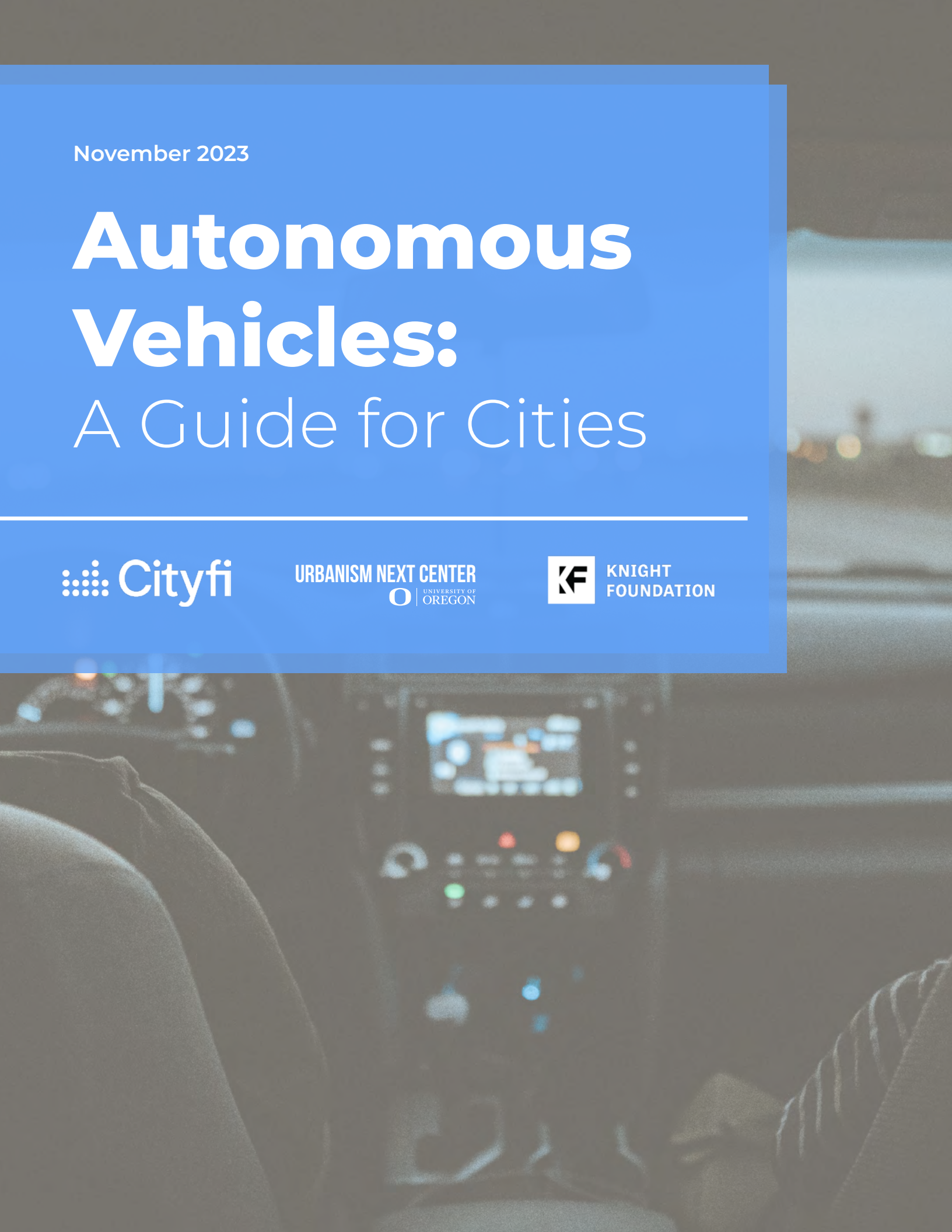
November 2023

Autonomous Vehicles:
A Guide for Cities

Cityfi

URBANISM NEXT CENTER
UNIVERSITY OF OREGON

KNIGHT FOUNDATION



Acknowledgments

From 2018-2023, through an initiative of the James S. and John L. Knight Foundation (Knight Foundation), Cityfi and Urbanism Next convened and collaborated with four local governments from across the country - San Jose, Detroit, Pittsburgh and Miami-Dade County - as they experimented with and learned from publicly-managed autonomous technology pilots and demonstrations.

From sidewalk delivery devices to autonomous vehicles (AVs), the vital importance of proactive policy, planning, and community engagement was learned. These learnings, along with input from various cities and stakeholders across the country, informed the content and recommendations of this Guidebook. Investments like that of the Knight Foundation, which allow cities to experience, learn, and develop policy together around a new technology, is vital to creating informed, empowered cities that are prepared to respond to and shape AV deployments.

This report was written, edited and designed by:

Cityfi: Story Bellows, Karina Ricks, Erin Clark, Camron Bridgford, and Carolina de Urquijo

Urbanism Next Center: Nico Larco and Thomas Götschi

Cityfi and Urbanism Next would like to thank the following people for their contributions to this report and for their work with the Knight AV Initiative:

- Bernardo Rivera Muñozcano | Knight Foundation
- Ramses Madou and Sarah Abroff | City of San Jose Department of Transportation
- Chase Klingensmith, Angie Martinez, and Kim Lucas | City of Pittsburgh Department of Mobility and Infrastructure
- Jarice Rodriguez, Irene Soria, and Carlos Cruz-Casas | Miami-Dade County Department of Transportation and Public Works
- Tim Slusser, Tony Geara, and Konner Petz | City of Detroit Office of Mobility Innovation
- Jack Gray | Ford City: One
- Jen Cheek, Wren A. Ruiz, Andrea Iglesias, and Tiffinie Bratcher | Urban Health Partnerships
- Lilian Coral | New America
- Amanda Howell | Oregon Department of Transportation
- Gabe Klein | Joint Office of Energy and Transportation
- Becky Steckler | ECONorthwest
- Stephanie Dock | DDOT
- Mark Kopko | PennDOT
- Kristin White | FHWA
- Patrick Smith | NYCDOT
- Julia Friedlander | SFMTA
- Kristopher Carter | MassDOT
- Collin Moffett | North Central Texas Council of Governments
- Thomas Bamonte | Metropolitan Planning Council
- Gary Rosenfield |MATA Transit
- Ashlyn Kong and Terra Curtis | CPUC

Table of Contents

I. Introduction

1. Why an Autonomous Vehicle (AV) Guidebook?

City streets are in a period of rapid and ongoing disruption.

Urban travel changed profoundly at the turn of the last century with the introduction and (soon after) rapid expansion of the automobile. Motor vehicles dramatically changed street design and many aspects of urban life without any conscious public dialogue or deliberate policy design to guide or manage it.

While autonomous vehicles are still experimental and nascent in many corners of the U.S., this same kind of unguided tectonic shift is possible, should the technology prove out.

There is an opportunity, however, this time around, to engage both industry and community in purposeful demonstrations and proactive dialogue to craft foresighted policy to guide deployments to advance community goals and the public good.

This Guidebook was created in response to cities currently struggling to manage and influence autonomous vehicle pilots and deployments happening on their streets, as well as cities trying to prepare for these pilots. The Guidebook offers considerations, tools, and examples of various ways to manage effectively autonomous vehicle deployments.

A Note for Readers

While we aim for this Guidebook to be suited for a general audience with a basic understanding of autonomous vehicle technology, readers may want to read further about AV taxonomy and terminology (SAE International's Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles), and other resources such as NACTO's Blueprint for Autonomous Urbanism: Second Edition, and Urbanism Next's A Framework for Shaping the Deployment of Autonomous Vehicles and Advancing Equity Outcomes.

2. Overview of the Guidebook

Who is this Guidebook for?

This Guidebook is primarily a tool and guidance for city staff and leadership to prepare for and respond to autonomous vehicle testing, pilots, and deployments in their city.

This Guidebook may also be useful for:

Public stakeholders looking to more effectively engage in autonomous vehicle policy development

AV developers and operators looking to better understand how to work with cities and align with city goals

State and federal governments looking to better understand how to meaningfully collaborate with cities on AV policy and governance

Non-profit organizations and academic institutions looking to support city preparedness for AVs and other future disruptive technologies

What is the definition of "Autonomous Vehicles"?

For purposes of this Guidebook, references to AVs or AV technology mean:

A private, public, or nonprofit transportation service or technology that uses public streets or sidewalks, and which has the capability to drive a vehicle, in all or specified conditions, without active physical control or monitoring by a human operator.

AVs can include vehicles deployed by passenger transportation network companies (TNC), shuttles or buses, personal delivery devices (known as sidewalk robots), and even unmanned aircraft devices.

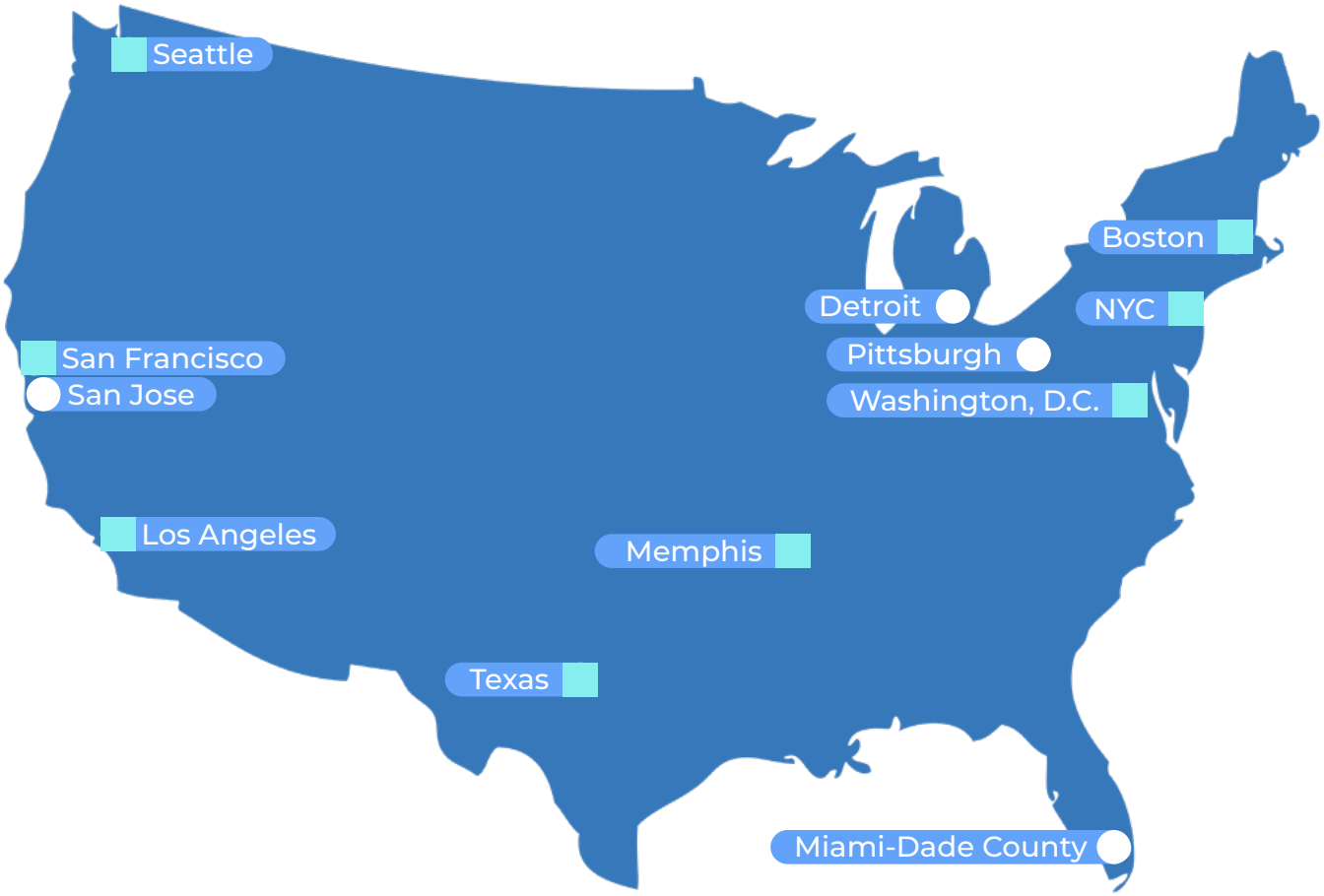
What Are the Goals of this Guidebook?

- Help cities define their local goals, objectives, and metrics for outcomes related to publicly available autonomous vehicle technology.
- Help cities understand if and when partnerships and/or demonstrations with AV operators is right for them.
- Ensure the community is engaged and empowered to co-define outcomes and objectives of local demonstration or deployment of AV technologies.
- Accelerate nimble responses from local governments when autonomous vehicles arrive for testing or deployment.
- Encourage the exchange of knowledge and lessons learned between cities and partners.
- Provide priority considerations and actions for capacity-strained government staff.
- Facilitate consistent policy, metrics, and processes across municipalities.
- Facilitate productive partnerships with innovators and stakeholders.

How Was this Guidebook Developed?

This Guidebook was developed through first-hand demonstration pilots, community engagement, policy development, and research. Detroit, Miami-Dade County, Pittsburgh, and San Jose were all Knight Demonstration Pilot cohort members. These agencies tested AVs in different capacities within their respective locations. Furthermore, a coalition was formed with members of the Pilot cohort and representatives from various agencies and organizations in San Francisco, Washington, D.C., New York City, Seattle, Memphis, Texas, Boston, and Los Angeles.

Knight Foundation Autonomous Vehicles Initiative (AVI) participating locations



3. Stages in the AV Development Process

How is the AV industry building AV technology, and for whom?

Gaining clarity on this question is vital for the future of city streets. There are three primary types of AV activities happening in cities: research and development, demonstrations, and deployments. We call these the "3 Ds."

Case Study: Pittsburgh

Pittsburgh is home to Carnegie Mellon University - the birthplace of autonomous vehicle technology in the U.S. Until recently, Pittsburgh had the highest concentration of AV companies, R&D, and on-street testing in the country.

Pittsburgh is a mid-sized city with complex roadways and topography, making it a "double black diamond" for AV testing. Pittsburgh is aware that they are prized as an R&D capital rather than a target for early deployment and scaled service of AVs. These factors impacted how Pittsburgh approached its planning and policy development around AVs, leading to a greater focus on public safety and implications around testing on public streets. Therefore, Pittsburgh's approach to piloting considered the potential for AVs to fill last-mile connections in the near term and less of a focus on service locations.

Research & Development is taking place in cities across the country with or without their awareness. R&D is not always happening on public streets; research-based testing might be incognito. R&D includes virtual modeling (often in a classroom or lab), as well as testing on closed, private tracks. If you're in a city with a university that leads in robotics and engineering, these types of R&D activities may be taking place. In general, virtual modeling and private track testing should be of little concern to a city's transportation department. However, R&D often includes mapping and testing the technology on public streets with a human operator or safety driver behind the wheel.

Demonstrations also referred to as pilots, are often focused more on marketing and user adoption for the private sector AV operator, or understanding workforce and rider response when integrating AV technologies into transit services. Demonstrations and pilots may offer free rides or experiences interacting with an autonomous vehicle. These are often one-off events or services for a set time period, and this generally includes a human safety driver behind the wheel. If an operator is seeking to host a demonstration or launch a pilot in your city, it is a good indication that your city is a target for early deployment.

Deployments move beyond a demonstration or pilot and indicate a level of confidence from the AV operator[1] that the AVs can safely operate on public streets, at least under certain conditions, and provide reliable service to customers. They generally come in two flavors: limited-revenue service and scaled service. To date, San Francisco, CA and Tempe, Scottsdale, Chandler, and Mesa, AZ are the only U.S. cities in which commercial service deployments have launched (via Cruise and Waymo).

Possible role of cities in each of the stages:

Development

- Investor in technology development
- Testbed manager for real world testing
- Two-way data sharing partner

Demonstrations

- Use-case designer and tester
- Demonstration sponsor
- Demonstration evaluator
- Public educator and "truth teller"
- Co-creator

Deployments

- Operating domain owner and manager
- Public safety provider
- Traffic enforcement entity
- Right-of-way manager
- Land use regulator

1 Levels of confidence and how safety is measured varies among operators - see "How Safe is Safe Enough" on page 54.

4. Cities' Roles in AV Technology

There has been debate on what exactly cities' role should be in the development, demonstration, and deployments of AVs.

While most cities have limited regulatory authority over AVs, cities are often at the heart of AV deployments. Cities are responsible for:

- Safe operations in the public right of way;
- Engaging residents who have questions about the testing or demonstration of a new technology;
- Determining if or how AVs help achieve a city's transportation and mobility goals;
- Regulating the curb (e.g., the area at which the transaction - pickup, drop off or delivery - most often occurs); and
- Acting as a convener of key stakeholders and facilitating productive engagement across these stakeholders.

This Guidebook further encourages federal and state regulators to collaborate with cities so that critical issues around AVs that impact cities can be contemplated and addressed in federal and state laws and regulations.

For example, there are areas, like curb management and public safety, where city authority to oversee and manage AVs should be preserved in state and federal law.

Maintaining Momentum with an Iterative Technology

It is important to keep in mind that the development, demonstration, and deployment of new technologies, especially those as complex as AVs, is not a linear process.

There are often unmet promises from developers, times of rapid progress followed by stalls or short regressions, and generally a lot of "fits and starts." This can make it difficult for cities to dedicate consistent time and resources into learning about and preparing for these new technologies, let alone keep the community engaged. However, consistency is critical to remaining informed and responsive to the ever-changing environment and development of AVs and other new technologies.

Stay Current on AV Technology

AV technology continues to evolve, iterate and change. Maintaining internal subject matter expertise of a rapidly changing technology in a shifting policy and regulatory landscape is often difficult for city staff, particularly when the city does not have a staff member dedicated to AV technologies. Here are some ways cities can stay up to date on the latest in AVs:

Set alerts for your state legislature and federal register so you'll be aware of any newly introduced legislation or notices of proposed rulemaking that relate to AVs

Federal Highway Administration (FHWA) Automated Vehicle Activities and Resources

National Highway Traffic Safety Administration (NHTSA) Automated Vehicle Resource Page

Urbanism Next's Autonomous Vehicle research and resources page

Harvard Kennedy School Autonomous Vehicle Policy Initiative

National Association of City Transportation Officials (NACTO) Autonomous Vehicle resource page

Intelligent Transportation Society of America (ITSA) Automated Vehicle Working Group

Cities may additionally wish to track industry and advocate resources, while keeping in mind the intentional perspective and biases. These include:

- Partners for Automated Vehicle Education (PAVE)
- The Autonomous Vehicle initiative of SAFE
- Autonomous Vehicle Industry Association (AVIA)

II. Assessing the Landscape

At present, AV deployment is uneven across the United States. Variables such as climate, city size, demographics, assumed market demand, urban complexity, politics, regulatory environment, and investor prerogative play key roles in where, when and if deployments happen locally.

Whether developers have already deployed AVs on city streets, are soon to, or might never, cities can consciously assess the potential risks and benefits of the technology, as well as determine the levels and types of engagement they should have in the process, and what levers of influence they possess.

1. Consider AV Deployment Factors

- Define Mobility Principles and Broader City Goals
- Weigh Alignment of City Goals, Technology, and Community Readiness
- Assess the Technology Landscape
- Evaluate Near-Term AV Developer Interests
- Assess Additional Impacts of AV Deployment
- Consider Other Influential Factors

Define Mobility Principles and Broader City Goals

Assessing the landscape requires cities to clearly define their points of view, objectives and priorities.

Without clearly articulating and aligning with goals and desired outcomes, cities run the risk of wasting valuable time and resources engaging with AV developers for purposes that do not advance the public good.

Cities have broader, intersecting goals and needs than most AV technologists focus on. Beyond roadway safety, cities are also working to mitigate past racial and economic disparities and injustices; reduce primary, secondary and tertiary environmental and social impacts; enhance transportation and housing affordability; and promote compact, walkable communities, among other goals.

Cities may have narrower goals for specific demonstrations, such as gaining greater understanding of community response to the technology, utility in addressing specific mobility gaps, or interactions with public safety personnel or emergency situations.

Cities have a clear stake in both the demonstration and deployment of automated vehicles in their communities. They have an obligation to intervene or advocate to promote and protect local community values and priorities.

Mobility principles can:

- Speak to the desired outcomes that new and disruptive mobility initiatives have the potential to deliver.
- Speak to the outcomes a community wants the city to ensure and signify an openness to meaningful innovation and experimentation from private industry.

Lastly, it is important that mobility principles do not just exist to check the box. They need to be operationalized. Cities should measure pilot opportunities using criteria aligned with their mobility principles and publicly report on outcomes.

Source: Unsplash | Maria Oswalt

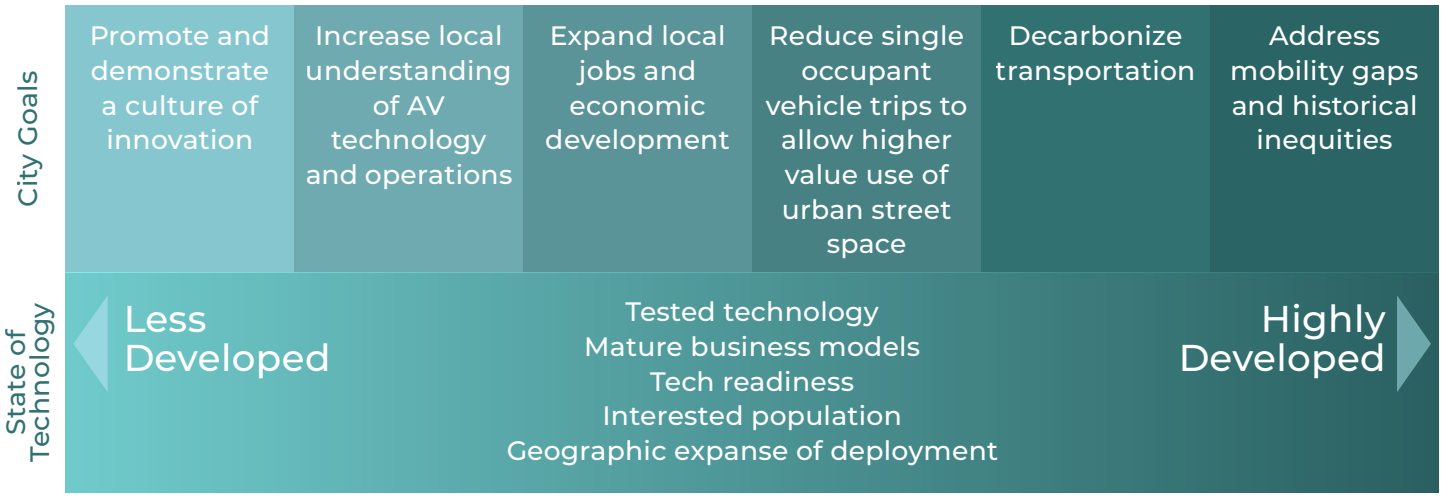
Weigh Alignment of City Goals, Technology, and Community Readiness

Effectively engaging in AV demonstration and deployment can require substantial time and resources from city and community stakeholders.

Cities first need to weigh the alignment of their desired outcomes with the realities of current and near-future AV deployment. For instance, having the goal of broadly servicing local trips does not align well with a technology that is in an early state of development with limited numbers of vehicles in a confined area. Cities should consider the state of the technology, their own technology readiness, the likelihood AV companies will want to deploy in their area, and potential funding sources to support demonstration or focused deployment to help decide if they should engage.

No matter the depth of desire to develop local stakeholder and staff expertise around these topics, if AV companies are not interested in your city, it will be difficult to make demonstration or deployment happen, outside of finding ways to directly fund and procure them. Cities should also be clear-eyed about the amount of effort required for effective engagement, the barriers to AV interest in their area, and the potential benefits and challenges of AV demonstrations and deployment for their constituents.

Below is a matrix of common city goals around this technology and the relative state of the technology functionality, business model, and city technology readiness/acceptance needed to realize those goals.



Assess the Technology Landscape

Cities should assess various aspects of the technology landscape (discussed further below) to assure AVs are at a sufficient level of development to deliver on city goals.

Understand Use Cases. Use cases describe a specific purpose, setting, and requirements for a possible use of AV technology (e.g. first/last mile transit extension; home deliveries by sidewalk-robots; etc.). What is/are the use case(s) that will advance your city goals? Are there potential unintended consequences of the use case application(s)?

Understand the State of the Technology. Is the technology able to reliably function for your desired use case(s) and in the various operating environments needed to achieve stated goals? While this is a critical issue, it has proven difficult to assess, as AV companies can be overly optimistic and cities can have an incomplete understanding of desired use cases or environmental variables. Demonstrations can help build this understanding prior to broader deployment; however, the relatively short time frame of a demonstration period will likely be inadequate to fully understand the effect on long term goals.

Understand the State of Related Business Models. Do viable business models exist - or can reasonably be expected to exist in the near-future - for the target use cases and the scale of deployment needed to address city goals? During the demonstration phase operations may be subsidized in a way that may mask long term fee or funding models necessary for sustainability.

Determine the City's Own Technology Readiness. What is the city's technological capacity/experience with necessary technologies, data standards, data sharing agreements, infrastructure needs, emergency service needs, and regulatory structures needed for tech testing and/or deployment? Before engaging with AV companies, it is important for the city to understand its own capabilities with regard to data and operations.

Assess Stakeholder Interest and Understanding of the Technology. Are key stakeholders interested in this technology and do they see it as a solution to problems they are facing? Do they see themselves potentially using this technology (in terms of safety, convenience, affordability, and use cases)? Does the political will needed for this engagement exist?

Generally, the more a city is attempting to achieve broad, real-world transportation impacts, the more developed each ofthe topics on this page need to be.

If operators are primarily only testing and have fairly limited deployment scale, hours, and geographic coverage, then engagement should focus on culture, tech-related economic activity, and city stakeholders gaining experience with the technology. On the other hand, if operators are targeting scaled-up deployments, then cities need to understand the benefits and challenges to operations, impacts on the transportation system, equity challenges, and how to best shape deployments to support community goals.

Evaluate Near-Term AV Developer Interest

Some cities are so attractive to AV companies, they have already initiated AV deployments (whether locally desired or not). Other cities are currently being eyed for deployments. Some demonstrations are the result of local incentives to attract activity. But in the eyes of an AV developer and their investors, many places are currently undesirable for operations - at least in the near term.

Once a city understands the alignment (or misalignment) of AV technology and service models with local goals and objectives, it is critical to also understand likely AV developer interest in their locality. This will help a city gauge if AV operations are likely to come to their community sooner rather than later, if incentives are necessary to attract AV activity (if so desired), or if AV operations in the near-term are unlikely.

Industry interest is by no means assured, as market priorities and the state of the technology can dictate AV developers' willingness to engage with cities. Uneven or halting progress in AV technology or investment has left many interested cities waiting without a matching AV developer willing to engage, while other cities have deployments without invitation. AV developers are under tremendous pressure to translate their visions and promises of an autonomous future into profitable and functional deployments. If AV developers are not interested in engaging with your city, funding and political capital put into AV engagement will be wasted and can become a political and financial liability.

Testing the technology can create opportunities, such as staff learning and community experience, and present challenges, including inconsistent engagement and communities feeling they will not reap longer-term benefits due to testing.

The following page outlines common factors to consider in a local deployment. A community that meets some, but not all, of these key considerations, may make a good place to test but not necessarily a place for early, large-scale deployment.

Common considerations in local deployment:

Operating Environment Complexity: AV developer deployment decisions often center on taking incremental steps in the complexity of the operating environment in which they are testing. Common site selection criteria include street widths; the complexity of the street system (grids versus irregular street patterns); condition of pavement, marking, and sign infrastructure; density of people walking, biking and using transit; weather; and topography.

Potential Future Market and/or Use Cases: With the need to translate this technology into viable business models, AV developers seek operations in areas that can eventually become profitable deployment markets. Variables for this are market size and population, development density, demographics such as age, educational levels, and wealth, as well as locations that suit profitable use cases. A key consideration for some AV developers is if they see local government itself as a future client of services (e.g., AV-based transit) and not simply as a future operating environment (e.g., robo-taxis).

Exclusivity: Public transportation is a public service and often not a profitable endeavor. Equitable, public-serving mobility, likewise, is a difficult sector in which to make a profit. Mobility companies of all stripes are currently flexing their government relations muscles to carve out exclusive operating agreements, which is expected to be the case for AV operators. The less competition, the greater the chances of market stickiness and brand loyalty across markets. Cities wishing to attract AV activity (in line with local goals) might signal the potential for exclusivity in their locality.

Existing Technology Sector Talent/ Expertise: AV testing and deployment is a significant staffing endeavor with a need for experienced technology employees and researchers. Cities with high concentrations of engineering, product, and coding talent will attract AV developers to open operations in the area.

Funding Opportunities: AV developers invest substantial funds in testing and deployment, and as such, are attracted to external funding and grant opportunities to help defray these costs. This can be a significant lure for AV operators, and many instances of testing and deployment occurred specifically because governments (at all levels) and philanthropies offered this funding. One difficulty with this is that when external funding ends, companies may abruptly end testing and deployment in the area.

Public Relations and Political Opportunities: AV developers must constantly address investor interest/oversight as well as an evolving regulatory environment. Deployments that create positive news about testing and deployment - and that are located near target audiences - can be useful in investor relations and government lobbying efforts.

Permissive Regulations and Supportive Governments: AV regulation is a dynamic space, and AV developers are attracted to areas with regulations and governments that are supportive of AV services and testing, facilitate deployment, and minimize corporate risk. While a permissive regulatory environment might entice AV developers, cities must weigh the tradeoffs and think strategically if losing leverage is an acceptable outcome.

Consider Whether Current Infrastructure is Adequate for a Pilot

Through funding from the Knight Foundation, four cities and Kiwibot collaborated to better understand if personal delivery devices (PDDs) could provide services to people during COVID.

While the demonstrations revealed the values of PDD service models, they also highlighted the relationship between infrastructure and emerging services. Various obstacles impeded PDD operations, including, but not limited to, missing sidewalk segments, encroaching vegetation, and missing curb ramps. The demonstrations reinforced that fundamental infrastructure and safety improvements are often a precursor to new technologies being able to deliver claimed benefits.

Source: Miami-Dade County

Assess Additional Impacts of AV Deployment

While AVs can serve some city goals, they can threaten others. Cities should be introspective to ensure they are not pursuing technology for technology's sake.

Once a city has established that AVs can serve and advance their community goals, they must also step back and evaluate potential impacts and unintended consequences of AV deployment.

This evaluation will help cities shape demonstrations, regulations and operating agreements in order to guide deployments that minimize negative impacts and amplify benefits. While difficult to assess prior to deployment, impact criteria might include:

Safety for all road users: Does the technology improve the safety not only of AV passengers, but also of pedestrians, cyclists, transit riders, emergency responders, and road maintenance workers? This should also take into account whether AV deployment shifts travel behavior and induces mode shift. These things are difficult to assess given the early state of AV deployment, but the topic is being evaluated by state and federal governments.

Equity and affordability: Does the technology exacerbate existing inequities and disproportionately benefit white and high-income riders who already have substantial mobility options? Will AVs provide expanded mobility options for individuals currently unable to drive? Will they be affordable for low-income populations? Finally, will AVs be sufficiently geographically widespread so they are available to a broad group of users, or will viable business models tend to concentrate availability in denser and wealthier areas?

Transportation network impacts: Will AVs have similar impacts as ridehail companies, where deadheading and repositioning increase congestion and vehicle miles traveled (VMT)? Will AVs achieve network efficiencies as they scale and optimize their routing? Can AVs improve first/last mile access to transit? Can they reduce parking or will they require designated parking to ensure curb access or storage during idle times?

Land Use: Will AVs contribute to sprawl? Will the projected ease of travel with AVs push residents to move further from central cities and expand metropolitan footprints, therefore multiplying VMT and consuming even larger areas of land around cities?

Energy Use: How will AVs impact energy use? AVs are projected to be largely electric, but what are the lifecycle energy requirements for computer processing and communications? Will AVs require new infrastructure to recharge? How will large-scale deployment of AVs affect energy demand from automated vehicles or other vehicles?

Emergency services: How might AVs impact the delivery and operations of police, fire, and emergency medical services? How will AVs interact with these services, and how will data be shared with these services?

Workforce Impacts: Will the technology cause significant impacts in employment - particularly to current ridehail, transit, and freight drivers? What new skills and job opportunities will this technology create and sustain?

Efficiency and Effectiveness: Is this technology the most efficient means of achieving desired goals, and do the potential benefits outweigh the external costs and level of risk associated with deployment?

Source: Unsplash | Connor Gan

Consider Other Influential Factors

These additional considerations could impact a city's willingness to put energy and resources into engaging with AV testing and deployment:

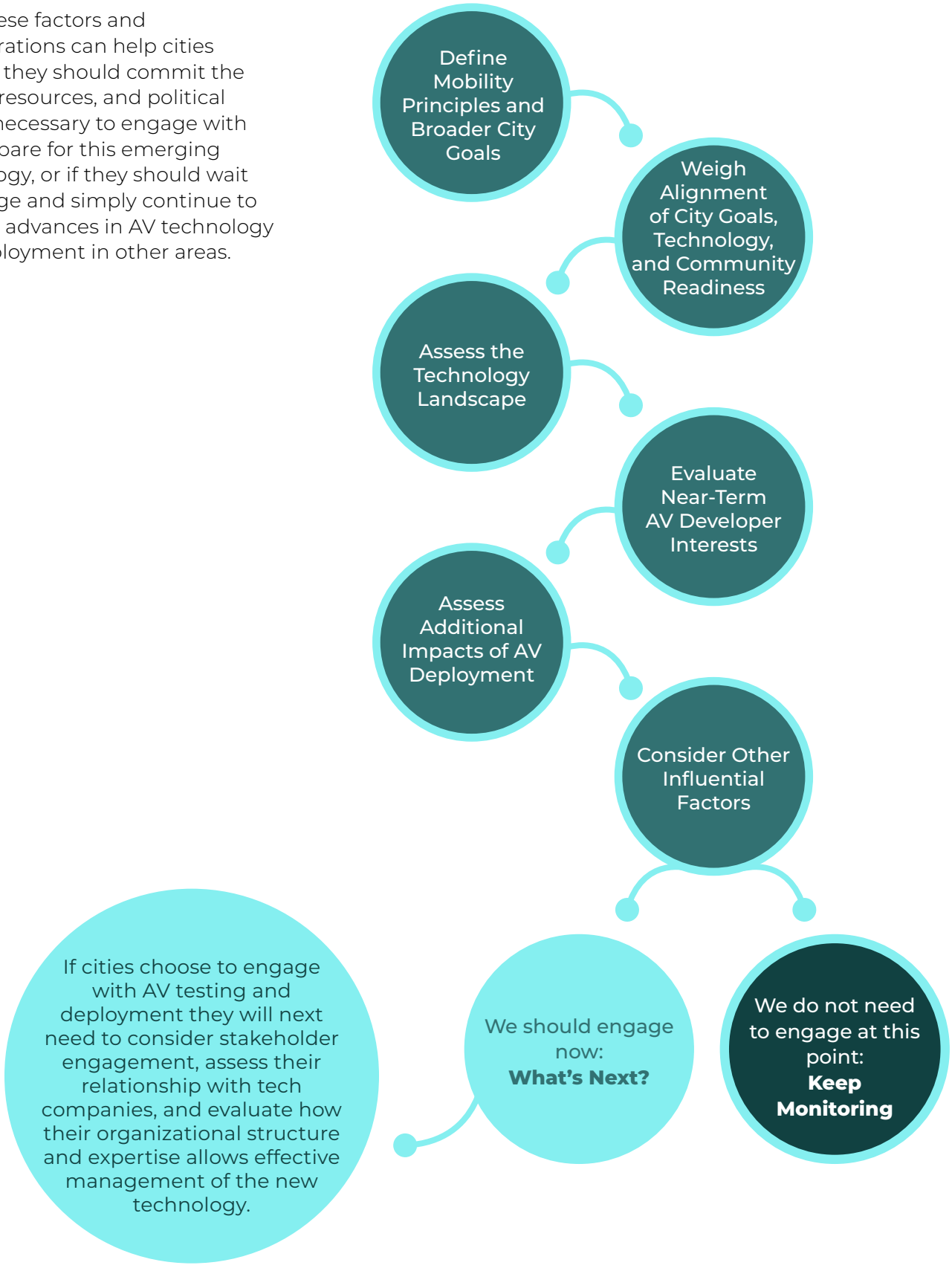
City and Partner Capacity (now and in the future): Effective engagement around AV testing and deployment requires expertise and time from various departments across a city government, as well as engagement with relevant public agencies and various community stakeholders. Cities need to assess their ability to allocate resources for near and long-term testing and deployment, as well as their willingness for continued community engagement, ongoing communication, use of political capital, and the maintenance of stakeholder trust.

Shaping Upcoming Legislation at Other Levels of Government: Federal and state government AV-related legislation is sure to have long-standing impacts on cities. Well-informed cities and community stakeholders with experience around this technology will be better positioned to help shape this legislation in ways that are broadly beneficial to cities. While this could offer strong motivation to engage with AV testing and deployment, the cost of this engagement will need to be borne by that city, even though the benefits may be far-reaching.

Private Sector Pressure: Many states passed regulations that curtail cities' abilities to limit AV testing and deployment, opening a path for AV developers to test and deploy regardless of the city's readiness or their community's desire. These cities may need to allocate staff time and resources to quickly build expertise, develop effective community stakeholder and private sector networks, and develop trust to best shape deployment that aligns with community goals.

Source: Unsplash | Jack Finnigan

All of these factors and considerations can help cities weigh if they should commit the energy, resources, and political capital necessary to engage with and prepare for this emerging technology, or if they should wait to engage and simply continue to monitor advances in AV technology and deployment in other areas.



Identify Stakeholders to Engage[2]

Existing shared mobility and AV pilots suggest that a broad group of stakeholders are either affected by these innovations and are needed to effectively shape their deployments. Varying stakeholder knowledge, belief, and/or urgency about this technology will influence the methods and tools for engagement.

An added challenge is maintaining stakeholder engagement given the occasional stop and start nature of AV technology advancement.

Some cities have sprinted to advance pilots, only to see their industry partners suddenly close shop, change priorities, or shift resources dedicated to the pilot. At a minimum, cities must tap into the expertise, ideas, and perspectives of the following stakeholders:

Government:

Local, state, and federal governments play a vital role in regulating AVs, ensuring their safety, and managing the infrastructure needed to support them. This includes both staff (transportation, emergency services, legal, planning) and elected officials.

Industry partners:

AV manufacturers, technology providers, and other industry partners are critical stakeholders who can provide valuable insight into the technological and operational aspects of AV deployment.

Residents and Community Groups:

Residents and community groups, including business owners and advocacy organizations, can provide feedback on the impact of AVs on their daily lives and help ensure that AV deployment benefits the community as a whole.

Academic institutions:

Universities and research institutions can provide expertise in fields such as transportation planning, data analysis, and human behavior to help inform AV deployment strategies.

Non-profit organizations:

Non-profit organizations focused on sustainability, safety, and social equity can provide valuable insights on the potential impact of AV deployment on these issues.

2 This Guidebook discusses stakeholder engagement beyond identifying stakeholders later in the document on page 31.

2. Relationships with AV Developers and Operators

AV testing and deployment holds inherent risks and ventures into an unknown future.

Neither the public nor the private sector have clear ideas on how this technology will unfold, both have a strong need to learn from each other, and both are in mutual need of the other to shape deployment to benefit both communities and businesses. This unknown future and mutual need has the strongest chance of arriving at positive outcomes if there is trust between the public and private sectors. AV companies and other private sector stakeholders that feel their decisions are under a microscope by the public sector may develop a defensive posture and be resistant to share information or collaborate on solutions. Public sector stakeholders that feel that they are being ignored or their expressed concerns are dismissed will be uncooperative, can be vocal and shape public opinion, and can create hurdles to deployment wherever possible.

Cities should assess the current relationships, level of knowledge, and trust they have with key technology stakeholders. These relationships are strongest when there is a clear understanding of the motivations, goals, and limitations of each stakeholder. Building trust is not easy, but starts with clear and open communication between groups, sharing of information in both directions, a constructive mindset, and the minimizing of finger-pointing - particularly when plans go astray or hurdles emerge.

It should also be noted that companies developing the AV technology may not be the eventual and long-term operators of AVs. The landscape is still unclear, with the possibility that current AV developers may be operators, or they may also simply deliver AV equipped vehicles while third party operators (similar to TNC companies) are the ones who are user-facing and run services in cities. AV developers and AV operators have substantially different roles, with different goals, pressures, and needs for engagement with cities. Generally, it will be important for local governments to have productive relationships with whomever operates AVs at the local level.

Source: Unsplash | Elisabeth Carpenter

3. Define a Decision-Making Framework to Manage New Technology

While the desire to develop a relationship with AV operators and other stakeholders may exist, a city's organizational structure, chain of command, decision-making ability, culture, level of knowledge, and degree of dedicated resources will determine their ability to work effectively with the private sector. Deep hierarchies where staff are not empowered to make certain decisions, where final decision-making power is unclear, or where staff simply do not have sufficient time, funding, and support to engage with new technologies will be challenging. Staff that are not well informed about an emerging technology, do not understand the technology's broad regulatory implications, do not have the support of critical departments within the city, or do not understand the business needs and concerns will not be effective.

Cities should adopt a decision-making framework that establishes principles, outcomes, and negotiating principles/boundaries that enable quick and informed action at the programmatic level.

Additionally, cities need to ensure there is a clear 'front door,' so a technology provider knows who and how to best engage with a city. For many private sector companies, city government structure, protocols, and norms are difficult to discern. Facilitating this understanding can diffuse difficult situations and create an environment that invites more open public/private sector collaboration.

4. Understand the Regulatory and Management Authority

Since 2017, state legislatures have been passing legislation governing AVs and preempting local control over their regulation.

This means that from a legal standpoint, most cities can't, or won't be able to, limit AVs on their streets, require registration or licensing of AVs, require specific data or reporting, or regulate their operation (as some cities do with TNCs). This puts cities in a tricky position when it comes to managing public streets and being responsive to community feedback regarding AVs.

There are ways in which cities can still influence AVs on public streets.

Most prominently, most cities control the curb. This is important because most AVs operating under a robotaxi or other passenger or goods pick-up/drop-off model rely on the curb space to make money since that is the point of transaction. Therefore, in a desire to manage congestion and other environmental factors, local governments could regulate AVs, like airports regulate TNCs, by limiting the number of vehicles allowed in certain areas, managing the demand for curb space, designating specific areas for AV pick-up and drop-off, and charging curb access or permit fees to help manage AV programs and invest in infrastructure.

Additionally, data-sharing is a helpful way to incentivize collaboration with the private sector. Data on road closures, building and construction permits, and special events is extremely helpful to AV companies, both when testing on public streets as well as during pilot demonstrations and deployments. Ensuring their technology is aware of route changes or unusual environments the AV may encounter helps mitigate the risk of a disengagement or delay in service.

Aside from regulatory actions, the voice of public officials - particularly coordinated voices - matter to AV companies and their pilots and deployments. Even where preempted by state regulations, the influence city officials have over public perceptions and acceptance of AV technologies can be an important tool in collaboration and negotiation with AV companies.

State Regulation

In some states, such as California, AV operators must obtain approval from a state agency (such as the Public Utilities Commission) to deploy AVs on public streets without a safety driver and offer a commercial service to the public. In other states, such as Florida, the state legislature has cleared the way for AV deployments, requiring minimal authorization or oversight. In both examples, local governments are preempted from regulating or overseeing AVs.

Source: Unsplash | Timo Wielink

III. Getting Ready

This section provides an overview of the issues to be taken into account before launching a pilot or deployment of an AV technology. If a city determines through Sections I and II that the AV technology is not worth putting the capacity and resources necessary into preparing for (or against), they will not need to move on to this section.

1. Engage with Public Stakeholders

AV technologies should not be introduced into the public right-of-way in a vacuum. In fact, observing and understanding how new technologies operate under real-world circumstances is tremendously valuable for both policymakers and operators. Ensuring that various stakeholders are consulted, informed and educated; expectations are managed; feedback is shared and responded to; and next steps are communicated requires intentionality, planning, and resources.

AV companies often claim to provide public benefit; however, the public is often not included in transparent testing, evaluation, or use of the technology - particularly historically excluded groups like low-income residents, people of color or persons with disabilities. Community engagement in all stages of development, demonstration, and deployment can guide design and operations that fit the needs of targeted populations, build trust, and facilitate public adoption.

IAP2's Spectrum of Public Publication was designed to assist with the selection of the level of participation that defines the public's role in any participation process.

Increasing impact on the design

	Inform	Consult	Involve	Collaborate	Empower
Public Participation Goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
Promise to the Public	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions, and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

To maximize outcomes and benefits, cities should engage a diverse range of community representatives and stakeholders to improve the value of demonstrations, shape future deployments, inform other use cases, and evaluate the technology across a spectrum of perspectives and needs.

The depth of engagement ranges from broad-based messaging to **inform**, to deeper connection to **consult** or **collaborate** with stakeholders, or ultimately to **empower** stakeholders to meaningfully form and shape the technology, service model and/or pilot and ultimate deployment.

Messaging around risks and risk management is critical for cities to share with community stakeholders. With AVs and new technology solutions comes the possibility for failure, and the need to pivot. Communities should be prepared for this possibility, and cities will be better positioned to manage risk if these messages and conversations are consistent and direct.

Cities should be transparent with communities around the reality that failure is often required for success and getting it right. So long as appropriate mitigation, guardrails, and communication are in place, cities and the public should have a level of tolerance for some failures during pilots.

Engaging public shareholders should include:

Stakeholder Mapping

Identify who should be involved and to what capacity

Designing Outreach

Define the engagement methods needed aligned to the different stakeholders

Follow Up

Share findings and next steps with the stakeholders engaged

Stakeholder Mapping

In an ideal circumstance, potential stakeholders are already known and channels for advancing community engagement around a pilot already exist at this stage. In reality, many communities do not have the appropriate engagement practices or channels simply waiting to be activated.

Including key stakeholders early can help build trust and ensure their views are represented at the outset of conversations and not as afterthoughts.

A critical first step is to map the community of stakeholders. Not all stakeholders require the same level or type of engagement. The RACI (responsible, accountable, consulted, and informed) model can be a useful tool for addressing levels of engagement, as it helps identify stakeholders that are responsible for outcomes, accountable for outcomes, need to be consulted, or need to be informed about progress. This can help clarify roles and responsibilities for different stakeholders.

Cities also need to assess the base level of AV understanding of various stakeholders. As with any emerging and quickly changing technology, cities should err on the side of sharing information with stakeholders, giving them opportunities to interact with the technology and better understand its benefits and limitations. These opportunities are critical to enable stakeholders to best shape development and, ultimately, deployment.

An example of the RACI model:

R Responsible	A Accountable	C Consulted	I Informed
Pilot team: Who is responsible for managing the technology and ensuring it is safe?	**Local government:** Who is accountable for making sure the pilot complies with relevant regulations?	**Community members:** Who should be consulted to provide feedback on the impact of the pilot on their daily lives and to shape deployment to serve their needs?	**Tangentially related stakeholders:** Who should be informed of any changes that could affect them?

Designing Outreach

Once stakeholders are identified and mapped, city staff should align engagement methods with the needs of different stakeholders.

Cities should be transparent about the type of outreach being conducted.

The messages that need to be shared will depend on the opportunities that stakeholders have to shape decision-making, which ideally will include input to help shape piloting and deployment. Stakeholders quickly recognize disingenuous engagement if they are being asked to shape something that is already predetermined.

A key element of effective engagement is managing expectations. The more open and transparent a city, agency, and/or company can be with the stakeholders, the more likely a long-term and trusted relationship will take shape.

Cities have access to tried-and-tested models for community engagement around innovation and experimentation. There is no "one size fits all" approach to engagement, but many best practices apply to cities across the United States. Some examples of successful community engagement approaches include the following:

Source: City of Pittsbugh

Source: City of San Jose

Community Liaison Model (Miami-Dade County): using trusted community members, such as long-time residents, to serve as key resources to engage fellow residents.

Periodic stakeholder meetings (Pittsburgh): gathering stakeholders for consistent conversations over time to educate, build trust, and empower the community to engage in conversations around AVs.

Pop Up Events (San Jose): bringing information to communities when and where they are able to engage, including bringing the technology to communities for interactive events in which members of the public can touch and experience the new technology and ask questions.

Community-First New Mobility Playbook (NUMO): This playbook explains the 'community first' approach to professionals working in and with governments that are dealing with integrating new mobility services into existing transportation systems. It lays out why this approach means both better business and better community value, and provides you with both the minimum standards as well as sophisticated strategies to accomplish your goals.

Policy Link Community Engagement Guide: This guide discusses the benefits of community engagement, and provides general guidelines one should consider in engagement with stakeholders and specific strategies that will be helpful to implement these guidelines.

Socializing a City's Mobility Principles

Sharing a city's mobility principles with the community can clarify how and why an agency makes decisions that prioritize (or deprioritize) particular testing, piloting, or deployment opportunities.

A useful tool for socializing an agency's principles with stakeholders is to develop a document articulating them. Cities do not need to start from scratch. For example, see Pittsburgh, D.C., and Seattle, models worth exploring as a baseline, and then modify them to fit a city's unique needs and context.

The more formalized these principles become, the better positioned local governments will be to spark conversations with stakeholders - whether staff, industry, or community.

Follow Up

While it may seem unnecessary to highlight, all too often a community or stakeholder group is engaged early on or during a project or pilot demonstration, but never hears back about findings or next steps.

Effective community engagement strategies, close the loop and ensure reasonable feedback mechanisms are available in order to build a foundation of trust and illustrate a city's willingness to create authentic community engagement and participation opportunities.

Before starting an initiative, it is useful for a city to think through the best moments to provide feedback to various stakeholders and constituents, so that expectations can be managed ahead of time.

Revisit Key Considerations for the AV Demonstration or Deployment

With every specific opportunity to demonstrate or deploy AV technology, cities should review some of the key considerations before dedicating limited city or agency resources to a test or pilot.

While not overly complex, it is advisable to return to a few key questions before continuing to advance:

1. How will an initiative serve mobility principles?
2. How will it not harm mobility principles?
3. What is the value it brings to the community?
4. What is the level of trust that exists (or does not exist) between or among parties?
5. What is the problem we are looking to solve?
6. What does success look like?

2. Incentives & Investment

Much of this Guidebook so far has focused on managing and prioritizing industry-driven opportunities. Yet, proactive city investment can lure and support AV technology opportunities that serve desired outcomes.

Cities can clearly set expectations of technology providers.

They can share investment roadmaps, challenges, and areas where they are looking for partnership with the private sector to support innovation or advancement toward particular outcomes. In addition to sharing information, AV partners in cities can also expand broadband internet access, offer digital literacy training, and enhance sidewalk or bike lane connectivity as platforms to support and encourage experimentation and innovation.

As cities explore their roles in facilitating innovation, it is important to understand the full range of options they have to position themselves in shaping deployment of AVs. Based on the learnings of working directly with cities exploring AVs, Urbanism Next developed a "Framework for Shaping the Deployment of Autonomous Vehicles and Advancing Equity Outcomes", which identifies the following tools and levers cities may have to shape AV outcomes, displayed in the graphic below:

Summary of Tools and Levers for Equitable AV Outcomes

Education and coordination

Public education and outreach	• Empower communities with knowledge about options • Conduct public AV project and mobility needs outreach
Stakeholder coordination	• Provide political assistance • Develop trust between partners • Create and coordinate AV working groups • Coordinate with businesses • Assist in cross agency coordination

Allowing, shaping, assisting, and providing AV services	**Allow AV pilots or deployment**	• Modify laws to allow vehicles in the right-of-way (ROW) • Clarify liability and responsibilities
	Shape the market	• Limit the number of operators • Limit the number of vehicles • Reduce barriers to entry • Ensure compliance with existing regulations and agreements

	Operational limits, requirements, and tools	• Require operating or business permits (or other regulation that allows for operation)
		• Require vehicle occupancy minimums and VMT maximums
		• Charge fees or taxes
		• Require equitable access programs. These programs could:
		  • Require communication/offerings in multiple languages
		  • Create a service coverage area and wait time minimums
		  • Require vehicle accessibility
		  • Require multiple forms of ride reservation and payment (not only smart phone based)
		  • Require low-income fares
		  • Require local hiring and fair labor practices
		• Require or incentivize activities/vehicles that reduce GHG emissions
		• Ensure safety between passengers, as well as vehicles, pedestrians, and bicycles

	Process assistance	• Facilitate procurement • Allocate staff time and resources to AV pilots and deployment • Allow variances to facilitate AV pilots and deployment
	Purchasing or subsidizing AV services	• Provide direct financial assistance • Directly purchase AV services
Investments and infrastructure	**Technology and data investments**	• Set standards for data and platforms • Require data sharing and reporting • Create technology resources • Share information (such as construction, delays, or use permits) regarding changes in the ROW • Develop and/or support MaaS • Provide a framework and standards for integrated payment and booking
	Physical infrastructure investments and management	• Limit or prioritize AV access to infrastructure • Manage travel-lane access for AVs • Designate and manage curbside access • Invest in tech-ready transportation infrastructure • Invest in infrastructure improvements for congestion management and/or AV deployment

This table was adapted from Urbanism Next's "Framework for Shaping the Deployment of Autonomous Vehicles and Advancing Equity Outcomes"

3. Partnerships and Private Sector Engagement

Many cities and agencies have different approaches to engaging with the private sector, ranging from "roll out the red carpet, not the red tape" to strict regulation.

Responsible management and oversight is essential to effectively manage partnerships with the private sector.

As mentioned, cities have a variety of tools and levers at their disposal to guide engagements with AV developers and operators. Like cities, private sector companies are all different, so it is important that cities know what the company needs for a viable local demonstration or deployment. A startup, for example, may have much less tolerance for delays than an established company, but may be more open to collaboration and co-design with public agencies.

All partnerships - both strong and weak - will encounter their fair share of challenges. It is important to go in with that understanding and be prepared to manage and address the unexpected. This is best done if there is a well developed and trusted relationship before a demonstration or deployment is fully designed and launched. Cities and AV entities should mutually understand the timelines, drivers, and expectations of each partner, and discuss the types of risks that cities can take on, those that the private sector partner can take on, and what is untenable to either.

Sometimes mutually agreed upon third parties are necessary for a productive relationship. Data sharing, for example, has been a particularly prickly issue with public agencies desiring detailed performance and operational data and AV developers, citing proprietary or personal information data protection, can resist anything but broad, aggregated, and episodic reports. Third parties such as academic institutions, nonprofits or trusted data insight platforms can mitigate risks that public and private sector partners could not do on their own.

This Guidebook is intended to promote mutually beneficial outcomes.

This requires consistency in partnership management and strong communication. It requires transparency and openness not typically shared among public and private partners. When benefits tend to accrue to one side or the other, relationships fall apart and a party disengages. To help relationships through challenging times, it is helpful for cities to remember that new mobility solutions are needed to address long persistent gaps and for private partners to appreciate the local controls - such as access to the curb, traffic operations, or infrastructure conditions - necessary to their route to profitability. Prior to entering into an agreement or local market, it is important that each partner understands the tools and levers of each partner. If desired outcomes are clearly communicated and understood at the outset, there should be fewer surprises and greater mutual collaboration.

4. Revisit Local Ordinances and Regulations

When exploring the potential development, demonstration, or deployment of AVs in the public right of way, cities must revisit local ordinances and regulation, particularly if a technology falls into a "gray area" of current municipal code or state law.

For example, traffic codes need to clarify and firmly define "driver" (e.g. a natural person or operating system), the role of local government in regulating artificial intelligence, traffic management, enforcement and police powers, and other "gray" terminology. Cities should ask the following questions while exploring potential demonstrations or deployments:

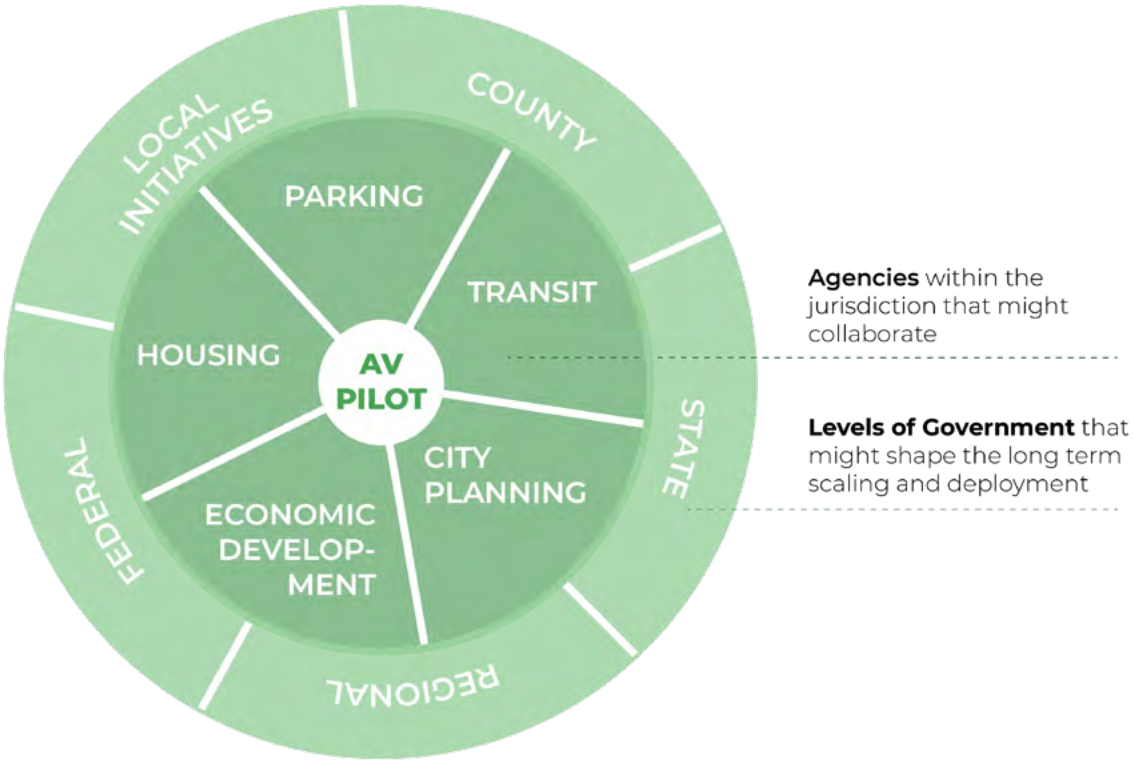
- Are there reporting requirements or limitations in existing code?
- Are there operational design domain (ODD) limits, such as where vehicles can operate, during what time of day, or under what weather conditions?
- Are there limits to the scaling of deployments?
- Has liability been established by law/court decision?
- Are there requirements for law enforcement engagement?

5. Collaboration Across Jurisdictions and Sectors

One of the most overlooked elements of piloting and experimentation in cities - regardless of sector - is cross-agency and cross-jurisdictional collaboration. While every city and context is different, cities need not reinvent the wheel and often stand to learn quite a bit from each other. That said, meaningful collaboration is not easy, and requires intentionality to derive significant value.

This kind of collaboration can be structured based on the type of risk that each entity or agency is positioned to take. While this approach is more traditionally explored in the private sector, different public sector agencies (see the diagram below) have different tools and levers at their disposal that influence the types and amount of risk each can take.

There's certainly a continuum of collaboration opportunities for cities to explore, from lightweight information sharing, to more intense cohort or regional collaboration programs. It should be noted that the testing, piloting, and deployment of AVs also offers opportunity for collaboration across agencies within a particular jurisdiction and various levels of government.



IV. Demonstrations & Piloting

Why & How to

1. Benefit of Pilots and Demonstrations

Emerging and disruptive mobility, like autonomous vehicles, are often first introduced through smaller scale pilot demonstrations before expanding to full scale deployment. This has benefits for the government, public stakeholders, and industry.

Private industry will often use initial demonstrations for real-world testing and refinement of various aspects of the technology, vehicles, operations, and/or service models. For government agencies, limited scale pilots can be a lower-risk opportunity to learn, observe, and experience the technology, and daylight potentially unanticipated risks and benefits. Demonstrations can help industry and public sector alike to develop public policy and management protocols accordingly.

The public is often the least aware of emerging technologies and unable to fully participate in decision making governing their use or prohibition. Pilots and demonstrations are a way for the public to experience AV technology. Transparent and voluntary public participation in AV technology or service model development can help reveal unexpected or unanticipated uses, obstacles to use, and concerns or enthusiasm grounded in tactical understanding rather than hype or speculation.

Pilots and demonstrations are most successful when local public agencies are engaged in their design and approval.

A pilot should have a clear and finite scope and duration; defined metrics for evaluation against public policy objectives; and commitments about when and how a pilot will end, or how and by whom a determination to scale up deployment will be made. Policymakers must be alert to alleged demonstrations that are less about collaboration and learning and more intended as a means to entrench the technology for larger scale deployment.

A pilot should have:

Clear Scope: with clear goals and objectives.

Defined Success Metrics: with specific data points to measure against public policies.

Limited Duration: that defines when and how the pilot will end.

Point Person: with decision-making capabilities to determine when to end or scale the deployment.

2. Selecting a Use Case

A demonstration is a good way to not only observe AV technology, but also to test out how it might serve (or fail to serve) particular uses.

The so-called "use case" - the purpose for which a technology can or should be used - should align with public policy objectives and be mutually agreed upon by both industry and public agencies. Ideally, target users or intended beneficiaries are also engaged in use case selection and design.

The demonstration sponsor - whether industry, government, or community - should also define a clear set of metrics to evaluate whether the new technology is actually serving the intended use and bringing benefit to the intended or claimed beneficiaries. There should be a clear nexus between measures and the identified use or uses.

Demonstrations are best when oriented toward public policy needs. For example:

- How might application in this way bring benefit to historically marginalized people?
- How might AVs be deployed to reduce climate-related emissions?
- How might they reliably improve the safety of the transportation system?

3. Assessing Risk

Both public agencies and emerging technology innovators need to assess - and minimize - risk to the public when introducing new and/or unproven technology for real-world testing and demonstration. Partners can manage risk by limiting the scope and phasing complexity over time. Most AV developers start with a "minimally viable product" (MVP) or prototype with limited geography and hours of operation. Risk can be lowered with smaller vehicles or devices, small fleets, low operating speeds, operations in unpopulated or low-density areas, and avoidance of critical transportation corridors or vulnerable groups.

Public agencies and entrepreneurs seeking to demonstrate (or deploy) should mutually review, as well as assess and confirm risk mitigation protocols are actively in place.

Sharing this information with the public can help to reduce public concern, as well as enhance public understanding of the technology and the commitment to safety and security in its operation. Understanding is a common precursor to trust and thus a vital step in gaining public acceptance.

Source: Miami-Dade County

4. Pilot and Demonstrations Considerations

Agreements and Permits

Demonstrations or deployments in the public right-of-way should be transparent to the public and public agencies. Ideally, there are formal agreements (commonly called "Service Level Commitments" or SLC) between the AV entity and local public authorities. These SLCs outline the contours of operation, provide safeguards for the public, and define measures to evaluate public benefit.

The agreement should include clear, consistent, and enforceable provisions for terminating operation if it does not conform with the agreement.

Some demonstrations or deployments may be required to get permits prior to operation. Permits may include operating permits, occupancy permits, access permits, or similar. Permit authority may be vested at the state and/or local level. Where a locality lacks permit authority, operators should nonetheless seek to establish agreement with local authorities as policing, right of way management, and land use is generally held at the local level.

Consider the following terms and conditions when entering into an agreement with an AV operator:

- Definition of objectives
- Specific scope of services or activities permitted
- Obligations and responsibilities of the company
- Troubleshooting allowances and expectations
- Performance metrics (e.g. safety, service area, customer cost, accessibility, etc.)
- Data reporting requirements
- Cadence of regular assessments
- Agency authority for operational review

Data Management/Collection Plan

Both demonstrations and deployments should have a clear and relevant plan for data collection and evaluation. This is vital to assess learnings and generally inform the continued evolution of the technology, service models and business plans.

The data plan should be developed in advance and be clearly understood by operators or testers.

Where appropriate, the data management, collection, and reporting requirements should be included within any permit. The Mobility Data Specification (MDS) and Curb Data Specification (CDS) developed through the Open Mobility Foundation (OMF) is a well defined and consistent data reporting specification developed by a working group represented by autonomous vehicle developers, public agency staff, and other relevant stakeholders. The specifications includes a number of data fields that can provide critical insights into performance and interaction with other roadway users and overall transportation network performance.

The data management plan and protocol should outline safeguards to eliminate or protect personally identifiable information (PII). Data gathered should have a clear nexus to public policy objectives or priorities such as safety, street operations, equitable services, sustainability goals, or other governmental concerns. Data retention and storage protocols should also be defined. Additional resources for data management and governance can be found via MetroLab Network.

Source: Miami-Dade County

In conjunction with data reporting using MDS and/or CDS, a city should consider requiring the following types of data from the AV operator:

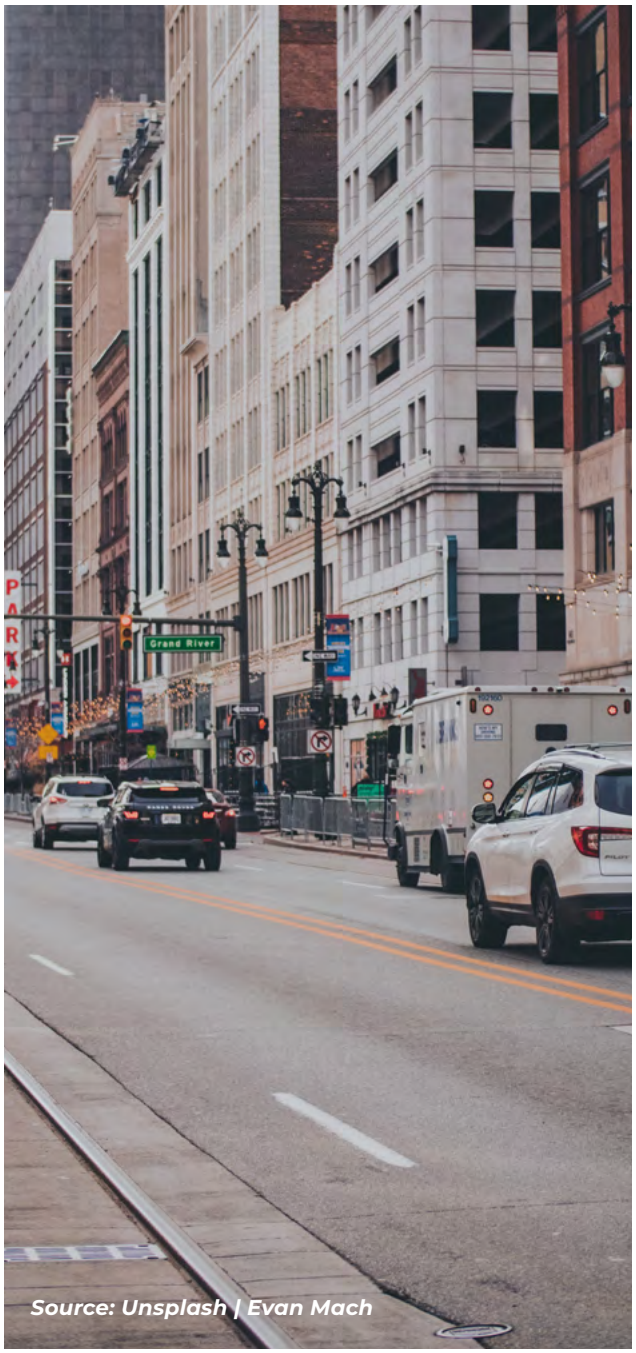
- Fleet size and statistics (types of vehicles)
- System operational characteristics (geography, hours and days of operation)
- Ridership statistics (e.g., number, geographic distribution and demographics)
- Trip statistics (number, distance, with or without passenger, origin and destination)
- System connectivity or competition (e.g., proximity to transit services)
- Battery charging information (if an electric vehicle)
- Service availability
- Crashes and any associated injuries (passengers, as well as people and property outside the vehicle)
- Passengers demographics (e.g., passengers using a mobility aid)
- Service suspensions
- Operational failures (e.g., unintended stops, running stop signs, etc.)

Procurement

Government agencies may wish to initiate demonstrations or services themselves to control all aspects of design, deployment, and learning. In this instance, the agencies must procure the technology. Because it is a new technology with a limited number of providers, procuring AV services can challenge typical procurement methods. In most cases, government-led programs must be procured through a competitive bidding process. This can introduce challenges if a locality is wishing to test a particular provider's service or engage in fast and focused demonstrations.

Increasingly, public agencies are designing unique procurement processes or partnerships specifically suited to pilots or demonstrations.

For example, some cities have secured philanthropic funding, which can allow expedited contracting. Other cities establish agreements with local universities or institutions to serve as their research arm and contracting entity. Some cities have established municipal innovation authorities or independent agencies uniquely crafted to engage in experimentation with new technologies or service models. Each city is unique, however, and procurement processes or partnerships should be discussed and approved internally through the proper channels.



Source: Unsplash | Evan Mach

Policy Development

Pilots and demonstrations can be useful tools to inform a sensible "first draft" of policy.

Current government policy often fails to fit or contemplate emerging technologies like AVs, as well as their associated operations and service models. Because public policy is generally a slow and engaged process, AV companies may try to slot AV technology into an ill-fitting existing policy or operate completely outside of policy.

By creating permitting avenues that allow controlled, low-risk pilots of manageable size, government agencies - and the public they serve - can observe the technology and fairly rapidly craft policy frameworks that protect and promote the public good while permitting further iteration of desirable technologies.

Flexibility/Agility

The purpose of pilots and demonstrations is to test, observe, and learn. Often, this may require minor or significant adjustments to the originally designed demonstration.

New, revised, or additional operating policies or rules may be introduced over the course of a demonstration.

Pilots and the permits that often authorize them should be designed in such a way to permit flexibility and agility as more is learned over the course of the demonstration. This must include the possibility of suspension or termination if there is significant reason for concern. Making these "in flight" adjustments can both help the pilot succeed and accelerate innovation and learning with regard to the technology.

As with so many aspects of innovation development, it is critical to convey to the public and other relevant stakeholders how and why adjustments are being made and outline nimbleness in the pilot demonstration process.

Source: Unsplash | Remi Gieling

Transparency and Objective Evaluation of Outcomes[3]

Pilots and demonstrations are intended to promote learning.

Objective evaluation of quantitative and qualitative measures collected over the course of the pilot are essential to assess the effectiveness, benefits, and impacts of the associated technology and service models.

The evaluation should be objective, including preferably being compiled by a party not directly involved in the pilot or its management and oversight. Evaluations should be publicly available for review and consumption at a predetermined regular cadence to promote and support informed participation in public policy making.

Duration and "Off-Ramping"

Pilots and demonstrations test, evaluate, and learn about new ideas. As such, there should be clear parameters around learning objectives, timeline, and next steps to terminate, iterate, or scale the demonstration pilot to full scale deployment.

Setting clear boundaries around the duration of a pilot (and sticking to them) is critical to gaining public confidence and trust.

Agencies and private AV operators should plan for how to withdraw the technology in the event of failure or at the conclusion of the demonstration period. Especially where AV technologies are designed to fill critical mobility gaps, plans should ensure that populations in need are provided for if and when the experimental technology is withdrawn.

3 Before proceeding to Deployment (See Phase V: Deployment)

V. Deployment

1. Pre-launch

Soon before new AV services launch, a city and AV company should work together to educate the public on the technology.

The public should understand (or have access to resources to understand):

1. How to safely use or interact with the AV (both as a passenger/user and outside the vehicle)
2. What personal information is being collected and how it is being protected
3. Who to contact in the event of an emergency
4. Who to contact with feedback or non-emergency complaints

In addition, all relevant city staff and departments should be aware of the launch date and details (and should build on the education/engagement done during the planning and demonstration phase). In particular, it is important that public safety officers working in the area have information to provide if they receive calls from the public. They should also know how to respond to unexpected behavior or traffic violations by the AV.

Source: Unsplash | Katherine Hanlon

2. Launch and Scaling

A launch event helps bring together all of the staff, vendors, stakeholders, and community members to celebrate the beginning of a community-informed deployment and to thank all participants for their engagement and expertise – getting to a deployment is no easy feat!

If pilot demonstration planning, engagement, and collaboration are done correctly, a deployment should be a celebration of everyone who worked to get to the launch.

Take an incremental approach

Deploying a new technology, especially one with as many implications and complexities as AVs, does not have to be an all or nothing proposition. Even after demonstrating, deployment should start small and have defined criteria to meet before it moves to the "next step" or larger scale. This might mean proving the technology out with a human safety driver behind the wheel until an agreed upon safety threshold has been met. After safe operation without a human operator, the city may be comfortable with commercial rides being offered to the public, or a select portion of the public who volunteered and received education and training.

How Safe is "Safe Enough" When it Comes to AVs?

This is a million dollar question right now, as state and federal safety standards for AVs don't currently exist in the U.S. However, it is important for city staff to know that industry safety standards do exist. These safety standards have been created collaboratively across industry stakeholders (e.g., AV companies, researchers, safety experts, etc.). Interestingly, many AV companies who participated in the development of these industry safety standards fail to subsequently adopt and comply with those standards.

A helpful start for cities to determine "how safe is safe enough" for AVs to operate on public streets should be to ask the AV operator to confirm they are complying with the latest industry safety standards.

As of the date of this document, the most current industry safety standards can be found here.

3. Monitoring, Evaluating, and Reporting

Setting performance measures during the planning phase before launch will ensure the city's ability to meaningfully understand not only how the technology performs, but also whether the business model provides a valuable service for the community. Often, measuring an AV operator's success requires willingness from the company to provide performance and operational data. (See the list of recommended data in IV. Piloting "Why and How To"). These performance indicators should be collected in addition to public surveys and observations/experiences from public officials and staff.

Often, AV operators are reluctant to share data and information with public agencies.

There may be claims of proprietary information or protection of users. In some cases, such as experience with AV technology to date, limited data may be collected by state or federal authorities, while localities are precluded from requiring additional data reporting that would help manage the local system and evaluate performance or benefit of the technology. In these instances, it may be necessary to gather and report proxy or observational data. This may be by using a high level scoring rubric for each tester or operator - much like a student report card based on classroom participation or a "5-star" restaurant review system. Proxy data can also be collected using existing city systems, such as traffic or curb sensors.

Ideally, an evaluation report should be released to the public at regular intervals, if not in real time.

While operations always uncover unexpected learnings along the way, the city should have a clear sense of how it is going to measure success at the outset.

While formal evaluation reports may be limited, the city should regularly monitor AV operations and have access to data from the operator upon request. This will ensure city staff can be responsive to incidents and pivot or pause operations when necessary.

How Do I Get the AV Operator to Share Data with the City?

Requiring data sharing from a private sector operator is often difficult, particularly if the city has been preempted from regulating AVs by their state legislature.

However, there are still ways to incentivize data sharing, such as providing dedicated curb space to AV companies in exchange for data sharing or by leveraging the various incentives listed on the "tools and levers" graphic in Section III.2 Incentives & Investment.

Further, public-private partnerships in which the city and operator collaboratively engage in a demonstration or launch service likely means contractual agreements have been entered. If this is the case, the city should ensure the operator is contractually required to provide certain data to the city (and the city can offer traffic or other construction and obstruction permit data in exchange).

4. Transparency, Public Relations and Continued Working Relationships

Continued working relationships with the AV operator, as well as engagement with the community and other stakeholders, does not end when deployment begins. Be sure there is clarity in the operator contract (or at minimum a verbal agreement) as to how the operator will continue to engage with the city and the public throughout the course of service and evaluation periods.

Further, the public and other stakeholders need to understand the channels by which they can provide feedback or lodge complaints (in addition to emergency contacts mentioned earlier in this section).

A good private sector partner will be willing to respond to the public in partnership with the city when issues arise (and they will - that is why demonstrations are helpful!).

If (or when) things do not go to plan - be transparent with the public about what happened, how it is being addressed, and what changes, if any, will be made moving forward.

This is imperative to gaining public trust and confidence in the technology and will ultimately benefit the provider in the long run as well.

VI. Evaluating, Iterating, and Sharing

Technology evolution and use in the real world is an ongoing process. Innovation, as well as policies and protocols to support or manage it, can be accelerated when public agencies share their experience, learnings, and strategies with one another.

Public agencies and stakeholders should plan ahead to actively evaluate and assess AV (and other emergent) technologies to see how they work in their environment and community, as well as how they can be contributing (or conflicting) services to public mobility objectives. Both demonstrations and deployments should iterate over time to be more responsive to public needs, enhance functioning within the larger transportation ecosystem, and reduce friction and conflict. Finally, public agencies, stakeholders, and testing and deployment entities should share information with other communities to support continuous learning, evolution, and advancement.

1. Managing and Staying Current with Ever-Evolving Technology

The innovation curve is rapidly accelerating. New vehicle form factors (shapes and sizes), features, operating models, and digital systems to support mobility are introduced on a monthly (or more frequent) basis. It is hard for public agency lead staff to stay on top of the constantly evolving and expanding technologies and use cases, and even harder for the general public.

Building a community of counterparts across cities and agencies can help public officials stay current with critical changes in AV technology and consider how changes may affect or serve their communities.

Working collaboratively, public agencies and stakeholders can gain a fuller perspective more rapidly than waiting to individually experience each interaction of AV technology and application. This sharing of information - both amongst the public and industry - can help the technology iterate and more rapidly innovate to address challenges and negative impacts, as well as better serve the public interest.

Source: Unsplash | Gibblesmash

2. Demonstrate, Evaluate, Iterate, Repeat

What the long-term state of AV deployment looks like is still largely unknown, and both the public and private sectors are continually learning. This means that premature, rigid policies on AVs run the risk of becoming quickly outdated, ineffective, or even counterproductive to their intended outcome. Based on the state of development, cities should focus on near-term, first-pass policies while setting the expectation - both internally and to external stakeholders - that policies and requirements will evolve over time.

To inform how these change, cities need to evaluate the demonstrations and deployments occurring in their cities, and have clear goals and open communication with all stakeholders. Cities also need to focus on a range of learnings, including:

Process learnings: How has the city's process in engaging and developing demonstrations and policies worked? This includes goal setting, the development of relationships and trust with all stakeholders, internal collaboration between city departments, internal and external communication, procurement processes, decision-making needs and abilities, flexibility if conditions changed or learnings emerged, and how feedback has been gathered and applied.

Operations learnings: How has the actual operation gone? This includes evaluating issues such as the effectiveness of real-time communication between the city, AV operators, and other key stakeholders; the success of data sharing and data standards; and any challenges that arise with emergency services.

Outcome learnings: How have demonstrations or deployments led to measurable outcomes in the community? This includes understanding who and how many are served and any unintended impacts. Were the desired outcomes achieved, and was this technology the most efficient and effective means of getting to those outcomes? Note that in early, limited demonstration pilots that serve a small number of people, it is likely that outcome impacts will be difficult to identify beyond anecdotal stories. This can be useful in shaping future demonstrations or deployments, but cities should be clear about the level of certainty regarding outcomes and the difficulty of extrapolating from limited pilots.

AV development and demonstration should be thought of as an iterative endeavor, with the learnings from each pilot or deployment informing the next iteration of policy and development.

Cities should develop roadmaps that target the learnings they want to gain in both the near and long-term, and structure policies or procedures to help achieve those learnings.

3. Building and Maintaining Staff Capacity

Staff capacity to manage, evaluate, track, and anticipate AVs and other emerging, and potentially disruptive, technology is a luxury that most cities and other local governments lack. Public agencies are often challenged to adequately staff and service conventional duties and demands. Nonetheless, places that identify staff to lead and coordinate new and emerging mobility technologies and services will find benefit in the ability to anticipate and either invite or manage AV technologies. Designated staff can begin to identify policy and governance gaps before such technologies arrive and initiate a predictable and effective policy pathway beneficial to both community and technologists.

While ideal to have staff dedicated to tracking and preparing for emergent mobility technologies, few places have the resources to do so. As an alternative, cities can partner with colleges, universities, consultants, and even trusted community partners (such as a business improvement district) to serve as augmented staff capacity and strategic advisors.

Regular meetings and clear roles, responsibilities and expectations are critical for such a relationship to address the need he need for additional capacity.

Strategic advisors could support policy, design and manage demonstrations, grow agency staff technical knowledge of emergent technologies, and help hypothesize and evaluate their implications and potential benefits to proactively manage and respond.

National organizations can also be a valuable network for both learning and sharing, and help grow staff capacity and foundational knowledge. For example, the Intelligent Transportation Society of America (ITSA) has a broad membership base and many valuable working groups that can provide and develop foundational knowledge. The National Association of City Transportation Officials also has committees relevant to AV policy and management.

Source: Unsplash | Thomas Loizeau

4. Disseminating Learnings and Paying It Forward

Certain cities and places are the target of new and emerging mobility technologies and services, as well as the frontier of public learning and experience. These are typically larger cities and/or cities with a significant technology ecosystem. They generally have a high density of potential consumers and/or an innovation workforce to develop and advance the technology.

Cities with experience with and exposure to AVs can help others by sharing lessons, creating model codes, allowing or assessing performance models, and fostering discussion on the advantages and challenges of the technology and use cases.

Larger cities can also help smaller surrounding communities or suburbs by building networks with staff and public leaders in these places, as well as inviting collaboration and observation into their experiences with new technologies. Good examples of regional and national collaboration across communities include Minneapolis, Seattle, Pittsburgh, NUMO - the New Urban Mobility Alliance, and the Learning Center of SUMC - the Shared Use Mobility Center. The Research Library of the Eno Center for Transportation also documents numerous case studies and summaries.

Public learning, evaluation, and iteration is key to promoting progress in AV technologies that have real capabilities, promise, and effect at addressing critical gaps in equitable and sustainable mobility.

Source: Unsplash | Bernd Dittrich

Hyperlinks and URLs

I. Introduction

- *SAE International's Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicle*, https://www.sae.org/standards/content/j3016_202104/, Society of Automotive Engineers (SAE) International
- *NACTO's Blueprint for Autonomous Urbanism: Second Edition*, https://www.dropbox.com/s/4yichvwcyjsfo8m/NACTO_Blueprint_2nd_Edition_singlepages_small.pdf?dl=0, National Association of City Transportation Officials (NACTO)
- *Federal Highway Administration (FHWA) Automated Vehicle Activities and Resources*, https://highways.dot.gov/automation, Federal Highway Administration (FHWA)
- *National Highway Traffic Safety Administration (NHTSA) Automated Vehicle Resource*, https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety, National Highway Traffic Safety Administration
- *Urbanism Next's Autonomous Vehicle research and resources page*, https://www.urbanismnext.org/technologies/autonomous-vehicles, Urbanism Next
- *Autonomous Vehicle Policy Initiative*, https://www.hks.harvard.edu/centers/taubman/programs-research/autonomous-vehicles-policy-initiative, Harvard Kennedy School
- *Autonomous Vehicle resource page*, https://nacto.org/program/autonomous-vehicles/, National Association of City Transportation Officials (NACTO)
- *Automated Vehicle Working Group*, https://itsa.org/s/automated-vehicles/, Intelligent Transportation Society of America (ITSA)

II. Assessing the Landscape

- *Kiwibot*, https://www.kiwibot.com/, Kiwibot

III. Getting Ready

- *Community Liaison model*, https://urbanhp.org/liaison-framework/, Urban Health Partnerships
- *Community-First New Mobility Playbook*, https://communityfirst.numo.global/about/, New Urban Mobility Alliance
- *Policy Link Community Engagement Guide*, https://www.policylink.org/sites/default/files/COMMUNITYENGAGEMENTGUIDE_LY_FINAL%20%281%29.pdf, PolicyLink
- *Pittsburgh (Shared + Autonomous Mobility Principles)*, https://apps.pittsburghpa.gov/redtail/images/5172_Pittsburgh_Shared_and_Autonomous_Mobility_Principles_03_01_19.pdf, City of Pittsburgh, Office of the Mayor
- *D.C. (Autonomous Vehicles Principles Statement)*, https://dmped.dc.gov/sites/default/files/dc/sites/dmped/publication/attachments/Autonomous%20Vehicles%20Principles%20Statement_0.pdf,The District of Columbia Interagency Working Group on Autonomous Vehicles (AVs)
- *Seattle (New Mobility Playbook)*, https://www.seattle.gov/Documents/Departments/SDOT/NewMobilityProgram/NewMobility_Playbook_9.2017.pdf, Seattle Department of Transportation

- *Framework for Shaping the Deployment of Autonomous Vehicles and Advancing Equity Outcomes*, https://www.urbanismnext.org/resources/a-framework-for-shaping-the-deployment-of-autonomous-vehicles-and-advancing-equity-outcomes, Urbanism Next
- *"roll out the red carpet, not the red tape"*, https://www.nytimes.com/2016/09/11/technology/no-driver-bring-it-on-how-pittsburgh-became-ubers-testing-ground.html?smid=url-share, New York Times

IV. Pilots and Demonstrations

- *Open Mobility Foundation*, https://www.openmobilityfoundation.org/, Open Mobility Foundation
- *MetroLab Network (Model Data Governance Policy And Practice Guide)*, https://metrolabnetwork.org/datagovernance-guide/, MetroLab Network
- *MDS (Mobility Data Specification)*, https://www.openmobilityfoundation.org/about-mds/, Open Mobility Foundation
- *CDS (CurbData Specification)*, https://www.openmobilityfoundation.org/about-cds/, Open Mobility Foundation

V. Deployment

- *the most current industry safety standards can be found here*, https://www.sae.org/standards/content/j3018_202012/, Society of Automotive Engineers (SAE) International

VI. Evaluating, Iterating and Sharing

- *Intelligent Transportation Society of America (ITSA)*, https://itsa.org/, ITSA
- *National Association of City Transportation Officials*, https://nacto.org/, NACTO
- *Minneapolis (Shared Mobility Collaborative)*, https://mnsharedmobility.org/, Minnesota Shared Mobility Collaborative
- *Seattle (New Mobility Playbook)*, https://www.seattle.gov/Documents/Departments/SDOT/NewMobilityProgram/NewMobility_Playbook_9.2017.pdf, Seattle Department of Transportation
- *Pittsburgh (Autonomous Technology)*, https://pittsburghpa.gov/domi/autonomous, City of Pittsburgh
- *NUMO*, https://www.numo.global/about, New Urban Mobility Alliance
- *Learning Center of SUMC*, https://learn.sharedusemobilitycenter.org/, Shared-Use Mobility Center
- *Research Library of the Eno Center*, https://enotrans.org/resources/research-library/, Eno Center for Transportation

Cityfi

URBANISM NEXT CENTER
UNIVERSITY OF OREGON

KNIGHT FOUNDATION