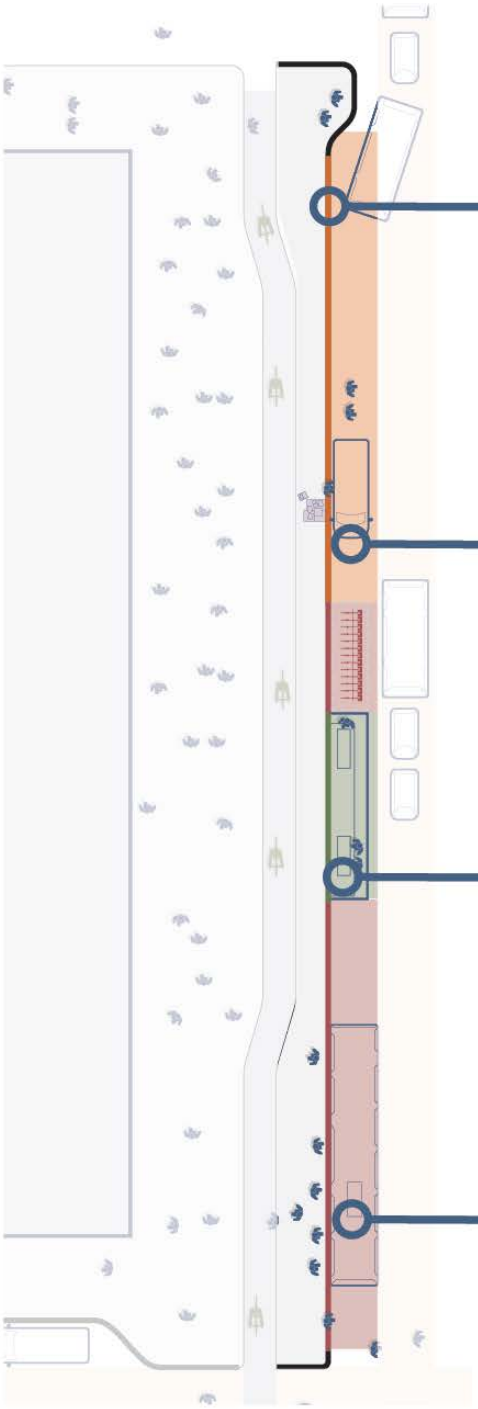
Vehicle storage occupies the majority of curb space today. Vehicles circle the block looking for unoccupied spaces and cities rely on parking enforcement and ticketing for a significant amount of revenue.

Bicycle lanes blocked by freight or vehicles loading passengers are a common occurence. These instances dangerously force cyclists into adjacent vehicle travel lanes or the 'door zone'.

Transit stops are heavily used during peak periods, but may be blocked by non-transit vehicles, especially during off-peak periods when bus frequency is lower. At other times this space may simply stand empty.



Tomorrow



Passenger loading space is available on busy urban streets during peak periods for high prices in comparison with side streets. As vehicles are charged by time, increased occupancy decreases costs per user. Drop-off space for smaller fleet vehicles is available on each block, but is priced according to demand.

Freight is a high-value use but consumes a large amount of time and square footage; pricing will guide companies to consolidate orders and improve efficiency, using high value right of way for the time necessary.

Public space is allocated on most major streets to provide people walking or lingering a place to interact. These spaces create more liveable and welcoming streetscapes.

A rapid bus stop, every third of a mile, is primarily used by buses, but microtransit is permitted to use it when it is not occupied by a full-sized bus.

The Fully Autonomous Future

A real-time curbside management system could work on an instant reservation basis, where specific vehicles can automatically reserve timeslots a few minutes in advance of arrival at a site, with the free market determining what they pay for the amount of flex zone time they use.

Creating a more dynamic and nimble system gives private companies as well as public agencies more tools to get the best use out of the curbside space. For example, high-value uses, such as drop-offs for disabled passengers or grocery deliveries, can be prioritized in both time and space.

Pricing the Curb

Cities should price curb space dynamically, prioritizing uses that align with their values, possibly through real-time bidding. Prices for low occupancy modes on major urban streets will be higher than those on side streets.

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