ARUP

Urban Curb Management Strategies: The State of the Practice Post-Pandemic

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Contents

Uber ARUP

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Executive Summary

If you're reading this report, you're likely aware of the paradigm shift that's been happening in urban communities about the highest and best use of the curb. Historically handed over to free parking for private vehicles, the movement to rebalance our streets and public spaces has been working towards a more dynamic model for curbside uses.

We are at a unique point in time—post-pandemic 2024—when cities are adjusting on a longer-term scale to urban patterns and demands seen during and after the pandemic, as well as attempting to codify temporary changes initiated during the pandemic. These trends, evolving technologies, and rising demands for loading and delivery present new challenges to cities to manage the curb.

This study draws on extensive research and insights about the latest practices in curb management to support urban mobility, access, livability, safety, equity, and economic development. We examined U.S. cities, reviewed literature, and interviewed practitioners and policymakers to identify key strategies for optimizing curb use and unlocking its potential.

Reading this report

This study summarizes the state of the practice of curb management in the United States, identifies the key challenges and opportunities to improve curbside performance, highlights salient findings throughout the course of this research, and provides recommendations for curb management practitioners and policymakers.

It is organized by the following topics:

1. Maximizing Productivity
2. Reducing Curb Demand
3. Addressing Safety
4. Dynamic Management
5. EV Charging
6. Access for Autonomous Vehicles

These topics are not the only lens through which to look at curb management, but also a reflection of where policy, research, and operations are today and what must be considered to prepare curbs for the decades to come.

Curb Functions in their Urban Context

Key issues, practices, and recommendations

Managing demand effectively is critical for cities to ensure that passengers, deliveries, parking, public spaces, and other users and uses are able to access the curb efficiently and equitably. A well-managed curb can support broader city goals like adapting to changing transportation needs and technology, improving safety, supporting local businesses and economic development, and enhancing mobility and sustainable practices.

This report explores six areas where cities can maximize the potential for the curb based on a review of existing city policies, pilots, strategies, and reports.

1. Maximizing productivity at the curb

Inefficient curb management results in congestion, safety issues, and valuable curb space that is occupied by a small number of users or activities. To counteract this, cities are deploying strategies to make their curbs more productive for all users and activities.

One of the main strategies cities are experimenting with is dedicated loading areas for specific uses. While not a new concept, providing space to support the surge in on-demand delivery vehicles, passenger loading areas in active nightlife areas, and establishing clearer regulations have had positive results. Automated enforcement has also been effective in reducing transit delays due to illegal parking in travel lanes and bus stops.

To get the most use out of limited curb space, recommendations include:

- Establish curb productivity measures that incorporate deliveries, mobility, activation, safety, and equity.
- Repurpose curb space for the most productive uses based on established priorities and goals for the street, neighborhood, or land uses.
- Integrate curb demand and delivery vehicle forecasting into the planning review process to design and program the curb to anticipated needs.
- Prioritize proactive curb management based on operational and equity needs, rather than reactive management based solely on complaints.

2. Reducing curb demand

In addition to optimizing performance at the curb, cities are pursuing strategies to reduce and redistribute demand away from the curb. Reducing demand can include prioritizing shared mobility over private vehicle use. Redistributing demand can include strategies such as pricing or use limits to spread curbside demand out and use nearby curbs and off-street facilities, or even to shift peak-hour deliveries to off-hour deliveries.

To know what can be shifted and where, cities are collecting data on how curbs, off-street parking, and off-street loading infrastructure are being used by all users. When tied to clear actions, data can help focus these types of initiative to areas where they are most impactful.

To shift demand to loading space in buildings or underutilized curbs, recommendations include:

- Update building codes and retrofit existing facilities to provide sufficient space for delivery management.
- Shift curb demand to off-street infrastructure and underutilized curb space.
- Make urban deliveries more efficient through practices like consolidation, vehicle right-sizing, and last-mile delivery lockers.

3. Addressing safety

At a time when traffic safety is a top priority for cities across the US, curb locations present a unique set of safety issues and challenges. Competition for the curb can introduce conflicts, particularly when activities overflow into adjacent travel lanes.

In addition, collision data is incomplete as it pertains to the curb, making it difficult to measure, evaluate, and address safety in these locations. Despite the data limitations, many cities have been nimble in deploying proven safety countermeasures that can maximize safety at curbside locations.

To incorporate citywide traffic safety initiatives into curb management approaches, recommendations include:

- Identify opportunities to implement safety countermeasures in concert with curb management policies and practices.
- Collect data to identify curb policy-related collision factors to better inform safety policies and practices.

4. Dynamic and informed curb management

Curb digitization and real-time data have become crucial components for cities to implement dynamic and informed curb management. By leveraging technological advances, cities are improving their ability to maximize benefits of the curb.

However, there are significant staffing and budgetary challenges to collecting, analyzing, and utilizing this data using traditional methods. Ways of collecting and using data are evolving but are still intensive and often require third-party vendors to help cities collect data to support curb access and measure curb regulation efficacy.

To digitize the curb for specific management goals and outcomes, recommendations include:

- Define clear outcomes and goals before digitizing the curb.
- Collect data only when dynamic curb management will be implemented.
- Update payment and pricing systems and interfaces.
- Use data to support a system that focuses on preventing bad outcomes and creating value for system users.

5. Electric vehicle charging

Cities are increasingly investing in publicly available electric vehicle (EV) charging infrastructure to support the growing number of electric vehicles. The infrastructure required for on-street EV chargers does not allow flexible curb uses, or changes in the short term, so cities need to carefully plan how and where on-street EV charging is installed to maximize their benefit without infringing on other priorities.

EV charging at the curb requires infrastructure and long dwell times, so it is locked in as an exclusive use that cannot change dynamically during the day or easily change over time. Therefore, cities typically consider EV charging as a storage use that is a low curb priority on most streets.

To determine the optimal location and utilization for public EV charging along the curb, recommendations include:

- Implement on-street charging in contexts with equity needs in addition to charging needs, like neighborhoods with low access to private charging points. Even in these contexts, charging should still come after more significant curb priorities (e.g. transit, pedestrians).
- In busy commercial areas, prioritize other curb activities and locate EV charging off-street.
- Invest in fast-charging infrastructure at strategic locations (e.g. airports, highways, downtown parking garages), given the costs and challenges of installing DC fast chargers at the curbside. This can include off-street locations or lower-demand curb spaces.

6. Access for autonomous vehicles

Autonomous Vehicles (AVs) are not yet prevalent, but they are growing fast with recent adoption in San Francisco, Las Vegas, and Phoenix. Through advanced sensors and mapping technologies, AVs can navigate and park in existing spaces, adapting to conventional curb layouts without requiring significant infrastructure upgrades.

AVs are programmed to follow operating rules, such as only picking up or dropping off passengers at the curb or other designated location. Not all AVs operate the same way, however, so clear and consistent rules and designated loading areas for AVs are key to safe and smooth operations.

To optimize AV access at the curb, recommendations include:

- Identify designated loading zones and unloading areas for pick ups and drop offs, and expand them for AV use.
- Clearly communicate curb space and desired AV drop-off locations.
- Prioritize shared AV trips and shared AV fleets over single-occupant trips and private ownership.
- Design for AVs to improve access for transit and people with disabilities.

Implementation

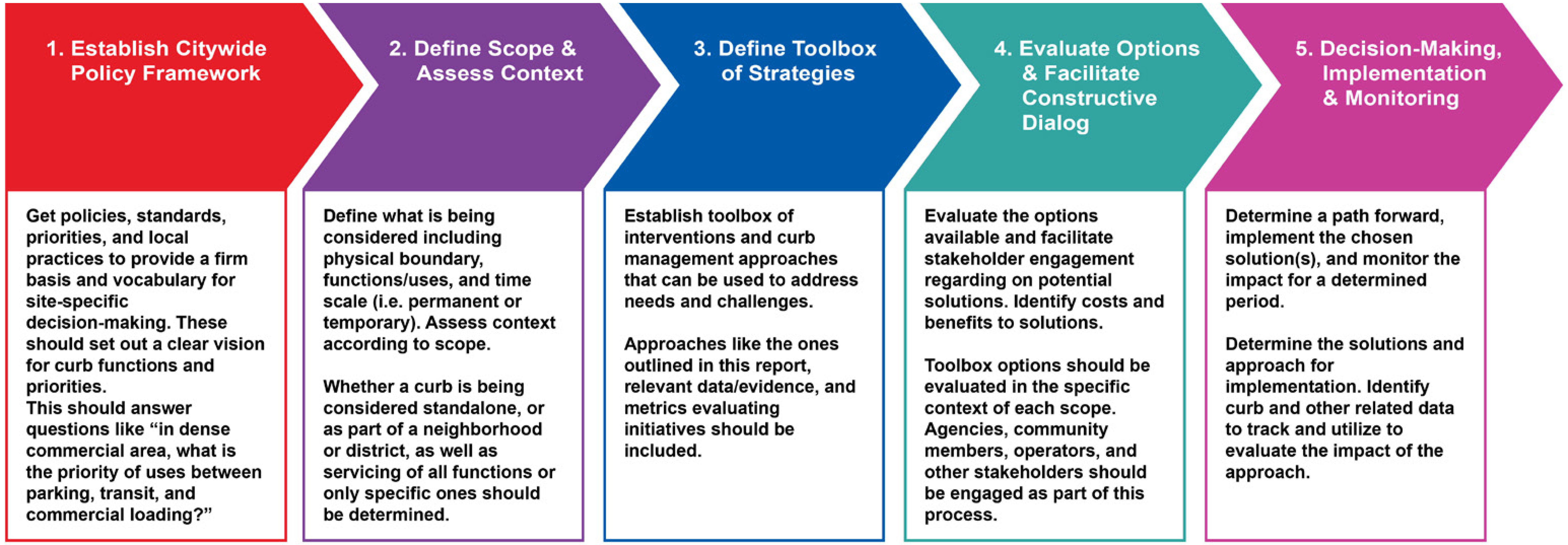
Implementing these strategies often comes with challenges and trade-offs that must be addressed in coordination between stakeholders and public agencies. Cities should set clear policy priorities and establish a transparent, consistent decision-making methodology. This approach will streamline the process, build trust, leverage available data and facilitate effective decision-making. Figure 1 shows an example of the kind of decision points that an implementation methodology can address.

Common aims, competing needs

Cities across the country share high-level goals for their curbs, such as safety, quality of life, etc. However, curb allocation and management decisions are context-sensitive and require difficult compromises, often with significant implications for adjacent property owners, tenants, and the larger community. Therefore, decisions are inherently local, reflecting unique local conditions and community priorities.

A robust menu of options

Like all urban mobility challenges there is no simple, one-size-fits-all solution, and cities must contend with limited funding and political forces. However, cities can take advantage of the strategies explored in this report to proactively manage the curb using a mix of policy, physical infrastructure, operational changes, and emerging technology that is creating new opportunities.



The authority responsible for curb management should define their own specific approach in coordination with stakeholders. External parties, like Uber, should be given the opportunity to participate in this process and advocate for positive outcomes for riders, drivers, and communities.

Figure 1
Approach to curb allocation

Introduction

Why curbs matter

Curbs are the boundary that separates the roadway physically and visually from the sidewalk. More than a space for on-street parking, curbs support the movement of people and goods, access for people to a variety of transportation modes, public activation, utilities, and services.

More is being demanded of the curb from long-standing and more emerging uses of the curb such as commercial delivery, shared mobility, electric vehicle charging, waste management, outdoor dining, and more. While cities recognize the value of curbs and are implementing new policies and practices to optimize curb use, they are still experiencing the negative effects of excess demand and inequitable curb access: congestion, pollution, safety issues, transit delays, quality of life impacts, missed economic opportunities, and lost revenue.

What is curb management?

Curb management is the strategic allocation of curb space to maximize community benefits such as access, safety, equity, sustainability, and economic goals. Challenges of implementing curb management strategies include factors such as limited funding and staff resources, challenging political dynamics around reallocating curb space, and the complexity of addressing multiple issues simultaneously at the curb.

Funding and resourcing constraints can hinder the implementation of comprehensive solutions, while political dynamics may slow down decision-making processes and limit change. Addressing complex issues such as parking demand, pedestrian safety, and commercial activities concurrently requires careful coordination and resource allocation. Innovative approaches and collaboration among stakeholders are essential to overcome these challenges to manage the curb effectively in urban areas.

Background

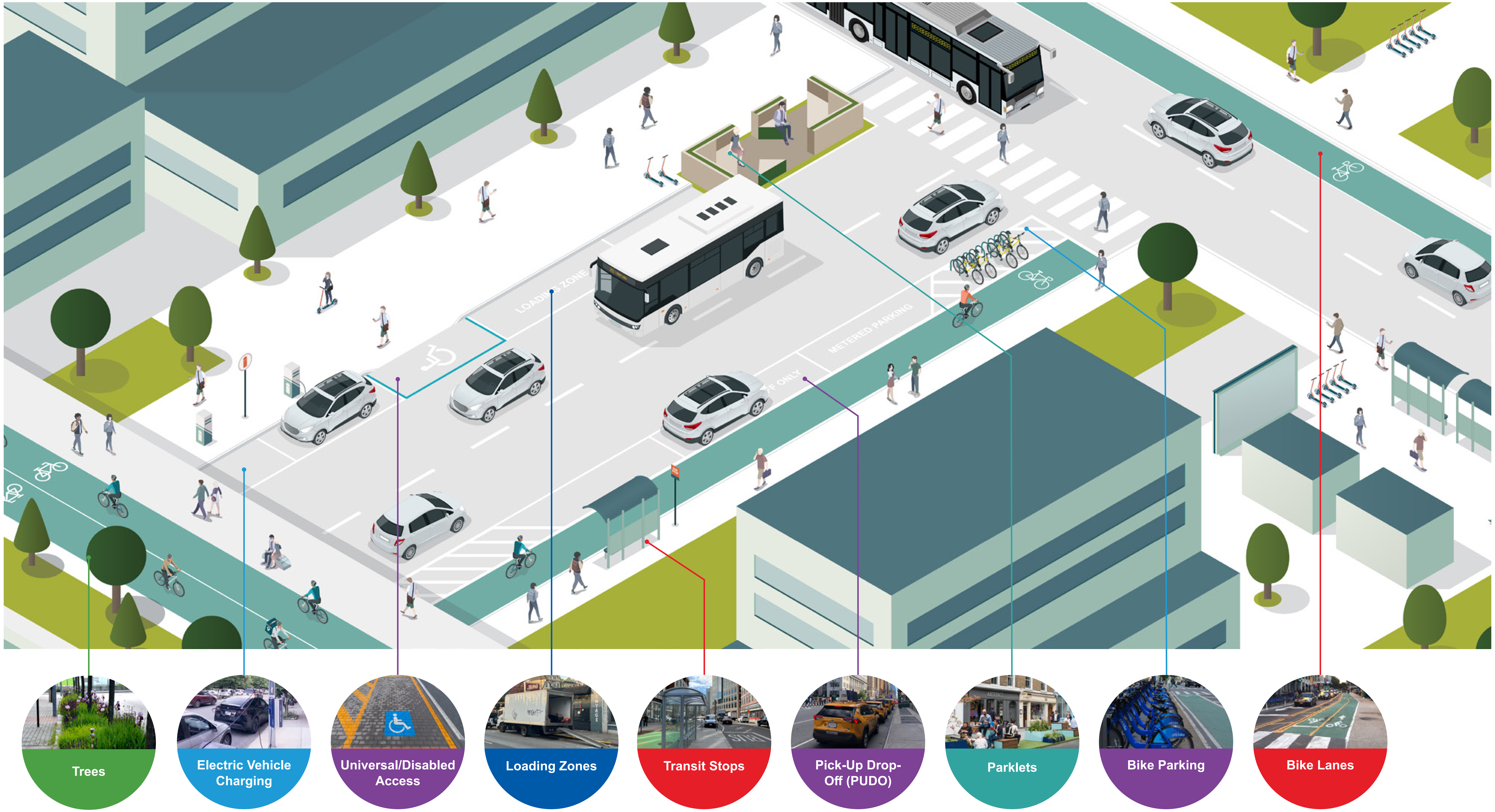
Curb uses

Curbs are a public asset and should be managed as such. Since the early 20th century, however, the majority of curbs have been used for little more than free parking for private vehicles. The overabundance of free parking persists today, in cities like New York, for example, where approximately 97% of the city's roughly 3 million on-street parking spaces are free.[1] Effective curb management involves policies and strategies designed to reduce street parking's inefficiency and rebalance the curb to better accommodate other uses.

Today's curbs must serve a diverse range of functions. Cities group curb uses into functional categories, such as this combined example drawn from Seattle,[2] San Francisco,[3] and New York.[4]

97%
of New York city's roughly 3 million on-street parking spaces are free

Categories	Definition	Examples	
Mobility	Movement of people and goods	– Bus or transit lanes – General travel and turn lanes – Peak hour-only travel lanes	– Driveway access – Curb extensions and walking lanes – Bike lane
Access for People	People arriving at their destination or transferring between different modes of transportation, not including long-term vehicle storage	– Transit stops – Pick-up/drop-off (PUDO) zones – Passenger loading zones – Micromobility storage	– Short-term/metered parking – Taxi zones – Universal/Disabled Access
Access for Commerce	Goods and services reaching their customers and markets	– Commercial vehicle loading zone – Truck loading zone – Customer pick-up of goods	– On-demand delivery – Parcel delivery
Activation	Programming and installations for vibrant social space	– Seating – Public art – Street festivals	– Parklets and outdoor dining – Food trucks
Services	Curb space dedicated for public services and utilities	– Fire hydrants and lanes – Utility maintenance and repairs – Waste storage/collection	
Greening	Enhancing aesthetics and environmental health	– Trees – Plantings – Stormwater management	
Vehicle Storage	Providing storage for vehicles and equipment	– Long-term parking – Bus layovers – Construction parking	– Electric vehicle charging



Key

- Mobility
- Access for People
- Access for Commerce
- Activation
- Services
- Greening
- Vehicle Storage

Curb demands are changing

The rise of ride-sharing services, changes in consumer behavior, and emerging technologies are contributing to a wider range and higher intensity of curb demands than ever before. At the same time, there has been an unprecedented movement to reclaim the street and curb space for social needs, which was sharply accelerated during the pandemic. Cities are taking a hard look at how to address these changes in a complex environment, most significantly reallocating space from on-street parking to accommodate more demand for limited curb space. Our values for the curb have changed, which is yet another reason to make sure that curbs are performing to their highest and best use.

Delivery demand for freight

Driven by the growth of e-commerce and online shopping, freight delivery has significantly increased, prompting innovations in last-mile logistics and delivery technologies to meet escalating expectations for faster and more convenient shipping options.

In 2023, e-commerce sales in the United States were $1.1 billion,[6] a 325 percent increase from a decade earlier.[7] Over the same decade, the number of packages processed by the United States Postal Service increased 78% percent from 4 billion[8] to 7.1 billion,[9] after peaking at 7.6 billion in 2021.[6] As a result of increased e-commerce sales, residential deliveries have grown to account for nearly 60% of UPS shipping activity.[10]

Due to the rapid increase in package volume and a shift to residential delivery, curb space is becoming increasingly scarce. Delivery drivers often obstruct traffic lanes and rights-of-way in urban areas because they cannot find convenient legal spaces to deliver packages. In Seattle, more than half of delivery vehicles park in unauthorized locations while delivering packages.[11]

Electric vehicle charging

With the rise in electric vehicle (EV) sales (over 1.4 million sold in 2023), public charging infrastructure has expanded by 70%, with more than 170,000 public EV chargers now available.[12] Cities are exploring options to install on-street EV charging facilities to support the transition, but the permanency of the infrastructure and lack of flexibility to accommodate other curb uses is a challenge.

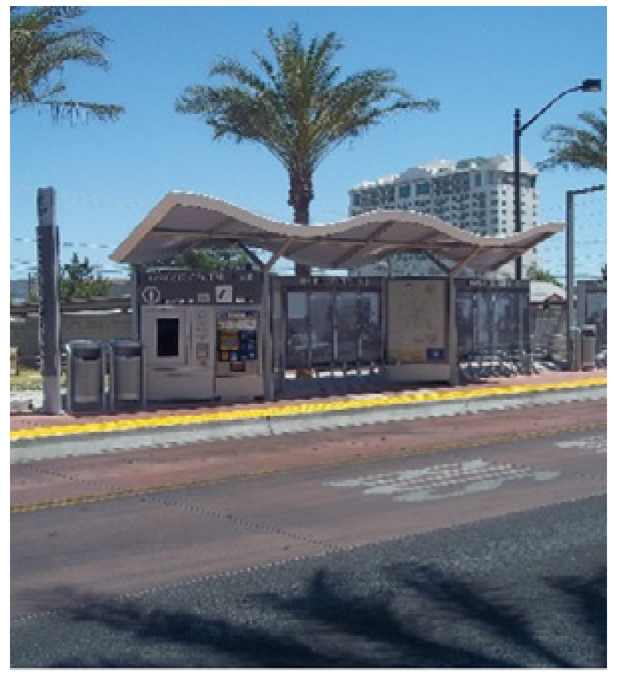
New York City has installed a network of 100 on-street EV charging points and plans to continue expanding.[13] Siting chargers in residential areas with multifamily housing and and concentrations of for-hire vehicle drivers is particularly important.

Pick-up/drop-off at the curb for passengers

Increased use of ride-hailing, taxi, transit, and other forms of shared mobility has contributed to higher curbside pick-up and drop-off demand, leading to increased competition for curb space and necessitating more efficient management strategies. In New York City, For-Hire Vehicle (Uber, etc.) trips have returned to already high pre-pandemic levels, averaging 20 million trips per month.[5]

Micromobility

Micromobility, such as bicycling, bike-sharing and e-scooter systems, is utilizing curb space for bicycle lanes, dedicated parking, and docking. Despite the challenge of repurposing curb space, often previously used for car parking, cities are implementing these changes to support the safe, efficient, and low/zero-emission movement of more people using less space than automobiles.



Public transit

Cities are implementing dedicated transit lanes, queue jumps, bus boarding islands and bus bulbs to improve transit speeds, and reliability.

On-demand delivery for food and goods

As consumer habits shift to convenience, and delivery apps become increasingly popular, businesses are adapting to meet the growing demand for quick delivery of food and other goods. Without adequate or efficient access to the curb, on-demand food delivery can sometimes result in drivers needing to circle to find parking or loading zones, which can result in congestion, curbside management, and safety challenges in dense, urban areas.

Instead, cities should consider converting single-occupancy vehicle parking to loading zones that be be utilized more efficiently for deliveries.

Autonomous vehicles

In February 2024, Waymo reported that its driverless vehicles in San Francisco carried over 100,000 passengers and traveled more than 475,000 miles, more than doubling in the six months after receiving approval for unlimited expansion in San Francisco from California state regulators.[14] Autonomous Vehicles (AVs) are not yet prevalent, but they are growing fast with recent adoption in cities like Las Vegas and Phoenix.

Through advanced sensors and mapping technologies, AVs can navigate and park in existing spaces, adapting to conventional curb layouts without requiring significant infrastructure upgrades. This flexibility underscores the potential for AVs to integrate seamlessly into existing urban environments while still benefiting from evolving smart city initiatives.

Curb priorities and goals

Managing the curb effectively requires setting priorities that align with surrounding land uses. A curb hierarchy prioritizes curb functions for each land use and is a critical step in allocating curb space rationally, while supporting a city's broader goals, such as improving mobility, improving safety, reducing congestion, and supporting businesses and neighborhood vitality. San Francisco, for example, prioritizes access for people and goods over vehicle storage to support commercial areas, downtown, and major attractors. Most cities using curb hierarchies first allocate space for movement (e.g., travel lanes, transit lanes, and bike lanes), based on their plans for each transportation mode.

While curb hierarchies are essential for prioritizing use, their real-world application is not without challenges:

- **Incremental changes:** Curb changes are often implemented gradually through a mix of coordination with private developments and infrastructure projects, proactive changes to streets or neighborhoods, and reactive responses to request and complaints.
- **Data limitations:** Most cities lack comprehensive data on curb space, making it difficult to assess and improve curb management effectively, often requiring significant effort and cost to gather the necessary information.
- **Political resistance:** Proposals to remove or price parking frequently encounter strong opposition from drivers and local businesses accustomed to free or exclusive use of the curb.

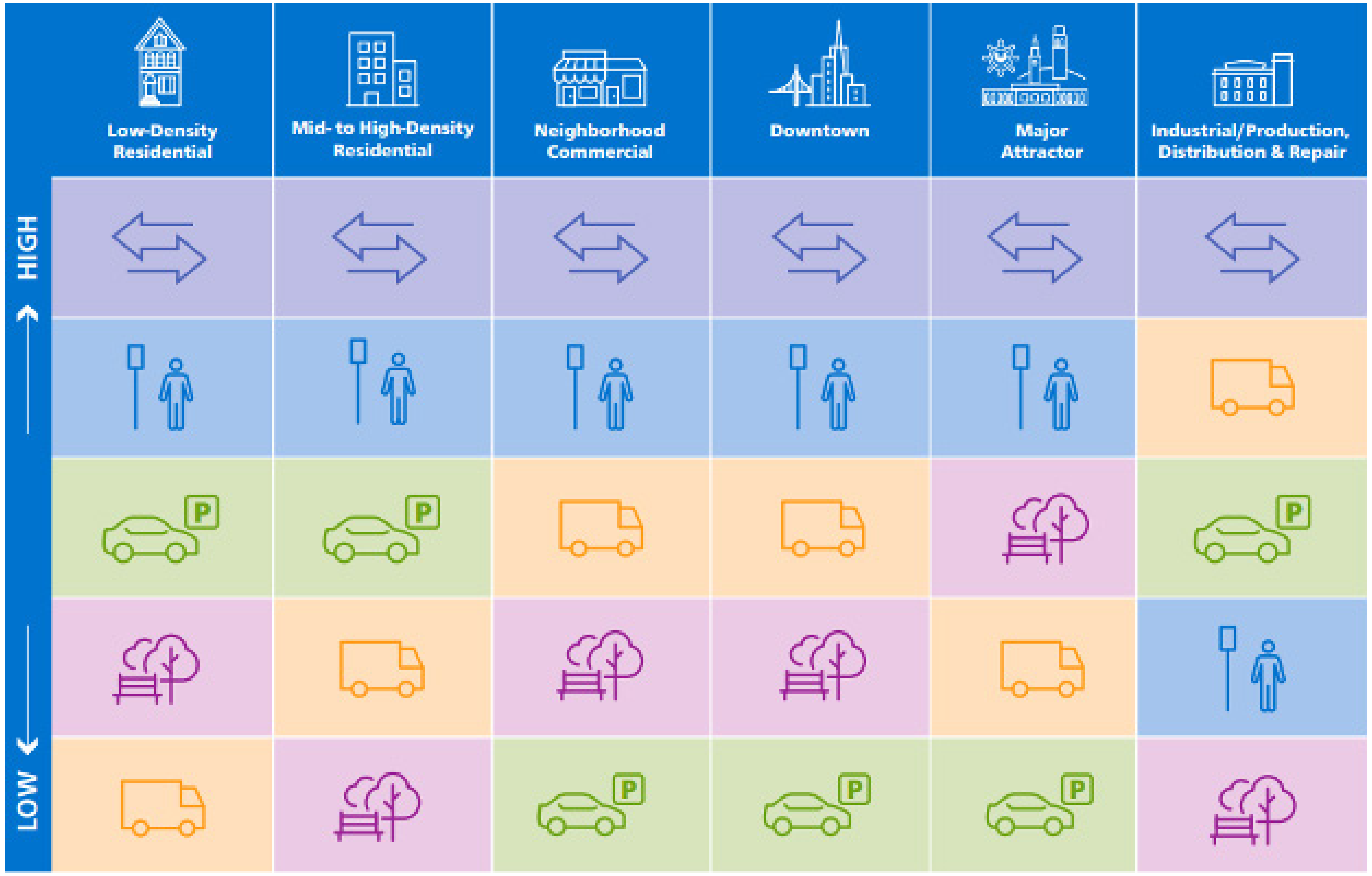


Figure 2
San Francisco Curb Functions Priorities by Land Use[1]

Key Topics

While more cities are recognizing the value of curbs and implementing new strategies to manage them, they are facing key challenges and opportunities in the following areas. These categories are by no means exhaustive but were defined based on the literature review and interviews with policymakers and practitioners. Each section presents the state of the practice, emerging strategies, case studies and highlights of outcomes, and recommendations for cities and operators.

The key topics are:

1. Maximizing productivity at the curb
2. Reducing curbside demand
3. Addressing safety
4. Dynamic and informed curb management
5. EV charging
6. Access for autonomous vehicles

Outdoor Dining

1. Maximizing Productivity at the Curb

State of the practice

As the needs of the curb have evolved, cities have often taken an ad hoc approach to addressing them, adding a pickup/drop-off zone or expanding loading zones, for example. This has functioned in eras and parts of cities with lower demand for all the different uses of the curb, but as demand has increased, the margin for error and inefficiency has become smaller. Inefficient curb management results in congestion, safety issues, and valuable curb space providing minimal value to users. To counteract this, cities are deploying strategies to make their curbs more productive for all users and activities. This means taking a holistic approach to the curb and providing as much access as possible to as many uses as (reasonably) possible. Simply put, it means cities can utilize the same amount of curb space to do more.

Increasing passenger throughout

Cities are looking at the key functions of the curb and the efficiency that curb management offers to serving those functions. Studies in San Francisco[15] and Cincinnati[16] tested a curb productivity index, which considers the number of passengers served per linear foot of curb, normalized by vehicle length. The studies found the same curb space serves more people when it is used for pick-up/drop-off than when used for parking and reallocated curb space accordingly. While this approach could be adapted to other curb functions, there is no agreement on comparing the productivity of different curb functions. Which is a more productive use of the curb: 10 deliveries or 10 passengers in an hour? Twenty bus riders or twenty bike share users in 30 minutes? The answer is context- and politically sensitive. With curbs as a finite resource, cities need to consider how to shift curb demand to underutilized blocks and off-street facilities, off-peak times of day, and to modes and methods that put less pressure on the curb.

Uber's Nightlife Mobility Planning Guide[17] focuses on how to plan dedicated passenger loading zones that are used productively, while also helping to reduce congestion on roadways, minimize unsafe loading behavior, or support shared mobility around pedestrian-only areas. Seattle's pilot of late-night pick-up zones in the Capitol Hill neighborhood found that geofenced pick-up zones were successful in alleviating congestion, maintaining clear routes for emergency vehicles, and disbursing crowds more efficiently at the end of the night.[18]

Improving transit outcomes

Surface transit service is frequently impacted by illegal parking and congestion resulting from curbside activities. Strategies such as allocating adequate loading zones and automated enforcement have been effective in reducing double-parking and transit delays. For example, The New York City Loading Zone Expansion program resulted in a 73% reduction in double parking.[19] Currently, both New York and San Francisco are using on-bus cameras to issue fines for vehicles blocking their travel, with New York seeing a 5% increase in bus speeds and a 20% reduction in collisions[20] and San Francisco seeing a reduction in delay for buses by 3 to 20 percent.[21]

Providing safe, comfortable bicycle networks

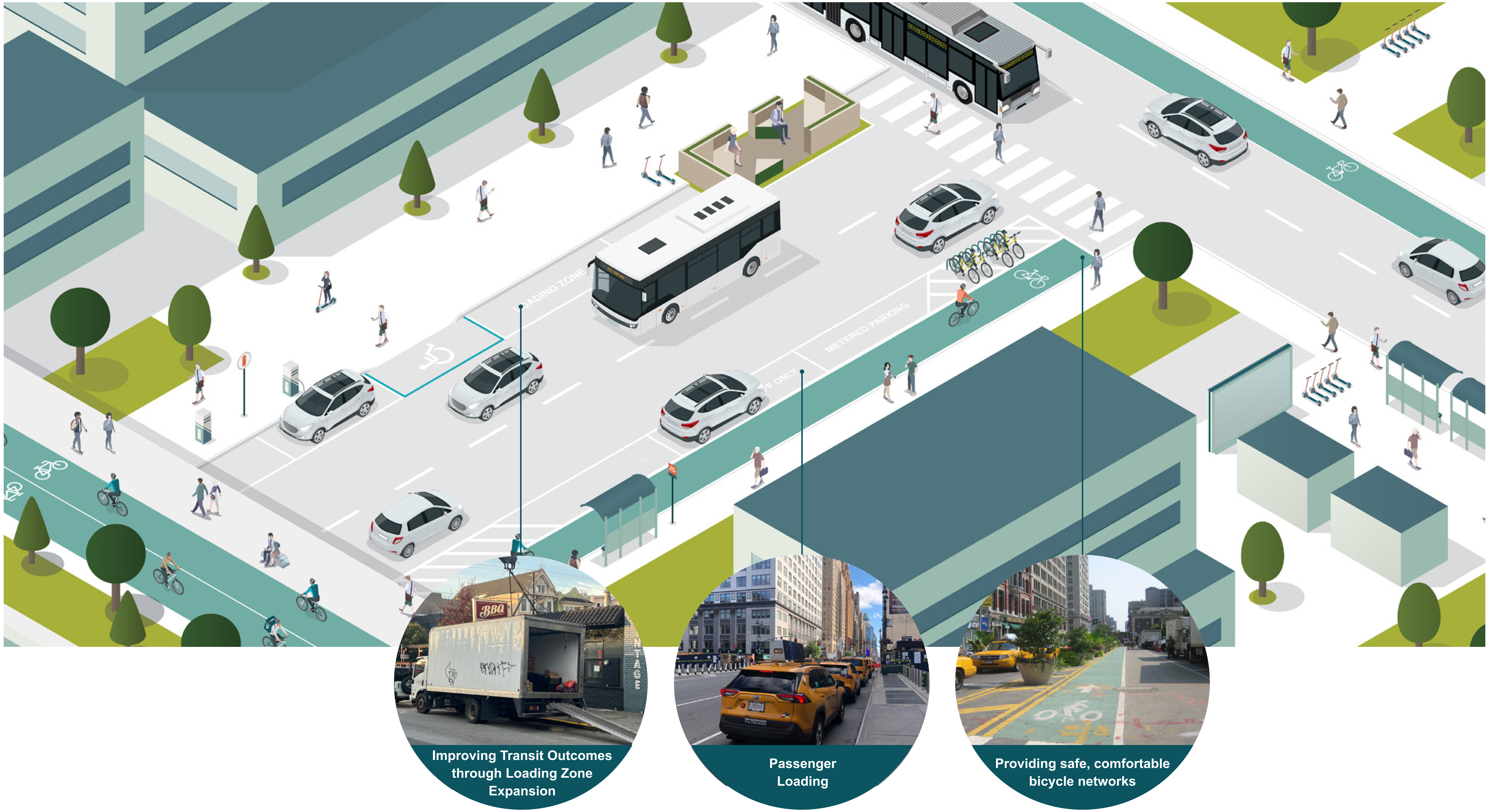
Many cities have reallocated curb space to provide amenities that support bicycling and micromobility trips, such as on-street bike and scooter parking and bike share stations. The provision of physically separated bike lanes and protected intersections has been an effective tool to optimize safety and comfort for people on bikes, while also creating a more productive curb because this infrastructure support use by more people than vehicle parking.

New York Curb Initiatives successes:

73%
reduction in double parking

5%
increase in bus speeds

20%
reduction in collisions


Improving Transit Outcomes through Loading Zone Expansion
Passenger Loading
Providing safe, comfortable bicycle networks

Loading zones for urban deliveries

Many restaurants and ghost kitchens (restaurants serving customers exclusively by delivery and take-out) are not well equipped with space to accommodate the high volumes of on-demand deliveries they generate. In response, cities have piloted curbside loading programs to improve curbside efficiency for deliveries. Whether it is because cities are not allocating sufficient pick-up drop-off space, order output varies widely across restaurants of the same size, or because the patterns of demand for online orders are too complex for small businesses to anticipate, delivery vehicles can often congest the curb in front of restaurants and overwhelm the public realm in cities like San Francisco and New York.

In Columbus, Ohio, the city is designating loading zones to mitigate the impacts of on-demand deliveries and reduce congestion. The Loading Management Zone pilot, which provided on-demand and reservation-based loading space for deliveries (truck and on-demand/food), prevented an estimated 9,700 illegal or double-parking events, based on surveys of registered drivers and the 19,000 check-ins to the pilot loading zones.[22]

In New York City, the Loading Zone Expansion program established new loading zones and provided clearer regulations on the use of loading zones to prevent inefficient uses. In addition to the aforementioned double-parking reduction, the pilot saw efficient average dwell times (26 minutes), high utilization (up to 600 vehicles per space per month in some cases), and is continuing to evolve and expand.[23]

The NYC DOT has also sought to reduce congestion by shifting deliveries from trucks and vehicles to cargo bicycles, through the Commercial Cargo Bicycle Pilot, which permitted commercial cargo bikes enrolled to load and unload wherever commercial vehicles are permitted in addition to loading and unloading at designated cargo bike corrals.[24] The reliability of the loading space has proven to be a strong incentive for companies, which must share their fleet GPS data with the DOT in exchange for enrollment. So far, the pilot has found that 80% of cargo bike deliveries are made to residential addresses, most of which are on side streets with no commercial curb regulations.

Cargo bikes are uniquely equipped to deliver to these areas without causing road blockages and safety problems during unloading and can therefore have a positive impact on congestion.

In 2019, a Chick-fil-A restaurant opened in downtown Brooklyn along a bustling arterial street. Despite 70% of the restaurant sales coming through mobile orders, the location has little infrastructure to manage high delivery volumes safely.[25] The curb was dedicated for bus stops and a travel lane when the store first moved in, but delivery driver loading, double parking, and bicycle parking causing dysfunction has driven the City to reconsider its designation.

The City added a bike corral for delivery workers to wait for pick-ups, but it has been insufficient for the volume of bicyclists, and drivers continue to double park, creating obstacles and safety issues on the street.

Areas of extremely high demand come with a unique set of issues for cities. How do cities get out in front of these challenges before conflicts cause complete breakdown and irreversible consequences?

80%

of cargo bike deliveries in NYC are made to residential addresses

Trucks double parking to unload

Opportunities/recommendations

The following strategies should be considered for maximizing productivity in curbside operations:

Repurpose curb space for more productive uses based on priorities and goals established for the street, neighborhood, or land uses.

– Changing curb uses without an overall framework can lead to ad hoc regulations that overlook the true value of the curb and preserve outdated uses that do not reflect the community’s needs or goals.

Integrate curb demand and delivery vehicle forecasting into the development review process to match the curb to anticipated needs.

– By reviewing plans earlier and considering curb priorities and types of demand, the design and operations of both the development and the curb can be adjusted to accommodate future demands more efficiently. This can be accomplished by evaluating land use, building programs, demographics, mode splits, and delivery generation to forecast overall curb demand, drawing on approaches used in parking demand analyses. The sooner that the conversation about curb management is initiated, the greater the number of strategies available to manage demand.

Establish curb productivity measures that incorporate deliveries, mobility, activation, safety and equity.

– While comparing one curb function against another is challenging, curb productivity measures can be used to evaluate how well curb policies are meeting goals and identify opportunities to optimize curb functions to accommodate more activity in less space and time.

Prioritize proactive curb management based on operational and equity needs, rather than reactive management based solely on complaints.

– Vehicles double parking and blocking buses, bus stops, or bike lanes may be reported in some neighborhoods, but not others. Regardless of whether a community raises issues to the city, they are indicative of inefficient curbs and a potential opportunity to prioritize more productive curb uses, while also improving mobility and access.

2. Reducing Curb Demand

State of the practice

In addition to optimizing performance at the curb, cities are pursuing strategies to reduce and redistribute demand from the curbside to underutilized curbs, off-street facilities, and lower-demand times of day. Reducing demand can include prioritizing shared mobility over private vehicle use. Redistributing demand can include strategies such as pricing or use limits to spread curbside demand out and use nearby curbs and off-street facilities, or even to shift peak-hour deliveries to off-hour deliveries.

To know what can be shifted and where, cities are collecting data on how curbs, off-street parking, and off-street loading infrastructure are being used by all users to implement strategies, typically at the street and neighborhood scale. When tied to clear actions, data can help focus these types of initiative to areas where they are most impactful.

Reducing private vehicle parking demand

One of the main strategies cities are implementing to reduce demand for parking include conversion of on-street parking spaces to pick-up/dropoff (PUDO) zones, and relocating of private vehicle parking to off-street locations or lower-demand curb areas.

On-street parking conversions to PUDO zones can discourage single-occupancy driving and support more people using shared vehicles in the same curb space, and is particularly useful for high-density areas and areas with significant commercial activity (e.g. Business Improvement Districts).

Relocation of vehicle parking to lower-demand areas can free up the curb for higher-priority uses as well. Cities are facilitating this shift with a variety of tactics, some of which are low-effort and low-burden, like more actively communicating the availability of lower-priced parking nearby. In cases where there may be revenue loss challenges associated with the shift, they can be offset through increased fees collected from underutilized spaces, benefits of providing access for more people in high-demand areas, and street safety improvements.

Managing access for deliveries at the curb and off-street

Managing commercial vehicles at the curb is challenging because demand is driven by consumer orders, less responsive to pricing, and often location-sensitive. Delivery drivers typically park close to their destination, both out of necessity and personal convenience, regardless of the curb space legally available. The cost of tickets for illegal parking is absorbed by larger delivery companies. Additionally, commercial deliveries have different issues and constraints, depending on whether they are on-demand deliveries (e.g., Amazon) or freight deliveries (e.g., food vendors delivering to restaurants).

Among commercial deliveries, on-demand deliveries present a particular challenge given that they require pickups, the drivers do not have as much regularity in routes, and delivery volumes often vary independently of square footage and/or business type. Acknowledging that, businesses that generate significant on-demand delivery volumes can improve conditions and impacts on surrounding areas by providing dedicated pickup space if possible (off-street is preferable, though not always possible), encouraging legal parking with educational tools and performance incentives, and managing demand to keep delivery volumes within capacity constraints (or shifting demand to other locations and ghost kitchens where possible).

Nonetheless, cities are pursuing a variety of strategies to reduce or redistribute loading demand, including:

– Providing dedicated on-street space for loading. For example, New York City has expanded commercial loading zones and is allocating more space for delivery staging and sorting through the Neighborhood Loading Zones initiative.[26] Other cities, such as Philadelphia,[27] have experimented with making curb loading regulations and availability digital and allowing delivery operators to reserve space, while only paying for the time they use.

– Incentivizing commercial deliveries to happen at off-peak hours and overnight. The Off-Hour Deliveries program in New York City currently operates at 1,100 locations, and not only relieves curb demand at peak hours but also improves the speed and reliability of deliveries.[28]

– Encouraging deliveries to use off-street loading facilities, and requiring or incentivizing buildings to provide them. Off-street loading is not adequately available in dense cities; For example, in Seattle's downtown, uptown and South Lake Union neighborhoods, only 13% of buildings have private loading infrastructure,[29] but the city is exploring requirements for residential buildings downtown to provide off-street loading.[30] When off-street loading facilities are available, delivery operators often still use on-street locations where they perceive that it will save them time or be more convenient to perform the delivery.

- Establishing microhubs, on-street or off-street, where goods from larger freight vehicles are consolidated to smaller, low-emission vehicles or cargo bikes for last-mile delivery. This can result in lower curb demand at delivery locations and fewer vehicle miles traveled. A New York City pilot is focused on on-street microhubs due to challenges off-street, including cost, physical constraints of trucks accessing parking garages, building regulations, and liability of storing goods and electric vehicles overnight in parking garages. While results of the pilot are forthcoming, operators are reportedly attracted to the predictability of dedicated space. Incentives are needed to change behavior, however, because cities, operators, and drivers are accustomed to delivery vehicles double parking in travel or bike lanes with little penalty.
- Facilitating strategies that make the last 50 feet of deliveries more efficient, like parcel lockers, delivery pickup hubs, and improved wayfinding and signage (e.g. Uber app updates for courier drop-offs).[31] A Seattle study found that parcel lockers can reduce delivery dwell time at the curb by up to 33% and reduce delivery times by up to 78%,[32] however they do not work for perishable food delivery. New York City will be evaluating the impact of delivery lockers on delivery management through LockerNYC, a one-year pilot in 2024.[33]

13%
of NYC buildings have private loading infrastructure.

33%
reduction potential in delivery dwell time at the curb can be achieved with parcel lockers

78%
reduction potential in the time to complete the delivery of a package.

Relocating passenger loading activities

In locations with high and/or concentrated volumes of passengers (e.g., arenas, entertainment districts, airports), passenger loading demand at the curb presents safety and traffic congestion issues and can require designated pick up drop off off-street or on adjacent, lower-demand side streets. In these cases, and during special events, Uber's On-Site Loading Manual[34] recommends:

- Establish pick-up locations where drivers and passengers will not cross paths prior to the intended pick-up point. This improves safety and operations by avoiding unnecessary conflicts for pedestrians and drivers, as well as the potential for passenger pick-ups in an undesirable area. The Seattle DOT and Urban Freight Lab partnered to build on this concept by testing designated loading zones with geofencing, which limited pickups to loading zones. The study found that combining passenger loading zones and geofencing increased driver compliance in stopping at the curb and reduced the average amount of time drivers stopped to load/unload passengers.[35]

Considerations for on-demand food delivery

On-demand food delivery services have proliferated in recent years,[10] with food prepared at both restaurants and ghost kitchens. Ghost kitchens exclusively serve on-demand food delivery orders and either operate from an existing restaurant's kitchen or a separate commercial kitchen. After an expansion during the pandemic, many ghost kitchen operations are shrinking due to changes in demand and the challenges of operating multiple virtual brands from the same limited kitchen space with similar peak demands.[36]

Both restaurants and ghost kitchens with a high volume of food deliveries often struggle to accommodate delivery vehicles safely and efficiently, particularly at peak times. As such, they are often located in busy commercial areas with limited access to off-street facilities, where the delivery demand they generate is in direct competition with other curb demands.

There are several challenges with on-demand food delivery that cities need to reconcile. Many delivery platforms batch orders, meaning that a delivery person may pick up multiple orders from one restaurant and drop them off to customers in the same area, or pick up multiple orders in the same area during a single trip, with the goal of increasing delivery efficiencies and reducing vehicle miles traveled and emissions. However, challenges exist with ensuring reliable and quick delivery times for customers. Opportunities for batching orders are also limited because many restaurants accept orders from multiple delivery platforms, resulting in multiple drivers delivering orders in the same area, which could otherwise be batched with a centralized delivery system. In general, neither restaurants nor ghost kitchens are required to limit or manage deliveries to address safety and congestion issues.

Cities are challenged to manage this issue and its contribution to congestion, and on-demand food delivery applications and their impacts on the transportation network are still evolving.

Opportunities/recommendations

The following strategies should be considered for reducing curb demand, considering curb demand earlier in design and operations planning, rather than as an afterthought, and thinking more comprehensively about how to manage oversubscribed curb space.

Update building codes and retrofit existing facilities to provide sufficient space for delivery management.

Building parking requirements have continuously evolved but loading dock requirements have not followed suit.

- Many cities have not updated requirements for new buildings to reflect modern demands for deliveries. For example, in New York City, off-street loading requirements for commercial land uses have not been updated in decades, and residential developments are not required to provide off-street loading to accommodate the hundreds or thousands of deliveries received a week.
- The land use review process for new development and permits can include strategies to reduce impacts on the curb, such as on-street PUDO zones, off-street loading facilities, curb management, and traffic management plans.
- Strategies are not limited to providing loading docks, which may be impractical to provide at the necessary scale but can also include operational strategies or performance measures for how deliveries are handled to avoid negative impacts to the curb and public realm.

Shift curb demand to off-street infrastructure and underutilized curb space.

Map unloading spaces to help plan a city's comprehensive network of loading and unloading areas, as well as communicate the availability to delivery drivers.

- Providing operators with large data sets for parking and PUDO zones would improve efficiency of deliveries and lead to more better space utilization.
- When seeking to reallocate curb space to higher performing uses, also identify underused off-street spaces in parking lots, garages, or side streets to relocate vehicle parking and tourist/visitor parking off-street. Existing garages are often poorly equipped to support larger vehicles, even large vans making deliveries, but they can still be utilized to offset other curb demand like parking.
- Pickup space for on-demand deliveries should be provided, off-street where possible. On-demand deliveries require drivers to make pickups with unpredictable wait times, often in places with no loading space. Providing clear pickup space can prevent double parking, cyclist queuing on sidewalks, and unsafe loading conflicts with moving lanes.

Make urban deliveries more efficient through practices like consolidation, vehicle right-sizing, and last-mile delivery lockers.

Data regarding vehicles and delivery patterns is lacking to inform the most data-driven approach. The size of trucks, routes, delivery dwell times, etc. could all provide more insight into how to manage loading activity. It is impractical, however, to report all trips.

- Loading zone and delivery hub implementation should be done strategically to address goals. Areas where double parking is common, delivery volume is high, and bus stops/lanes are located are all potential targets. Targeted implementation will yield the highest efficacy.
- Mode shift and scale-appropriate vehicles should be incentivized for deliveries when possible. Providing priority space for smaller trucks, vans, and cargo bicycles as appropriate can encourage delivery operators to use vehicles that can maneuver and load/unload legally in their routes, reducing double parking and congestion.
- Work with freight/parcel delivery operators to identify vehicle right-sizing (adjusting vehicle size to appropriate street context and volume of goods being moved) opportunities, as well as to identify opportunities for consolidation of commercial deliveries, using microhubs or consolidation centers.
- Introduce metered loading for commercial trucks and consider dynamic pricing/enforcement policies in areas with high demand to incentivize more efficient deliveries and discourage users from using loading space for non-loading activities (e.g., idling between deliveries).

3. Addressing Safety

Efforts to address traffic safety over the past decade have brought unprecedented funding, advanced analytical tools, and effective countermeasures to reduce the risk of collisions, injuries, and fatalities. While traffic safety is a top priority for cities across the US, curb locations present a unique set of safety issues and challenges.

Competition for the curb can introduce conflicts, particularly when activities overflow into adjacent travel lanes. At curbs where demand exceeds capacity, many activities spill over or shift to non-designated spaces. This is particularly apparent with loading activities:

- Trucks and vans have larger areas of blind spots, with limited or no visibility of what is happening around the vehicle, that can result in injuries to other road users while truck drivers are traveling to or accessing their destinations.
- Drivers frequently double park for quick access to their destination, blocking bike lanes or travel lanes, that can result in unpredictable movements and put bicyclists at risk.

Passengers loading or unloading can result in pedestrians stepping into the roadway at unexpected locations, introducing conflicts with moving vehicles. In addition, collision data is incomplete as it pertains to the curb. Collision data currently collected in the US does not have enough locational detail to provide meaningful information on curbside activities & safety:

- National-level data (FARS) only specifies whether a collision occurred in or outside of the roadway.
- State-level data (SWITRS, TIMS) only identifies if a collision occurs at an intersection or mid-block. It does not identify the exact location of a collision (e.g., in a travel lane, parking lane, etc.).
- City-level data may include greater detail but is still limited.

There is also no way to identify whether TNCs are involved in collisions, as there is no marker for this vehicle type in crash reports. Written narrative information in crash reports can provide clues but is not standardized and is intensive to analyze.

State of the practice

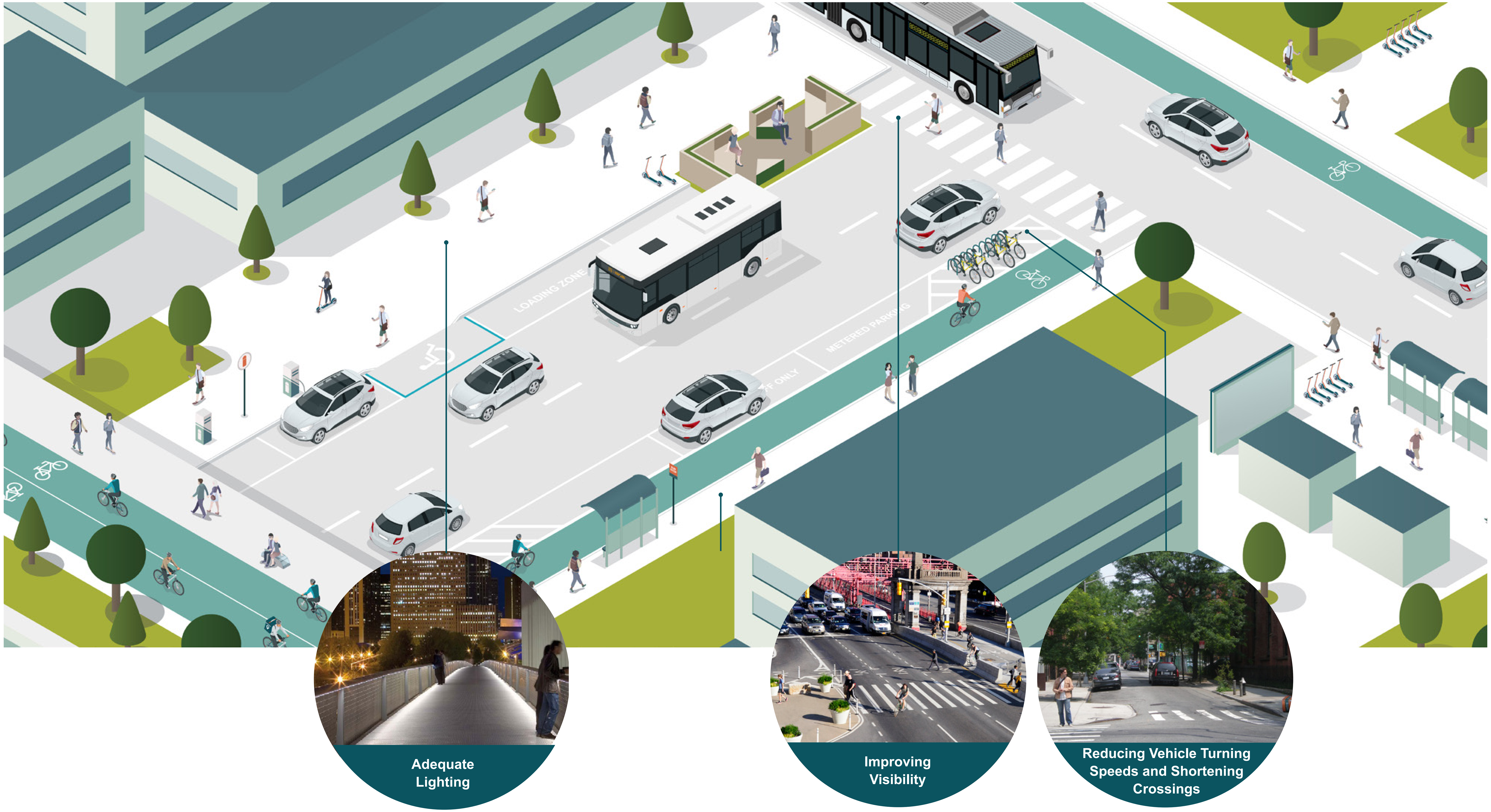
Safety countermeasures

Despite the data limitations, many cities have been nimble in addressing safety issues at the curb. Cities are deploying proven safety countermeasures that can maximize safety at curbside locations, such as:

- Shortening pedestrian crossings with curb extensions, which increase pedestrian space and visibility, and can provide space for bike parking, bike share stations, seatings, planting, and street furniture.
- Reducing vehicle turning speeds with curb extensions and other treatments to encourage slower, safer vehicle turns and increased yielding to pedestrians and bicyclists.
- Improving visibility by daylighting intersections and active mid-block locations by removing parking within 20-25 feet and installing physical barriers to prevent vehicles stopping or loading.
- Daylighting is most effective when physical barriers, such as bollards, plastic delineators, bikes, or curb extensions, are installed to reduce the need for enforcement of parking restrictions. In 2023, New York launched a street safety initiative to daylight over 1,000 intersections throughout the city, though this does not include a commitment to installing barriers. NYC DOT previously found that daylighting without barriers provides minimal safety improvement and may enable vehicles to make turns more quickly.[38]
- Adequately lighting curb areas with pedestrian scaled street lighting to ensure visibility.
- Timing signals to include Leading Pedestrian Intervals (LPIs), which typically give pedestrians (and in some cases cyclists) a 3-7 second head start when entering an intersection with a corresponding green signal in the same direction of travel. LPIs enhance the visibility of pedestrians in the intersection and reinforce their right-of-way over vehicles making turns, which contributes to a safer, accessible environment for pedestrians and fewer conflicts for drivers navigating turns. Of the approximately 13,500 signals in New York City, about 45% (6,100) have LPIs. Providing safe crossings at intersections can reduce unplanned crossings mid-block, thereby reducing possible conflicts at the curb.

Organizing the curb to minimize conflict and improve safety

Whether by providing protected space for bikes and buses, separating loading from pedestrian and bike movements, or by keeping the curb clear and organized, curb management can reduce conflicts to contribute to wider safety goals. Providing space at the curb results in fewer conflicts, fewer vehicles blocking bike lanes/bus lanes/travel lanes, allowing everyone to move and act more predictably.



13,500
signals in New York City, and

45%
have LPIs

Opportunities/recommendations

The following strategies should be considered for prioritizing safety in curbside operations:

Collect curb use data for all users to better plan access to the curb and avoid safety issues before they happen.

Utilize the data collected to inform PUDO expansion, loading zone expansion, and other curb management initiatives.

Collect data to identify all users and inform safety policies and practices after collisions happen.

With Vision Zero policies in place, many cities are already analyzing crash data and prioritizing changes where injuries and fatalities are concentrated. Cities should look to understand what types of users are involved in crashes, because the policy, design, and education solutions to address them will look different depending on the specific types of vehicles (e.g., private vehicle, shared vehicle, taxi, rideshare, on-demand delivery vehicle, delivery bike, personal bicycle, etc.).

Identify and collect data on behaviors that are indicative of curb conflicts.

Collecting data, whether by observation, survey, or public request, about behaviors such as loading in the street, double parking, dooring, blocked bus stops and bike lanes, can identify locations in need of curb management to avoid conflicts that end up in a crash report.

Implement safety countermeasures in concert with curb management policy.

- Design safety countermeasures to support a diversity of curb functions. For example, daylighting is most effective when coupled with design elements that block off the space, shorten crossings, or slow turning vehicles. Otherwise, drivers illegally load/park along red curb areas which then require enforcement. Hoboken, NJ is cited as a success, but they usually block off the space, so the safety benefits are likely the result of more visibility, shorter effective crossing distances, and smaller effective curb radius.
- To reduce double-parking by delivery vehicles, allocate more space for loading, and ensure loading zones are sized and positioned for delivery vehicles to easily access them.
- Prioritize curb availability as a metric for passenger access, goods access, and vehicle storage so that there is less need to circle looking for a space, less illegal parking, and fewer associated safety issues with other street users. This means that the measure of success of the curb is just as much focused on reliable, available space as it is on proper space being allocated for the functions in consideration.
- Pursue automated enforcement as much as possible to reduce violations that negatively impact safety.

Prioritize curb access for transit, carshare, rideshare, and micromobility to encourage alternatives to private vehicle usage.

- Provide infrastructure for people to travel safely by all modes and prioritize the most vulnerable users. Everyone is a pedestrian for some portion of their trip, and enabling more people to safely access and travel via micromobility, transit, and shared vehicles, rather than private vehicles, contributes to safer and more efficient streets. This means not only prioritizing bicycle lanes, transit movement, and even additional walking space along the curb, but also access and storage needs for these modes: bus stops, bike parking, bike share and micromobility stations, and bus layover space.

4. Dynamic and Informed Curb Management

State of the practice

Curb digitization and real-time data have become crucial components for cities to implement dynamic and informed curb management strategies. By leveraging technological advances, cities are improving their ability to maximize benefits of the curb, including:

- Data-driven decision making based on curb usage patterns.
- Dynamic pricing and regulations adjusted based on real-time demand and availability.
- Flexible curbs that can accommodate varied uses at different times.
- Communication with drivers and fleets on curb regulations, availability, and changes to increase access, reduce circling, and double parking.
- Continuous monitoring and evaluation to identify areas for improvement, implement changes regularly, and prioritize areas for enforcement.

Cities face staffing and budgetary challenges to collecting, analyzing, and utilizing this data using traditional methods. Methods for collecting and updating data have previously been more labor-intensive (e.g., conducting manual counts) or incurred high costs and maintenance issues (e.g., occupancy sensors) that can produce piecemeal rather than robust data. Ways of collecting and using data are evolving but are still intensive and often require third-party vendors to help cities collect data to support curb access and measure curb regulation efficacy.

Digitizing curb inventory

A digitized curb inventory is a digital representation of physical assets and the legal regulations governing the curb. It is composed of both physical elements, such as signs, and the physical space and time constraints associated with the infrastructure. With a digitized inventory, curb use regulations can be effectively communicated to the public; curb use data can be stored and compared over time; curb inventory data can be used for research and grant applications; and curb inventory data can be coordinated with municipal permit processes. In a consistent geospatial format, curb data should be accessible and easy to understand. Examples of this are the CurbLR data model from SharedStreets and the Open Mobility Foundation's Curb Data Specifications. Many cities, such as San Jose, Minneapolis, and Boston, are working towards implementing curb data specification (CDS) to improve management, communication, and interfacing.[39]

As of spring, 2024, the following efforts are underway:

- In Minneapolis, the city is digitizing activities at the curb as part of the larger strategy to price and manage use of the curb to encourage walking, biking, and using transit, and to discourage driving alone. This initiative has a timeframe of up to three years.[40]
- In Boston, the city received a $2 million SMART grant (March 2024) to digitize the curb via machine learning and computer vision
- In San Jose, the degree to which the curb digitization is completed (received a SMART grant in 2023) is still in progress, but the long-term goals are clear: "ensure more people and businesses can easily access curb space as needed, while increasing safety by cutting traffic congestion."[41]
- In Seattle, the city maintains maps of Curb Spaces by linear foot, through GIS layers. The Seattle DOT received a $2 million SMART grant to digitize the curb and is currently working to bring all layers and information together into the Curb Data Specification (CDS) format to improve commercial vehicle curb access.[42]

Cities are in various stages of digitizing towards CDS standards, but projects like the SF Park Pilot have proven the value that data-driven curb management can provide. The pilot digitized and collected real-time data for parking, with the goal of improving drivers' ability to find it. The SFMTA was able to hit block occupancy target rates by dynamically adjusting pricing, while overall lowering the average hourly rate at parking meters and garages.[43] Having a digital curb inventory and real-time data enabled greater curb efficiency and better outcomes for users.

Capturing real-time data

Several private companies offer real-time data collection using in-ground sensors, sensors mounted to sign posts, or cameras affixed to buildings and light poles. However, sensors can unreliable and expensive. For example, snow and cold weather were found to diminish battery life and confound sensors in Boston.[44] Washington, D.C. estimated sensor costs for 18,000 metered spaces at $2.25-4.8 million, with annual operating costs of $1-3.2 million.[39] Due to cost of installation, maintenance, and short operational life of parking occupancy sensors, San Francisco shifted to monitoring parking occupancy using smart meters to inform their demand-responsive pricing program.[45]

Data collection using computer vision can leverage existing camera infrastructure to collect occupancy data, inform enforcement checks (or automate issuance of fines/towing if possible/legal in context). Urban Freight Lab offers a step-by-step guide for planners looking to collect curb utilization data on their own.[46]

Automated enforcement

The common method of using parking control officers for curb enforcement is labor-intensive and expensive. Some cities are now testing automated enforcement for bus lanes, bus stops, bike lanes, and even curbside uses like parking and loading.

Pittsburgh deployed a pilot for commercial loading zones that used camera detection to indicate real-time parking violations to enforcement officials for targeted issuing of fines, with automatic ticketing as the next step of the pilot. While data on fully automated enforcement has not yet been released, partial automation reduced double-parking by 60% and reduced double park dwell time by 25%.[47]

Opportunities/recommendations

– **Define clear outcomes and goals for digitizing the curb.** Curb digitization is an attractive idea, but no small undertaking, and it will not solve many curb management problems on its own. Cities should define outcomes and the tactics to deliver them that are associated with each metric to be captured through digitization.

– **Collect and use data only when dynamic curb management will be implemented.** Leveraging data effectively can lead to better strategies and outcomes, including digitization, digital monitoring, and enhanced or targeted enforcement.

– **Update payment and pricing systems and interfaces. Payment systems and pricing models often use complicated systems that could be better streamlined.** Cities should take curb digitization as an opportunity to communicate regulations and policy more effectively, price the curb dynamically in areas with high demand/utilization exceeding capacity and focus on simplicity for users.

– **Support systems that focus on preventing bad outcomes and creating value for system users.** Digital penalty systems must be designed to penalize repeat offenders, with consideration made for smaller vendors and operators that generally are following regulations. The system should also focus on increasing availability and reliability, thereby creating value for system users.

– **Use innovative and cost-effective approaches to supplement data collection and enforcement.** Collect data through innovative, low-cost means like requiring AV operators to gather data in exchange for operations permits, cameras on buses (for enforcement and curb inventory data),[19] cameras on street sweepers[47] and other municipal vehicles, etc.

60%

reduction in double-parking achieved in the pilot area through partial automation of parking systems in Pittsburgh. including

25%

reduction in double-parking dwell time

5. EV Charging

State of the practice

Public electric vehicle (EV) charging facilities are important to enabling EV use for the general public, especially those without access to home charging. The transportation sector is a significant contributor to greenhouse gas emissions, prompting federal and state initiatives to decarbonize through electrification and achieve net-zero emissions by 2050. Electric vehicle sales have increased, with over 1.4 million EVs sold in 2023, and public charging infrastructure has expanded by 70%, with more than 170,000 public EV chargers now available.[48] Despite the growth in public charging options, approximately 80% of EV charging occurs at home, with multifamily buildings accounting for less than 5% of home charging primarily due to space constraints.[42] The infrastructure required for on-street EV chargers does not allow flexible curb uses, or changes in the short term, so cities need to carefully plan how and where on-street EV charging is installed to maximize their benefit without infringing on other goals like access for people, goods, and mobility.

80%

of EV charging occurs at home, and

5%

or less of home charging occurs in multifamily buildings.

Determining where to install EV chargers

Cities are increasingly investing in public on-street and off-street EV charging infrastructure to support the growing number of electric vehicles. EV charging at the curb requires infrastructure and long dwell times, so it is locked in as an exclusive use that cannot change dynamically during the day or easily change over time. Therefore, cities typically consider EV charging as a storage use that is a low curb priority on most streets. Equity in siting EV charging stations is a key consideration, ensuring that low- and moderate-income communities have access to charging facilities. In Los Angeles, the Charge4All site suitability tool is being used to identify suitable sites for EV charging from a regional to curb scale, based on stakeholder's goals, including dense areas of multi-unit dwellings, equity, vehicle miles traveled (VMT), and more.[49]

Where possible, cities are prioritizing investment in EV charging off-street. New York City is planning a large, publicly accessible EV charging station at JFK Airport, including fast charging, to capture demand at a large trip generator located along the highway.[50] As EV adoption increases, opportunities will continue to expand to re-allocate space dedicated to Internal Combustion Engine (ICE) vehicle infrastructure, like gas stations and parking garages, for EV charging.

Maximizing EV charger access and utilization

Maximizing the utility of public EV chargers at the curb will require signage and enforcement to ensure that vehicles vacate the space after their charging session is complete. In 2023, New York City found that on-street EV charging spaces were blocked by ICE vehicles 16% of the time, with the majority of non-compliant vehicles blocking the space for less than 30 minutes, indicating that the available space was used opportunistically for short-term parking.[51] EV drivers also face the challenge of fully charged EVs remaining parked in front of the charging station after the session is over. NYC DOT found that EVs were actively charging 81% of the time they were plugged in; higher prices during peak hours (6 AM-9 PM) can help to facilitate turnover.[45]

Automated enforcement could be leveraged as a tool to deter non-EV drivers from blocking the spaces. A representative from Los Angeles described targeted enforcement to keep non-EV drivers out of EV charging spaces as an equity issue, as the EV drivers are using on-street L2 charging spaces because they do not have access elsewhere.

EV charging for freight

While cities like Santa Monica and New York are piloting green loading zones to encourage freight delivery by more sustainable modes, like electric vans and electric-assist cargo bikes, most cities are not prioritizing charging infrastructure for commercial vehicles given the challenge of reconciling the high turnover of vehicles making deliveries with long dwell times for charging, as well as the desire to support multiple vehicles and high curb utilization.

Opportunities/recommendations

Cities should implement on-street charging where permitted by existing curb regulations and only in contexts with particular equity needs, like underserved neighborhoods with low access to private charging points or a high concentration of for-hire vehicle drivers.

Support for-hire vehicle (FHV) drivers by providing dedicated on-street charging spots, recognizing their role in urban mobility and lack of off-street parking options. However, if AVs become more prevalent, or FHV drivers are using fleet vehicles, this will reduce demand for EV charging by FHV drivers.

– EV charging for AVs in particular should be sought off-street. Enforce on-street EV charging regulations with an emphasis on fairness, ensuring that those without private parking have access to public charging spaces.

Prioritize EV charging off-street because off-street charging typically has long dwell times and precludes curbside space from being used for other functions. As shown in Figure 3, charger infrastructure varies as does the associated dwell time. This factor influences the suitability of the curb for accommodating charging.

Invest in fast-charging infrastructure at strategic locations (e.g., airports, highways, downtown parking garages), rather than curbs, given the costs and challenges of installing DC fast chargers at the curbside.

– Invest in fast-charging infrastructure near highways and airports to facilitate quick charging for travelers and commuters, given the challenges and requirements for placing this infrastructure on curbs and other locations.

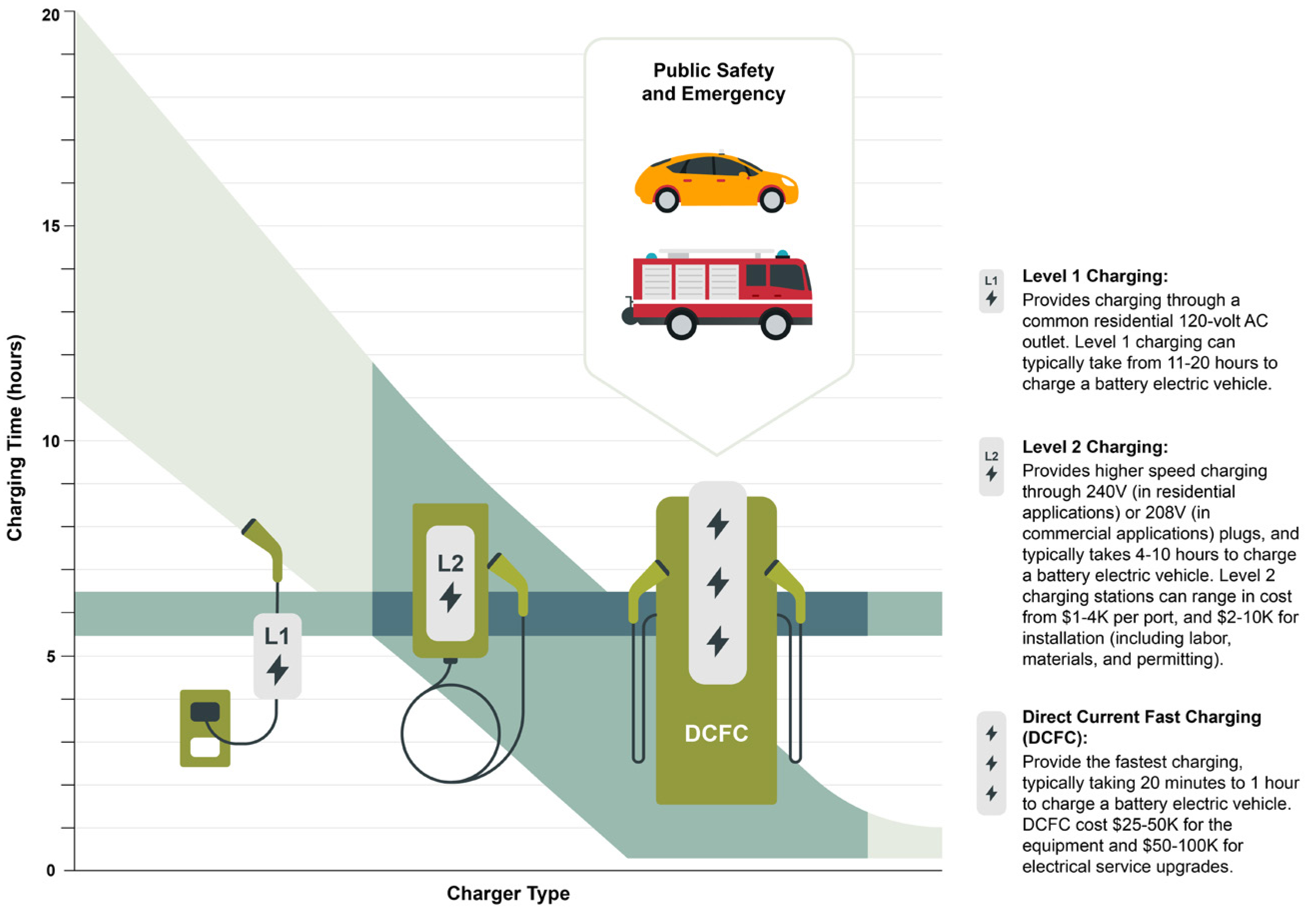


Figure 3
EV Charging Times by Charger Type

6. Access for Autonomous Vehicles

State of the practice

When vehicles cannot access the curb, passenger loading and unloading in the travel lane contributes to congestion and creates unsafe situations for vehicles, cyclists, and pedestrians. Adoption of autonomous vehicles (AV) may impose similar unintended consequences, unless curb management provides access and space for passenger unloading. Safe and efficient AV pickups/drop offs is imperative not only to meet demand for typical AV users, but because AVs will play a role in transit services and have an impact on cyclist and pedestrian safety.

AVs operate best and safest when provided reliable, legal curb space

AVs are programmed to follow operating rules, such as only picking up or dropping off passengers at the curb or other designated locations. AVs may wait, search for another space, or make drop offs in a moving lane (where legal per state code) when they encounter an occupied loading zone. Waiting or circling is not preferable given the passenger delay and congestion implications, but in-lane unloading can create safety conflicts for pedestrians, cyclists, and drivers and also contribute to congestion. Not all AVs operate the same way, however, so understanding their rules and operation is crucial to ensuring that curb management facilitates safe and smooth operations for users, pedestrians, cyclists, and drivers. Providing reliable designated pickup drop-off (PUDO) space can mitigate many risks that AVs may contribute to when loading and unloading.

Design and locate PUDOs effectively

Designing PUDO zones that facilitate easy access for uses including AVs, possibly through dedicated spaces that allow for quick stops rather than parallel parking, is essential. Similar to PUDO zones for ride hailing users, enhancing PUDO zones by considering comfort, speed, reliability, and overall experience may support the willingness of AV users to walk further in exchange for certainty. Incentives could be offered to encourage use, and the design of these areas must take into account the context of each location to be effective.

Digital inventory and real-time data

A digital inventory of the curb can help AVs find a suitable, safe location for passenger access. Limited curb information and lack of available loading space can hinder AVs from operating efficiently in certain neighborhoods, especially where the curb is primarily occupied by long-term parking and passenger loading zones are uncommon. As cities digitize the curb, there is also a drive to collect real-time data, which is useful if used to inform real-time/dynamic policy. Given that real-time data is not always necessary and can be resource-intensive and costly to collect, data collection efforts should be made judiciously and when data is tied directly to an outcome or policy.

AVs and paratransit access

AVs will likely play a role in providing paratransit services, particularly where rideshare is already integrated into the system, like in Boston with MBTA's RIDE Flex Program.[52] As cities prepare for this use case, curb management should be elaborated to better meet the needs of people with visual impairments and disabilities. Making PUDOs accessible to curb cuts, visually marked and signed, and compliant with ADA requirements will contribute to cities that are accessible for all and prepared for AVs.

Opportunities/recommendations

Cities should seize the opportunity to shape curb use towards the desired outcomes of Autonomous Vehicle (AV) technologies and focus on managing curbs in a way that prioritizes transit and incentivizes the use of shared autonomous vehicles in ways that contribute to broader goals:

- **Prioritize the shared and efficient use of autonomous vehicles.** The more AVs are used for single-occupant trips and owned privately, the more likely they are to increase congestion, curb demand, parking demand, and conflicts with more sustainable modes like walking, bicycling, and transit. Cities should consider strategies to discourage single-occupancy AV trips, especially in high-demand urban areas, while giving preference to AV shuttles or ridesharing vehicles, mirroring strategies such as congestion pricing or low-emission zones to reduce vehicle miles traveled and improve air quality. Shared-use AVs can improve efficiency, reduce zero-passenger miles and reduce parking demand at the curb and off-street.
- **Design for AVs to improve access for transit users and people with disabilities.** AVs may be a good fit not only for fixed-route transit, but also for paratransit because of potentially lower operating costs than human-operated vehicles and the ability to be dispatched on-demand. AVs must be designed to be accessible to users with disabilities, and by extension have access to loading zones where passengers, with and without disabilities, can smoothly and safely board.
- **Expand designated loading zones and unloading areas for shared modes, including AVs.** To serve the anticipated increase in demand for AVs, cities should expand loading areas to provide right-sized, predictable, and consistently available spaces to avoid traffic congestion and ensure reliability. Integration of these spaces with other functions at the curb must be done with careful planning to maintain efficiency and prevent conflicts. Curb space should be accompanied by clear signage, curb markings, and can be supported by digitization to communicate directly with AV systems.
- **Clearly communicate curb space and desired drop off locations for AVs to all curb users.** Digitizing the curb can be a crucial aspect of preparing for AVs, while supporting opportunities to allocate curb space dynamically according to demand. As AV adoption increases, further features like integration of curb information into onboard navigation systems can be developed. AVs could also contribute to mapping of the curb if cities use the permitting process to require shared autonomous mobility operators to provide curb data to cities in exchange for access to the curb.

Recommendations

Managing demand effectively is critical for cities to ensure that passengers, deliveries, parking, public spaces, and other uses are able to access the curb efficiently and equitably. A well-managed curb can support broader city goals like adapting to changing transportation needs and technology, improving safety, supporting local businesses and economic development, and enhancing mobility and sustainable practices.

This report explores six areas where cities can maximize the potential for the curb based on a review of existing policies, pilots, strategies, and reports.

1. Maximizing productivity at the curb

Inefficient curb management results in congestion, safety issues, and valuable curb space that is occupied by a small number of users or activities. To counteract this, cities are deploying strategies to make their curbs more productive for all users and activities.

One of the main strategies cities are experimenting with is dedicated loading areas for specific uses. While not a new concept, providing space to support the surge in on-demand delivery vehicles, passenger loading areas in active nightlife areas, and establishing clearer regulations have had positive results. Automated enforcement has also been effective in reducing transit delays due to illegal parking in travel lanes and bus stops.

To get the most use out of limited curb space, recommendations include:

- Establish curb productivity measures that incorporate deliveries, mobility, activation, safety, and equity.
- Repurpose curb space for the most productive uses based on established priorities and goals for the street, neighborhood, or land uses.
- Integrate curb demand and delivery vehicle forecasting into the planning review process to design and program the curb to anticipated needs.
- Prioritize proactive curb management based on operational and equity needs, rather than reactive management based solely on complaints.

2. Reducing curb demand

In addition to optimizing performance at the curb, cities are pursuing strategies to reduce and redistribute demand away from the curb. Reducing demand can include prioritizing shared mobility over private vehicle use. Redistributing demand can include strategies such as pricing or use limits to spread curbside demand out and use nearby curbs and off-street facilities, or even to shift peak-hour deliveries to off-hour deliveries.

To know what can be shifted and where, cities are collecting data on how curbs, off-street parking, and off-street loading infrastructure are being used by all users. When tied to clear actions, data can help focus these types of initiative to areas where they are most impactful.

To shift demand to loading space in buildings or underutilized curbs, recommendations include:

- Update building codes and retrofit existing facilities to provide sufficient space for delivery management.
- Shift curb demand to off-street infrastructure and underutilized curb space.
- Make urban deliveries more efficient through practices like consolidation, vehicle right-sizing, and last-mile delivery lockers.

3. Addressing safety

At a time when traffic safety is a top priority for cities across the US, curbs present a unique set of safety issues and challenges. Competition for the curb can introduce conflicts, particularly when activities overflow into adjacent travel lanes.

In addition, collision data is incomplete as it pertains to the curb, making it difficult to measure, evaluate, and address safety in these locations. Despite the data limitations, many cities have been nimble in deploying proven safety countermeasures that can maximize safety at curbside locations.

To incorporate citywide traffic safety initiatives into curb management approaches, recommendations include:

- Identify opportunities to implement safety countermeasures in concert with curb management policies and practices.
- Collect data to identify curb policy-related collision factors to better inform safety policies and practices.

Recommendations

4. Dynamic and informed curb management

Curb digitization and real-time data have become crucial components for cities to implement dynamic and informed curb management strategies. By leveraging technological advances, cities are improving their ability to maximize benefits of the curb.

However, there are significant staffing and budgetary challenges to collecting, analyzing, and utilizing this data using traditional methods. Ways of collecting and using data are evolving but are still intensive and often require third-party vendors to help cities collect data to support curb access and measure curb regulation efficacy.

To digitize the curb for specific management goals and outcomes, recommendations include:

- Define clear outcomes and goals before digitizing the curb.
- Collect and use data only when dynamic curb management will be implemented.
- Update payment and pricing systems and interfaces.
- Use data to support a system that focuses on preventing bad outcomes and creating value for system users.

5. EV charging

Cities are increasingly investing in publicly available electric vehicle (EV) charging infrastructure to support electrification and emission reduction goals. The infrastructure required for on-street EV chargers does not allow flexible curb uses, or changes in the short term, so cities need to carefully plan how and where on-street EV charging is installed to maximize their benefit without infringing on other priorities.

EV charging at the curb requires infrastructure and long dwell times, so it is locked in as an exclusive use that cannot change dynamically during the day or easily change over time. Therefore, cities typically consider EV charging as a storage use that is a low curb priority on most streets.

To determine the optimal location and utilization for public EV charging along the curb, recommendations include:

- Implement on-street charging in contexts with equity needs in addition to charging needs, like neighborhoods with low access to private charging points. Even in these contexts, charging should still come after more significant curb priorities (e.g. transit, pedestrians).
- In busy commercial areas, prioritize other curb activities and locate EV charging off-street.
- Invest in fast-charging infrastructure at strategic locations (e.g. airports, highways, downtown parking garages), given the costs and challenges of installing DC fast chargers at the curbside. This can include off-street locations or lower-demand curb spaces.

6. Access for autonomous vehicles

Autonomous Vehicles (AVs) are not yet prevalent, but they are growing fast with recent adoption in San Francisco, Las Vegas, and Phoenix. Through advanced sensors and mapping technologies, AVs can navigate and park in existing spaces, adapting to conventional curb layouts without requiring significant infrastructure upgrades.

AVs are programmed to follow operating rules, such as only picking up or dropping off passengers at the curb or other designated locations. Not all AVs operate the same way, however, so clear and consistent rules and designated loading areas that include AVs are key to safe and smooth operations.

To optimize AV access at the curb, recommendations include:

- Identify designated loading zones and unloading areas for pick ups and drop offs, and expand them for AV use.
- Clearly communicate curb space and desired drop-off locations for AVs.
- Prioritize shared AV trips and shared AV fleets over single-occupant trips and private ownership.
- Design for AVs to improve access for transit users and people with disabilities.

Implementation

Implementing these strategies often comes with challenges and trade-offs that must be addressed in coordination between stakeholders and public agencies. Cities should set clear policy priorities and establish a transparent, consistent decision-making methodology. This approach will streamline the process, build trust, leverage available data and facilitate effective decision-making. Figure 1 shows an example of the kind of decision points that an implementation methodology can address.

A general approach to curb allocation and management decision-making should include:

- Establishment of citywide and/or district policy framework. Get policies, standards, priorities, and local practices to provide a firm basis and vocabulary for site-specific decision-making including goals, curb allocation designations, access hierarchies, and priorities. The framework should include curb management procedures, outline a locally curated toolbox of strategies, identify decision-makers (e.g., a commission, board, public official, etc.) and define the collaboration/stakeholder and public stakeholder engagement process.
- Scope definition. As specific questions/requests/planning or design projects emerge, define the scope of what is being considered. Scope definition not only includes physical location and scale (e.g., parcel, block, corridor, or district), but the curb uses and needs, and alignment with permanent and temporary initiatives.
- Research and assessment of context. Establish a data-driven, fact-based baseline for stakeholders and decision makers. Evaluate existing conditions and anticipated changes (land use, physical conditions, transportation operations and performance, etc.) as well as local policy context. In cases where useful and relevant, collect, aggregate, summarize, and communicate data.
- Definition of toolbox of strategies. If appropriate, define what different approaches are possible. Foster collaborative idea-generation/co-creation of options, execute technical evaluation, and summarize benefits and cost of trade-offs.
- Facilitation of constructive dialogue. Throughout the process, create the space and process for different stakeholders to be heard.
- Decision-making. Ultimately, the designated decision-making person or body makes the final call.
- Implementation and monitoring. Enact or construct, then have a process to evaluate how it performs and identify modifications, if needed.

The agency responsible for curb allocation and management (typically a city's Department of Transportation) should define their own specific approach in coordination with other institutional and commercial stakeholders. External parties, like Uber, should be given the opportunity to contribute to this process, advocate for its development, and share precedents.

Common aims, competing needs

Cities across the country share high-level goals for their curbs, such as safety, quality of life, etc. However, curb allocation and management decisions are context-sensitive and require difficult compromises, often with significant implications for adjacent property owners, tenants, and the larger community. Therefore, decisions are inherently local, reflecting unique local conditions and community priorities.

A robust menu of options

Like all urban mobility challenges there is no simple, one-size-fits-all solution, and cities must contend with limited funding and political forces. However, cities can take advantage of the strategies explored in this report to proactively manage the curb using a mix of policy, physical infrastructure, operational changes, and emerging technology that is creating new opportunities.

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