BLUEPRINT FOR AUTONOMOUS URBANISM

Second Edition

NACTO

National Association of City Transportation Officials

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New York, NY 10017

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ABOUT NACTO

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

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

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LETTER FROM THE CHAIR

The autonomous revolution will be humanized.

A century ago, the automotive age swept across the nation, and cities responded not by adapting cars and trucks to the varied uses of the street, but with a relentless clearcutting of obstacles from curb to curb—including pedestrians—and all but eliminating street life.

Subsequent generations of urban planners built upon this, hollowing out downtown urban cores and rebuilding them with congestion and traffic danger, replacing housing with parking lots, and eviscerating surface transit and urban economies. Today, as we enter the third decade of the 21st century, and as we anticipate the arrival of self-driving vehicles on city streets, we have a historic opportunity to reclaim the street and correct these mistakes. This course correction starts with a plan.

The ***Blueprint for Autonomous Urbanism*** is centered on people and restoring life to our streets—showing how to adapt new mobility technologies to our cities instead of the other way around. If technology can help us redesign streets to meet needs beyond moving cars, they start to look very different. Curbsides promote commerce and shared mobility and are priced accordingly. Vehicle travel lanes occupy only as much road space as they need to move people efficiently so they are not saturated with thousands of single-occupancy vehicles. And a greater proportion of the street space is dedicated to the kinds of mobility that really make our cities move: public transit, walking, biking and shared rides. Remapping the street will also require putting freight in its place so it can fulfill its vital commercial role more safely and efficiently.

The Blueprint looks to the autonomous future as a chance to revolutionize the street for everyone who uses it, and not just a revolution in the technology that runs on it.

Janette Sadik-Khan

ACKNOWLEDGEMENTS

NACTO would like to thank Bloomberg Philanthropies and the ClimateWorks Foundation for their support of this important work that will prepare city streets for the future. NACTO also thanks David Vega-Barachowitz and Ben Gillies for contributing to this publication.

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Foreword to the Second Edition

Since the publication of the first edition of the ***Blueprint for Autonomous Urbanism*** in 2017, the landscape of automated vehicle policy and technology has evolved considerably. The cautious optimism that characterized the ***Blueprint***'s first edition has been tempered by recognition of the enormity of the policy foundation that must be laid for us to reach a human-focused autonomous future.

Like the first ***Blueprint***, this edition lays out a vision for how autonomous vehicles, and technology more broadly, can work in service of safe, sustainable, equitable, vibrant cities. This vision builds on and reinforces the past decade of transformative city transportation practice. It prioritizes people walking, biking, rolling, and taking transit, putting people at the center of urban life and street design, while taking advantage of new technologies in order to reduce carbon emissions, decrease traffic fatalities, and increase economic opportunities.

Unique to the second edition is the urgent focus on policies that prioritize efficiency and equity. Increasingly, policy makers are realizing that merely shifting from current to autonomous technologies will not be enough to address the climate and safety challenges that we face or to address long-standing racial and socio-economic inequities. Instead, the autonomous future must be guided by thoughtful, bold, transformative public policy and street design practice that reduces driving and vehicle miles traveled (VMT) and offers mobility and opportunity to everyone, not just those in cars.

At the core of the ***Blueprint*** is the fact that automation without a comprehensive overhaul of how our streets are designed, allocated, and shared will not result in substantive safety, sustainability, or equity gains. To this end, this edition focuses on four key policy areas—transit, freight, pricing, and data—that form the bedrock of a sustainable, vibrant future. Written by and for cities, the second edition of the ***Blueprint for Autonomous Urbanism*** charts a path that cities and policy makers can embark upon today to achieve our vision for tomorrow.

About This Document

This edition of the ***Blueprint*** is organized into three parts, taking the reader through the principles and political structures that underscore and shape our vision of the future, key policy choices around transit, pricing, freight, and data that can reshape our cities, and finally, exploring the sweeping vision for city streets of the future.

Shaping the Autonomous Future Today

The future will depend on decisions we make today. What are the values that underscore our vision of the future? What is the status of technology and where could intentions collide with reality? How can cities leverage the powers at their disposal to affect long-term change and influence the shape of the city and the region? What are the challenges that cities may face in working to ensure that an autonomous future always puts people first?

Policies to Shape the Autonomous Age

Transit, pricing, freight, and data management are four key areas where thoughtful AV policies can significantly improve mobility, health, vibrancy, and the quality of life in cities. How can transit be prioritized to shape the autonomous future? How can pricing be used to ensure efficiency and equity? What must be done now to ensure a thriving workforce in an autonomous age? What technologies support sustainable, efficient transit and freight operations?

Design for the Autonomous Age

Cities hold the key to designing a livable autonomous future. How can and should cities design their streets to ensure that AV technologies support a livable, human-centered future? How should we shape our streets and our curbsides today to ensure that we realize the true benefits of AVs tomorrow?

1

Shaping the Autonomous Future Today

Photo: NACTO (Chicago)

1.1

The Role for Cities

As home to over 80% of the US population, cities have a critical role to play in shaping automated vehicle policy. Our future depends on how well our urban regions connect people to jobs, to housing, to social opportunities and educational institutions, and to livable, vibrant communities. Cities and municipal governments hold many of the policy levers that can ensure that AVs augment the people-centered future we want.

Technological advances must be driven by human-centered values and priorities, translated into thoughtful, bold public policy. To reach a people-focused autonomous future, cities, and government at all levels, must make decisions today that are based on key principles of safety, public good, equity, and sustainability. AV technology must be harnessed to decrease VMT, not to merely make long drives more palatable. City governments must work rapidly to change how street space is designed and allocated before yesterday's values become enshrined in tomorrow's concrete.

AV technology, policy, and roll-out must focus on transit and efficiency. As Earth's ambient temperature approaches the point of no return in global warming models, reducing GHG emissions by prioritizing transit, biking, and walking takes on added urgency. Fixed-route transit, made reliable and appealing through network redesign and transit prioritization policies, is the most efficient transportation mode and also uniquely adaptable to AV technology in the near-term. In prioritizing streets for transit operations, cities can carve out a clear, near-term application for AV technology and take strides today to reduce emissions.

Cities must retain access to data to ensure that transportation and technology policy serves the public good. With much of AV technology still in its infancy, the full benefits and implications of new transportation technologies are still unknown.

Shared AVs could significantly reduce congestion and the need for parking, opening up new options for transit, biking, and walking. However, early research shows that urban ride-hail services (widely thought to be a precursor model for AV fleet services) are increasing congestion, undercutting transit services, and siphoning off the wealthiest riders[1]—outcomes all contrary to public sector goals. Other data suggests that, even if customers share half of all their ride-hail trips, those trips in total still add 2.2 miles of travel for each personal automobile mile taken off the road.[2]

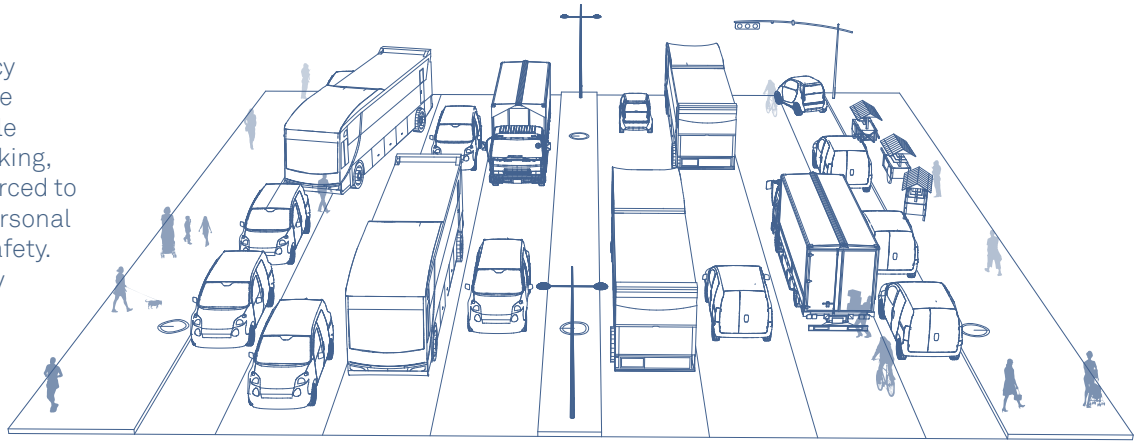
With so much potential and with so much still unknown, cities must have access to data to ensure robust, evidence-driven decision making. However, today, most cities are restricted from accessing information about how ride-hail services and other new transportation service providers impact congestion and VMT, making it difficult to create meaningful policy to address externalities. Cities must act now to build allies in statehouses and Washington to access data and fight off corporate-backed preemption efforts. Legislation that reduces government access to information about how mobility technologies are operating on city streets, or restricts government's ability to manage technology, will only hurt the public.

City governments must work rapidly to change how street space is designed and allocated before yesterday's values become enshrined in tomorrow's concrete.

Transforming the Street

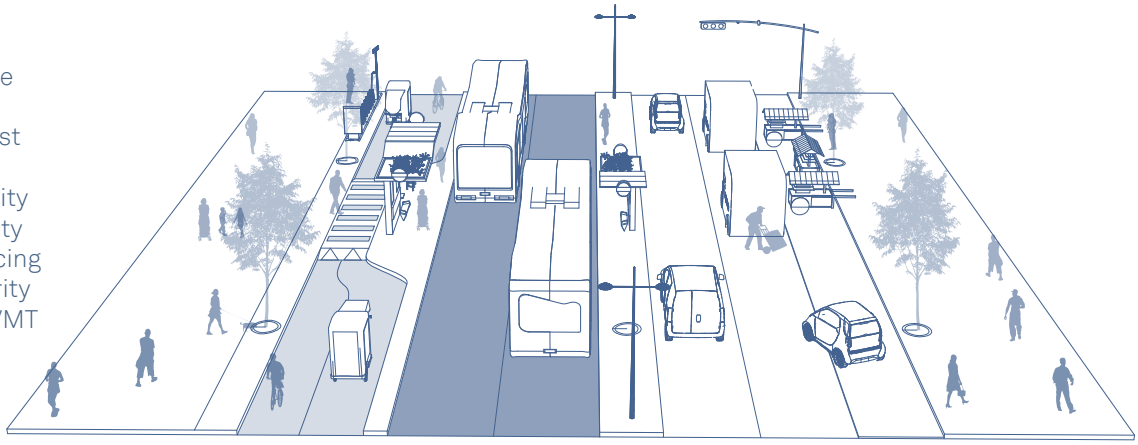
Today

Single-occupancy vehicles (SOV) are prioritized. People taking transit, biking, or walking are forced to compete with personal cars, reducing safety. Transit efficiency decreases, VMT increases.



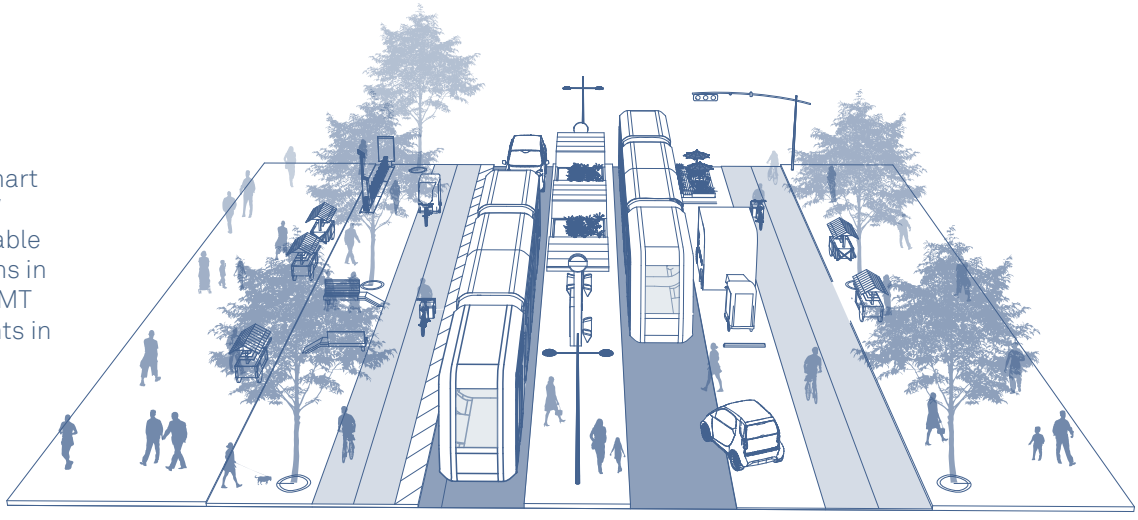
Interim

Cities re-organize their streets to prioritize the most efficient modes, increasing mobility options and safety for everyone. Pricing and transit-priority policies lead to VMT decreases.



Future

Supported by smart street design, AV technologies enable further reductions in emissions and VMT and improvements in safety.



The Role for Cities (continued...)

Safety must remain at the forefront of both public and private-sector decision making. AV technologies could offer significant safety gains for people taking transit, walking, biking, rolling, and driving. To realize these benefits, governments must ensure that the private sector remains fully accountable for the performance of the vehicles they produce. AV technologies that cannot reliably see people of all shapes and sizes in all conditions cannot safely operate on urban streets. Even with AV technology in the driver's seat, vehicle speed will remain the main determinant of fatality or injury; as such, AVs operating in urban areas should be limited to speeds of 25 mph or less. As AV technology develops, cities, states, and the Federal Government must work together closely to ensure that safety, not profit, stays at the fore of decision making.

Changes in land use and policy are essential to ensure that the benefits of AV technology are equitably shared. As cities prepare for automation, land use policy is an important tool to ensure that housing, economic and educational opportunities, and community hubs are connected and accessible. Cities that adopt land use policies that foster dense, affordable, and walkable places will find that their communities and regions will thrive, connected and supported by a wide array of efficient transportation options.

Conversely, land use policies that encourage low-density development will create more congestion and more pollution, even if people aren't behind the wheel. Cities that try to manage growth through ex-urban development will find themselves tied to a shrinking array of unsustainable, inequitable transportation options. In a dispersed, sprawling context, AV technology could exacerbate existing racial and socio-economic inequities, locking lower-income and marginalized people into increasingly long commutes on lower-quality service. Cities must act now to reassess their land use policies and prioritize sustainable, affordable, efficient modes.

Automation offers opportunities and trade-offs for jobs and labor. The advent of AV technology heralds huge shifts in labor markets, a staggering array of new job opportunities, and changes in workforce development needs.

However, without thoughtful workforce development and education policies, technology could exacerbate existing inequalities, further sealing us into a world where zip code determines job options, educational attainment, and life expectancy. Working together, cities, unions, and the private sector must rethink the skills necessary for an autonomous age and start developing policies and job training programs to ensure opportunity for all in this new economy.

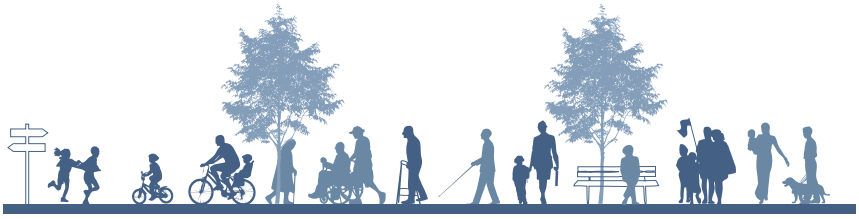
> AV technology must be harnessed to decrease driving, not to merely make long drives more palatable.

Cities need not, and in fact cannot, wait for AVs to fully materialize to start achieving their safety and sustainability goals. Levels 4 and 5 automation are still under development. In a best case scenario, even if every new vehicle purchased today were fully automated, it would take at least two decades for AVs to make up ninety percent of the vehicles on the road.3 The urgency of our climate crisis and the soaring US traffic fatality rate requires more immediate action.

Regardless of the timing of the autonomous revolution, better street design and land use policy are key to achieving a safe, equitable, sustainable, people-focused future. Decades of experience have shown us that simple, physical changes to street geometry can have huge impacts on safety and how people choose to travel. Our most successful cities and most competitive regions are those that enable residents to move safely, efficiently, and reliably. By redesigning their streets, cities and people will shape technology policy for decades to come.

People come first in the autonomous age.

People walking, biking, rolling, and resting get first priority for street space and resource investments.

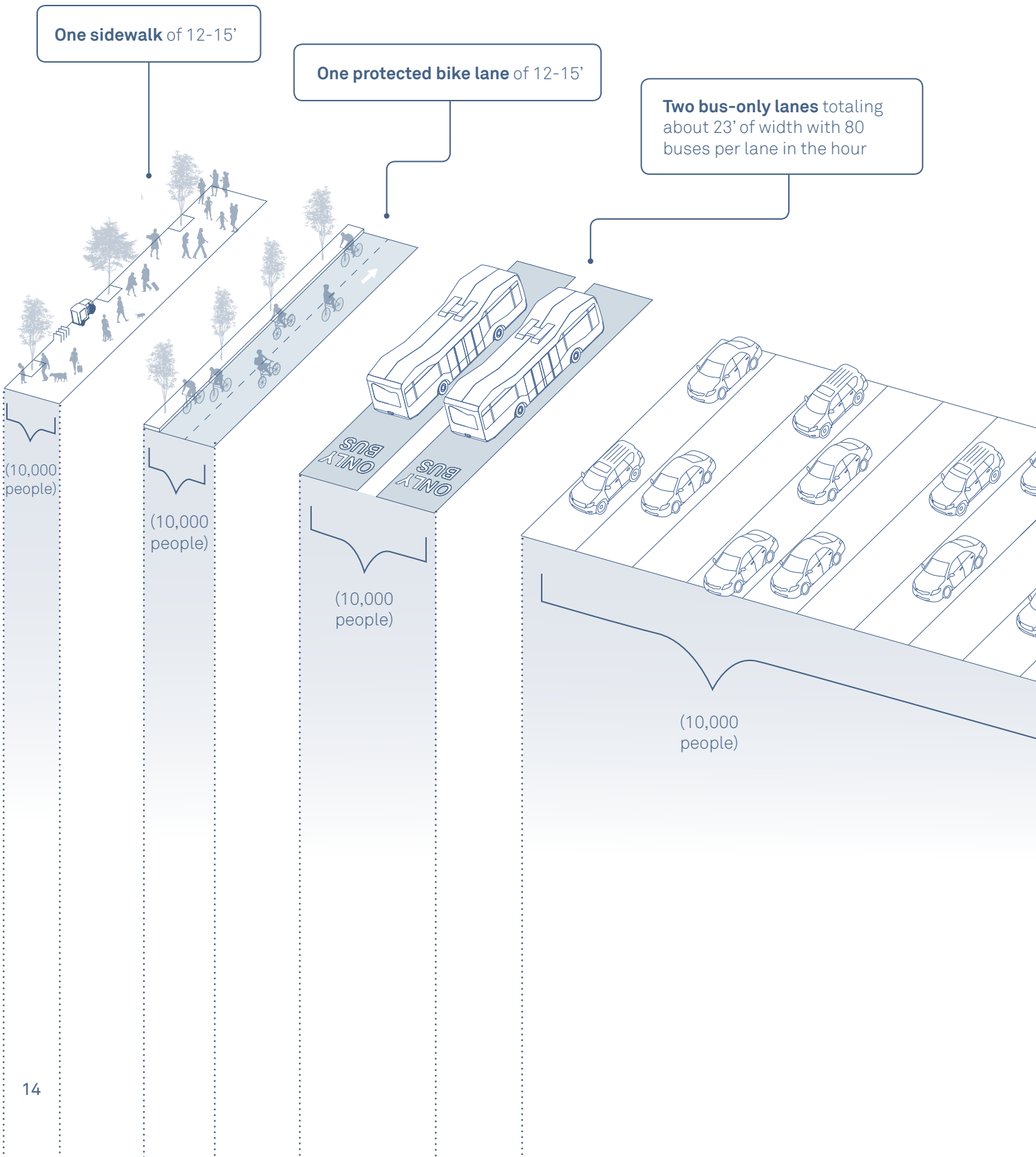


Building for **high-capacity on-street transit** is essential for growth without congestion.

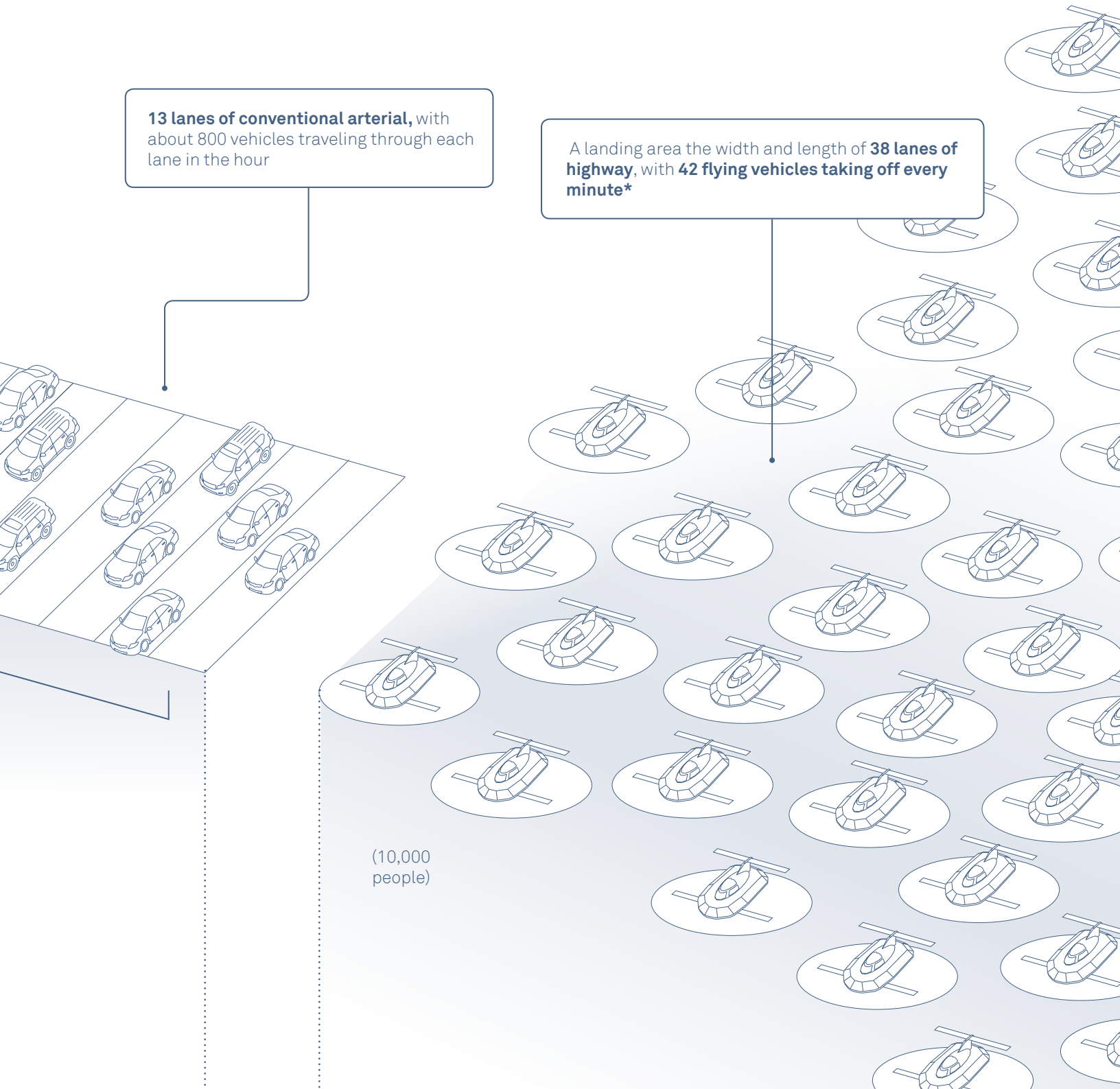
Freight and delivery services are consolidated to increase efficiency. Vehicles are downsized.

Private vehicles and parking are deprioritized.

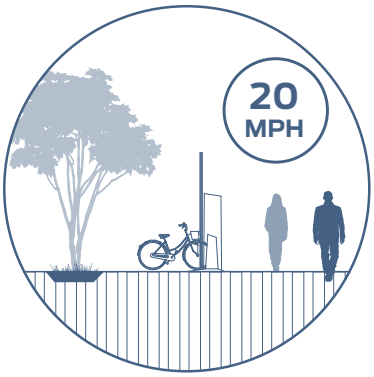
What Does It Take to Move 10,000 People Per Hour?



*Uber estimates that its conceptual Uber Air skyports could accommodate 1,000 landings per hour on a footprint of 1 to 2 acres. Assuming four passengers per vehicle, accommodating 10,000 passengers per hour would require a footprint of 2.5 to 5 acres[4]



Principles for Autonomous Urbanism



Design for Safety

Street design that prioritizes safety for people walking and biking creates streets that are safer for everyone. Cities must enshrine their values in concrete and policy today, in order to shape a people-focused landscape with AVs tomorrow. With speed as the major factor in the majority of traffic fatalities, cities should design streets that necessitate lower speeds. Automated vehicles should be programmed for low speeds (25 mph or less) on city streets, and programmed to automatically detect and yield to people outside of the vehicle.

Move People Not Cars

If AV technologies focus on private cars and single occupancy vehicles, they will increase congestion and traffic fatalities, exacerbate economic and racial inequalities, and leave us even less equipped to mitigate the impacts of climate change. To avert this dystopian outcome, cities must prioritize the modes that move people efficiently—transit, biking, and walking—by reallocating street space and supporting people-focused street redesigns with smart pricing, curbside management, and data policies.

Distribute The Benefits Equitably

Technology offers new tools to address and rectify the structural racial and economic inequalities that limit the potential of people and communities. In policy and practice, cities must consider equity from all angles—access, safety, labor, mobility, affordability, and engagement—and actively ensure that the benefits of automation are shared equitably across cities and communities.

Data-Driven Decision Making

New transportation technologies are generating more data than ever about activity on city streets. To ensure the best outcomes for the public, cities must have information about what is happening on city streets. At the same time, cities must strengthen their ability to push information out to companies and private citizens to nudge their operations towards the public good.

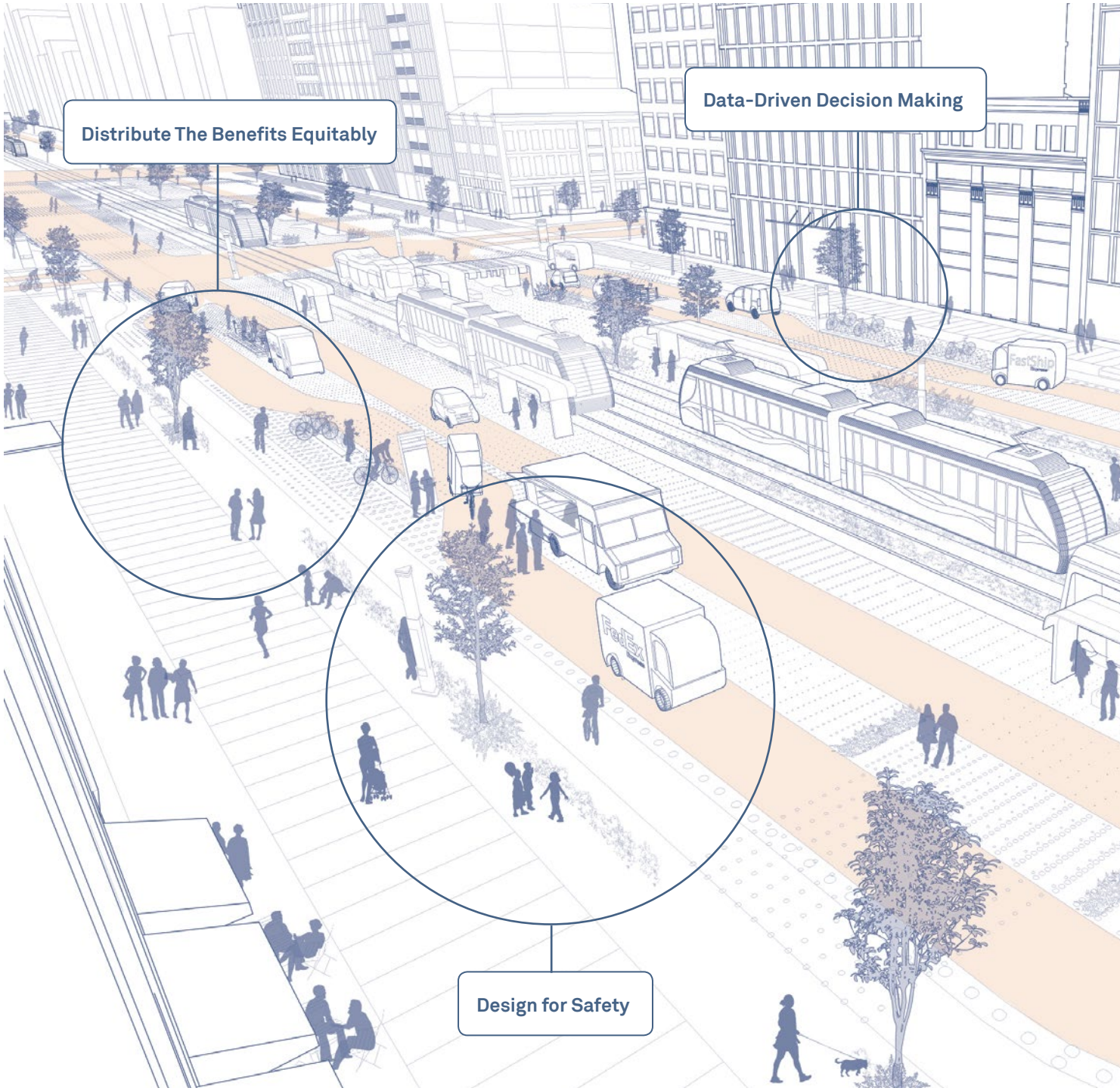
Technology is a Tool

AV and technology policy must be driven by human-centered values and priorities. AVs are not a solution unto themselves, rather they are a tool to achieve better city transportation outcomes. Cities must set policy to maximize the public benefits of technology and lead the transition to a new inclusive and sustainable economy for all.

Act Now!

Cities that are proactive now will ensure the people-focused future they want, with more efficient and sustainable land-use patterns, and redesigned streets for safety and efficiency. Rather than setting public policy based on the limits of technology, or the profit margins of a new industry, cities can proactively ensure that AVs augment city goals.

Principles on the Future Street




Move People Not Cars
Act Now!
Technology Is A Tool

How AVs could Help, or Hurt, Cities

Negative Outcome

Safety

Federal and state governments authorize AVs to operate on public streets before developing objective and verifiable safety performance standards and tests that ensure automated driving prevents injury collisions and fatalities among all right-of-way users. Governments fail to hold companies accountable for fully complying with traffic laws. These failures result in no improvement in today's street safety record while creating new risks and hazards.

Transit

Elected officials demonize transit as inefficient and archaic, state and federal support wanes, systems begin to cut or privatize service, and demand declines. People who rely on transit are increasingly stranded as service deteriorates.

Privatized services adopt large-scale loyalty rewards programs, re-stratifying transportation into a system of haves and have-nots, with longer wait times and less convenient routing for those without means.

Pricing

States prohibit congestion pricing so travel remains "free." Due to the low price, many individuals travel more in inefficient vehicles, burdening cities, themselves, and the environment with the negative externalities of unfettered driving.

Privacy

Governments fail to define journey data (e.g., "bread-crumb" route information, starts/stops, etc.) as personally identifiable information (PII) or to enact comprehensive data protection legislation. As a result, companies and governments alike acquire unprecedented access to the private actions and movements of citizens.

Data

The Federal government determines that private companies control the data automated vehicles generate, reinforcing a business model based on data sales and consumer loyalty. Companies grant 'free' rides in exchange for data (and travel routes that take customers past certain stores).

Freight

High speed platoons of autonomous freight vehicles make roads increasingly dangerous or impassable. In cities, sidewalk bots proliferate, taking away valuable space from pedestrians and cyclists. Delivery drones increase noise in urban areas to unhealthy levels. Unemployment rises as AV-based freight services put people out of work.

Streets

Federal and state officials require dedicated AV lanes, taking street space from other uses. As individuals choose private AVs over transit and travel costs plummet, congestion increases, and pedestrians and cyclists become second-class citizens, relegated to walkways above or below grade for their own safety.

Curbs

States prohibit local governments from regulating private mobility companies, so curbs become increasingly cluttered as companies compete, unimpeded, for space to pick up and drop off passengers.

Positive Outcome

Safety

Federal and state governments adopt objective and verifiable safety performance tests that set a high performance bar that protects all right-of-way users, including those in urban areas. AVs, programmed to travel at 25 mph or less depending on street context, dictate the speed of traffic for all motorized vehicles, reducing the overall speed on urban streets and, as a result, reducing the frequency and severity of crashes. Excess road space, created by slower moving, more efficient AVs, is used to build better, safer places for people walking and on bikes. Safer street design helps cities

Transit

Transit agencies and street departments work together to redesign streets, adopt new technologies, and modernize network planning, making transit faster and more reliable. New technologies, including real-time information, flex-route vans, limited ride-hail services, and integrations of active mobility into transit trips allow transit to cover more of the city, bridging the gap to lower-density places. Trip planning apps and other information/communications tools allow for smarter transit planning and route development. Mobility becomes smarter, while also becoming more equitable and reliable.

Pricing

State and local governments partner to charge a fair price for travel and parking, mitigating congestion and helping to fund a more equitable transportation system.

Privacy

The Federal government passes comprehensive consumer data protection laws, similar to the GDPR in Europe. Cities, states, and the courts define journey data as PII. Governments gain the benefits of increased data for planning and regulation while people preserve their right to control how it will be used and who will see it.

Data

Federal, state, and local regulators require public and private sector actors to share data. Access to more robust mobility data allows governments to make better investments in transportation infrastructure, facilitating balanced, multi-modal transportation.

Freight

Coordinated freight management reduces the number of large vehicles in and around urban areas. Local delivery, which is complex, nuanced, and varied, remains a human job. Freight distribution centers allow the majority of deliveries to take place via e-bikes or other small, high-efficiency modes. Workforce transition plans provide real opportunities for people formerly employed in freight.

Streets

Cities and the private sector together embrace streets as public spaces, fostering design and engineering practices that balance walking, biking, driving, and transit. AV-only lanes are reserved solely for automated mass transit.

Curbs

Cities pass new curbside management plans committing any space savings from reduced parking or lane requirements to public use. Cities use curbside space for parklets, green infrastructure, bus lanes, bike lanes, and small-scale vendors and kiosks.

1.2

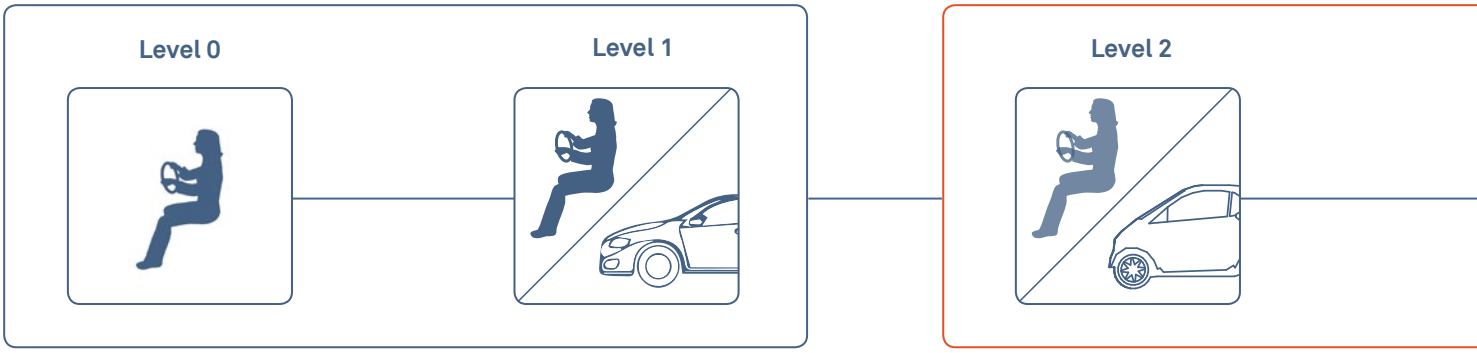
Levels of Automation

Autonomous driving technologies are still in their infancy. In order to clarify the possibilities and limitations of these technologies, the National Highway Traffic Safety Administration (NHTSA) and the Society of Automotive Engineers (SAE) have categorized AV systems into five levels, according to their ability to operate in real-world conditions.[6] Each of the five levels of automation hold different levels of opportunity and risk to people both inside and outside the vehicle.

There are unique challenges inherent in operating autonomous vehicles in cities and urban areas. City streets are complex and unpredictable, populated by large numbers of road users traveling at different speeds, on different modes, and in different directions. As a result, some technologies that have proven benefits in less complex, limited access highway contexts, may not yet be appropriate for urban conditions.

Today

Emerging



No Automation

The human driver does all the driving.

Driver Assistance

An advanced driver assistance system (ADAS) warns and/or assists a human driver with steering or braking/accelerating. Current examples include adaptive cruise control, forward collision warning, and emergency braking systems.

Partial Automation

An advanced driver assistance system (ADAS) controls both steering and braking/accelerating simultaneously. The human driver must continue to pay full attention and be ready to intervene at any time. User manuals for vehicles equipped with these technologies warn users not to use them in city traffic or at intersections.[5]

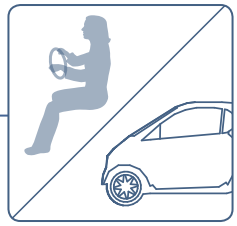
Dangerous on Urban Streets

Level 2 and **Level 3** systems pose significant risks on city streets because they can lull drivers into complacency and inattention while simultaneously requiring that they be ready to resume full control of the wheel at any moment.[7] In 2018, in Tempe, AZ, a vehicle operating in Level 3 autonomous mode under the supervision of a trained safety driver hit and killed a woman crossing the street.[8]

Probable Future

Potential Future

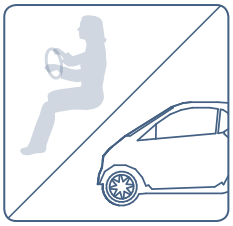
Level 3



Conditional Automation

An automated driving system (ADS) can perform all aspects of driving under some circumstances (e.g., on a freeway, or in a low-speed traffic jam). The human driver must continue to pay full attention and be ready to intervene at any time, even though the vehicle may appear to be fully driving itself.

Level 4



High Automation

An automated driving system (ADS) performs all driving tasks with no expectation that a human driver will intervene as long as the vehicle stays within its specific operational design domain (e.g., a mapped geographical area, or within certain weather conditions).

Level 4 technology is still under development and its potential abilities remain uncertain. Key questions remain unresolved, including what a Level 4 vehicle should do upon leaving its operational design domain (e.g., during an unexpected severe weather event).

Level 5

Full Automation

An automated driving system (ADS) on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving. Level 5 technology is still under development and its potential abilities remain uncertain.

How AVs Work

Automated vehicles (AV) interpret their environments using a combination of real-time sensors, GPS signals, and LIDAR data. Using image and pattern recognition software and engineer-assisted training and software development, the promise of AVs is that they will one day be able to accurately detect all people, objects, conditions, and events in the road and react in the safest manner possible, avoiding collisions and improving safety for all users.

AVs use a variety of sensors, advanced software engineering algorithms, and machine-learning to "see" the street, and determine the appropriate path or actions. The decision making process requires an AV to synthesize four types of information to determine its next move and safely navigate towards its destination.

- **Location: Where am I located?**
  Sensors must physically match the location of the vehicle with the map and other reference points.
- **Perception: What's around me?**
  Sensors must detect objects of all types and shapes including traffic signals and signs, lane markings, people, and animals.
- **Prediction: What's everyone doing?**
  Advanced engineering algorithms and machine learning tools analyze all data inputs (e.g., location, perception, and dynamic factors like speed, acceleration and direction) to decide what will happen.
- **Planning: What should I do next?**
  Building on all inputs, AVs use behavior prediction software to draw from all the sensor information to determine what is the appropriate course of action or path of travel.

As of today, AV technology is still in the development and testing phase. As noted in a recent report on large vehicle design, produced for NACTO by the USDOT Volpe Center, technologies that are precursors to AVs, such as automatic emergency braking or forward collision warning, are incapable of recognizing people in many contexts. These include: people walking in groups, children and people shorter than 3.2 ft., people pushing strollers, wheelchairs, bicycles or other objects, people standing on manhole covers or steel plates, people carrying things like umbrellas or luggage, in low-light or nighttime conditions, and in adverse weather.[9]

While automated vehicles may eventually surpass human drivers prone to error and distraction, policy makers should be careful to recognize and understand the assumptions and limitations that went into their programming and test their ability to detect objects and events and successfully negotiate complex situations. Just as human drivers must pass a driving test, AVs should be held to high standards of performance and review by public officials charged with protecting the safety of all, especially the most vulnerable road users (e.g., people walking, bicycling, children, and seniors).

Light Detection and Ranging (LIDAR)

Two 360-degree sensors use light beams (millions of laser pulses per second) to determine the distance between the sensor and other objects. LIDAR measures the time it takes for light to reflect off a surface and return. There are three main types of LIDAR for AVs: short, mid and long range. These sensors together provide a surrounding view of their environment to process the objects and events immediately in front or further afield.

Ultrasonic Sensors

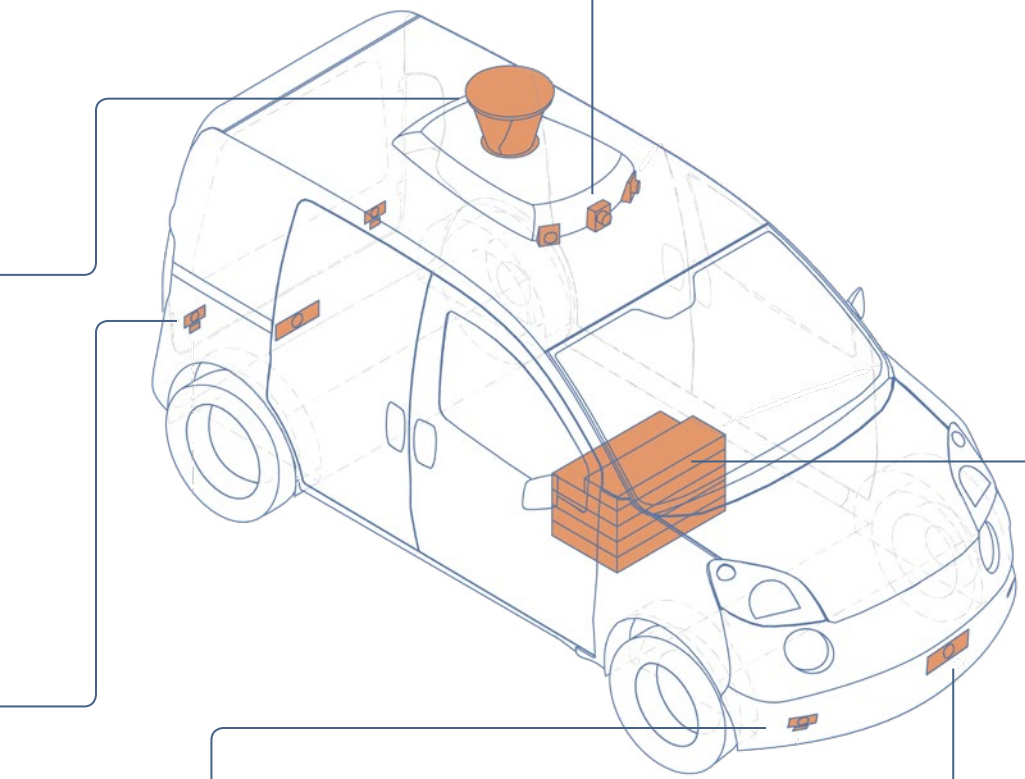
Vehicle-mounted sensors provide information about nearby objects. This data is typically used in parking assistance and backup warning systems.

Infrared Sensors

Infrared sensors detect lane markings, pedestrians, bicyclists, and objects that other sensors can find difficult to identify in low light and certain environmental conditions.

Cameras

Cameras mounted on the vehicle identify moving and static objects.



Prebuilt Maps

Prebuilt maps are stored in the vehicle's memory and are often utilized to correct inaccurate positioning due to errors that can occur when using GPS and INS. Given the constraints of mapping every road and drivable surface, relying exclusively on maps can limit the routes an AV can take.

Dedicated Short-Range Communication (DSRC)

Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) systems send and receive critical data such as road conditions, congestion, crashes, and possibly, rerouting. DSRC enables platooning.

Inertial Navigation Systems (INS)

INS uses gyroscopes and accelerometers to determine vehicle position, orientation, and velocity. INS and GPS are typically used together to improve accuracy.

Global Positioning Systems (GPS)

GPS locates the vehicle by using satellites to triangulate its position. Although improved since the 2000s, GPS is only accurate within several meters.

Radio Detection and Ranging (RADAR)

A sensor that uses radio waves to determine the distance between obstacles and the sensor.

1.3

Local Action in the Face of Uncertainty

Uncertainty frames the future of AVs. In particular, two major sets of questions loom large. First, how will AVs work, especially in cities? Will their safety promises be realized? Second, how will AVs be regulated? Who will have a seat at the table? Who will control the narrative?

One of the biggest promises of AVs is their potential to reduce traffic fatalities. However, this is also one of the biggest areas of uncertainty. The federal government, to date, has largely allowed the AV industry to govern itself on matters of testing and safety. This market-focused approach leaves key safety questions unresolved such as: How will companies determine when a vehicle is considered 'safe'? What authority will cities have in regulating new vehicles on their streets? Should companies be required or allowed to market AVs differently in urban vs limited-access street environments? How will companies be required to program their technology to prioritize the safety of passengers versus the safety of passers-by in the event of a crash or potential crash?

While the initial reports around AVs suggested a rosy safety outlook, recent analyses are more skeptical. NHTSA has retracted its study that suggested that Tesla's Autopilot reduced crashes by 40 percent.[10]

> Today, cities are the testing grounds for autonomous vehicle technology. As such, strong local authority over AVs is necessary to meet ambitious transportation policy goals.

A recent report by the International Transport Forum found that commercial vehicles operating at level 3 and 4 automation are "unlikely to be able to operate comprehensively in the dense urban environments.[11]

The second major area of uncertainty is how AVs will be regulated and by whom. Today, cities are the testing grounds for autonomous vehicle technology. As such, strong local authority over AVs is necessary to meet ambitious transportation policy goals. However, a variety of proposed state and federal preemption bills such as the SELF DRIVE Act and the AV START Act threaten cities' ability to be responsive to citizen needs, or in some cases, to access information essential for good policy making or oversight.

In cities and other urban areas, state or federal preemption can pose unique safety risks because it assumes, incorrectly, that urban and rural/suburban streets operate the same. Instead, the volume and diversity of street users, speeds, and modes makes urban streets infinitely more complex than limited-access, rural, or suburban roads. Cities need the power to set contextually appropriate limits and gather information about new modes, especially at a time when the market is rapidly changing and agreed upon conventions are not yet set.

All too often, in creating state or federal level guidelines to govern local conditions, key issues are lost. For example, most federal transportation and design guidelines and regulations are developed for highway driving and rural roads. They require higher speed limits, wider lane widths and larger turning radii. When applied in urban settings and city cores, these highway design standards encourage faster driving and have increased traffic fatalities. To manage both the uncertainty around the safety of AVs and uncertainty around cities' ability to regulate autonomous vehicles on their streets, cities must take action now.

Cities should...

Fight for Their (Rightful) Seat at the Table

Cities must secure their place at the negotiating table. As individuals and in coalition, cities should monitor Congress and state legislatures to ensure that they don't enact legislation that conflicts with local priorities of improving safety, cutting congestion, and establishing sustainable transportation policies. Collectively, cities represent national majorities of population and economic activity; they can leverage this power to fight for representation on a national level. Engaging elected officials early and often on a shared city perspective on AV policy is and will continue to be crucial in sustaining cities' voices in the debate. City control will be critical in the fight for data from AV companies.

Engage Allies Early

Automation threatens to disrupt or altogether eliminate millions of jobs in the commercial driving industry. Preventing major negative social outcomes is already a top priority for elected officials. City and labor representatives have a responsibility to engage early and regularly in order to explore and understand the AV issues together, and map out pathways for a "just transition" that will gradually phase disrupted workers into new roles.

Manage the Message

City officials can actively shape narratives around automation and need not wait for the private sector to lead the conversation. Cities should reject policy proposals that shift the burden of responsibility from manufacturers to individuals or require cities to build new infrastructure solely to accommodate new technologies. For example, some have suggested AV-only lanes and pedestrian detection beacons as safety measures. However, such proposals will make people less safe by degrading the urban environment, paving the way for platoons of autonomous cars, and prioritizing the least efficient, least sustainable mode of transportation. Cities must keep the focus on people, not technological capabilities, to ensure a people-centered future.

Enshrine Priorities in Concrete

In most cases, the power to change city streets lies firmly in city hands. In the face of uncertainty, cities must leverage all their tools to reshape their streets now in ways that prioritize people and high-efficiency transit, regardless of what the future holds. Physically changing streets today to reduce speeds, encourage bus ridership, walking, and cycling, and create a more welcoming urban realm will increase the likelihood that AVs will be developed as a force for good. Cities can strengthen their hand by using quick-build tools to create political constituencies that support people-focused streets. Similarly, most land use decisions happen at a local level. Changing zoning today to support transit, encourage density, and ensure affordability, will spur development patterns that will shape cities for decades to come.

Actions for City Council and the Departments

A wide array of city departments and government stakeholders play key roles in guiding and shaping AV policy and regulating AV technologies. Cities can accrue the full benefits of AV technology through thoughtful policy coordination and strong communication between these departments and stakeholders. Early action can help cities set the stage today for a successful, sustainable, human-focused autonomous future.

Mayor, City Manager, and City Council

Local political leaders must assess existing and potential technologies by considering how they can support city needs and goals. In budgets and policy, political leaders should focus on the rapid redesign of city streets to prioritize high-efficiency modes like transit, biking, and walking. To ensure positive outcomes, they should engage now with elected officials at the state and federal level to ensure that urban interests are represented.

Potential action items:

- **Direct transportation and public works departments to build people-focused infrastructure** that can increase transit reliability and convenience, and address safety issues today.
- **Lobby to shift control over local speed limits to local governments** and authorize the use of active speed-reduction tools, like speed cameras, that are proven to increase safety outcomes.
- **Establish an interagency working group,** including labor representatives, on shared, connected, electric, and automated mobility to map out action plans for all city agencies to increase safety and plan for adoption of shared, electric vehicles in both the near, and autonomous, futures.
- **Explore and pursue pricing strategies** to reduce VMT and congestion and better manage curbside demand.

Transportation & Public Works Departments

Transportation departments should focus on redesigning streets to support high-efficiency modes like buses, biking, and walking; revising on-street parking requirements to better manage curb-space usage; and enhancing pedestrian space.

Potential action items:

- **Take advantage of quick-build tools** to rapidly increase the quality and quantity of transit facilities, protected bike lanes, and pedestrian spaces.
- **Create a detailed asset map of curbs and curb-side regulations** including loading zones and parking areas for regulatory, maintenance, and management purposes.
- **Coordinate with Transit Authorities to enhance bus operations** through transit only lanes, transit signal priority, and improved bike/walk connections to transit stops.
- **Explore curb pricing for commercial and passenger vehicles** to improve safety and efficiency and manage congestion.

Transit Authority

Transit authorities should focus on network redesign, improved communications, and emerging operations tools to increase transit ridership. They should explore electrification options and test new technologies that can enhance service reliability and convenience.

Potential action items:

- **Coordinate with transportation and public works departments to better designate road space for buses**, increasing the reliability and convenience of service and rebuilding a constituency for transit.
- **Explore existing and emerging technologies that improve transit service reliability** such as real-time information, off-board fare payment, transit-signal priority, and electrification.
- **Redesign bus-networks** to prioritize efficiency and reliability and eliminate transfer fees to encourage ridership.
- **Develop and support digital systems** to better enable regulation, monitoring, management, and planning of transit services.
- **Establish working group or taskforce that includes labor** and employee representatives to assist in the development of workforce training programs and address concerns and training needs of operations, maintenance, and customer relations staff.

Taxi Commissions

Taxi commissions should develop frameworks to regulate autonomous ride-hail services. They should also work with their counterparts in revenue services, transit, planning, and transportation to determine how regulations can support the City's urban planning, transportation, sustainability, and equity objectives.

Potential action items:

- **Develop a standard data-sharing agreement** for ride-hail and micro-transit operators.
- **Evaluate jurisdictional questions and define the scope of the Taxi Commission** over microtransit services, ride-hail services, and other emerging service models.

Actions for City Council and the Departments (continued...)

Parking Authority

Parking and transportation managers should work with the Transportation and Planning departments to create a comprehensive parking strategy for the city, including a plan to gradually remove metered parking, obtain real-time information about on-street parking demand, and assess different future uses for city-owned parking garages.

Potential action items:

- **Plan to shift from on-street vehicle storage** by developing plans that consider the reuse and reallocation of space devoted to curbside and municipal parking.
- **Future-proof for reduced parking demand** by creating redevelopment strategies for existing city-owned garages and other developments with required off-street parking.
- **Explore opportunities for sensor technologies** to better understand on-street parking demand in real-time.

City Planning

Planning departments should adopt policies that encourage efficiency and density to continue promoting the use of transit and active transportation. They should evaluate how automated vehicles might impact sustainability, equity, safety, densification, and transit-oriented development as certain planning assumptions, such as parking minimums, trip generation rates, and loading requirements, will need to evolve as AVs become prevalent.

Potential action items:

- **Zone for density and affordability** by increasing opportunities for mixed uses; increasing allowable residential FAR, especially around transit; eliminating minimum parking requirements; and using mandates and incentives to address housing affordability.
- **Eliminate parking minimums** and reassess how loading requirements and trip generation rates will need to change in the lead up to widespread AV adoption.
- **Promote shared and high capacity mobility** by adopting code that supports complete streets and walkable communities.

Information Technology

Information technology departments must prepare for the enormous datasets that AVs will generate. They should determine what data city agencies will need, and what capacities the city as a whole needs to develop to store, analyze, and protect this information. Data management policies should be updated holistically and routinely to adapt to new data needs and threats. Initially, they will need to work closely with the taxi commission to determine how best to acquire data from ride-hail companies.

Potential action items:

- **Define journey data as "personally identifiable information"** and ensure that existing policies around data management are appropriate and up-to-date.
- **Determine current data storage requirements** and capabilities to inform an understanding of future needs.
- **Explore cybersecurity concerns and privacy protocols** with sister agencies.
- **Prioritize open formats** and tools in all development and procurement in order to ensure that cities can take advantage of the best technologies without getting locked into proprietary tools.
- **Support DOTs in the development of digital systems** to manage assets, enable regulation, monitoring, management, and planning.

Employment and Administrative Services

Labor and workforce professionals should work with the Transportation Departments & Transit Authorities to prepare the workforce for automation and develop a clear understanding of what kinds of jobs can and cannot be automated.

Potential action items:

- **Conduct a citywide assessment of how AVs could impact existing and future jobs** with an emphasis on the effects a labor transition would have on communities of color, immigrants, and refugees.
- **Develop workforce development strategies** for transit and freight drivers and other professions that may be impacted by AVs.
- **Overhaul city and transit agencies' hiring practices** and exams to bring in a more nimble and diverse workforce and develop on-going training programs to ensure all employees, existing and future, are ready for the challenges and opportunities ahead.

Actions for City Council and the Departments (continued...)

Sustainability, Energy, and Environment

Sustainability offices and related agencies should begin planning and implementing charging infrastructure for municipal fleet vehicles. They can also work with Transit Authorities, City Planning, and Revenue Services departments to determine Electric Vehicle Supply Equipment (EVSE) siting strategies and adoption plans.

Potential action items:

- **Develop strategies for allowing companies to site EVSE infrastructure**, considering potential impacts on the energy grid.
- **Quantify the positive and negative environmental impacts of AVs,** considering the development of regional transportation and energy models.

Fleet Service

Fleet services, including paratransit, should explore opportunities to transition fleets to smaller electric service vehicles, especially for fire, police, and maintenance services.

Potential action items:

- **Explore opportunities to introduce existing and emerging safety technologies,** such as speed governors, on all fleet vehicles.
- **Develop fleet transition plans** to identify opportunities for electric vehicles and AVs.
- **Explore opportunities to right-size fleet vehicles,** focusing on procuring and using the smallest appropriate vehicle for the job, and adopting Direct-Vision standards for all large vehicles.

Police & Fire

First responders must consider how automated vehicles may impact operations. Agencies must inform themselves on how automation might impact risks of terrorism or cyberattack, and coordinate with other agencies to reduce risks and take advantage of opportunities posed by autonomous vehicles.

Potential action items:

- **Engage with transportation and technology experts** to develop understanding of AV technologies, explore the implications of converting fleets to AVs, and train first responders on AV technology.
- **Coordinate with transportation and public works departments to use street design to enforce slower vehicle speeds** and increase pedestrian/bike/transit-only space in downtown areas to reduce risk and lethality of autonomous vehicle-as-weapon attacks.
- **Develop in-house expertise on cybersecurity threats** that could remotely access vehicle data and controls.

Revenue & Budget Services

Revenue, budget, and finance departments should undertake a comprehensive analysis of how revenue sources may change with automation and supporting policies. In particular, they should explore opportunities for pricing public goods and city assets to support city policies around sustainability, equity, and efficiency.

Potential action items:

- **Document the revenues impacted** by AV adoption and assess strategies for offsetting those losses.
- **Create a priority-based framework for pricing** that encourages high-efficiency and sustainable modes while sending price signals to discourage inefficient, single-occupancy vehicle travel.
- **Support city efforts to explore and pursue pricing strategies** to reduce VMT and congestion and better manage curbside demand.

The Division of Regulatory Powers

Historically in the US, the Federal Government has held the authority to regulate vehicles and products, while states, through their Departments of Motor Vehicles and license requirements, have presided over regulation and qualifications for the driver. In other words, the Federal Government has traditionally assumed the responsibility for ensuring that the vehicle performs as required, while the states address individual safety by creating rules around what skills are necessary to be allowed to drive.

AVs complicate the historical division of regulatory authority because the vehicle is the driver. As a result, the traditional role of states—determining what skills are necessary to be allowed to drive—may be supplanted by the federal prerogative to decide what features and abilities AVs need in order to operate in the public right-of-way. In turn, cities, which traditionally hold sway over local issues such as curbside regulations, face the potential of being preempted by their states, which may seek to control where AVs can go.

The questions around regulatory authority grow even more complicated as companies, competing to market new technologies first, lobby at the federal level to expand options to test and deploy self-driving technologies on city streets populated by real people. Since 2016, USDOT has adopted an increasingly hands-off approach to oversight of AV technologies, relying on companies to adhere to voluntary technical standards.[12]

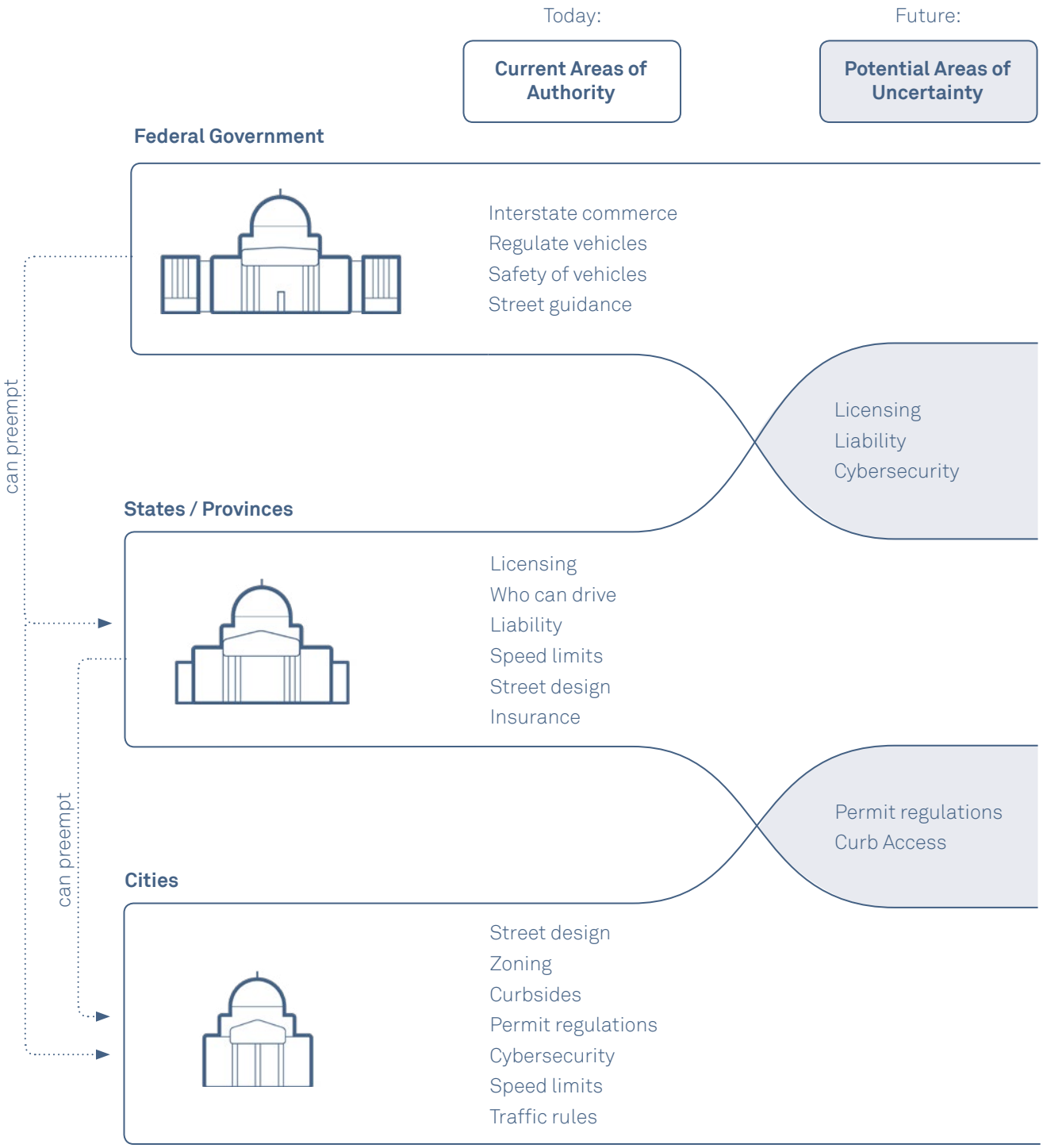
In efforts to exercise influence over AV policy, especially on city streets, local governments have attempted to establish frameworks for AV testing and developing standards for data sharing between private companies and local governments. In response, there has been considerable effort from companies to pass federal legislation preempting cities from regulating and managing autonomous technologies.[13]

The Federal Perspective

To date, USDOT has taken a market-driven approach to the regulation of AV technologies. USDOT supports voluntary technical standards and strongly encourages local governments to seek assistance from "industry associations, private sector consultants, and automation technology developers" to both test vehicles and understand the implications of this technology.[14] The National Highway Traffic Safety Association (NHTSA), a branch of USDOT, has currently only issued a voluntary, twelve-point safety checklist for AV operators and no longer requests safety assessment letters for companies to receive federal approval for testing.[15]

In their latest document guiding national AV development, Preparing for the Future of Transportation: Automated Vehicles 3.0, USDOT notes that its role in vehicle automation research is to "support the testing and deployment of novel technologies...and the development of voluntary standards that can enable the safe integration of automation." [16]

Traditional & Emerging Areas of Authority

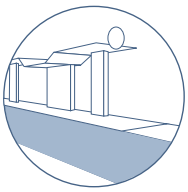


Emerging Issues

As traditional areas of authority continue to shift and evolve between cities, states, and the Federal Government, a number of issues related to safety and access to information will likely come to the fore.

Vehicle Safety

A major anticipated benefit of AV technologies is their potential to reduce traffic crashes, injuries, and fatalities because autonomous vehicles can be programmed to always travel at low speeds that are appropriate in urban areas, and to "see" and avoid people more reliably than human drivers. However, there is still an active debate over who will be responsible for ensuring these safety benefits come to fruition. To date, the Federal Government has largely allowed the AV industry to govern itself on matters of testing and safety. Key safety questions are still unresolved, such as: who will determine when a vehicle is 'safe' and what criteria will they use? How will companies be required to program their technology to prioritize the safety of passengers versus the safety of passers-by in the event of a crash or potential crash?



Infrastructure

Cities and states have historically made local decisions about infrastructure design. However, if NHTSA determines that vehicle-to-infrastructure technology falls within its safety jurisdiction, it could seek to become more involved in infrastructure planning and construction. More pessimistically, in a misguided effort to create a uniform landscape in which AVs can easily operate before lidar/sensor/camera technologies are 100 percent reliable, the Federal Government could try to compel cities to redesign streets in ways that prioritize AVs over other modes. AV-only lanes and associated barriers, such as pedestrian or bike gates, over-passes, and under-passes, as well as requirements that pedestrians and cyclists carry detection beacons, would be negative outcomes for people and cities.

Data Privacy and Information Access

Access to the data produced by AVs and other emerging transportation technologies is a particularly contentious topic. Like ride-hail and shared micromobility services today, automated vehicle companies will likely gather vast amounts of potentially personally identifiable data on people's travel behavior. Governments need this aggregate data to ensure safety on public streets and manage and regulate transportation services to best serve public goals. Meanwhile, companies are looking to protect trade secrets and profitability projections in a crowded marketplace. Complicating matters, the US lacks comprehensive consumer privacy protection policies that could guide how data is collected, stored, used, and shared. Already, ride-hail and shared micromobility companies have exploited the lack of clarity around data to lobby states and the Federal Government to limit the ability of local governments to require data reporting. State legislatures and Congress might further restrict what data cities can collect from automated vehicles. On the consumer side, lax federal oversight might even limit what states can require of automakers when it comes to informing consumers as to what data is being gathered and how it is used.

Cybersecurity

Cybersecurity risks raise major questions for AV proliferation. AVs are vulnerable to cyberattacks as hackers and other malicious parties can target the software within AVs or connected vehicle infrastructure to compromise safety. The risks of such attacks are inherently local as the people and infrastructure immediately around compromised vehicles are vulnerable targets. Comprehensively addressing this threat will require the Federal Government to create strong cybersecurity standards for vehicles and hold manufacturers accountable for breaches.

The Threat of Preemption

Preemption of local authority poses unique safety risks to people on city streets and in urban contexts because it limits the ability of local government to be directly responsive to the needs of its people. If federal agencies determine that state or local legal requirements interfere with national regulations, they could employ preemptive authority, in the name of removing "unnecessary" barriers. In "Preparing for the Future of Transportation," USDOT has already asserted its opposition to "unnecessary or overly prescriptive State requirements that could create unintended barriers for the testing, deployment, and operations of advanced safety technologies."[17] Cities must coordinate with and monitor congressional and state legislatures to ensure that control over city streets and policies remains at the local level.

Congressional Legislation

Historically, states have had far-reaching responsibility when it comes to mobility. However, congressional legislation could change that. In 2018, the Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution (SELF DRIVE) Act passed the US House of Representatives. The legislation attempted to, "[establish] the federal role in ensuring the safety of highly automated vehicles by encouraging the testing and deployment of such vehicles" and preempt states from enacting more stringent laws than the federal standard.[18] AV START, the Senate version of SELF DRIVE, similarly preempted State and local action on the design, construction, and performance of AVs. AV START ultimately failed to become law, leaving the door open to future federal action.

State Legislation

States could also exert authority over how AVs operate on city streets. Ride-hail services provide a good prediction of potential legislative outcomes for AVs. Currently, most local governments oversee ride-hail services through their taxi authorities or commissions. With the advent of app-based ride-hail services, however, many companies lobbied state legislatures to assert control of these technology companies at the state level, in some cases significantly reducing their level of regulation compared to taxi operators.[19] A similar pattern, although less successful to date, emerged in 2017-2018, as dockless bikeshare companies lobbied states to preempt cities' ability to regulate such programs.[20, 21, 22]

California Case Study

California provides a unique case study for the conflicts that may emerge with automation. As one of the first states to permit testing, California has revised its AV regulations a number of times over the last few years. The state's latest regulations outline requirements for commercial deployment. Companies intending to operate in California beyond testing must[23]:

- Certify the vehicle is equipped with an autonomous vehicle data recorder, the technology is designed to detect and respond to roadway situations in compliance with California Vehicle Code, and the vehicle complies with all Federal Motor Vehicle Safety Standards (FMVSS) or provide evidence of an exemption from NHTSA.
- Certify the vehicle meets current industry standards to help defend against, detect, and respond to cyber-attacks, unauthorized intrusions or false vehicle control commands.
- Certify the manufacturer has conducted test and validation methods and is satisfied the vehicle is safe for deployment on public roads.
- Submit a copy of a law enforcement interaction plan.
- If the vehicle does not require a driver, the manufacturer must also certify to other requirements, including a communication link between the vehicle and a remote operator and the ability to display or transfer vehicle owner or operator information in the event of a collision.

Notably, California leaves the determination of safety up to testing companies and federal regulators. Companies must self-certify that their cars can safely operate without a human, and while they must adhere to federal safety regulations, none currently exist. If other states follow a similar path, it will give significant leeway to federal regulators and the private sector to determine the speed and safety of AV testing and development.

Photo: WikiMedia Commons, Grendelkhan