Photo: WikiMedia Commons, Smiley.toerist (Lyon, France)

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Policies to Shape the Autonomous Age

Policies for a Thriving City

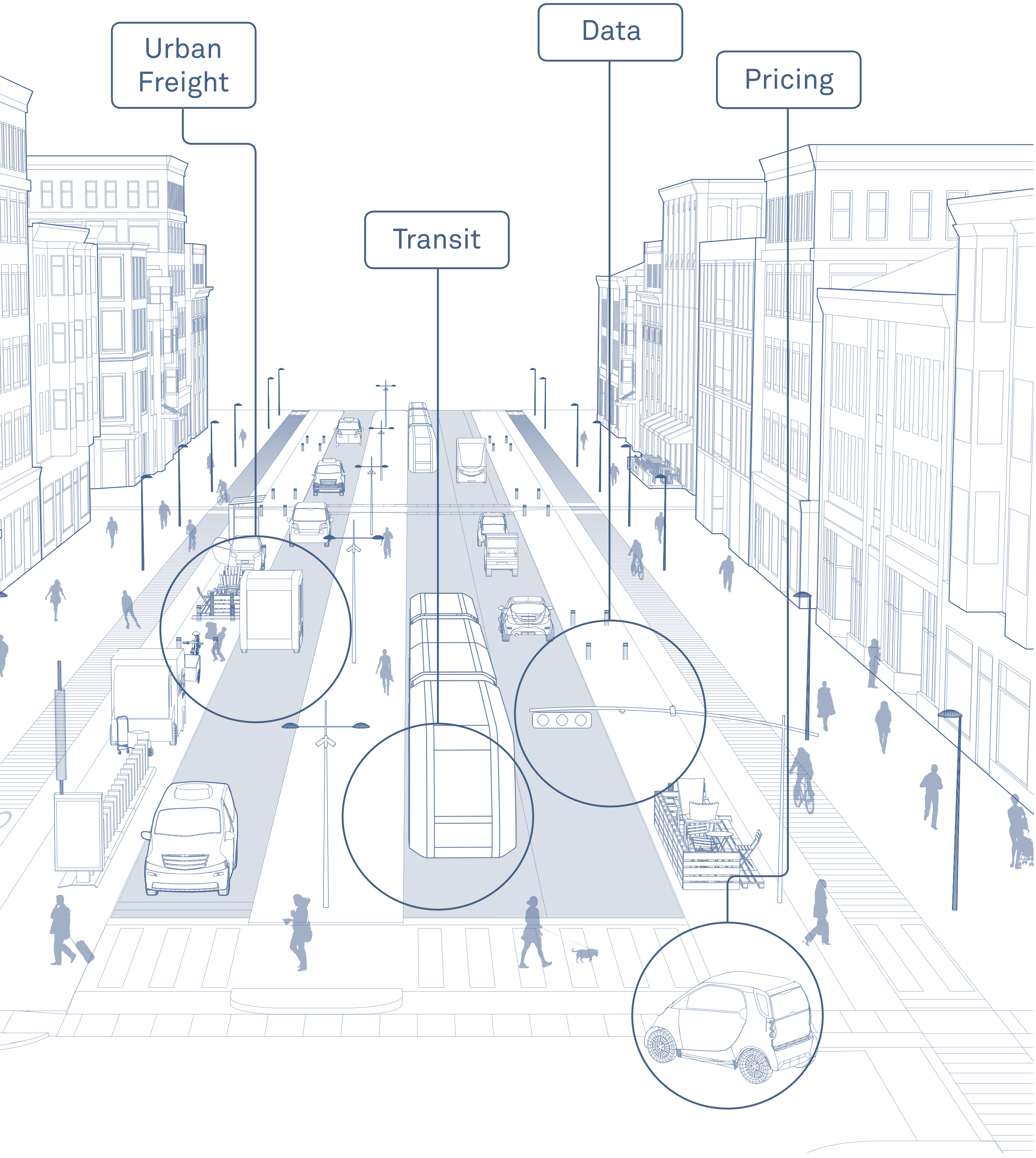
Today's urban mobility economy is dramatically different than it was five years ago and even more changes are on the horizon. Autonomous vehicle technology could dramatically lower the price of automobile trips, push demand to higher levels, and divert cities' attention away from centering low-carbon and active transportation modes.[24] In order to ensure that cities remain vibrant places for people to live, work, and play, cities must proactively pursue policies that harness technology while keeping key principles of efficiency, safety, and human-scale at the core of all decision-making.

By implementing proactive policies today, cities can act to ensure that the adoption of AV technologies improves transportation outcomes rather than leading to an overall increase in driving. As the largest markets for AV technology, cities have an opportunity to prioritize and regulate their existing infrastructure for the benefit of residents and the environment while shaping and scaling strategies to deploy new technologies for the betterment of their streets. By taking action now, cities can make a human-centric autonomous future a reality.

Crafting a truly people-focused autonomous future requires cities to take action today in four key interconnected policy areas:

1. **Transit**
2. **Pricing**
3. **Data**
4. **Urban Freight**

Already technologies that are considered precursors to automation are increasing congestion and causing major upheavals in the labor market. To achieve the best potential outcomes of AV technology, cities will need to grapple now with fundamental issues of how we choose to allocate a finite resource– public space in cities. Cities will need to rethink longstanding policies and practices for transit systems, transportation demand, data, and freight distribution in order to manage the impact of this new technology on their streets and leverage it for the improvement of the public realm.


Urban Freight
Data
Pricing
Transit


31 BALBOA
Ferry Plaza
5570
O'Farrell
TAXI

2.1 Transit

2.1

Transit

Transit is the key to a people-focused autonomous future. Regardless of technological advances, connecting people to each other and to their destinations in dense urban places requires reliable, frequent, high-capacity transportation networks. In focusing on improving bus and rail service today, cities hold the toolbox for accommodating growth without increasing congestion. By coupling transit priority street design, new automation capabilities, and big data streams, cities and transit agencies can unlock opportunities to improve urban mobility. Supported by city-wide pricing policies, like cordon pricing, off-peak delivery hours, and thoughtful, data-driven curbside management, transit can power economies and help more people get where they want to go.

Transit is one policy area where vehicle automation and its precursor technologies can have the most immediate direct impact. Automated technologies are especially suited for predictable, fixed routes. Operators can reduce costs and increase service quantity and quality by shifting or augmenting driving functions with autonomous technology. At the same time, many key safety and "conductor" functions will need to remain in the hands of people, opening up options for productive negotiations with labor unions. With more efficient near-term operations, transit agencies can increase service and serve more riders for the same operating cost. In the long term, full automation can enable agencies to further expand service.

The recent declines in transit ridership in the US underscore the need to invest in transit services today to ensure a sustainable, equitable future. For the past four years, fixed-route ridership has declined in most US cities by roughly 2 percent per year.[25] Increasing traffic congestion slows transit, causing riders to shift to using personal vehicles and ride-hail services. However, as demonstrated in cities like Vancouver, Seattle, Columbus, Toronto, and Austin, when transit is prioritized in street design, ridership increases.[26] Red bus lanes, all-door boarding, transit signal priority, and in-lane stops produced travel time gains as high as 23 percent.[27] In Toronto, the redesign of King Street led to a 17 percent increase in transit ridership in just one year.[28]

In focusing on improving bus and rail service today, cities hold the toolbox for accommodating growth without increasing congestion.

By increasing transit efficiency, technology can set the stage for the automation. For example, Computer-Aided Dispatch / Automatic Vehicle Location (CAD/AVL) systems can reduce the amount of time on-street transit spends in traffic. Advanced Driver Assistance Systems can increase safety for all street users and can reduce costly collisions that take vehicles out of service. Off-board fare collection and other emerging fare payment and transfer technologies can speed operations and make trips easier for customers. Vehicle-to-infrastructure communications can reduce emissions and address service bunching. Real-time data can help riders make trips that work for them, and can help operators match service to changing travel patterns. These tools can make transit stronger and support successful roll-out of AV technology and Mobility as a Service frameworks.

To prepare for AVs, cities should...

Enshrine a Commitment to Transit in Asphalt and Concrete

To prepare for AVs, cities and transit agencies should take bold strides to designate street space for transit. Such efforts will help transit take advantage of automation sooner (it is easier to automate a vehicle that runs on a fixed, routine route), and also rebuild ridership and a political constituencies for transit. Cities and transit agencies can begin by upgrading busy bus routes into rapid, high-frequency lines, adding transit-signal priority technology, and by investing in station infrastructure that anchors bus transit in place and supports better operations.

Redesign Bus Networks for Improved Travel Time and Reliability

Riders flock to transit when transit services are fast, reliable, convenient, and efficient. To best take advantage of the potential increases in efficiency offered by AV technology, cities and transit operators should collaborate on holistic transit network redesigns that will improve service and simplify transit operations. In particular, transit operators should prioritize frequency and convenient transfers rather than focus on offering one-seat coverage. Commute trips represent less than 1/3 of all trips; transit agencies should explore options to expand service at off-peak hours. AV technology can help agencies to expand hours and areas of operation, closing gaps in existing transit service while attracting more riders.

Start Transitioning Transit Fleets, Support Infrastructure, and Staff

Many safety, efficiency, and sustainability goals are already within reach with emerging technology. Cities and transit agencies can adopt Direct-Vision standards, set fleet fuel economy standards and target dates for fleet replacement, and tie targets to VMT reduction goals. Cities can prioritize electric vehicle infrastructure for buses and other high-capacity vehicles that reduce VMT. Finally, cities and transit operators can invest in staff development to ensure that workers have the technical skills to oversee and maintain autonomous fleets, and to engage in a wide variety of customer support and security functions.

Ensure Fleet Vehicles and Station Infrastructure is Wired for Technology

On-board and in-street information infrastructure is essential to support AV transit, better manage service, and communicate with riders. Cities should ensure they have the hardware and software necessary to support transit signal priority and vehicle-to-vehicle/infrastructure communications. Open-source data feeds can help cities and transit agencies collaborate with third-party developers and provide riders with useful trip planning tools and service updates.

Streamline Payment and Transfers

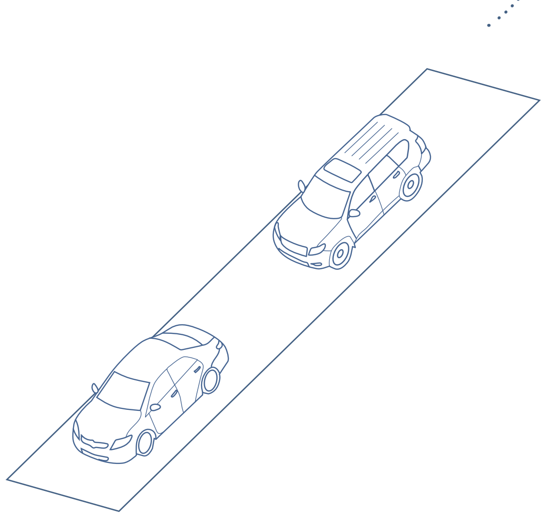
Complicated or proprietary payment systems and inefficient or costly transfers discourage people from choosing transit. Existing and emerging technologies can make fare payment clear and easy, and increase ridership now. Operators should eliminate transfer fees, offer discounts for multi-modal travel, and enable payment through a single portal for all services, whether public or private. In upgrading payment systems, cities and transit agencies should ensure economic equity. For example, transit agencies could cap fares once customers have paid the equivalent of a monthly pass.

Transit Moves More People, Faster

= 1,000 people

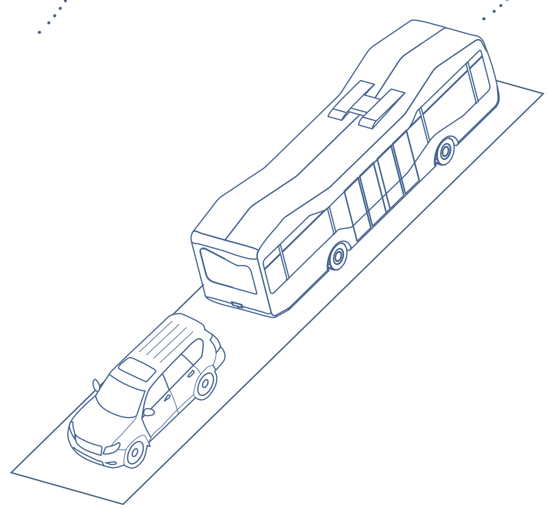
Private Motor Vehicles:

1,600 people
per hour (max)



Mixed Traffic with Frequent Buses:

2,800 people
per hour (max)

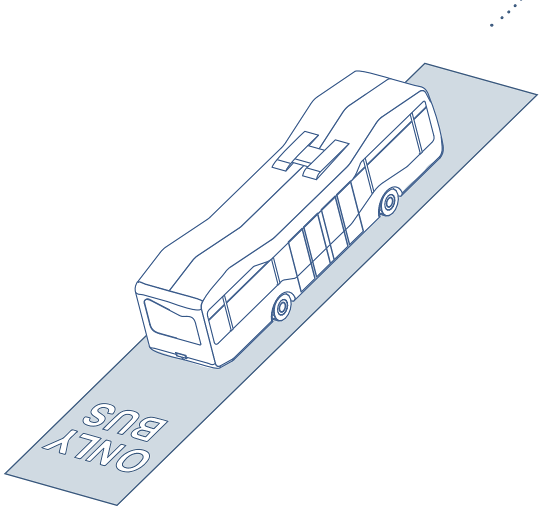


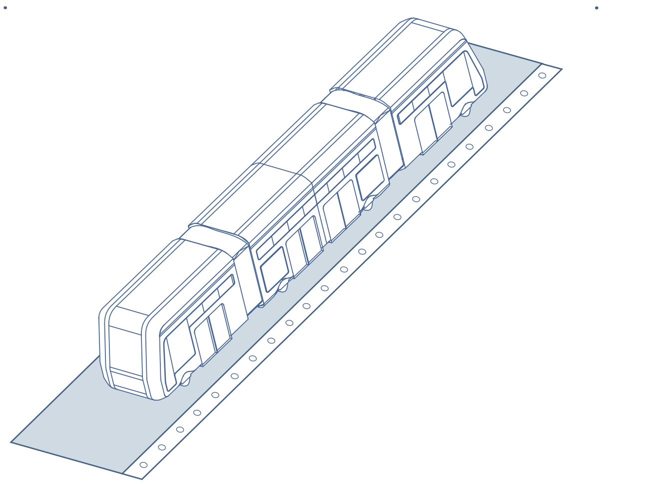
Dedicated Transit Lanes:

8,000 people
per hour (max)

On-Street Transitways, Bus or Rail:

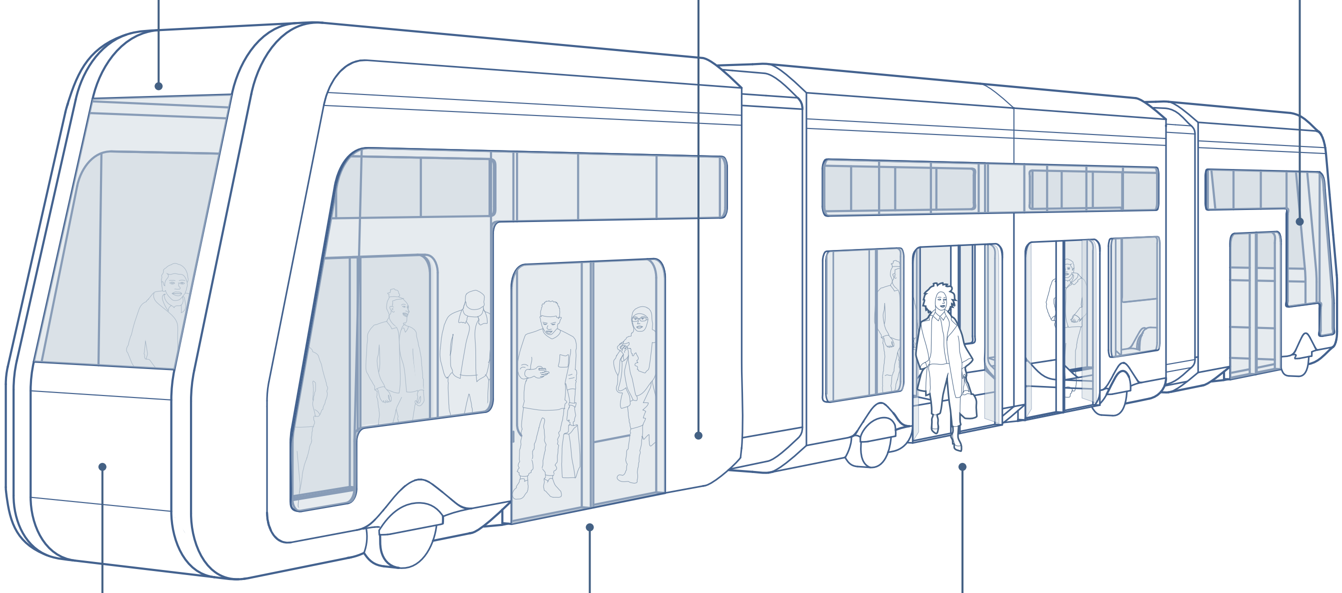
25,000 people
per hour (max)





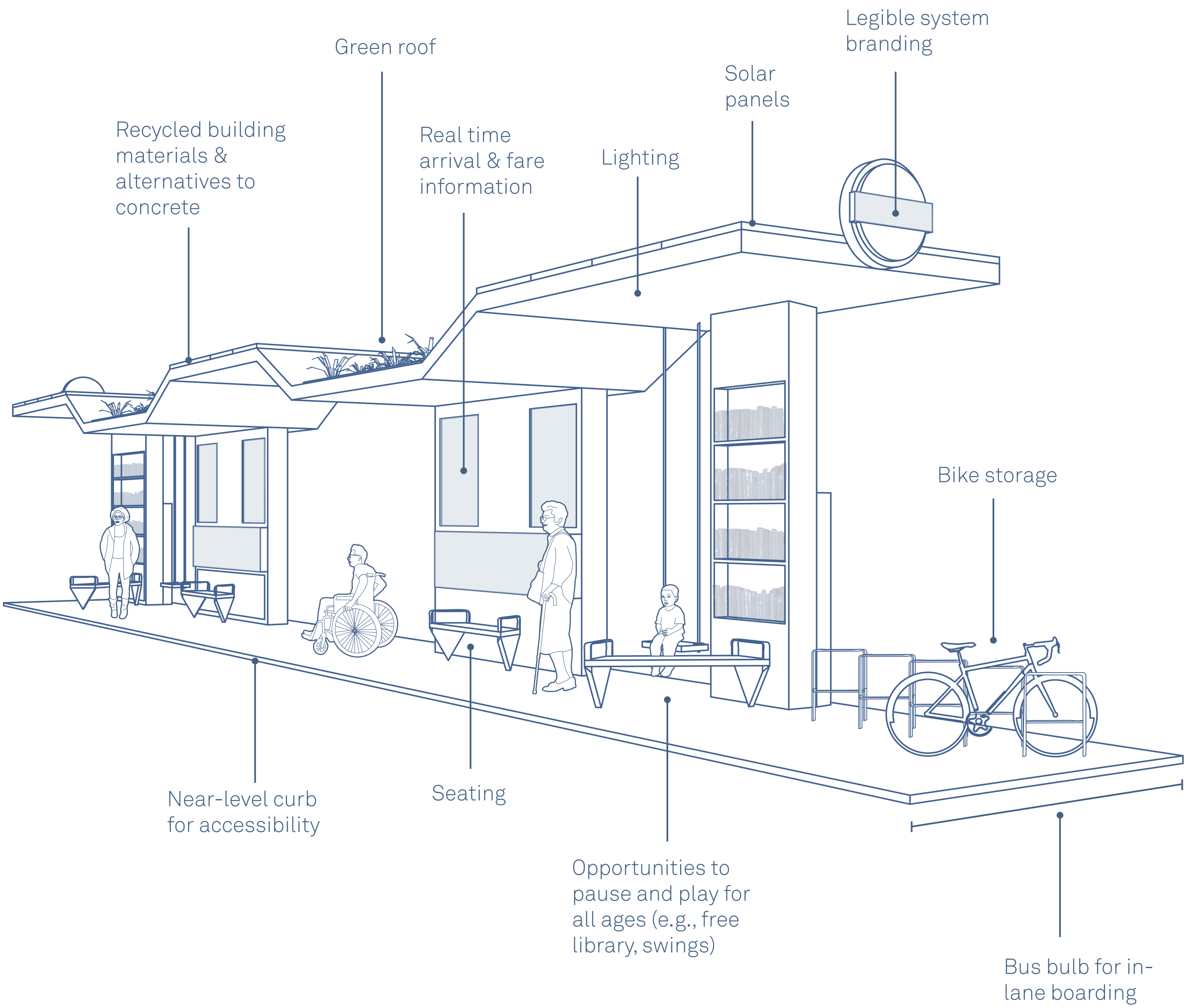
The Bus of Tomorrow

Technology offers huge opportunities to re-invent the bus, the workhorse of transit in North America. Even before autonomous transit vehicles appear on the market, cities and transit agencies can realize many of the promised safety, efficiency, and customer experience benefits by upgrading buses and station infrastructure. These decisions can help to bridge the gap between current service and fully integrated Mobility As A Service frameworks.



The Bus Stop of Tomorrow

New technologies can also reinvigorate public space, transforming bus stops into civic places. Real-time information can help riders make decisions about their travel choices. Embedded kiosks, vendors, and public services can enrich stations, providing riders and passersby opportunities to rest, shop, relax, and engage.



Transit, Labor, and Automation

The labor impacts of advances in automation will be complex and far-reaching, particularly for workers employed in the commercial driving sector. This includes 300,000 transit operations and maintenance workers[29], the majority of whom are members of public-sector unions. In particular for transit, the nature of the jobs may change considerably, shifting away from driving functions and toward more complex, varied jobs in communications, planning, customer service, maintenance, and security. To avoid major labor and political disruptions, cities must engage with their transit labor force early and often to examine where and how AV development will impact jobs and prepare for the workforce needs of tomorrow.

In an ideal autonomous future, technology will enhance transit's competitiveness, adding more riders and creating new jobs through strong service growth. Transit agencies can ensure this future by using their preparation for AVs as an opportunity to reshape and retrain their labor force in ways that can dramatically improve service. Savings from increased efficiency should be re-invested in workforce development to ensure that both current and future employees have the training and skills they need to thrive in a dynamic, uncharted autonomous future.

To prepare for the complexity and sophistication of jobs in an autonomous age, transit agencies, cities, labor unions, and workers should begin collaborations now to develop plans, policies, and procedures that make hiring simpler and increase diversity in recruitment. In addition, to ensure that existing and future workers can continue to adapt to innovations, agencies should expand opportunities for on-going career and professional development training, and create new vertical career pathways and opportunities for promotion.

As they prepare for the uncertainties ahead, transit agencies and cities should look to future-proof their workforces by rethinking and overhauling tools, like civil service exams, that guide hiring and promotion decisions. For example, in developing job descriptions, cities and agencies may want to prioritize agility and ability to learn, rather than requiring specific skills (such as having a driver's license or minimum years of experience or education) that may be inappropriate or obsolete in an autonomous age.

Micro-Transit, Micro-Niches

In urban areas, fixed route transit in designated rights-of-way is the most efficient way to move people in large numbers. The struggles of "micro-transit" services (e.g., Chariot, Bridj) show how difficult it is to aggregate more than a few riders into a single vehicle on a non-fixed route, even with app-based dispatching. Nationally, it costs more than six times as much money per passenger to run a demand response service than it costs to run fixed route bus services.[30] In the New York Metro Area, demand response services cost fifteen times more per trip than bus service.[31]

The bus's advantage comes from having riders come to it, rather than the other way around. Without the aggregation efficiencies of fixed-route transit or the point-to-point convenience of bicycling or cars, the niche for micro-transit is similar to that of carpooling or taxi-pooling: collecting riders from a few dispersed places and bringing them to transit stations or low-transit employment hubs. Some transit agencies have explored using micro-transit to replace low-frequency 'coverage' service or paratransit with on-demand service. However, to date, ridership in micro-transit pilots that replaced fixed-route bus service has typically been lower than the low-ridership 'coverage' bus routes that were replaced.[32, 33]

Informal transit in middle-income cities worldwide offers a lesson for microtransit and pooled travel services. Even with extremely low labor costs, these services show that high-volume, on-demand service is inherently slow, and gets outperformed by organized fixed-route service when it exists on a similar route.[34]

Photo: TransLink

Technology in Transit Today: Vancouver's SkyTrain

As North America's largest automated train system, Vancouver's SkyTrain illustrates the potential for integrating automation into transit networks. Operated by TransLink, SkyTrain is a driverless system providing rapid transit service to the entire Metro Vancouver region. SkyTrain serves more than 468,000 average weekday boardings, maintaining reliable two to three-minute headways throughout the day and eight- to ten-minute headways into the late-night.[35, 36] Operating three lines on grade-separated guideways, a digital railway signaling technology called SelTrac controls the vehicles' movements.

Shorter trains and platforms can be optimized for use in automated systems like SkyTrain. In addition to lower upfront costs, automated rail systems can run smaller trains at frequencies significantly higher than is possible for traditional systems. For instance, TransLink provides service every two to three minutes during peak times with a maximum capacity of 25,700 passengers per hour in each direction.[37] This efficiency has helped to bolster market development for the full transit system, where network-wide ridership grew 6 percent (and local bus ridership grew more than 3 percent) from 2016 to 2017.[38]

SkyTrain's high frequencies are due in part to the system's ability to operate without a driver. However, automated systems still have a need for employees across the system, such as for maintenance and customer service, safety, and security.[39] SkyTrain attendants staff most stations for these functions and cost savings from automated transit go towards improving customer service and keeping the system in a state of good repair. These customer-facing roles have the potential to enhance transit's competitiveness and performance.

Network Planning for the Autonomous Bus

AVs offer unique opportunities to address declining transit ridership in many North American cities by increasing bus service. To maximize these benefits, cities and transit agencies must match the increases in service hours and transit frequency provided by AV technologies with strategic network redesigns that help transit best serve the trips that people want to make.

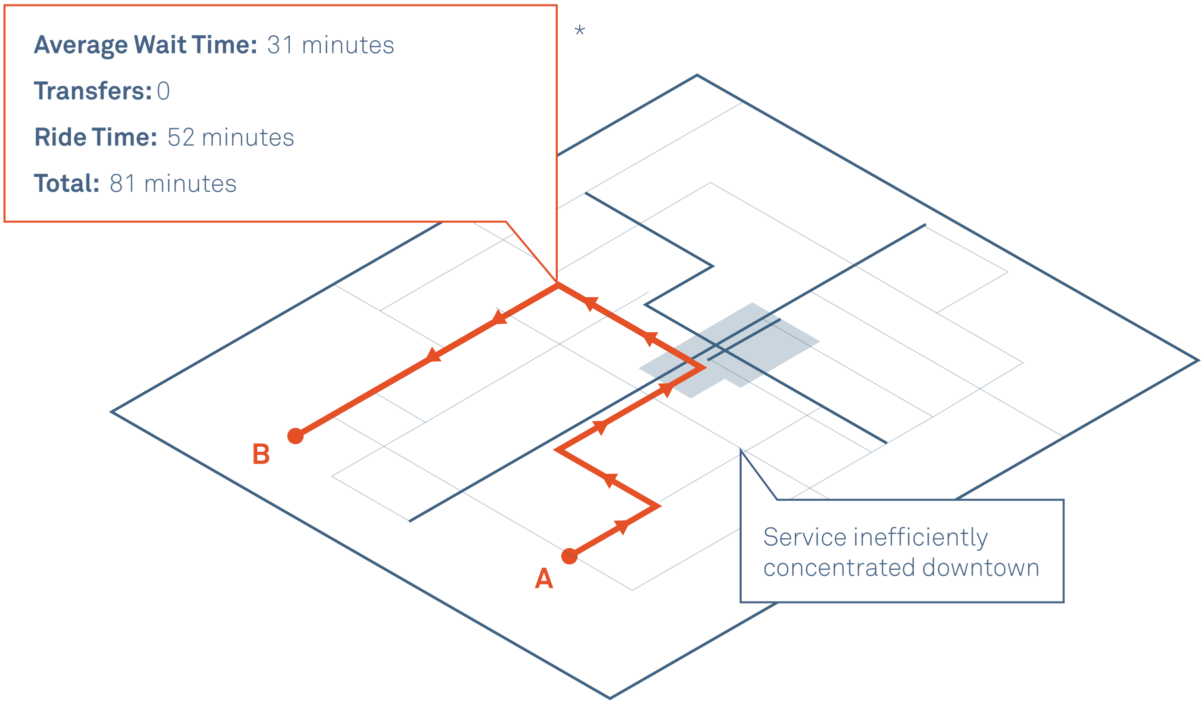
Bus network redesign is essential to the successful adoption of AV technology in transit. Today, many metro areas in the US are served by bus networks that radiate out from a central core. In these systems, a person traveling between two points outside of the city's downtown core may need to take the bus all the way into downtown, then transfer to another bus to make the trip back out to their destination. Radial networks typically facilitate one-seat, rush hour trips to the central business district but are inconvenient for the majority of types of trips that people make, for example non-commute trips, trips between neighborhoods, weekend or evening trips, or trips in polycentric regions. Even with increases in service that could come from AV-based transit, most radial transit networks would still fail to provide the kind of service that people need or want to shift from single-occupancy cars.

In contrast, grid-based network redesign can help transit agencies capitalize on the increased frequency and expanded service provided by autonomous buses by making individual trips time-competitive with single-occupancy vehicles and ride-hail. Grid-based networks are most efficient when supported by bus-only or bus-priority lanes. Even before AV buses are fully deployed, grid-based network redesign can help win back ridership. An analysis by Houston Metro of how a grid-based network would impact Houston found that, using the same number of service hours, they could reduce travel times by more than 20 minutes for 28% of trips, and reduce travel times by 5 to 20 minutes in an additional 49%.[40]

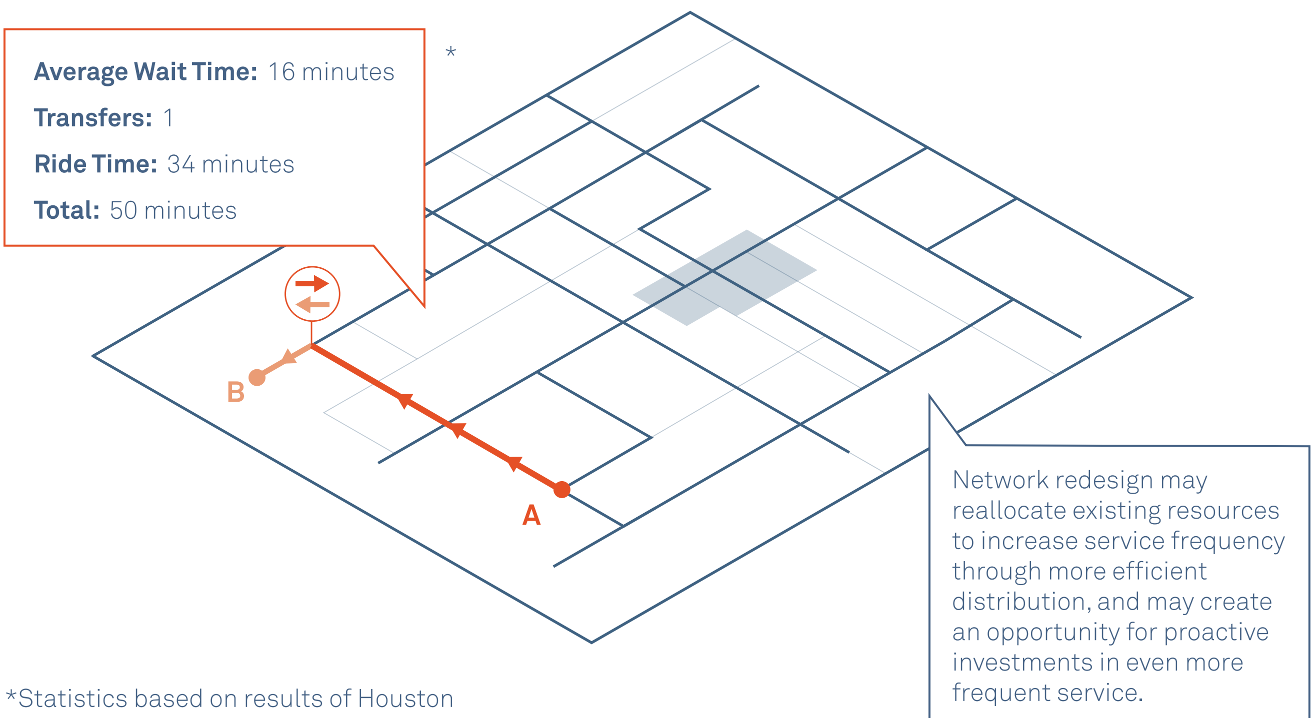
Tools for Better Transit: Signal Priority in Minneapolis

Minneapolis' METRO C Line bus rapid transit project began revenue service in June 2019, providing faster, more frequent service from Brooklyn Center to downtown Minneapolis. Transit Signal Priority (TSP) was enabled at 15 traffic signals along the route in Minneapolis. With this technology, a late running bus communicates with the traffic signal cabinet via a radio antenna, then the traffic controller either extends the green time or provides an early return if it arrives on red. TSP provides more reliable travel time with less delay at the traffic signals. The C Line project is the 4th bus route to install TSP in Minneapolis. There are now 70 traffic signals in the city with TSP and several more bus routes are planned to be upgraded in the next 5 years.

Network Today



Future Network



*Statistics based on results of Houston METRO's 2017 "System Reimagining Plan"

Photo: Alain Rouiller, Flickr (London)

2.2
Pricing

2.2

Pricing

Across the globe, traffic is getting worse. In the United States alone, vehicle miles traveled (VMT) hit an all-time high of 3.2 trillion miles in 2017.[41] US drivers spent an average of 97 hours sitting in traffic that year and the total cost of congestion, including productivity, fuel waste, and other factors, was over $300 billion.[42] Accelerating automobile use across the globe has dismal implications for climate change: in the US, transportation is responsible for the largest share of all greenhouse emissions, the most of any sector, with almost all of it coming from cars and trucks.[43]

> Absent policy mechanisms and incentives to encourage people to drive less, traffic will continue to increase.

Absent policy mechanisms and incentives to encourage people to drive less, traffic will continue to increase. A well-documented behavioral phenomenon, called "induced demand," shows that as governments build more or wider roads, people drive more and congestion gradually increases. While this impacts all travelers in terms of longer journey times, often the poorest residents are hit the hardest. With affordable housing options located farther from city centers and increasing numbers of people forced to commute long distances by car, low-income populations are most likely to be burdened by the time costs of increased congestion.

In an autonomous future, pricing is a core policy lever. New technologies could allow governments to gauge traffic in real time and accurately price travel demand to influence traveler behavior. Pricing would allow cities and regions to develop reliable funding sources for transit, providing more and better transit service to make it easier for people at all income levels to move around. By reducing the number of single-occupancy vehicles entering intensively used areas, pricing gives cities an opportunity to repurpose the public space. Such space could be used for sustainable transportation options like transit, bikes, walking, for small businesses and vendors, trees, and open space.

Pricing may also be needed to address the externalities of automation itself. Many transportation experts believe that AVs will lower the cost of travel and induce even more demand.[44] Without adequate government intervention, it is unlikely that the autonomous world will be shared. In such a scenario, the low cost of an individual automated ride could draw commuters off the transit network, encourage people to live further from cities, and add millions of vehicle miles traveled. Early studies are already showing that ride-hail services are increasing VMT.[45] The end result would be even more gridlock, imposing new costs on people, cities, and the environment. Pricing will be essential to avoid this dystopia.

Until recently in the U.S., elected officials have been reluctant to embrace meaningful congestion pricing. However, perhaps due to the rise of ride-hail services, the way that people think about transportation payment and pricing is evolving. Consumers are quickly becoming accustomed with "surge," variable, and peak pricing. Electronic tolling systems and payment platforms have made it more convenient to pay for travel. In March 2019, the New York State legislature passed cordon pricing authorization for New York City, and other cities may follow suit. Learning from cities such as Stockholm and London, which charge a fee to enter the city center, North American policymakers are exploring the potential of similar charges to cut traffic in the most congested areas of cities, and increase the efficiency of our transportation networks as a whole.

To realize the full value of the public right-of-way in the AV age, cities should:

Start Developing Pricing Plans & Policies to Reduce Congestion

Cities should take lessons from their peer cities around the world who have successfully implemented pricing policies. Cities and transit agencies should begin by empowering an independent body of diverse, local stakeholders to propose and evaluate pricing scenarios and funding streams to expand transit. The resulting public engagement can serve as a strong foundation for implementation.

Ensure Pricing Revenue is Dedicated to Improving Transit, Walking, and Biking

The full benefits of congestion pricing can only be realized when transit service is a viable and attractive alternative to driving. While cities can already take steps to improve transit's frequency and reliability, a commitment to using future revenue to expand transit options is essential to encourage and sustain mode shifts. Cities should also dedicate revenue towards investments in active transportation to support walking and biking.

Prioritize Equity When Pricing Mobility

Pricing policies make hidden costs (e.g., congestion, loss of productivity, traffic fatalities, air pollution, carbon emissions) explicit. As cost burdens shift and change, policy makers must ensure that low-income people are not inequitably impacted. Using revenues from pricing to support transit improvement is the best way to ensure equitable outcomes for everyone. In the research and public input process, cities can explore options to expand access to transit to help reverse the economic impacts of structural racism in transportation planning.

Develop a Coalition of Support

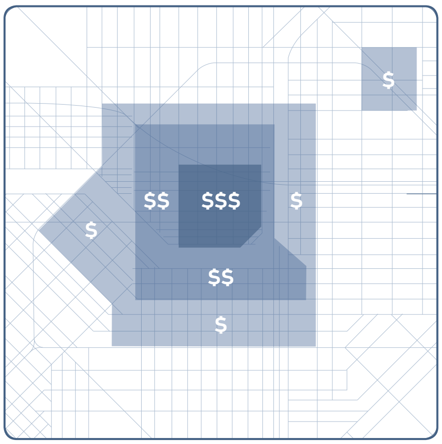
Support for congestion pricing must come from a broad coalition of local stakeholders, including the business community, grassroots activists, civic leaders, and elected officials. Building a broad base of support means undertaking a long-term, active strategy for community engagement and identifying coalition partners to assist in the development and promotion of a large-scale pricing policy.

Use a Data-Driven Approach to Implement and Evaluate Any Pricing Scenario

Accurate, comprehensive data about activity on city streets is critical to shaping and monitoring the impact of a mobility pricing program. Cities need robust data management policies and in-house expertise to determine where the highest levels of transportation demand exist and how different pricing tools can improve safety, congestion, and sustainability outcomes. Detailed data about regional and citywide travel behavior will inform successful implementation of pricing policies and their future impact.

Types of Congestion Pricing

Pricing can be divided into three categories, each focusing on a different aspect of the trip as the place to insert the financial incentive.

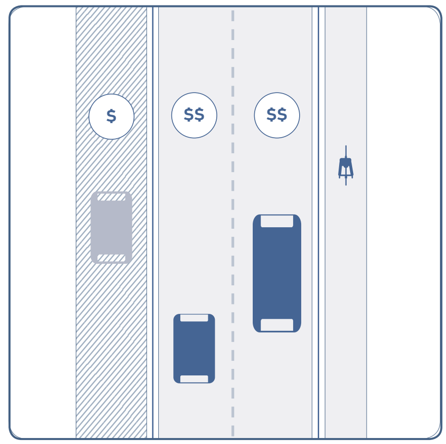


Price the Place

Cordon Pricing

Cordon or zone-based congestion pricing reduces congestion by charging a fee to enter a specific zone or zones of a city. Cities can establish zones based on land use or existing levels of congestion. Cordon pricing can be a flat fee or variable, changing over the course of the day to target congestion at peak periods. Cordons can also focus on specific vehicle types (e.g., high-polluting vehicles or large trucks). For example, in 2019, London instituted an Ultra Low Emission Zone (ULEZ) to reduce the number of high-polluting vehicles coming into central London and improve air quality. Cordon pricing produces the most significant results for congestion mitigation and greenhouse gas emissions reductions compared to other forms of road pricing. Using cordon pricing revenues to fund improved transit is key to congestion mitigation impacts.

e.g., London

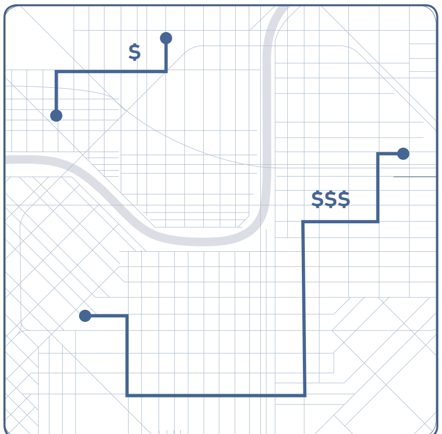


Price the Curb

Performance-Based Parking / Loading

In dynamic parking or loading zones, cities charge a fee based on use and/or time the curb space is occupied. A loading fee may be assessed for freight and passenger pick-up/drop-off. These fees require a detailed curb asset inventory, which many cities do not currently have. Increased precision in on-board GPS and newer, cheaper sensor technologies may increase opportunities for curb pricing in the future.

e.g., Washington, DC



Price the Trip

Per-ride Taxes and User Fees

User fees are designed to discourage types of single-occupancy vehicle trips at certain times and places. User fees are most often applied to ride-hail trips. How fees are assessed varies based on city and state legislation; some mechanisms create a stronger incentive to reduce driving. For example, ride-hail fees that are calculated as a percentage of the total fare may produce limited decongestion benefits because the financial (dis)incentive is tied to the passenger's travel, rather than to the vehicle's travel. That is, when there is no passenger—and therefore no revenue— there is no financial disincentive to drive.

e.g., Chicago

HOT / Managed Lanes

High-Occupancy/Toll (HOT) Lanes are designed to reduce congestion by incentivizing ride sharing. When well-placed, tolls can discourage local travel on major roadways or encourage drivers to consolidate or limit their trips. However, poorly placed tolls can actually make congestion worse. For example, in New York City, tolls on cross-city highways incentivize interstate traffic to shift to untolled local roads and bridges, increasing congestion in the city core.

e.g., Virginia

Vehicle Miles Traveled (VMT)

VMT fees are assessed based on the number of vehicle miles traveled. By directly pricing travel, VMT fees ensures stable revenue in light of changing vehicle fuel economies and ownership models. Over time, VMT fees could replace gas taxes and help fund infrastructure on a large scale.

e.g., Oregon

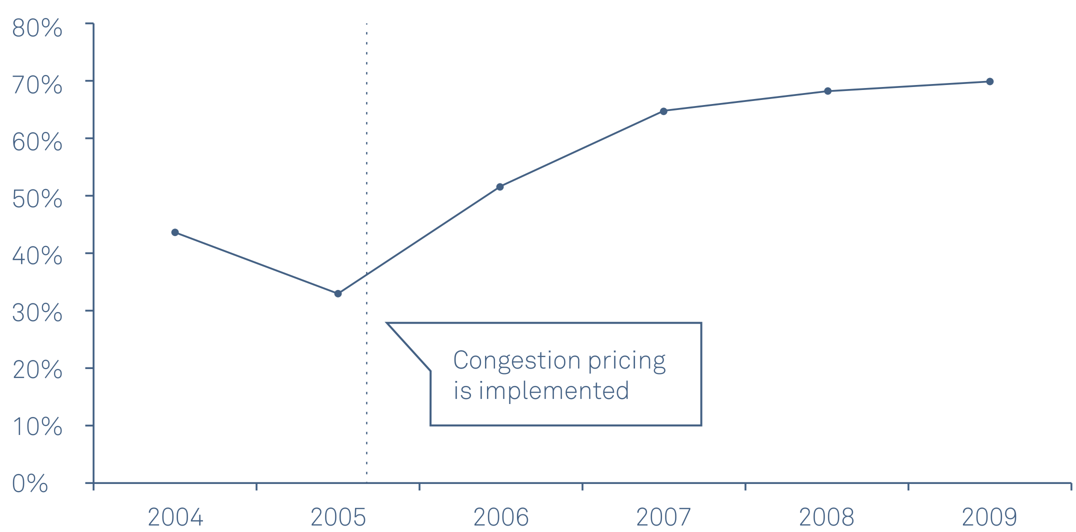
A Short History of Cordon Pricing

Private toll roads have existed in the United States since the colonial period. In the 1960s, William Vickrey suggested that the governments that build the roads should also charge 'customers' for their use. Vickrey's idea has gained popularity as the congestion and emissions impacts caused by unrestricted "free" driving have become evident. More recently, governments have begun to employ dynamic pricing to maintain free-flow traffic conditions along certain routes—such as I-15 in San Diego (in the high-occupancy vehicle lanes) or Route 66 in the Washington, D.C. metro area. These projects employ fluctuating tolls that change in $0.25 increments every few minutes depending on traffic levels.

Besides charging for travel on select roads, a number of cities, including Singapore, London, Stockholm, and Milan, have implemented a cordon charge to reduce traffic congestion and emissions in the city core. In 1975, Singapore implemented a flat charge of $1.30 per vehicle entering the city's central business district between 7:30 and 9:30 am, eventually switching to a variable fee depending on the time of day and direction of travel. London followed suit in 2003, charging motorists £5.00 to enter central London (the charge has since increased to £11.50). Stockholm, which introduced its cordon in 2006, charges a varying rate to enter the city that tops out at $4.40 during rush hour. In all cities, revenue raised from these cordon charges is used to fund transit service and other modes, which is essential to the success of the charge.[46]

In all the cities where it has been implemented, cordon initiatives have led to less congestion, reduced emissions, faster travel times, and improved pedestrian safety. In London, for instance, the charge reduced the number of automobiles entering the city by 30 percent.[47] Public approval is also strong. In Stockholm, for example, approval for the cordon charge started around 40 percent in the years prior to implementation, fell to around 30 percent right before the cordon was enacted, and then climbed quickly to around 70 percent as citizens saw the clear benefits of fewer cars in their city core.[48]

Stockholm Congestion Pricing Approval Rating



How Much to Charge

Key to achieving traffic and emissions reductions is identifying the appropriate price point for congestion charges, defining the purpose of the fee, and aligning the parameters of who is charged with the policy outcomes desired. For some types of pricing, like ride-hail user fees, the cost is passed on to riders who are already more likely to be affluent. As a result, higher charges may be necessary to reduce single-occupancy vehicle trips. Studies show that a flat $3 ride-hail fee, like the one recently adopted by New York City, would only reduce ride-hail trip volumes and mileage by 3 to 4 percent.[49] The same study by Schaller Consulting suggests that the average trip charge on ride-hail vehicles must be $10 or more to lead to a meaningful reduction in ride-hail vehicle miles traveled[50]. In many cities, the singular focus on ride-hail vehicles, combined with the low initial trip price, may mean that user fees do not adequately reduce congestion.

When cities with strong transit networks adopt cordon charges, the cordon price can often stay relatively low because people have an equally good alternative to driving; a minimal price nudge is enough to discourage single-occupancy vehicle use. For example, in Stockholm, the initial cordon fee was set at around $1 which produced an immediate 20 percent reduction of vehicle traffic into the city core.[51] Stockholm's success at a low cordon price point comes from its already strong transit network which it augmented with almost 200 new buses, 16 new routes, and new bike lanes. More recently, Stockholm has shifted its cordon to variable pricing based on time of day with a maximum charge of 35 krona (US $4.14). Experts note that in all successful cordon pricing examples, revenue from pricing is reinvested into buses and other surface transit which creates more and better alternatives to single-occupancy car use.

Determining the appropriate fee is tied to the behavior that the charge is meant to address and what alternatives people have. In places where there are fewer alternatives to driving, peoples' willingness to pay goes up. In 2018, a dynamic toll was enacted along I-66 leading into Washington, DC. The toll peaked later in the year at $46 due to high demand.[52] Similarly, London's new cordon, the Ultra Low Emission Zone (ULEZ), adds a £12.50 charge, in addition to the existing cordon charge, to high-polluting vehicles entering central London. This large charge suggests that a heavier price incentive may be needed to discourage high-polluting vehicle use, especially in the absence of options, especially for freight movement. To create more alternatives to high-polluting trucks, Transport for London and the Team London Bridge business improvement district have partnered to incentivize e-cargo trikes for freight and courier service in central London.[53]

Photo: Citytransportinfo, Flickr

Pricing for Equity

Ensuring that policies reduce, not exacerbate inequities, is essential to the success of any pricing policy. Pricing plans, in particular, often trigger conversations about equity because they force people to confront hidden racial and economic inequities caused by driving (e.g., longer commute times, increased traffic fatalities and reduced air quality in poorer neighborhoods and communities of color, less leisure time, increased carbon emissions, etc.). While research shows that the majority of people who would pay cordon charges have higher incomes[54], the systematic underfunding of reliable, convenient alternatives to single-occupancy driving, means that conversations about the immediate impacts of pricing are often fraught.

To ensure that cordon pricing schemes reduce economic inequities, policy makers often provide selective discount programs or exemptions. In London for instance, disabled drivers entering the cordoned zone pay only 10 percent of the total fee.[55] Existing transit pricing systems provide a model other cities can adopt to ease cost burdens on low-income individuals. London's Oyster and contactless systems, for example, track monthly fare payments and stop charging a customer once they have paid the equivalent of a monthly pass.[56] This assists lower-income customers who cannot afford the pass' up-front cost, and makes it more appealing financially to choose these modes.

Dedicating revenue from congestion pricing to expanding and improving transportation alternatives such as transit, walking, and biking is essential for addressing the equity impacts of pricing. Cities and agencies considering cordon pricing should center equity in their plans by using revenues to expand and improve transit frequency and reliability, exploring options to reduce transit prices and expand income-based discount programs, and augmenting employee training programs and benefits.

From Ride-Hail to AVs

Ride-hail companies are often viewed as a stepping stone to the automated mobility future. As a result, cities can explore pricing strategies now with ride-hail vehicle, gathering experience on how best to price AVs in the future. For example, the surge pricing model, brought into the general consciousness by ride-hail companies, could be a model for how cities might begin to calculate congestion pricing in the future. When the number of ride requests rises beyond the number of drivers on the road, companies begin to raise prices to both entice drivers to 'clock in' and convince at least some passengers to hold off on their travel. Surge pricing is updated based on demand in real time, meaning it can change within even just a few minutes, and is based on each individual driver and rider feeding information into a central platform rather than relying on on-street infrastructure to conduct vehicle counts—dramatically lowering the cost of monitoring the network.

Similarly, governments could charge an empty vehicle or multi-level fee: one rate for the period when the vehicle has a customer, and a second for when it is unoccupied. Such a structure would encourage trips while discouraging unnecessary idling and cruising. Already, data suggests that ride-hail vehicles operate without a passenger 30-60 percent of the time[57], underscoring the need for a pricing tool to correct the market. Many experts worry that this pattern could continue in an automated future, with privately-owned AVs driving their owners to work, dropping them off, then returning home for the day. Pricing would be an effective mechanism to discourage this behavior.

Automation has the potential to significantly alter the current ride-hail business model. Since companies are more likely to own their fleet, they have the means to collect higher profits compared to today's model where individual drivers receive some of the revenue from rides. Companies may also devise algorithms to minimize empty travel time. Based on the cost of driving without a rider, ride-hail companies may employ 'rematch' where a vehicle is assigned a new ride just as they finish their last one. Governments should monitor occupancy status of AVs and incentivize companies to minimize empty travel time, as opposed to remaining empty until finding the most profitable trip.

First steps toward pricing in North America

Vancouver, BC

In 2017, the TransLink Board of Directors and Mayor's Council on Regional Transportation empowered the Independent Mobility Pricing Commission to study options and potential impacts of congestion pricing in Metro Vancouver. The Commission consisted of 15 local leaders with backgrounds in transportation, business, and community organizing and advocacy. The Commission presented its final report in May 2018, demonstrating mobility pricing as a long-term, sustainable tool to address the region's transportation challenges.

Los Angeles

In early 2019, LA Metro's board of directors unanimously voted to approve the region's first-ever comprehensive analysis of various forms of congestion pricing in early 2019. The study covered pricing options from per-mile taxes, entry fees to certain neighborhoods, and per-ride fees on for-hire vehicles. These research aspects of Metro's road pricing initiative, named "The Re-Imagining of LA County" will take 12 to 24 months and include a strategy for addressing equity.

Seattle

In 2018, as part of Mayor Durkan's commitment to climate action, the Seattle Department of Transportation began a feasibility study on pricing. Working with the consulting firm Nelson\Nygaard, the city released a report in 2019 that analyzed congestion pricing strategies for Seattle with a special focus on equity. The study provides a starting point for discussions about what a pricing program might look like for Seattle and will inform a series of conversations and additional research around congestion pricing.[58]

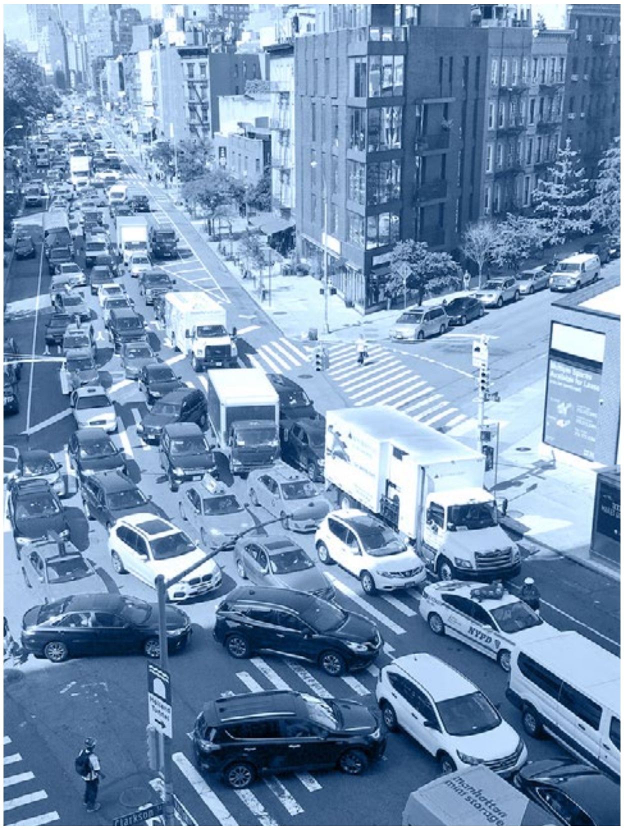
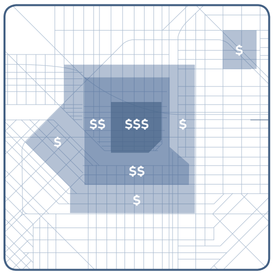


Photo: Doug Gordon / @BrooklynSpoke

New York

After more than a decade of effort from city government and advocacy groups, NYC is on the cusp of becoming the first US city to implement congestion pricing. In 2015, the advocacy group Move NY published a plan to reduce emissions from traffic congestion. In 2017, a fee on for-hire vehicles was put into into effect. In March 2019, the State Legislature approved congestion pricing with the stipulation that revenue from the program would fund transit improvements in the city. Congestion pricing is slated to begin in early 2021.

Congestion Pricing Case Studies

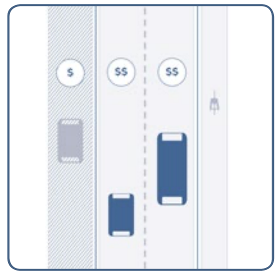


London, 2003

Drivers entering London's 8 square mile congestion zone must pay £11.50 between 7 am and 6 pm on weekdays. Across the cordoned zone, 1,360 cameras placed at 348 sites read the license plate numbers of automobiles entering and driving within it. Taxis, disabled drivers, and certain low-emission vehicles are exempt from the charge while zone residents pay 10 percent of the standard fee. The £2.5 billion in revenue raised by the charge was reinvested in public and active transportation.

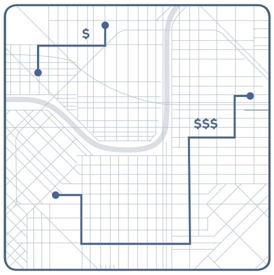
London's charging scheme cut congestion delays by 30 percent while increasing average travel speeds by 30 percent. The number of bus, rail, and bike trips all increased after the city introduced its pricing system with bus ridership reaching a 50-year high in 2011 and bike trips increasing 79 percent between 2001 and 2011.[60]

In 2019, the city launched the Ultra Low Emission Zone (ULEZ) in central London, covering the same area as the cordon pricing zone. Vehicles driving in the ULEZ must meet stricter emissions standards or pay a daily fee to drive in the area. The ULEZ is in effect all day, every day throughout the entire year.



Washington, DC, 2017

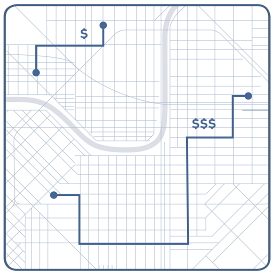
The Multimodal Variable Pricing Pilot (MVPP) in Washington, DC's Penn Quarter/Chinatown uses sensors and analytics to provide real-time parking availability information and price parking according to demand for nearly 1,000 spaces. Meters for these spaces are adjusted to one of eight price points between $1 to $5.50 per hour, depending on the time of day. Varying time limits, real-time traveler information, and adjustable parking fines are used as additional levers to influence demand. Initial results indicate that the program improved vehicle turnover and parking utilization, improved placard compliance, reduced the incidence of double parking, increased meter revenues, resulted in mode shift, and received positive feedback from local business owners, customers, and delivery drivers.[59] The pilot program became permanent in 2019.



Chicago, 2015

Chicago's city council passed a 52-cent per-ride surcharge on all ride-sharing trips in 2015, raised to 67 cents in 2018. While revenue from the initial fee went into the city's general budget and accessible vehicle fleets, proceeds generated from the 2018 increase are being invested in the Chicago Transit Authority (CTA). The fee will increase in 2019 to a total of 72 cents per ride.

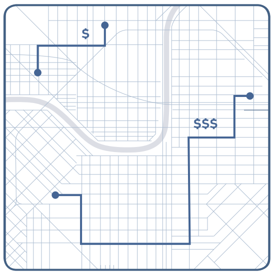
In 2017, the city raised $86.9 million from the fee, and is projected to raise an additional $37 million for CTA by 2019. These revenues are funding a $146 million capital improvement program to improve reliability and speeds over the next five years on the Red, Blue, Brown, Green and Pink Lines and a $33 million program to enhance system safety through the expansion and upgrading of system-wide security cameras and station security features.



Oregon State, 2001

OreGO is a VMT-based pricing program that began in 2001 and is currently in a permanent pilot phase. Voluntary participants pay 1.5 cents per mile-driven in place of the state gas tax. The program is designed so that any vehicle with higher than 20 mpg fuel economy would pay less than the current gas tax.

Those who opt in to the program receive a device to measure VMT and are reimbursed for state gas taxes paid at the pump. Amidst other state-level proposals to fund transportation projects, Oregon DOT stands ready to make the VMT program available to more users.



Virginia, 2017

In 2017, VDOT levied dynamic tolls on a 10-mile section of I-66, a highway running between Washington, DC and its suburbs. Previously restricted to high occupancy vehicles during peak hours, solo drivers can now use I-66's new express lanes by paying a toll. The tolls recalculate every six minutes using a pricing algorithm that responds to demand and keeps traffic flowing at a minimum of 45 mph. The tolls are in place in the peak travel direction between 5:30 to 9:30 am and 3 to 7 pm. Monday through Friday.

Photo: Seattle DOT (Seattle)

2.3 Data

2.3

Data

Data has always played a key role in transportation planning and management. But today, the sheer amount of data collected has transformed data from a planning tool into an integral piece of infrastructure. Current estimates suggest that AVs could produce upwards of 4TB of data every hour as they move throughout a city.[61] This unprecedented volume of data requires cities and companies alike to transform their data management practices.

Before the advent of mobile phones and GPS, transportation data collection was labor-intensive and, as a result, largely a series of "moment in time" snapshots of activity on the street. Typical journey data sets include manual traffic counts, automated traffic recorders, travel time runs, surveys, and trip diaries. Payment and turnstile data provide basic transit statistics.

The introduction of GPS to taxi fleets opened up a new world of transportation data, including average traffic speeds, origins and destinations, and total geographic coverage. Bike share systems gave cities new information about the total number of cyclists. More recently, app-based ride-hail and shared micromobility services have opened the door to an even wider dataset: real-time "bread-crumb" information about routes, precise pick-up/drop-off locations, time, trip duration, speed, and cost. AVs, which recognize, categorize, and assess environments in real time, will offer even more opportunities and challenges for data collection.

Questions about this data—how it is collected, managed, protected, and stored, by whom, and for how long—are fundamental to managing an automated future. Collected and managed thoughtfully, the data produced by AVs could provide essential information that cities can use to create policies to support positive outcomes for mobility, health, the environment, economic growth, equity, and sustainability. In contrast, poor management or misuse of data by either the public or private sectors could lead to significant degradations of personal privacy and reduce the amount of information available for public policy making.

For most individuals, data informs mobility decisions and helps save travel time. Private companies, meanwhile, use data collected from users to estimate demand, set rates, chart routes, and plan personalized trips. As markets integrate, vertically and horizontally, companies may want to use data gathered from one source (e.g., the route a person takes) to feed other products (e.g., stores along that route).

Cities hold a dual role. As consumers of data, cities need data to monitor road conditions, streamline operations, increase efficiencies, regulate vendors, and track trends over time. But, as the frontline of government that is expected to protect the public interest, cities must strive to ensure that personal data is collected, used, and stored appropriately. To prepare for the future, cities must prepare themselves to take on a strong role in data management and policy.

Defining Transportation Data

Transportation data can be divided into two major categories:

Journey Data
Journey data describes how individuals or goods get from A to B, including granular information such as where they stopped, what mode they used, or how many deliveries they received per week. Historically, journey data was challenging to acquire and time-consuming to collect. With the proliferation of GPS and Wi-Fi-enabled smart phones, journey data is now extensive. Many aspects of journey data are often personally identifiable information. Journey data is also referred to as mobility data, geospatial data, or trip data.

Asset Data
Asset data describes the infrastructure and how it is or can be used. This includes static information like the location of curbs, traffic lights, streets, or bus stops, and regulatory information (e.g., street closures, turn restrictions, etc.) about what is permissible. Today's digital asset databases are often incomplete and are incompatible with other datasets that are maintained by other agencies or private sector companies. In the future, asset data could include real-time information about use or restrictions - e.g., Is the parking space in use? Is the street open or closed? How fast are cars traveling? Did the vehicle cross the cordon line? Adding use and regulatory information to asset datasets could guide AVs and help manage street operations without triggering the privacy concerns that come with journey data.

Cities should...

Enhance Assets, Catalogue and Push Asset Data

Cities should catalogue their asset data and update street infrastructure so that they can push out real-time information about how streets are used (e.g., road closures, route restrictions, parking occupancy, delivery zone use, etc.). Cities can strategically partner with companies to implement counters and sensors. In some cases, the data collected by AVs themselves could be used to populate and maintain asset datasets. By taking an active approach to asset data, cities can guide the autonomous future in powerful ways.

Focus on Open Data Specifications & Interoperability

Open data standards are a critical precursor to successful collaboration between the public and private sectors. As the number of data tools on the market proliferate, cities face a real risk of getting locked into proprietary tools if they do not prioritize open data. Cities should review development and procurement policies to ensure that open data is a prerequisite whenever possible, and support efforts to create open standards and specifications.

Enhance and Update Data Management Policies

The rapidly growing volume and breadth of that data means that cities must proactively ensure that their data management policies are up to date. As discussed in the NACTO/IMLA *Managing Mobility Data* guidance, cities should ensure that journey data is classified as personally identifiable information and treated as such in policies around management, storage, dissemination, and use. Cities should ensure that their data policies and practices are routinely updated and should encourage responsible data management practice from mobility vendors operating in the public right-of-way.

Build Up In-House Data Capacity

Cities should build up internal staff capacity to analyze and manage data so they can evaluate the quality of the data they receive from private vendors and push out asset data more readily. In addition to augmenting software expertise to handle analysis, cities should develop internal staff capacity around key skill or expertise areas such as data management, statistics, auditing, and fraud detection.

Control the Means of Communication

The autonomous future will require a host of short- and long-range communication systems. Cities should prepare by developing policies to manage communications hardware in the public right-of-way, pushing back on federal preemption legislation, and supporting efforts to restore net neutrality, to ensure that everyone has the ability to participate. City-owned infrastructure like utility poles and street lights are increasingly at the center of debates about access, as 5G technologies, which are expected to be the future of communications, rely on a large number of small access points (vs. the smaller number of large cell towers that support existing networks). Control over siting for this equipment will shape the landscape of communications and the autonomous future.

Coordinate for Privacy

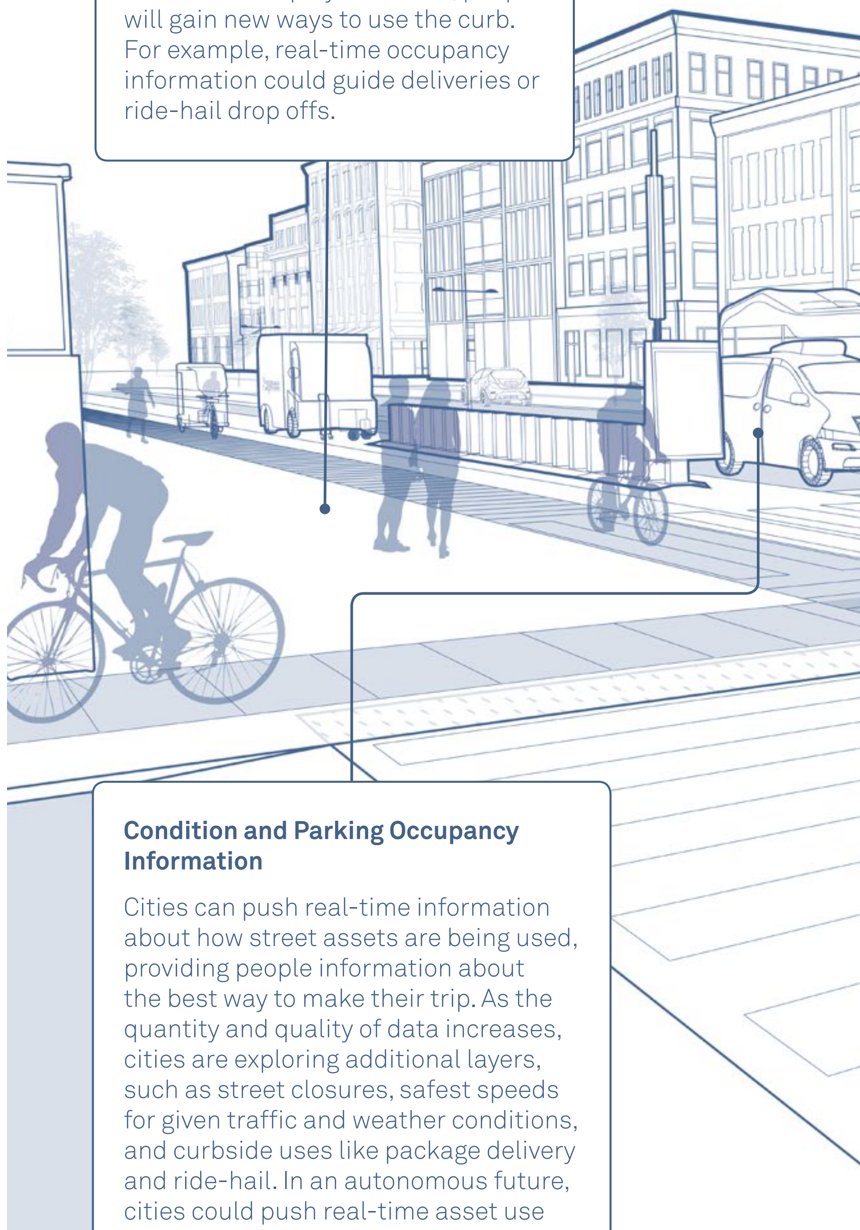
Unlike Europe, the U.S. lacks comprehensive consumer privacy protection policies that guide how data is collected, stored, used, and shared. Already, ride-hail and shared micromobility companies have exploited this policy vacuum to lobby states and the Federal Government to limit the ability of local governments to require data. Cities should coordinate with States and consumer protection groups to advocate for stronger consumer data protection laws, such as the GDPR in Europe.

Asset Data: The World Wide Street

Each day, billions of detailed, street-level data points are collected on everything from traffic speeds and volumes to travel patterns and transit use. This data is vital to the operations and management of streets. Street-level data points can be aggregated from a variety of different sources. The graphic at right depicts a selection of the diverse data streams that cities can use to better manage transportation networks and push asset information to users.

The Digital Curb

Curb space has become increasingly digital with the replacement of single-space payment meters by multi-space parking meters and pay-by-app services. As technology advances and cities and their private sector partners figure out how to best deploy new tools, people will gain new ways to use the curb. For example, real-time occupancy information could guide deliveries or ride-hail drop offs.



Condition and Parking Occupancy Information

Cities can push real-time information about how street assets are being used, providing people information about the best way to make their trip. As the quantity and quality of data increases, cities are exploring additional layers, such as street closures, safest speeds for given traffic and weather conditions, and curbside uses like package delivery and ride-hail. In an autonomous future, cities could push real-time asset use data to AVs to provide parameters for how they move about the city.

Counters & Sensors

Real-time counters and sensors can provide vital information about how the street is used. This information can be pushed out to other users to help them make transportation choices. Sensors can also inform signal timing. For example, the "walk" signal duration could be extended crossing a big street just after a full bus lets off passengers. Similarly, counters could recognize the number and speed of approaching bicycles and give cyclists priority at intersections.

Arrival & Travel Times

People make the best choices about how they want to travel when they know how long it will take and how much it will cost them. Transit authorities are already providing real-time arrival information. Routing apps provide information about travel times, parking availability, and costs. Multi-modal apps and on-street information displays can help centralize this information, making it even easier to access and use.

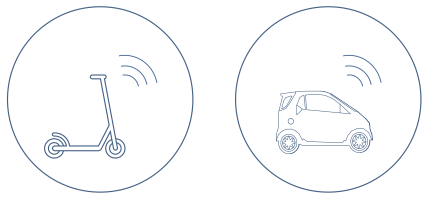
Connected Transit & Signal Priority

The bus is the original connected vehicle. Detectors or location data sent by the bus to either a central traffic management center or directly to the signal controller allows signal timing to be modified in real time to minimize stopping and other sources of transit delay. Networked transit signal priority could allow for better connections and increased reliability across the whole system.

The Path of Journey Data

Data Status: Collection

Actor(s):

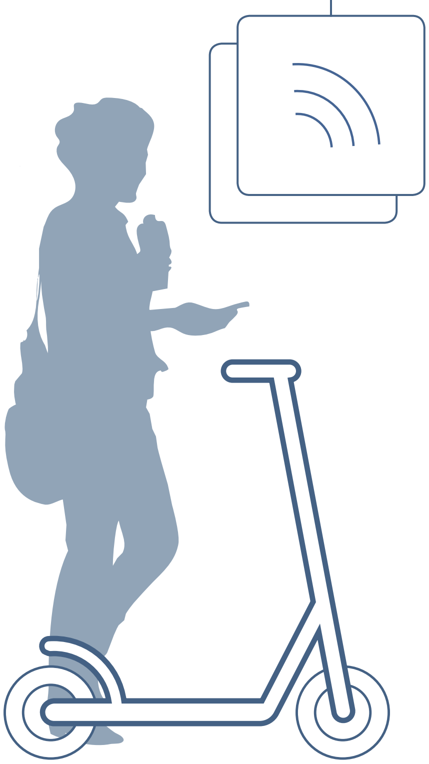


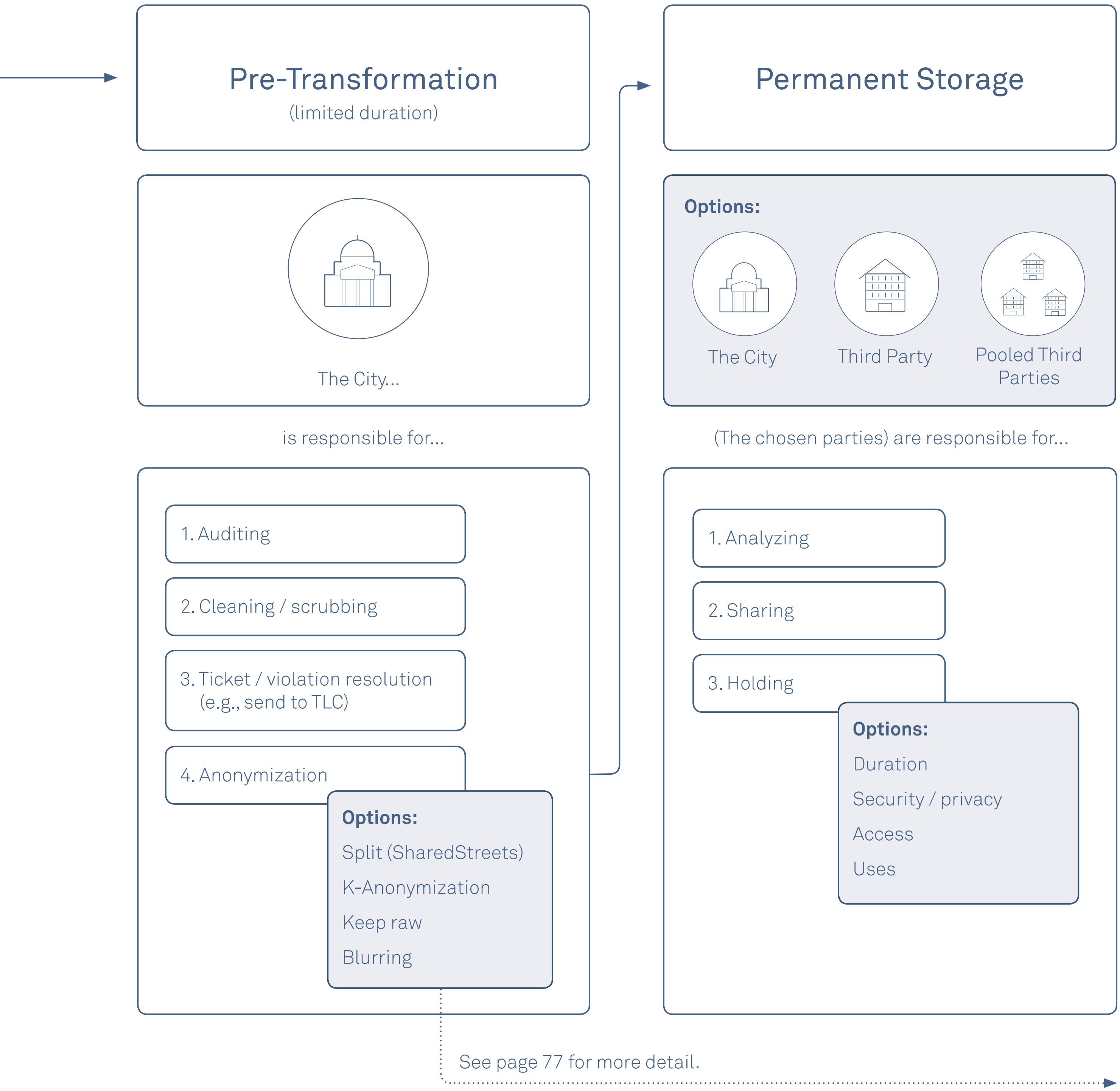
The Companies...

are responsible for...

Action:

...collecting data in established, city-developed format.





See page 77 for more detail.

The Challenge of Journey Data and Privacy

Regardless of who holds it, journey data poses unique privacy challenges. "Bread-crumb" data, for example, tracks a person's movement when location services are enabled on a phone. The GPS unit on the phone "pings" every few minutes or seconds, creating a detailed map of the route a person takes to walk to the grocery store or the speed at which they move. This information can be used to make informed decisions about transit service allocation or safety improvements. However, those same "bread-crumbs" could track a person to the doctor, a political rally, or a job interview. Such information is fundamentally private.

As discussed in ***Managing Mobility Data***, a guidance document co-developed by NACTO and IMLA, advances in data science and the huge increase in the volume, precision, and ubiquity of data mean that journey data is or can easily become personally identifiable information (PII). This happens in two ways:

Recognizable Travel Patterns – Even in anonymous datasets, people can be easily re-identified from their routine travel patterns – e.g., from home to work, school, stores, or religious institutions. The 2013 Scientific Report article, "Unique in the Crowd: the privacy bounds of human mobility" found that, in a dataset of 1.5 million people over 6 months, and using location points triangulated from cellphone towers, "four spatio-temporal points are enough to uniquely identify 95 percent of the individuals."[62]

Combined With Other Data – Journey data can be combined with other data points to become PII. For example, taken by itself, a single geospatial data point like a ride-hail drop-off location is not PII. But, when combined with a phonebook or reverse address look-up service, that data becomes linkable to an individual person. For example, in 2014, a researcher requested anonymized taxi geo-location data from NYC Taxi and Limousine Commission under freedom of information laws, mapped them using MapQuest, and was able to identify the home addresses of people hailing taxis in front of the Hustler Club between midnight and 6 am. Combining a home address with an address look-up website, Facebook and other sources, the researcher was able to find the "property value, ethnicity, relationship status, [and] court records" of individual patrons.[63]

Today's data management choices will impact the world we live in tomorrow. The public and private sectors alike should look to develop data practices and policies that increase the amount of information available for planning and policy making, while simultaneously increasing privacy protections and ensuring that data is protected and managed appropriately.

On the public sector side, cities must strengthen their data management and analysis capacity, recognizing that not all data analysis or aggregation methods are the same when it comes to protecting privacy or providing useful policy-making or planning information. Cities should also retool procurement and development processes to prioritize open standards to avoid getting locked into proprietary systems that may be unsuited to properly address privacy or planning and regulatory needs. As cities gather additional essential mobility data, they should work to educate lawmakers and attorneys on the ease with which mobility data can become PII to prevent inappropriate disclosures.

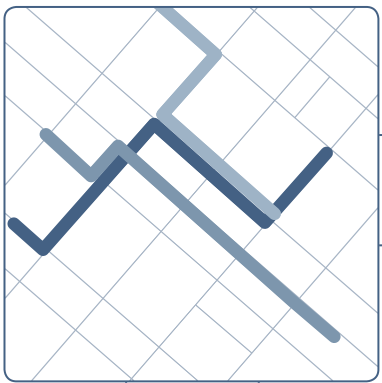
As the age of autonomous vehicles approaches, revelations about the data (over)-collection and loose handling practices of internet giants like Facebook[64], Google[65], and The Weather Channel[66], should be treated as a wake-up call. U.S. citizens lack federal-level data privacy protections, creating a state-by-state patchwork for protection. In response, calls for a "data bill of rights" are mounting.

The European Union's General Data Protection Regulation (GDPR) provides a good example of active government intervention to address privacy. First enacted in 2016, the GDPR defines basic protocols for protecting a person's privacy, including guidelines to limit the over-collection of data, rules for informed consent, and policies for anonymization, storage, and access. The GDPR is meant as a safeguard against the abuse of data by both private and public actors, who may be able to access personal information for personal use, abuse, or enforcement.

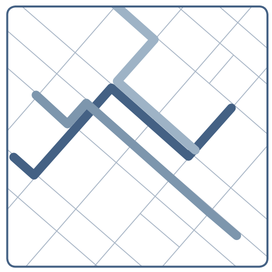
Data Anonymization Methods

Different data anonymization methods produce different results for analysis and privacy.

Generated Data

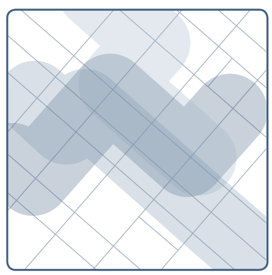


None (raw)



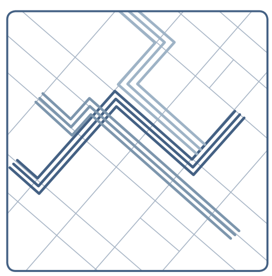
Data remains unprocessed. Individual trips can be tracked from start to finish creating significant privacy and liability issues for data holders.

Data Blurring



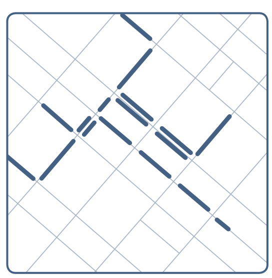
Aggregators remove decimal places from the latitude/longitude coordinates that make up each point in a GPS route (i.e. 40.6893002,-74.0444091 becomes 40.689,-74.044). Privacy issues can be reduced by decreasing the overall precision of the data itself.

K-Anonymization



Aggregators hold full unprocessed trip data until they gather enough identical trips to batch together. Data is then aggregated, and unprocessed records are deleted. Individual trip information can be accessed for the duration of time it takes to gather identical records.

SharedStreets Aggregation



Aggregators snap individual GPS points to individual street segments but divorce those points from other information about the trip in totality, such as origin or destination. Data precision remains high but an individual trip cannot be traced from start to finish. SharedStreets applies k-anonymity to data at the precision of street segments.


THE KINGS ARMS
e-cargobikes
CLEAN AIR MILES

Photo: Tomtek Photography for Team London Bridge (London)

2.4 Urban Freight

2.4

Urban Freight

Urban freight delivery is critical to the functioning of our cities. Supermarkets and restaurants need deliveries so that we can eat. Package services to the curb or to office loading docks are driven by deliveries that we request. Reliable, consistent delivery service allows cities to grow and thrive.

Largely driven by same-day and just-in-time delivery, the quantity of urban freight is growing rapidly. By 2020, the total number of annual packages delivered is expected to increase to 16 billion, up from 11 billion in 2018.[67] Coupled with growth in urban driving caused by ride-hail services, overall congestion is increasing. Experts estimate that, in 2016 alone, truck drivers spent 1.2 billion hours sitting in traffic at a cost of $74.5 billion in additional operations costs.[68] Unmanaged, automation could propel that to unsustainable levels. To prepare for an autonomous future, cities must develop sophisticated urban freight policies that prioritize and group deliveries to reduce the number of freight trips and increase efficiency and safety.

Automation offers unique opportunities for the movement of goods. Automated rail service, augmented by coordinated autonomous trucks, could transport goods cross-country. Incentivized and managed by thoughtful pricing and other coordinated policies, automated freight vehicles could drop goods at consolidation points at the edge of the city, transferring their packages to smaller vehicles and electric/human-powered delivery trikes. These smaller, city-scaled vehicles could then enter dense urban areas and take packages the last mile and the last 50 feet to the customer's door. Already, such policies are being tested; a recent survey of light electric freight vehicles in Amsterdam identified a variety of delivery consolidation structures and companies using e-trikes to make urban deliveries.[69]

> Cities must develop sophisticated urban freight policies that prioritize and group deliveries to reduce the number of freight trips and increase efficiency and safety.

Alternatively, autonomous freight could exacerbate dystopian outcomes. Autonomous, high-speed long-haul platoons of trucks could increase dangers on roads and highways. Uncoordinated autonomous delivery services could flood sidewalks with bots, making walking increasingly difficult and unpleasant. Drone delivery could significantly increase noise pollution and add a new dimension of chaos to urban streets.[70] The freight industry employs over 2% of the total US workforce[71], creating potential for widespread unemployment if workforce transition programs are not developed. Comprehensive coordination is essential to avoid this future.

Cities should...

Consolidate Based On Destination, Not Carrier

Today, most deliveries are organized by who is delivering it, not where it is going. As a result, especially in large office buildings, multiple carriers may serve the same building at the same time, adding unnecessary congestion to city streets. As is already in practice in parts of Europe, cities and their private sector partners should incentivize the creation of consolidation facilities that allow multiple delivery services to bring goods and packages to centralized locations. From there, packages going to unique or adjacent addresses can be combined into one shipment and delivered by e-bike or small delivery AV.

Off-Peak Delivery

Most commercial delivery and some portion of office delivery is regularly scheduled deliveries. To reduce freight congestion, cities and operators should use time-access pricing and incentives to reassign these to less congested times. In addition, shifting predictable deliveries to off-peak hours opens up space and opportunities for more urgent or unpredictable deliveries. Off-peak delivery could be combined with consolidation centers, which could help schedule last-mile delivery at workable times, especially for small businesses who might not have night staff.

Down-Size Freight Vehicles

Today, most trucks are too big for urban settings. Their size reduces their maneuverability on the street and makes it hard to find space for loading or unloading. As cities prepare for AVs, they should explore regulation and incentives to encourage companies to down-size their fleets, and prioritize smaller vehicles in municipal fleet purchases. Already, companies like UPS are piloting delivery services with electric bicycles. Similarly, commercial vehicles are adopting existing lower-level automated systems to enhance vehicle safety. In 2015, the European Union required all heavy goods trucks to employ these automatic emergency braking and lane keeping assist to reduce the risk and severity of collisions.

Develop A Curbside Asset Database

The key to managing freight is managing the curb. Cities should develop an active curbside asset database showing the location and size of existing loading zones, curb cuts, hours of operation, and other pertinent infrastructure, markings, and signs. Cities should also build data sharing agreements and partnerships with the private sector to conduct freight flow analyses to understand city and regional freight movements, including different types of deliveries and truck traffic flows.

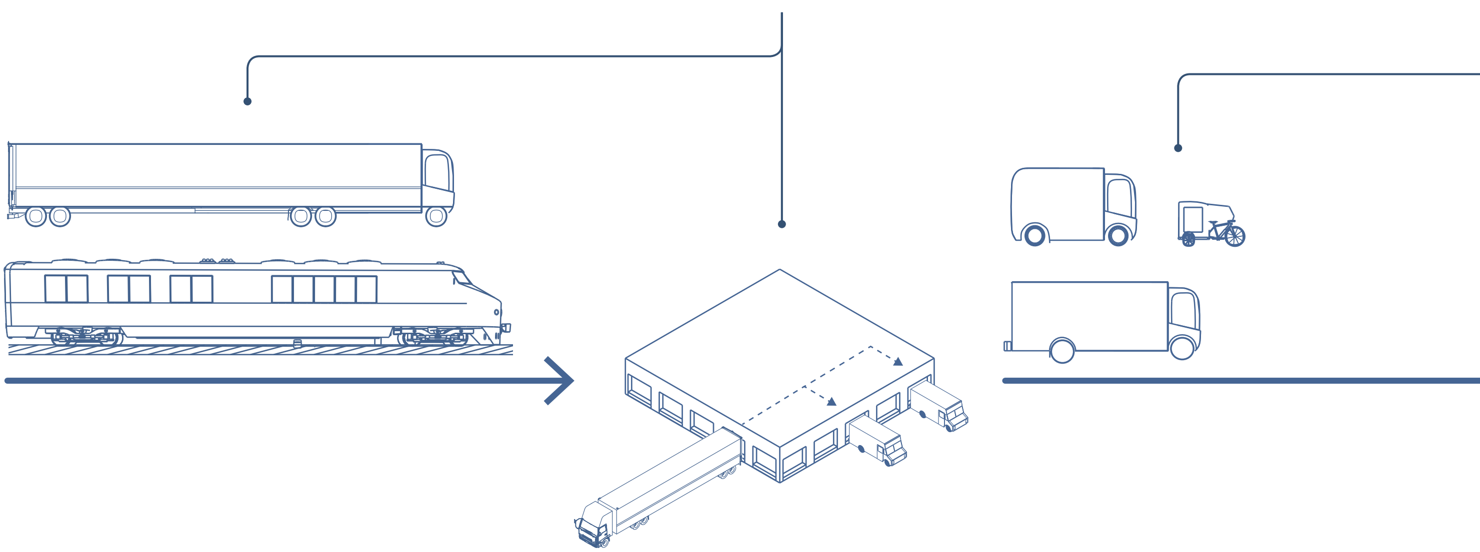
Freight Opportunities In the Age of AVs

Long-Distance Freight

For long-distance freight movement, autonomous technologies offer a number of efficiency advantages, allowing companies to move goods at all hours without increasing labor costs. For rail and truck freight, goods could be unloaded at strategically located depots in and around the city, to be consolidated into local deliveries.

Freight rail, in particular, is ripe for automation. Rail freight runs on a fixed track in a designated right-of-way, reducing the need for many of the peripheral awareness sensors that are essential for more complex environments like streets or highways. Already, precursor technologies, like positive train control which stops or slows trains when an obstacle is detected ahead, are in use.

For trucking, automation is further off. A number of companies in the U.S. and Europe are testing platoon systems for long-distance freight. Volvo, for example, is working on an automated tractor-trailer for repetitive long-haul operations.[72] As an interim step, before fully-automated platoons are on the highways, many companies anticipate using a human-driven vehicle at the head of a convoy to handle acceleration, braking, and steering, with automated vehicles following behind.



The Last Mile

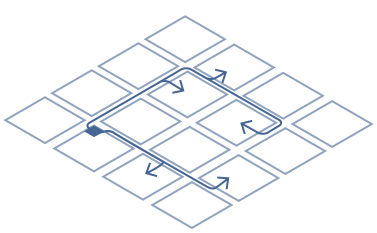
To handle the complexities of city streets, urban freight will likely best be handled by people using a combination of small AV-assisted and human-powered/electric vehicles. Supporting local freight delivery with automation and downsized vehicles would increase safety and enhanced route planning and efficiency. Especially in dense urban cores, smaller vehicles may be essential. For example, a central London courier firm found that their e-cargobike employees were capable of making more than 30 deliveries per day, versus 10-12 deliveries for their van-base employees.[73]

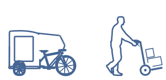
The high volume of commercial and office deliveries—multiple packages going to the same place but delivered by different carriers—shows the need for consolidation points. As is currently being explored in Europe, there are a number of options for how and where freight could be consolidated depending on what goods are being delivered and the frequency of delivery. For example, some companies rely on consolidation hubs outside the city center. Others create multiple mobile hubs by parking larger trucks at strategic locations and then completing individual deliveries via e-cargobike.

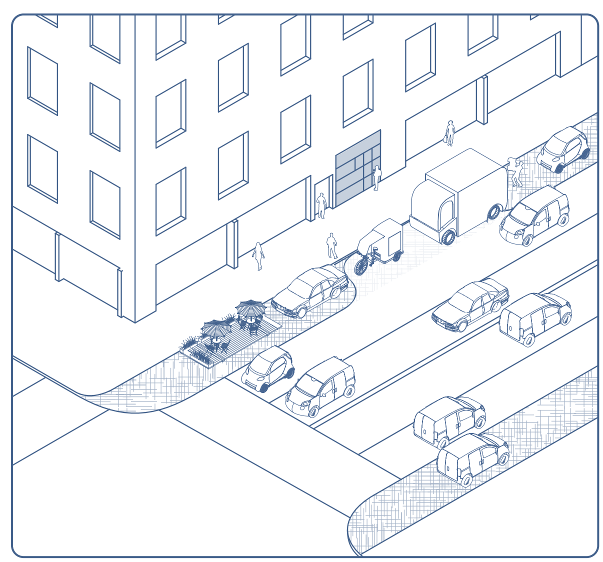
The Last 50 Feet

People remain the best solution for the last fifty feet. While a vehicle can use a digital mapping database to find an address, for example, it may have difficulty determining the exact delivery point (that is oftentimes around the back or side of the building). To increase efficiency, human labor can be augmented by electric carts.

The data architecture that underpins AVs has key implications for curbside management and freight as cities develop tools, predictive algorithms, and curbside reservation systems to better manage demand for the curb. For example, the City of San Francisco used sensors and variable meter pricing to create a demand-based parking management system that encourages parking turnover and reduces circling and double-parking. Drivers can find parking spaces via the SFPark app or website. To manage urban freight, cities could develop an SFPark-style system to inform delivery drivers of loading zone availability. Cities could use curbside asset management technology to develop a booking system where trucks can reserve space.







Labor in the Age of AVs

As with transit, the livelihood of the millions of individuals currently employed in the trucking industries is a key issue that must be grappled with in preparation for AVs. Together the trucking, taxi, and ride-hail industries employ almost 3 percent of the total American workforce, providing over 4.1 million jobs.[74] People of color are overrepresented in this industry, and automation's potential to displace these workers risk exacerbating financial hardship along racial lines.[75] Along with their federal and state counterparts, city governments have a responsibility to act to avert widespread labor disruption.

For freight, the complexity of urban streets and the nuances of where and how packages are delivered means that jobs created in the last mile and last 50 feet are likely to remain in human hands. However, these jobs may shift and change as AV technologies augment or assist human operations. Companies must act now to ensure that their workforce, and their future workforces, are trained and equipped for the technologies of the future.

Going beyond freight, there is no shortage of policies and programs governments could enact to mitigate the short-term effects of job loss accompanying automation. Cities can begin this process by evaluating the jobs that the AV development trajectory will impact. In the event of larger-scale job losses, cities are also empowered to strengthen the local social safety net by guaranteeing workers automatic unemployment insurance and access to medical care.

Acting unilaterally, cities can support employees driving municipal vehicle fleets by upholding collective bargaining and public sector unions. As a group, cities can advocate for stronger workers' rights and other creative solutions to automation-related labor disruptions such as a progressive basic income and worker ownership over AV fleets and companies.

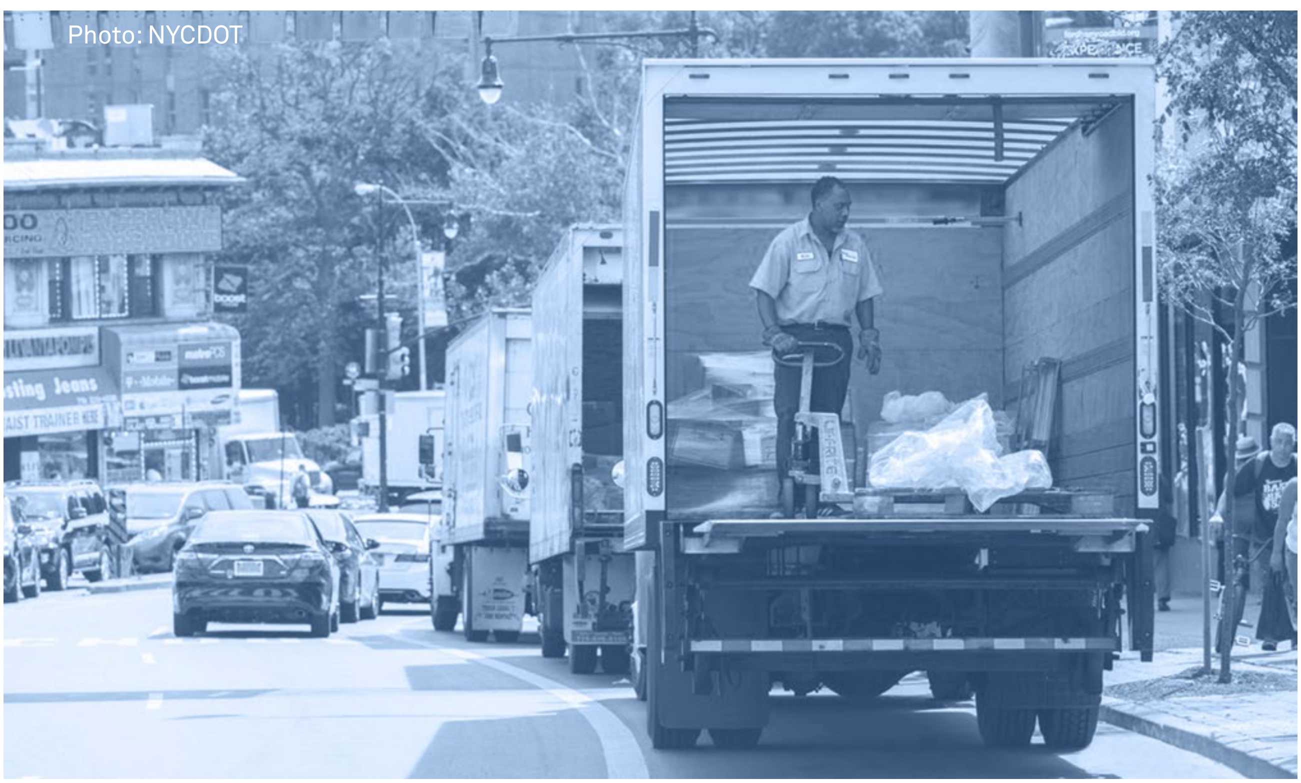


Photo: NYCDOT

Human-Scaled Freight

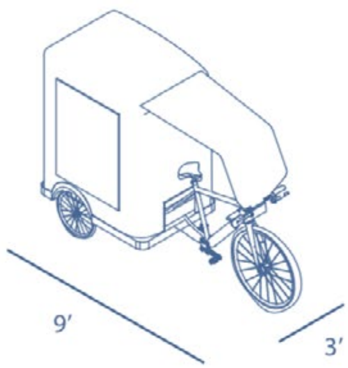
Nationally, large trucks comprise 4 percent of the U.S. vehicle fleet, yet are involved in 7 percent of pedestrian fatalities, 11 percent of bicyclist fatalities, and 12 percent of car and light-truck occupant fatalities.[76] In developing freight management policies to prepare for automation, cities and companies alike have an opportunity to increase efficiency and safety by reducing the size of freight vehicles operating in cities.

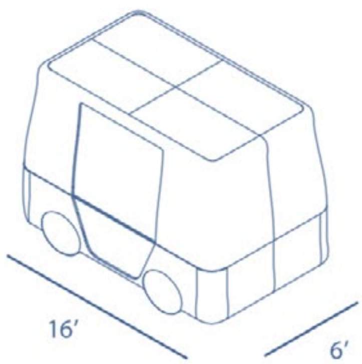
On the efficiency side, studies show that shifting to smaller vehicles can increase efficiency by speeding up loading/unloading times. This could increase the value of flex zones and help companies reduce the number of parking tickets they receive. Research conducted in Amsterdam suggests that e-cargobikes can be loaded/unloaded in about 3 minutes, versus a 12 minute average for the same amount of freight from a delivery van.

Similarly, by consolidating freight into smaller vehicles for consolidated last mile delivery, delivery companies may be able to run fewer half-empty trucks. As noted in NACTO's Optimizing Large Vehicles for Urban Environments reports, co-produced by the USDOT Volpe Center, on average, trucks in the US operate at anywhere between 50 percent and 90 percent capacity. USDOT reports that empty trucks drive over 20 billion miles per year. Consolidating packages going to the same or adjacent locations may help reduce unnecessary VMT.

On the safety side, reducing the size of freight vehicles has two benefits. First, larger trucks, regardless of if the driver is human or a computer, have slower stopping distances and are more lethal when they hit someone. Today, overall truck size, combined with outdated design features, mean that truck drivers have limited visibility, increasing the likelihood of a crash. Requiring Direct-Vision truck cabs, cab-over designs, and other visibility tools can increase safety now while also creating a new platform for sensor placement for autonomous and AV-assist tools.

Second, large trucks are less maneuverable than smaller ones, requiring cities to accommodate them with overly wide streets and intersections. The wider lanes and larger corner radii reduce safety by encouraging speeding and increasing crossing distances. As freight companies and municipal fleets shift to smaller vehicles, cities can design safer, more vibrant, human-scaled streets.

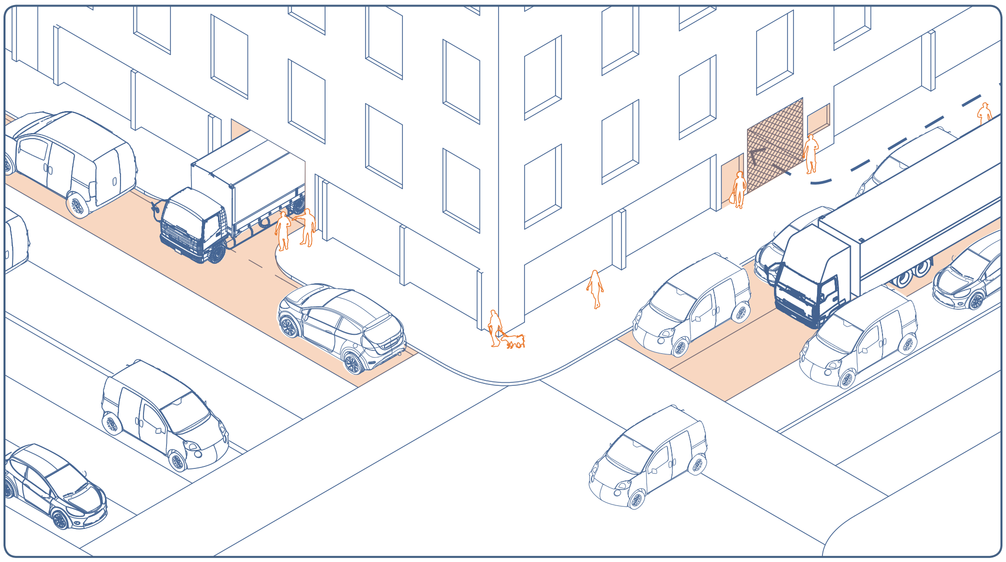




The Future of the Curb

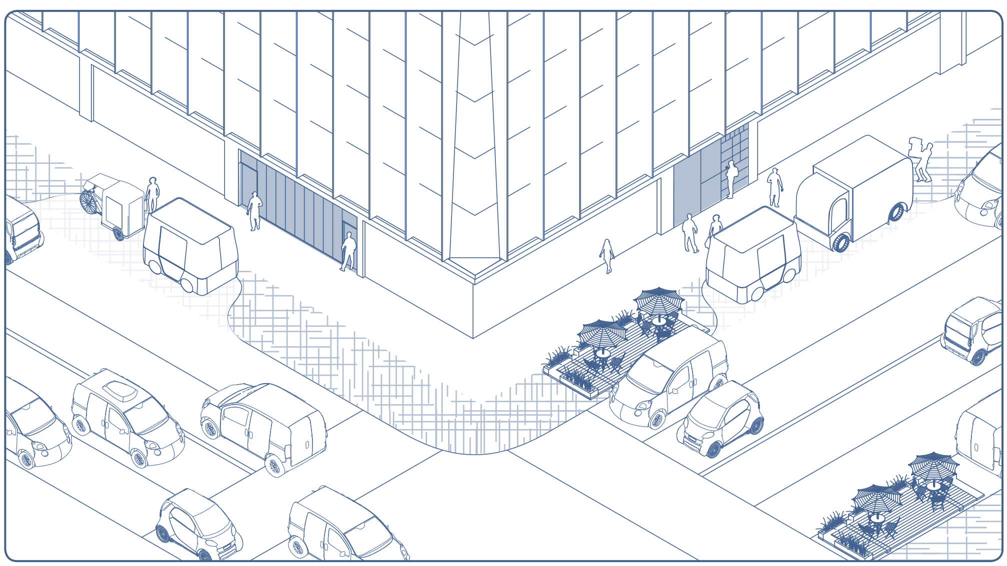
Today

Trucks can legally make deliveries only when a parking space or loading dock is available and open. However, loading docks are often undersized or used for parked cars, trash or storage, making them less reliable than intended. On street parking is first-come, first-served—not prioritized for delivery or essential services.



Future

Dynamic curbside pricing can more efficiently manage curbside drop-off and pick-up, creating incentives for both carriers and receivers to reduce their dwell time or risk paying escalating rates. Smaller vehicles increase efficiency and reduce loading/unloading times.



The Challenge of Micro-Freight Devices

Drones: A New Frontier for Cities

Delivery drones, or unmanned aerial vehicles (UAVs), are a relatively new addition to the urban freight landscape. These drones have the ability to deliver lightweight packages and are already used to deliver time-sensitive items such as medicine and blood samples to remote locations inaccessible by other means. In 2016, the Federal Aviation Administration (FAA) began allowing companies to test drones for commercial uses in the US. The agency set a limit on the combined weight of drones and their packages and required a licensed pilot to keep the device within sight at all times.

For cities, the proliferation of drones in urban airspace poses questions about jurisdiction, drop-off logistics, and extending management of the public right-of-way to spaces other than streets. Cities will have to contend with unprecedented noise pollution considering that the average commercial delivery drone is 85 decibels loud, comparable to a gas-powered leaf blower.[77] While the FAA historically regulates all airspace in the US, cities should take an active role in shaping the drone policy to mitigate potential safety, noise pollution, and space allocation issues.

Sidewalks: Not for Bots

Perhaps the most futuristic vision in the freight sphere is the notion of humans and robots sharing the sidewalk as bots the size of picnic baskets and filing cabinets trundle around delivering packages to customers. While states including Virginia, Idaho, Florida, and Wisconsin have relaxed rules to allow these vehicles to operate, San Francisco has notably restricted their use, requiring companies to apply for a limited number of permits and permitting the vehicles only in areas zoned for industrial use.

In dense areas where pedestrian activity is high, bots would likely clog the sidewalk and inconvenience or endanger people on foot. They should be severely restricted if not banned outright. In contrast, these small bots might have a role to play in more controlled environments such as industrial parks or university campuses.

Photo: Eduardo Famendes

Photo: Starship Technologies