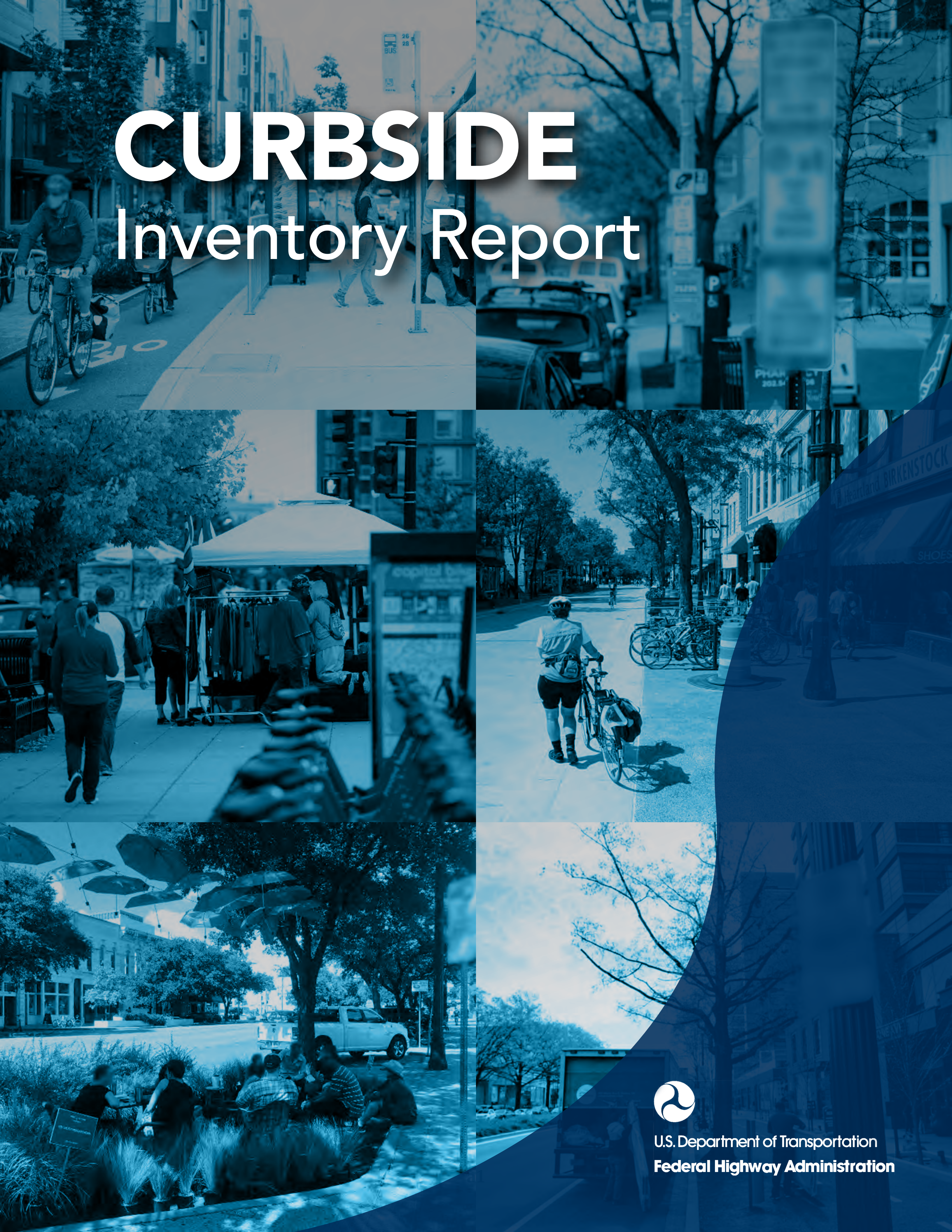
CURBSIDE
Inventory Report



U.S. Department of Transportation
Federal Highway Administration

FOREWORD

The *Curbside Inventory Report* has been prepared to convey current practices and emerging specifications in the area of curbside management. The report is intended to provide practitioners of all levels of experience with information on how to assess, gather, and analyze information to understand available information on curbside management inventories.

This is the first edition of this report and supplements the Institute of Transportation Engineers (ITE) *Curbside Management Practitioners Guide*. Images in the report are intended to serve as examples of the range of real-world existing conditions; they are not limited to best practices or approved designs or behaviors and in some cases may reflect conditions that are not recommended.

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Cover Images. Curbside management practices in Seattle, Washington, Washington, District of Columbia, Madison, Wisconsin, and Austin, Texas, USA. *Sources: Pedestrian Bicycle Information Center/Adam Coppola Photography, District Department of Transportation, and Pedestrian Bicycle Information Center/Dan Burden, and Austin Transportation Department/Flickr.*

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in2	square inches	645.2	square millimeters	mm^2
ft2	square feet	0.093	square meters	m^2
yd2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft3	cubic feet	0.028	cubic meters	m3
yd3	cubic yards	0.765	cubic meters	m3
NOTE: volumes greater than 1000 L shall be shown in m3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
TEMPERATURE (exact degrees)				
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm2	square millimeters	0.0016	square inches	in^2
m2	square meters	10.764	square feet	ft^2
m2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
°C	Celsius	1.8C+32	Fahrenheit	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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Disclaimers: Some figures in this report show emerging curbside management practices may not be compliant with the MUTCD and therefore shall not be installed on roadways open to public travel unless a request for experimentation is sought. Please refer to the MUTCD for details on official experimentation with novel traffic control devices or applications. Commercial concepts shown in figures is not an endorsement.

LIST OF TABLES

GLOSSARY OF TERMS

Access – The ability for all road users to use curbside functions.

Accessibility – Curbside accommodations for persons with disabilities.

Americans with Disabilities Act (ADA) – A civil rights law that prohibits discrimination based on disability. This includes ensuring that persons with disabilities have an equal opportunity to use the public rights-of-way in the transportation system.

Automated data collection – The collection of new information through the deployment of temporary or permanent electronic equipment that do not require a human operator.

Computer vision – The field investigating the development of systems, which allows machines to gain understanding from digital images or videos in an attempt to automate tasks for which humans rely upon visual senses.

Courier Network Services (CNS) – These services typically allow customers to order the delivery of food or some other type of good via a smartphone app or website, to be delivered as soon as possible or whenever required. CNS are also known as on-demand delivery providers (ODD).

Curb lane – The vehicle lane immediately next to the curb, usually designated for modes and uses needing access to the curb.

Curb productivity – The number of people or goods that a given amount of curb space can provide access to over a fixed amount of time.

Curbside – The space adjacent to the roadway travel lanes providing a transition zone between different functions and modes. It includes parking lanes and space on either side of the physical curb, and may include travel lanes temporarily used for curbside functions when the curb lane is fully occupied.

Curb space – The physical curb (e.g., concrete edging, gutter pan) that separates the sidewalk from the street, and the adjacent areas where markings and signage may be placed to regulate the curbside.

Figure 1. Graphic. Demonstration of curbside (border areas, physical curb, and curb lane where curb regulations more commonly apply) versus curb space (the physical curb and location for signage and markings to indicate curbside allocation and regulation). *Adapted from original source: Shared Streets.*

Curbside management – An overarching management program and/or plan to guide allocation and regulation of the curbside for optimized mobility and safety for all road users using the curb space.

Data validation – The process of confirming data accurately represents on-the-ground conditions as part of a process to ensure quality of the associated data.

Flex zones or dynamic curbs – An area of the curbside that needs to be flexible based on use, demand, and/or time of day in order to achieve highest and best use of the curb.

Freedom of Information Act (FOIA) – A federal law that requires the full or partial disclosure of previously-unreleased information and documents controlled by the United States Government upon request.

Geofencing – A geographic zone or perimeter around a point location that can be used as a virtual boundary. Geospatial systems can use geofencing to restrict activities to a specific geographic area (e.g., scooter-share usage might be geofenced to a specific neighborhood within a city).

Interagency data – Data from neighboring jurisdictions, special districts, transit agencies, and any other public entity that operates in or in conjunction with the primary agency. This data could include information about zoning, parcel records, transportation infrastructure, transit operations, business activity, parking occupancy and revenue, or collisions and citations.

Machine learning – A method of data analysis that seeks to automate analytical decision-making based on the computer system learning from data, identifying patterns in the data, and making decisions with minimal direction from an operator.

Manual data collection – The collection of new information through in-person, on-site observations and direct review of written policies, guidance, and procedures. These data sources require a person to collect data directly or manually deploy data collection equipment in the field. However, data collection may still involve sophisticated technical equipment such as apps, imagery processing algorithms, and digitization tools.

Manual on Uniform Traffic Control Devices (MUTCD) – The MUTCD is the national standard for all traffic control devices installed on any street, highway, bikeway, or private road open to public travel as incorporated by reference in 23 Code of Federal Regulations (CFR), Part 655, Subpart F.

Metadata – A set of data which describes and provides information about other data.

Mode Share – The proportion of trips undertaken using a particular mode (e.g., if 40 percent of trips are taken by private vehicle, then the mode share for driving is 40 percent).

Measures of Effectiveness (MOEs) – Specific, testable metrics that can be used to measure the performance of an intervention or policy before and after implementation.

Micromobility – Any small, low-speed, human or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled conveyances (FHWA, 2020).

Open Source – Software or processes for which the original source code is made freely available and may be redistributed and modified.

Radar sensing – The collection and analysis of digital images or video with radar (or microwave) sensors to collect data and programmable algorithms to analyze it.

Safe System Approach - Differs from conventional safety practice by being human-centered, seeking safety through a more aggressive use of vehicle or roadway design and operational changes rather than relying primarily on behavioral changes, and by fully integrating the needs of all users (pedestrians, bicyclists, older, younger, disabled, etc.) of the transportation system.

Single source of truth – The practice of structuring information models and data schema such that every data element is edited in only one place.

Third-party data providers – Non-governmental sources from which new datasets can be obtained, sometimes for a fee. These include mobility providers, goods and freight carriers, and specific-use data providers.

Treatments – Strategies, operational schemes, physical improvements, or other enhancements used to achieve project goals, including curbside management implementation.

Video sensing – The collection and analysis of digital images or video with video cameras to collect data and programmable algorithms to analyze it.

Vulnerable Roadway User – Those most at risk in traffic (e.g., those unprotected by an outside shield). Pedestrians, pedalcyclists, and motorcyclists are accordingly considered as vulnerable since they benefit from little or no external protective devices that would absorb energy in a collision (Constant, 2010).

INTRODUCTION

PURPOSE OF *CURBSIDE INVENTORY REPORT*

The *Curbside Inventory Report* (the Report) outlines the process of synthesizing data to create a strategic, data-driven approach to curbside management projects. It highlights the identification of appropriate measures of effectiveness (MOEs) to understanding project needs, the selection of appropriate data to evaluate MOEs and project alternatives, and the obtaining of selected data. This includes a discussion of methodologies for collecting new data relevant to curbside management projects through both manual, in-person observations and automated data collection equipment. Additionally, the Report identifies potential opportunities to obtain data through coordination with partner agencies, mobility providers, third-party vendors, and open-source data sharing.

The Report is based upon best practices identified by practitioners who have undertaken extensive data collection and management efforts with a particular focus on lessons learned from implemented curbside management strategies and pilots. It provides a breadth of information pertaining to both the current state of the practice and emerging technologies, which will continue to evolve the practice. New curbside management concepts and data collection methods are continually being developed, and readers are encouraged to investigate innovative approaches while also evaluating tested strategies.

RELATION TO *CURBSIDE MANAGEMENT PRACTITIONERS GUIDE* (ITE)

The *Curbside Management Practitioners Guide* (the Guide) published by ITE in November 2018, introduces the concept of curbside management. The Guide focuses primarily on the philosophy that feeds into the development of curbside strategies and projects. It includes discussion on different modal priorities and the interaction between different roadway demands, a toolkit of treatments—which may be appropriate to reinforce those priorities in different contexts—and a high-level description of the overall treatment selection process involved in implementing curbside management strategies and projects. Additionally, the Guide acknowledges the need for performance measurement and the inherent need for data—in some cases, a large number of different datasets—to make informed decisions regarding the assignment of curb space (ITE, 2018).

However, the Guide does not provide in-depth discussion describing the necessary steps for the selection of specific MOEs which may be appropriate for a given project or the avenues through which practitioners can obtain the data to support project evaluations. This Report builds upon the previous publication by expanding the discussion of data needs and data collection methods to assist the practitioner undertaking curbside management efforts. Specifically, the Report includes discussion on the best-available methods for establishing an inventory of curb designations, users, demand, and regulations. It also identifies the benefits and drawbacks of different types of data collection methods, including manual observations and automated methods.

Figure 2. Graphic. ITE published the *Curbside Management Practitioners Guide* in November 2018. *Source: ITE.*

Taken together, the ITE *Curbside Management Practitioners Guide* and the Federal Highway Administration (FHWA) *Curbside Inventory Report* provide a comprehensive manual that helps agency practitioners identify priorities and goals, select desirable performance measures, collect data to evaluate those measures, select appropriate treatments, and ultimately complete data-driven evaluations of projects and strategies both before and after implementation.

Evolutions in Curbside Management

Curbside management is a quickly-evolving space. Since the publication of the Guide in late 2018, demand for curb space across the United States has only continued to increase and diversify. New modes have been introduced on the street, needing to be regulated by agencies. Additionally, agencies continue to find innovative strategies and technologies to inventory and manage use of curb space.

Several trends in curbside use have emerged in the last year, particularly in relation to micromobility, transit, and freight. The introduction of electric scooters in most major cities has shifted the way that practitioners think about shared transportation and the use of the curbside. Demand for commercial deliveries has increased with the evolution of shared economies, on-demand delivery companies, and online shopping. As the form of goods delivery diversifies, there is increased pressure to use real-time data to monitor and manage demand for loading zones at the curb. Finally, FHWA has since provided interim approval for the use of red transit lanes as a traffic control device, meaning transit lanes could become an important function of curb space.

Historically, curbside management typically focused solely on parking for private vehicles and bicycles, travel, and freight access. However, the development of new modes such as fleet-owned car sharing and ride hailing began to transform how practitioners analyzed and allocated curb space. This transformation has continued with the recent growth in popularity of dockless micromobility devices (NACTO, *Guidelines for Regulating Shared Micromobility*, 2019). Trips on micromobility devices often begin and end at the curb as scooters and bicycles are often parked on the street or sidewalk. Agencies and micromobility providers should work together to manage where and how these devices are parked and available for public use.

Figure 3. Graphic. Examples of key curbside users, functions, and modes that typically need regular use of curb space. *Source: ITE.*

The growth of ride hailing and transportation network companies increased the importance of using real-time technology to regulate the curb. In particular, tools like geolocating and geofencing can be used to monitor and regulate ride hailing and micromobility. Geolocating uses GPS or other geographic data from a cell phone or other electronic device to accurately locate the device, while geofencing uses that location information to restrict use of ride hailing or micromobility to a specific area. For example, these technologies might regulate where ride hailing passengers can be dropped off or where micromobility devices can be parked.

Demand for freight and goods delivery has also continued to increase in-step with the growth in online shopping (United States Department of Commerce, 2019). The advent of on-demand delivery companies (also known as courier network services) and increased demand for curbside pickup has expanded the types of commercial loading space and has further increased demand for commercial loading space. This has increased the need for loading zones to accommodate freight and goods delivery into areas where it was not previously as critical.

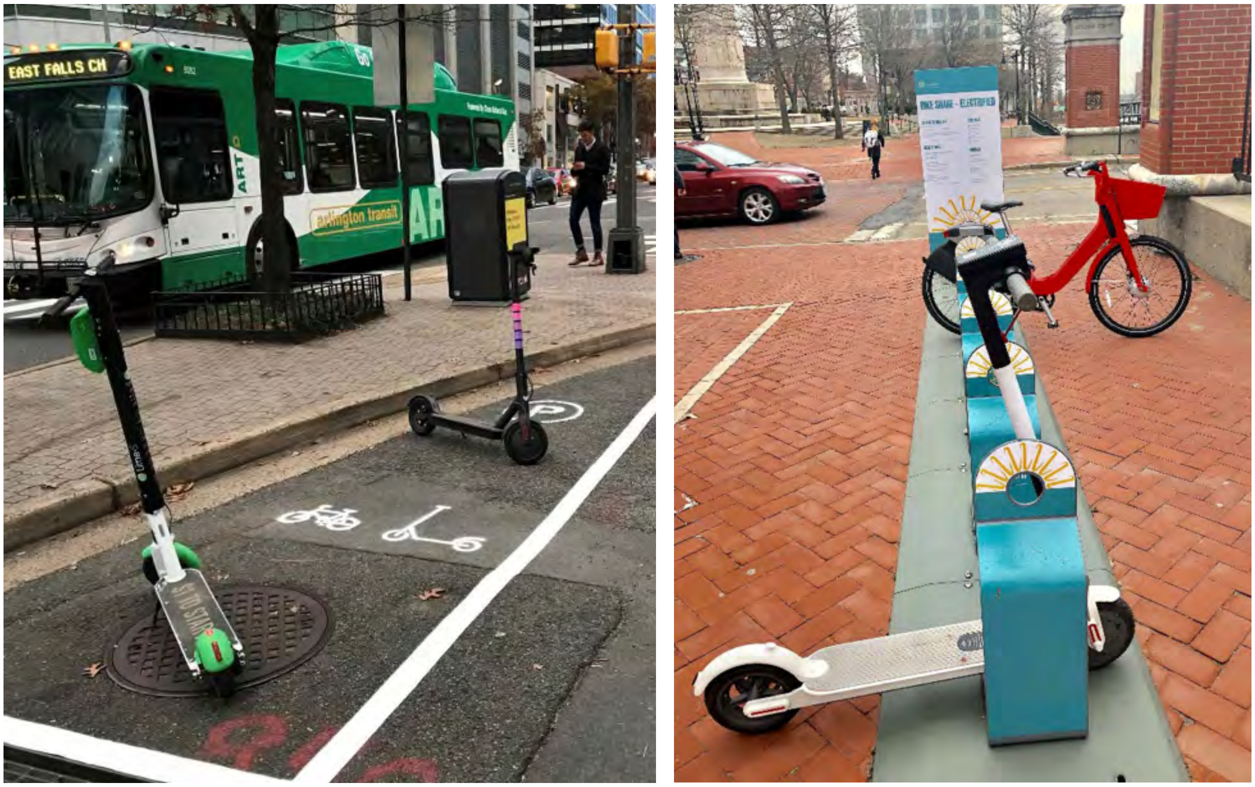


Figure 4. Designated shared mode parking areas or installing charging locations for micromobility devices are a few examples of how micromobility has shaped curbside in recent years.
Sources: Left: Arlington, VA, USA Department of Environmental Services Twitter. Right: ITE.

Additionally, these companies use independent operators who often lack commercially-registered vehicles, which diversifies the types of vehicles that might attempt to use commercial loading zones. Finally, new technologies to track and manage freight deliveries might allow for additional coordination and consolidation of deliveries. It should be noted that some utility-focused vehicles also use loading zones, and their use pattern is distinctly different than commercial vehicles.

The recognition of transit lanes using red-color pavement markings is a treatment designating a lane for transit along the curb. The use of red-colored pavement is an important step to add discernibility and visibility to areas designated for transit. Giving transit priority through designated lanes makes bus operations safer and more efficient. Some agencies have already implemented pilot transit lanes, some markings made permanent, and are expanding the use of red-colored pavement for transit lanes.

New uses, new management techniques, and new technologies will only continue to change the way the curbside is used and managed. As curbside demand evolves, so too should best practices in methods for data collection and data inventorying to ensure that the curb space is allocated, managed, maintained, monitored, and used efficiently and effectively. Updating and further inventorying curbside strategies and practices represents a tremendous opportunity in the transportation profession to align transportation priorities with physical operations and the allocation of real estate.

CURBSIDE MANAGEMENT IMPLEMENTATION

The Guide identifies numerous available tools and treatments for overall curbside management, including flex zones or dynamic curbs. Curbside management should include designing facilities for safe use by all ages and abilities, especially for vulnerable roadway users and persons with disabilities.

Practitioners should identify an appropriate duration for implementation of projects based upon considerations, such as level of success with similar projects, community feedback, anticipated future projects and cost. Ensuring the safety, mobility, and access of all road users should be at the forefront of any curbside management project process; this includes accessibility for persons with disabilities and consideration for all segments of the population. Safety of all road users at the curbside should be considered through the lens of the Safe System Approach. Curbside management projects typically fall into one of the following five project types:

- **Living previews** – These are the temporary, short-duration implementation of some or all of a proposed improvement project. These allow stakeholders to observe, interact, and comment on the project to onsite staff. Through observations, staff can collect real-time feedback from stakeholders in a manner that typically yields greater participation and better represents the proposed treatments than a visual representation of the project. These can be a particularly valuable tool to introduce stakeholders to projects, which may not be easily understood or have not been previously implemented in the area. Comprehensive quantitative data collection is typically not completed for living previews since their short duration often does not allow sufficient time for transportation conditions to normalize or stabilize.

- **Pilot projects** – These are initial implementations that are generally intended to test the viability of projects. They typically use more robust construction materials than living previews and are usually accompanied by more robust before, during, and after data collection to evaluate performance metrics. Pilot projects typically have a longer duration than living previews to ensure that conditions can normalize. Pilots can be used to collect data for evaluation or adjustment if a permanent or quick-build installation is pursued.

- **Quick-builds** – Projects may be installed more quickly using easily-adjustable or removable construction materials or equipment, potentially allowing modifications to the project as performance is observed. Quick-builds differ from a pilot project as they may be permanent in nature or may be an interim step to a permanent installation as opposed to an evaluation of a concept. Quick-builds may also be a cost-effective means to implement a larger number of projects in the short-term, with permanent installation coming later. It is important that quick-build projects involve transportation professionals and the approval of the jurisdiction to ensure that appropriate levels of safety, mobility, access, and other considerations are incorporated into these community-level alterations of the street.

- **Permanent installations** – Projects implemented with materials or equipment intended to be in place for the long term are considered permanent in nature. Some facets of permanent installations (e.g., physical construction of concrete curb, transit shelters, or traffic signals) may be difficult to modify once implemented, though signage and pavement markings that designate space may still be adjustable.

Figure 5. Photo. Living previews allow the short-term demonstration of new projects or concepts with temporary materials, such as this pop-up protected bike lane in Redwood City, CA, USA. *Source: Fehr & Peers.*

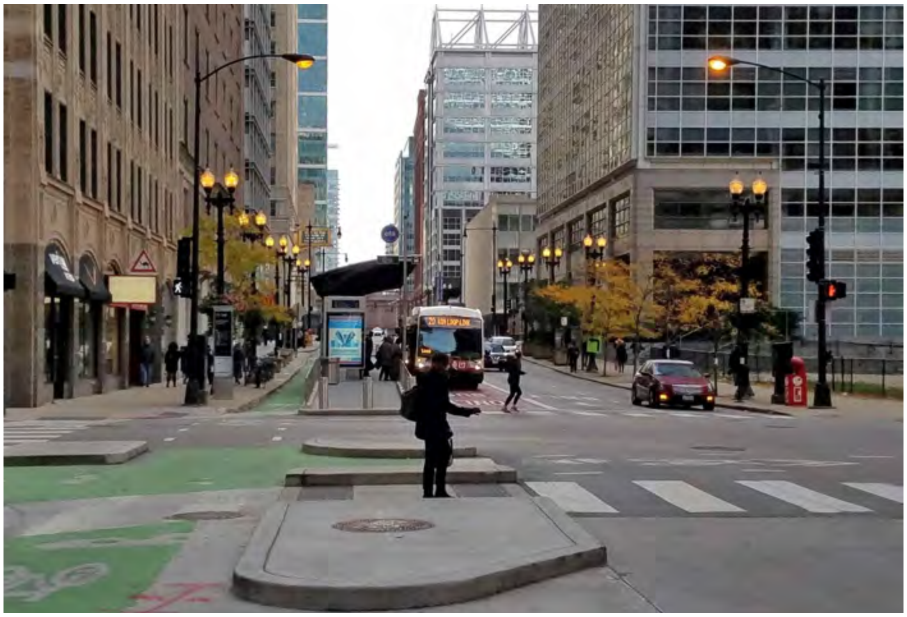


Figure 6. Photo. Cycle track transit lanes, and bus boarding areas implemented using permanent construction methods on Washington Street in Chicago, IL, USA. *Source: Fehr & Peers.*

- **Field adjustments** – Modifications made to an installed project based upon data, observations, or inventories are defined as field adjustments. This may include adjustments to pilot projects based on mid-pilot data collection or quick-build and permanent installations when post-project data indicate adjustments should be made.

Dynamic uses of curb space, such as flex zones or dynamic curbs, can be maintained with any of these implementation types; though it may be difficult to indicate through signs and markings to users for short-term living previews. Flexibility is generally the most restricted with permanent installations if they rely upon significant physical construction. Agencies can benefit from developing permanent installation projects with flexibility for future modifications in mind. These considerations are useful both for allowing projects to be adjusted in the short, medium, or long term based upon changing demands and performance.

Figure 7. Photo. Field adjustments to enhance turn radii were identified during implementation of a quick-build buffer-separated bicycle lane project in San José, CA, USA. *Source: Fehr & Peers.*

ESTABLISHING PROJECT GOALS AND DATA NEEDS

New curbside management projects may range in size from minor, standalone adjustments to existing curb assignments to major reconfiguration of public spaces or even new, jurisdiction-wide strategies. Regardless of project size, undertaking new curbside management efforts should begin by determining project needs and goals. Identifying city and agency priorities (e.g., modal priorities) and conducting public outreach can help determine these needs and goals. The public can provide feedback on issues they experience in the project area and weigh in on curb functions or changes they value most. Overarching project goals might be broad, such as to improve mobility, safety, access, and/or economic vitality. However, more specific aims within these goals should also be identified (e.g., provide space to accommodate ride-hailing vehicles, reduce bicycle and pedestrian collisions, or increase foot traffic in commercial areas). Curb management projects could further be used to align current patterns of use with existing city priorities and goals.

Figure 8. Photo. Attendees at a community engagement event jointly hosted by Capital Metro and Austin Transportation Department had the opportunity to share their desired goals and vision for specific streets. *Source: Austin Transportation Department.*

Equity is a critical consideration in identifying project goals and ultimately delivering curbside management projects. During public outreach, officials should maintain communication all segments of the population for input and feedback to gain and understanding of the needs of all curb space stakeholders and user groups. Inherent biases, including differences in existing activity and data availability in different communities, should be taken into account so that project goals are evaluated and enacted equitably.

Data collection—which, in this case, most accurately refers to the collection of any kind of information —should focus on defining existing curb uses, demands, and issues as well as metrics that can quantify the effects of curb projects. This data can range from conditions specific to the use of the curb or more general characteristics of the surrounding area.

Figure 9. Photo. Safe access and equitable mobility to the public realm for all road users should be key considerations in the development of all curbside management projects.
Source: District Department of Transportation.

Using data to survey existing conditions is a crucial supplement to public feedback and informal observations when determining if a curbside management project may be necessary. If a modification to the existing curbside management approach is desired, these data can then be used to identify relative levels of supply and demand so that an appropriate project can be developed to meet the identified goals and modal priorities. This data could include the area under study as well as conditions apart from the curb being studied, as other areas could serve as a point of comparison. Key existing condition information to be considered before developing a project includes the following:

- Enacted policies and regulations that pertain to allocation of space in the right-of-way, with emphasis on curb and parking policies and information on how those policies and regulations are enforced (e.g., parking designations, enforcement policies, policy exceptions).

- Existing allocations of space to various curb and mobility uses, including delineation of curb space to specific activities (e.g., signage, pavement markings).

- Overall access and mobility of the curbside, including improvements for persons with disabilities.

- Any monetization of existing curb space (e.g., metered parking, paid loading zones).

- Existing usage and activity demand, including use by disabled persons (e.g., parking utilization, number of loading events, freight/goods delivery activity, transit ridership).

- Identified operational and enforcement issues (e.g., double parking, blockages of travel lanes).
- Nearby land uses and transportation facilities that may affect project development (e.g., demand generators, nearby mobility alternatives, alternate on- and off-street parking options).
- Other existing non-mobility uses that activate public space (e.g., parklets, farmers markets, sidewalk cafes, pop-ups); the same data can also be effective in determining when demand for the curb changes, allowing projects to be adapted over time in response to evolving conditions.

During the development of a project, MOEs should be selected that reflect the stated goals of the curb project, especially safety, mobility, and access for all road users. Data that correlates with the stated goals should be collected before, during, and after implementation of the curb project to quantify how well the project achieves them. For example, a project might aim to reduce the number of passenger loading activities taking place outside of loading zones. If so, the agency could collect data on the location and volume of loading activity as well as quantify blockages to other transportation modes before and after the implementation of any curb changes. This would allow the agency to determine if the curb intervention successfully addressed MOEs such as increased loading zone utilization and reduced blockages. Data collection can be used as part of an iterative process to continue fine tuning the treatment. Finally, the same data can also be effective in determining when demand for the curb changes, allowing projects to be adapted over time in response to evolving conditions.

Figure 10. Photo. Having clear MOEs can help guide a project when you have multiple uses and modes on a busy street, such as Eye Street in Washington, DC, USA. *Source: Sarah Abel/ITE.*

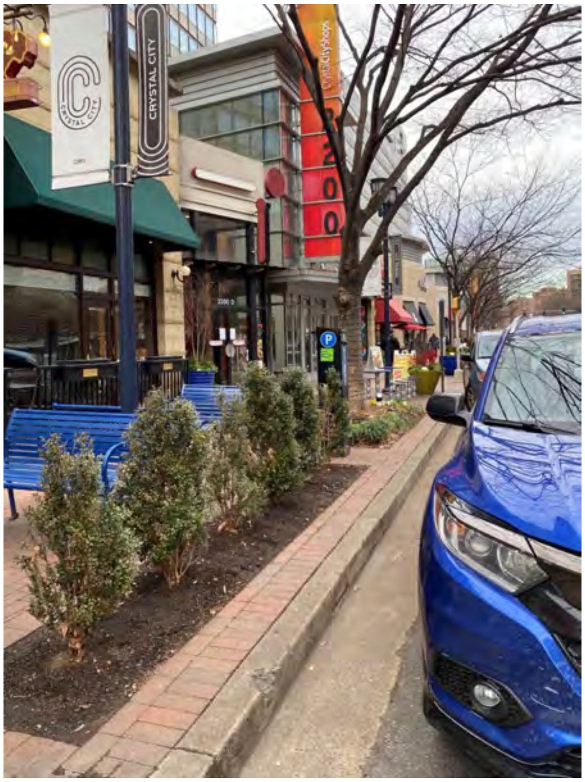


Figure 11. Photo. This is a mixed-use commercial area where many modes and uses are contending for curb space where clear project goals and MOEs can be effective in inventorying and allocating the curbside in Crystal City, Virginia, USA. *Source: ITE.*

Additionally, the geographic extent and period of data collection should be considered. For example, collecting data in an area not undergoing a new curbside management project can be used as a point of comparison to the treatment site when assessing MOEs. Similarly, the time period of data collection can be important when assessing MOEs. For instance, data collection over longer time frames (e.g., more than a year) will allow for the examination of long-term trends or potential seasonality effects.

Potential project goals and relevant MOEs are listed in the tables below and categorized per their relation to mobility, livability, access, safety, economics, and equity. Once project goals have been identified and appropriate MOEs selected accordingly, the dataset(s) needed to evaluate performance can be determined based upon these tables. These datasets effectively represent the sample data needs for the project under consideration. It can also be helpful to identify additional datasets to allow further points of comparison as needs arise (e.g., transit ridership may be a readily available dataset to evaluate transit operations even if improved transit reliability has not been identified as a specific project MOE).

Finally, the use of standardized data also helps to protect agency staff and practitioners against potential arguments about bias in the project development and results (LA Metro, 2016). As such, it is key to document the setting of community involvement in goal-setting and incorporate relevant data in decision-making.

Table 1. Personal Mobility

<table>
<tr><th>Typical Project Goal</th><th>Measure of Effectiveness (MOE)</th><th>Dataset(s)</th><th>Collection Method(s)</th></tr>
<tr><td>Increase overall curb productivity</td><td>Increase the number of people and/or access to goods the curb provides</td><td>Number of people or deliveries the curb provides access to across all transportation modes per chosen unit of curb space (typically measured in feet) and per chosen period of time (e.g., per 15-min period, per hour, etc., segmented by day of week/time of year)</td><td>In-field observations
Video data collection
Third-party mobility provider use and occupancy data</td></tr>
<tr><td rowspan="5">Improve transit operations (particularly for transit priority corridors)</td><td rowspan="2">Fewer blocked transit lanes (e.g., automobiles or loading activity located in transit lanes, impeding transit vehicles)</td><td>Count of observations of blocked transit lanes</td><td>In-field observations
Video data collection</td></tr>
<tr><td>Citations for blocking transit lanes</td><td>Interagency police citations</td></tr>
<tr><td>Improved transit reliability</td><td>On-time performance per transit stop
On-time performance per transit route</td><td>Interagency transit schedule adherence data (e.g., Automatic Vehicle Location (AVL) data), GTFS-RT</td></tr>
<tr><td>Improved transit ridership</td><td>Boarding per transit stop
Ridership per transit route</td><td>Interagency transit ridership data</td></tr>
<tr><td>Improved average transit speed</td><td>Average transit travel speeds</td><td>Interagency global positioning system (GPS), AVL data, GTFS-RT</td></tr>
</table>

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support bicycling (particularly for bicycle priority corridors)	Fewer blocked bicycle facilities (e.g., automobiles, loading activity located in bicycle facilities, impeding bicyclists, etc.)	Count of observations of blocked bicycle facilities	In-field observations Video data collection
		Citations for blocking bicycle facilities	Interagency police citations
	Increased comfort of bicyclists (perceptions of safety)	Before and after number of riders riding on the sidewalk Change in demographics and user behavior	In-field observations Video data collection
	Increased number of bicyclists	Count of bicyclists	In-field observations Video data collection Automated counters (e.g., pavement sensors, tube sensors)
	Additional bicycle parking provided	Amount of bicycle parking available compared to demand and building occupancy	In-field observations Interagency public agency databases

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support pedestrian accessibility and access to destinations	Fewer blocked crosswalks	Count of observations of blocked crosswalks	In-field observations Video data collection
		Citations for blocking crosswalks	Interagency police citations
	Fewer blocked sidewalks	Count of observations of blocked sidewalks	In-field observations Video data collection Third-party scooter-share or bike-share parking data
		Citations for blocking sidewalks	Interagency police citations
		Pedestrian travel time	In-field observations Video data collection
		Pedestrian wait time at intersections	In-field observations Video data collection Public agency databases
		Count of sidewalk gaps Count of pedestrian obstructions	In-field observations Interagency public agency databases

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Improve passenger loading	Fewer blocked transit lanes	Count of observations of blocked transit lanes (e.g., automobiles or loading activity located in transit lanes, impeding transit vehicles)	In-field observations Video data collection
		Citations for blocking transit lanes	Interagency police citations
	Fewer blocked bicycle facilities (e.g., automobiles, loading activity located in bicycle facilities, impeding bicyclists, etc.)	Count of observations of blocked bicycle facilities	In-field observations Video data collection
		Citations for blocking bicycle facilities	Interagency police citations
	Fewer blocked crosswalks	Citations for blocking crosswalks	Interagency police citations
		Count of observations of blocked crosswalks	In-field observations Video data collection
	Fewer blocked sidewalks	Count of observations of blocked sidewalks	In-field observations Video data collection
		Citations for blocking sidewalks	Interagency police citations
	Loading zone availability, accessibility, and utilization	Count of passenger loading instances by loading location, frequency of accessible connections to the sidewalk, and loading zone availability (e.g., in a loading zone, travel lane, or bicycle facility while loading zone is already occupied or unoccupied)	In-field observations Video data collection Parking/curb space sensors (if present)

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support complete trips	Improved transit ridership	Boardings per transit stop Ridership per transit route	Interagency transit ridership data
	Increased use of car-share	Count of people using car-share vehicles	In-field observations Video data collection Car-share usage data
	Higher occupancy in ride-hailing vehicles (e.g., increased use of shared ride-hailing vehicle rides)	Count of passengers per ride-hailing vehicle	In-field observations Video data collection Third-party ride-hailing vehicle company-provided data

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support non-automotive transportation modes	Increased number of bicyclists	Count of bicyclists	In-field observations Video data collection Automated counters (e.g., pavement sensors, tube sensors)
	Increased amount of bicycle parking	Count of the number of bicycle racks	In-field observations Interagency public agency databases
	Increased use of scooter-share or bike-share	Count of people using scooter-share or bike-share	In-field observations Video data collection Third-party scooter-share or bike-share ridership data
	Reduced conflicts on sidewalks both parking and operating	Walk audit	In-field observations Interagency public agency databases
	Increased amount of parking available for scooter-share or bike-share	Count of docks available for docked scooter-share or bike-share	In-field observations Interagency public agency databases
		Amount of space available for parking dockless scooter-share or bike-share	In-field observations Interagency public agency databases

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support sustainable transportation solutions	Reduced congestion and emissions levels	Count of vehicles on the road (used to calculate capacity/ operations, e.g., LOS)	Manual data collection In-field observations Communications-based sensing Automated counters (e.g., pavement sensors, tube sensors) Emissions data (if available)
		Average traffic speeds	Communications-based sensing Automated counters (e.g. pavement sensors, tube sensors)
	Reduced single occupant vehicle usage	Average vehicles available per household by census tract Aggregate vehicles per census tract Commute drive share per census tract Adoption rate of fleet owned car-share Allocation of parking spaces to fleet-owned car-share	Interagency census data (long term)
	Reduced parking demand for private vehicles	Parking utilization rates	In-field observations Video data collection Parking department data Automated counters (e.g., pavement sensors)
	Expanded opportunity for electrification of transportation modes	Availability of curb space to charge electric vehicles and micro-mobility devices	In-field observations Interagency public agency databases

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Improve parking operations	Target turnover levels achieved	Change in the volume of cars parked over a certain time interval	In-field observations Video data collection Interagency parking department data Automated sensors or detection (if available)
	Improve availability and distribution of accessible parking spaces	Building and land use codes, maintain inventory and conduct needs-based assessments of accessible parking spaces.	Interagency parking department data Public feedback Interagency public agency databases
	Improved wayfinding and user experience	User feedback on wayfinding experience	Survey or focus group
	Reduced parking demand for private vehicles	Parking utilization rates Adoption of fleet owned car-share Allocation of parking spaces to these fleet-owned car-share	In-field observations Video data collection Parking department data Sensors or detection (if available)

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Reduce vehicle congestion and improve vehicular flow	Reduced cruising behavior	Number of vehicles cruising for parking	In-field observations Video data collection Driver surveys
	Reduced congestion and emissions levels	Count of vehicles on the road	Traffic counts (used to calculate capacity/operations) Communications-based sensing Automated counters (e.g., pavement sensors, tube sensors) Interagency emissions data (if available)
		Average traffic speeds	Communications-based sensing Sensors or detection (if available)
	Improved emergency vehicle response time	Reported response times Modeled response times	Public agency response time data through interagency coordination (to verify reports and/or calibrate models)
	Improved vehicle travel time on designated streets	Vehicle travel time	In-field observations Video data collection Communications-based sensing Sensors or detection (if available)
	Increased average vehicle occupancy	Number of people within each vehicle	In-field observations Video data collection

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Maximize flexibility at the curb while maintaining access for all road users	Multiple curb uses supported in the same curb space simultaneously or sequentially (e.g., flex zones and dynamic curbs)	Regulations documenting which uses are permitted in the same curb space	Review of applicable agency policies In-field observations
		Curb design that accommodates all roadway users	In-field observations
		Number of different type of users observed at the same curb space	In-field observations Video data collection

Table 2. Livability

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Increase public space availability and use	Additional park/green space provided	Amount of green/park space available	In-field observations Geographic Information Systems (GIS) database
	Utilization of park/ green space	Number of people in or using the park/green space	In-field observations
	Additional seating/ community gathering space provided	Amount of seating/ community gathering space	In-field observations GIS database
	Enhanced public space activation	Number of events in public space	Calendar of community events Permit requests

Table 3. Access

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Decrease curbside obstructions	Persons with disabilities have equal access to facilities	Qualitative feedback from community members with disabilities	Survey or focus group
	Prevalence of obstructions impacting accessibility	Number of reported issues	Agency tracking system
	Eliminate sidewalk obstructions for the safety and mobility of all road users	ADA requirements, walk audits, and enforcement data	In-field observations Public agency databases Citations data
	Agency permits and processes ensure facility accessibility	Permit agreements ensure that any activities in the ROW (e.g. micromobility, cafes, business signs) do not jeopardize access	Review of agency permits, enforcement of compliance
Improve accessible parking and passenger loading zones	Reduced illegal use of accessible loading and parking zones	Number of observations of people without disability placards using accessible loading and parking zones	In-field observations Video data collection Citations data
	More accessible loading and parking zones provided	Number of accessible loading and parking zones	In-field observations GIS database Asset management system database
	Access from accessible parking spaces and loading zones to sidewalk	Accessible connections required by standard plan details and ADA Transition Plan data can identify obstacles	In-field observations Interagency public agency databases Public requests
	Accessible accommodations of parking meters and pay-stations	Requests and measuring demand demand	In-field observations Public requests

Table 4. Safety

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Reduce risk of danger for all roadway users	Fewer negative consequences of curbside access events	Observations of vehicles swerving, bicycles swerving, mid-block U-turns, mid-block crossings	In-field observations Video data collection
	Less risky consequences of curbside access events (e.g., collisions are less likely to affect vulnerable roadway users or less likely to be high-speed)	Population groups (e.g., pedestrians, bicyclists, drivers) involved in collisions	In-field observations Video data collection Local or statewide collision datasets (medium to long term)
		Speed at which collisions occur	In-field observations Video data collection Local or statewide collision datasets (medium to long term)
	Fewer near miss incidents	Observations of near miss incidents between vehicles, bicyclists, and/or pedestrians	In-field observations Video data collection Video detection On-board vehicle data on driver behavior
	Reduced pedestrian or bicycle conflicts with heavy trucks	Observations of conflicts between trucks and bicycles or pedestrians	In-field observations Video data collection
	Reduced moving vehicle violations	Citations for violations such as stop lights, red lights, crosswalk intrusions, and speeding	Police citations
Reduce collisions and improve safety of all road users	Fewer collisions	Number of collisions within the target area	Local or statewide collision datasets (medium to long term)
	Fewer roadway injuries or fatalities	Number of roadway injuries or fatalities in the target area	Local or statewide collision datasets

Table 5. Economics and Freight

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Improve commercial loading	Staff time coordinating deliveries reduced	Qualitative feedback from merchants	Survey Focus groups
	Enhanced availability and convenience of commercial and utility vehicle loading zones	Qualitative feedback from merchants and delivery drivers	
		Number and location of commercial and/or utility loading zones present and relative to businesses receiving deliveries	In-field observations Public agency databases
		Count of loading instances by loading location (e.g., in a loading zone, travel lane, bicycle facility, etc.)	In-field observations Video data collection Parking/curb space sensors (if present)
		Fleet search time for commercial loading space	In-field observations Survey Focus groups
		Violations received for loading outside of permitted commercial loading space and violations received by non-delivery vehicles that park in commercial loading spaces	Police citations
	Loading zone utilization	Count of commercial loading instances by loading location and loading zone availability (e.g., in a loading zone, travel lane, bicycle facility, etc. while loading zone is already occupied or unoccupied)	In-field observations Video data collection Parking/curb space sensors (if present) Third-party data (e.g., goods and freights carriers)

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Support vitality of local businesses	Provide cafe/ restaurant seating zones while maintaining sidewalk accessibility	Amount of café/restaurant seating provided, complaints about obstructions, and code enforcement cases	Permits and municipal revenue data
	Improved sales receipts	Number of sales made Dollar value of sales made	Tax/sales data
	Additional funding available for streetscape and façade enhancements	Money available for streetscape and façade improvements	Creation and funding of new Business Improvement Districts (BID)s or Transportation Management Associations (TMA) with revenue from curbside access fees or higher parking fees
Support municipal funding	Suitable funding streams for maintenance of curb projects is maintained	Money allocated for the maintenance of curb projects	Municipal revenue data Loading and parking fee revenue Return rate on curb usage fees (e.g., congestion pricing) Capital budget for curb program Total maintenance budget
More efficient staff processes to implement and monitor curbside management projects	Streamlined data collection and analysis procedures in place across city departments	Documentation of data collection and analysis procedures	GIS data library compiled, maintained, and frequently used
	Innovative technology in place for real-time efficacy monitoring	Documentation of technology in place for real-time efficacy monitoring	Inventory of citywide assets and regulations (e.g., restrictions or permissions)

Table 6. Equity

Typical Project Goal	Measure of Effectiveness (MOE)	Dataset(s)	Collection Method(s)
Minimize disruptions to curb space used by vulnerable roadway users	Changes do not have negative impacts on vulnerable roadway users	Qualitative feedback from vulnerable roadway users	Surveys Focus groups
Ensure equitable access to curb space	Changes include benefits for vulnerable roadway users	Qualitative feedback from vulnerable vulnerable roadway users	Surveys Focus groups
Make curb changes to support vulnerable roadway users	Changes to the curb prioritize curb uses valued by vulnerable roadway users	Qualitative feedback from members of vulnerable roadway users	Surveys Focus groups
	Increase or improve access to affordable mobility options	Inventory of available transportation options & their costs, service areas, etc.	Public transit agencies Third-party mobility providers
Improved public engagement for curbside management	High-functioning, public-private stakeholder body assembled and meeting regularly	Record of public engagement and number of attendees	Meeting minutes of group

EXAMPLES OF USING DATA TO MEASURE GOALS FOR CURBSIDE MANAGEMENT PROJECTS

The following case studies provide examples of the identification of project goals, appropriate MOEs, and data needs relevant to different curbside management projects.

King Street Transit Priority Corridor Pilot – Toronto, ON, Canada

The City of Toronto and Toronto Transit Commission embarked on a pilot project to re-imagine the public realm on King Street between Bathurst Street and Jarvis Street. The primary goals identified for the project were to move people more efficiently, support economic prosperity, and improve place-making by putting people first and improving transit reliability, speed, and capacity (City of Toronto, "King Street Pilot Study"). In order to evaluate these goals, the pilot involved the collection of a bevy of data before and during the pilot, including the following:

- Transit ridership
- Transit travel time and reliability
- Car travel times and volumes
- Pedestrian volumes
- Cycling volumes
- Economic point-of-sale data
- Public space amenities

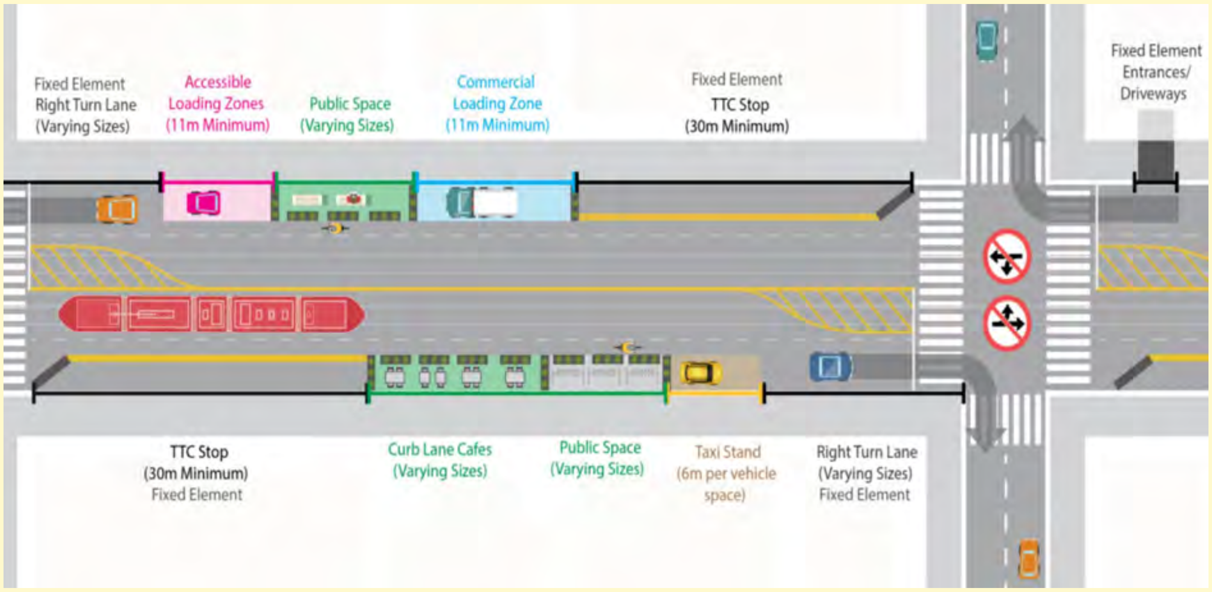


Figure 12. Graphic. In order to prioritize movement of people using all modes, the City of Toronto, ON, Canada and Toronto Transit Commission undertook a pilot to re-envision the public space along King Street in the downtown core. *Source: City of Toronto.*

These data were collected using a combination of video-analytic driven pedestrian, bicycle, and vehicle volume data, Bluetooth vehicle travel time monitoring, GPS-based transit data, and economic point-of-sale data obtained through interagency collaboration. Data evaluated for the annual summary published in December 2018 showed that transit ridership and travel time reliability have generally improved, cycling volumes have increased significantly, and public amenities were enhanced without major impact to vehicle travel times or economic activity (City of Toronto, "Annual Summary"). The City Council subsequently identified King Street as a permanent transit priority corridor.

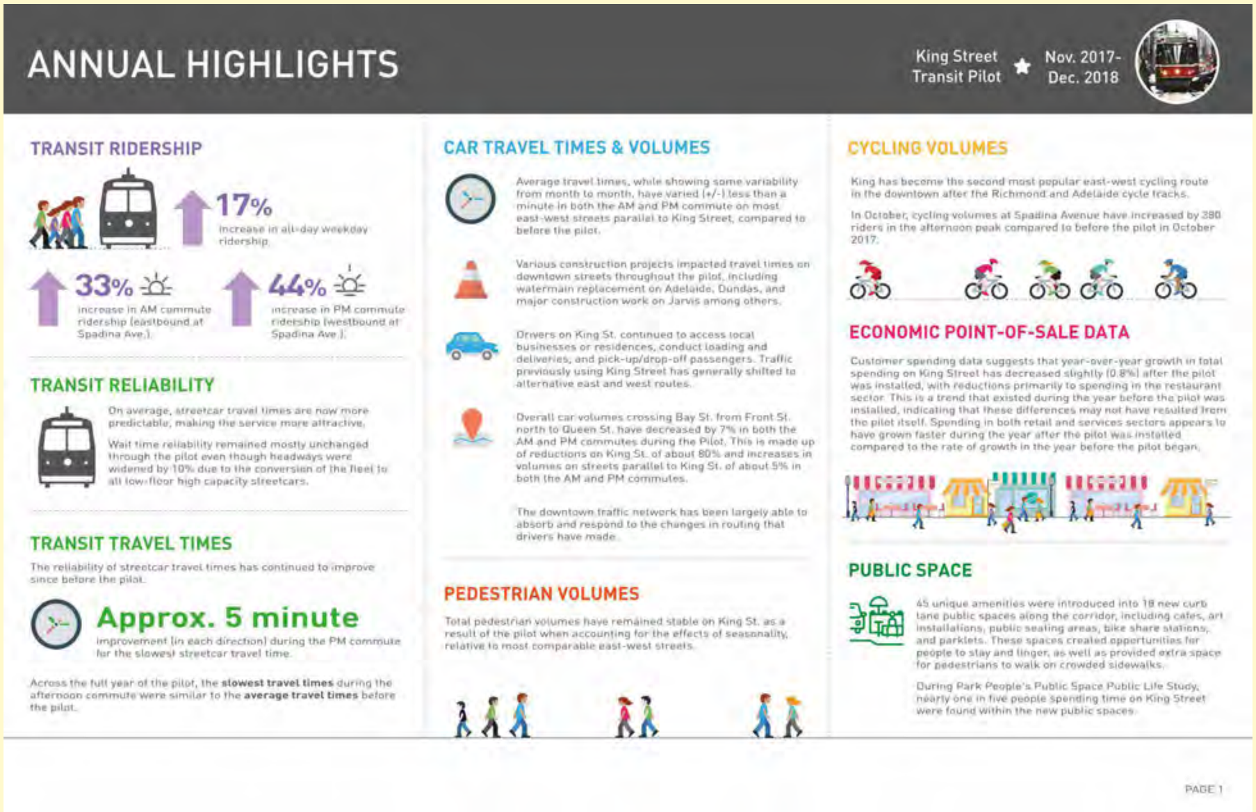


Figure 13. Graphic. The City of Toronto, ON, Canada and Toronto Transit Commission performed continuous data collection measuring the King Street Pilot Project and published reports summarizing outcomes at regular intervals. *Source: City of Toronto.*

District Department of Transportation curbFlow Pilot – Washington, DC, USA

The District Department of Transportation (DDOT) conducted a 3-month pilot with an application start-up called curbFlow to improve commercial loading throughout Washington DC. The DDOT curbFlow pilot allows delivery drivers (including those using non-commercial vehicles) to reserve curb space up to 30 minutes in advance. DDOT piloted this service in nine locations throughout the city and curbFlow employees recorded what types of vehicles used the loading zones. One of the goals of the pilot was to address double parking and illegal U-turn maneuvers related to delivery drivers failing to find suitable curb space for loading activities. As such, DDOT identified a need to collect before-and-after event-based data of these activities in collaboration with curbFlow. After the pilot concluded, DDOT found that double parking decreased an estimated 64 percent in the vicinity of the pilot locations.

Figure 14. Photo. As curb use is changing, agencies are adapting by using a multitude of different pilot projects to plan, adjust, and reallocate the curb One such example, shown here, is the curbFlow pick-up/drop-off pilot project undertaken by the District Department of Transportation in Washington, DC, USA. *Source: www.curbflow.com*

Metro Sidewalk Network Data Pilot – Minneapolis/St. Paul, MN, USA

Metro Transit of Minneapolis/St. Paul recently completed a pilot to evaluate improved pedestrian connectivity analyses utilizing walkshed travel time modeling. While most pedestrian transportation studies rely on "as the crow flies" travel distances or roadway network analyses to identify walksheds, these often do not accurately reflect pedestrian travel time variability caused by connectivity gaps or intersection delays. However, Metro developed a new methodology in which they manually created a sidewalk network by tracing aerial imagery and entering data on signal wait times to allow GIS network analysis of walksheds at three pilot locations. The goal of the pilot was to demonstrate that true walkshed analyses based on accurate modeling could enhance pedestrian and multi-modal trip planning, requiring the collection of physical world data to generate model results. The pilot found that the walkshed travel time methodology showed great potential as a scenario planning tool, allowing agency staff to quantitatively identify how walksheds may change in response to potential modifications to the built environment (Watercott, et al., 2019).

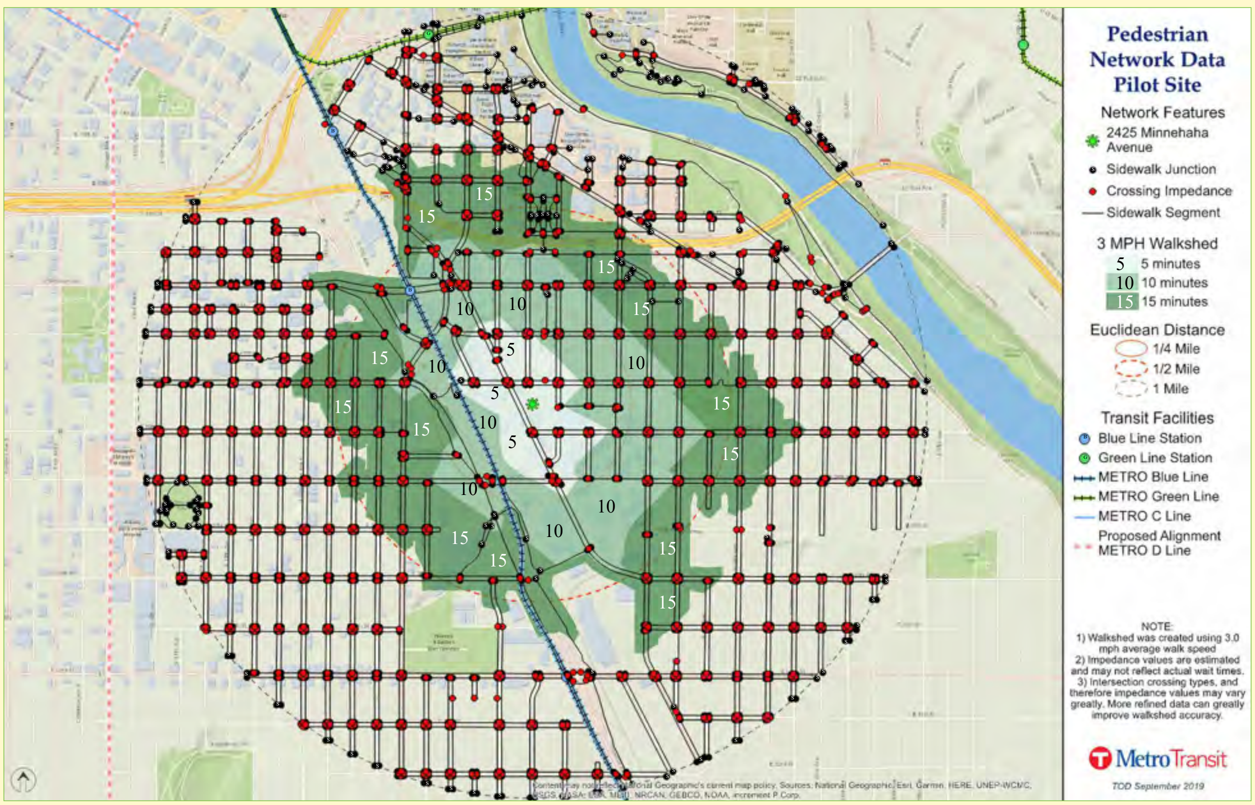


Figure 15. Graphic. Metro Transit of Minneapolis/St. Paul, MN, USA piloted a new methodology to evaluate pedestrian connectivity, including the digitization of sidewalks to develop more accurate walkshed maps through GIS network analysis.
Source: Metro Transit of Minneapolis/St. Paul.

Inner Sunset Curb Management Project – San Francisco, CA, USA

The San Francisco Municipal Transportation Agency (SFMTA) recently initiated a new curb management project in the Inner Sunset neighborhood of San Francisco. The project goals are to "improve safety and transit reliability while reducing congestion by reducing double-parking and other illegal parking and loading behavior" and "support economic vitality by ensuring businesses have the space they need for their customers and goods to get to the neighborhood" (San Francisco Municipal Transportation Agency). To determine the type of curb interventions needed, the SFMTA conducted intercept, resident, and merchant surveys, analyzed existing parking occupancy and loading patterns, and identified which transit stops had the highest ridership. This data helped the SFMTA create recommendations tailored to the characteristics of the neighborhood, which will lead to necessary adjustments in legislation and ultimately project implementation in 2020. SFMTA will subsequently evaluate the identified metrics post-implementation to evaluate project efficacy.

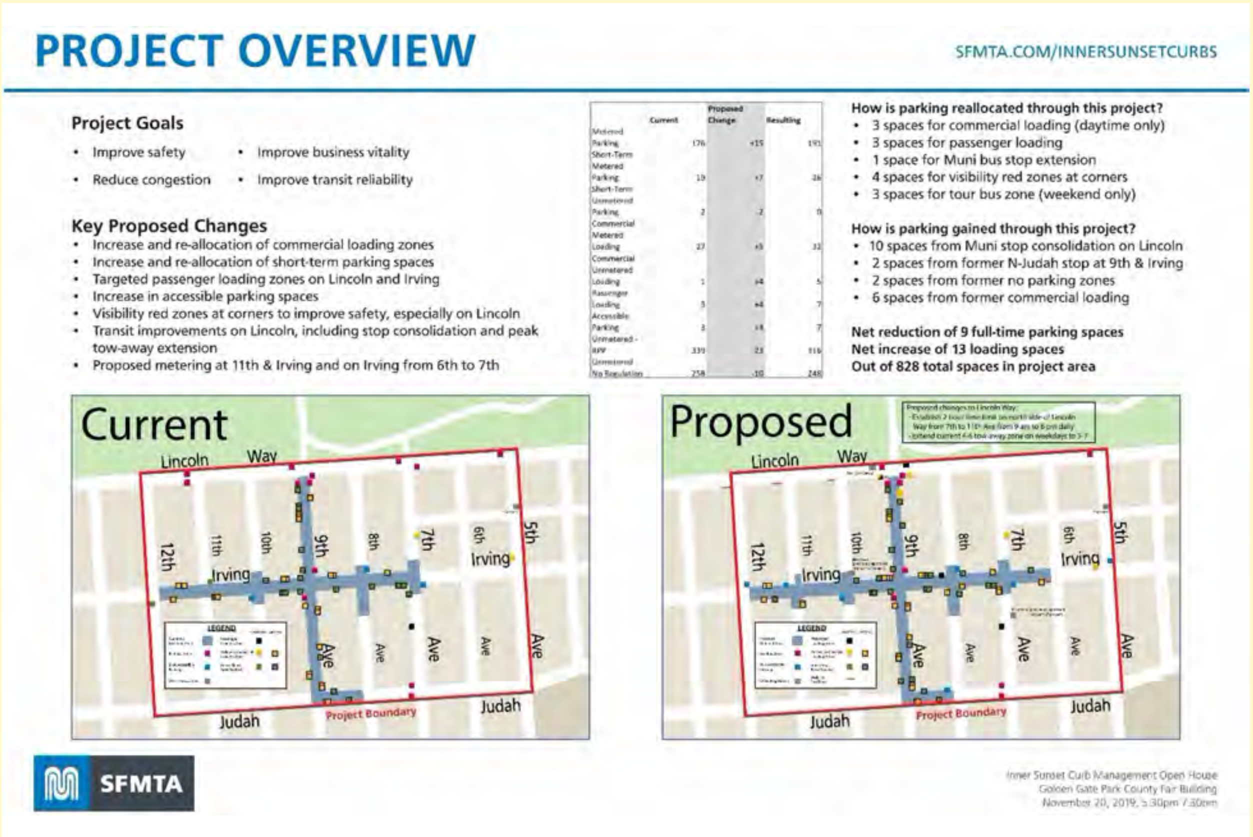


Figure 16. Graphic. Project goals and proposed changes for San Francisco Municipal Transportation Agency's Inner Sunset Curb Management Project in San Francisco, CA, USA.
Source: San Francisco Municipal Transportation Agency.

DATA INVENTORY METHODS FOR CURB USES, SUPPLY, AND DEMAND

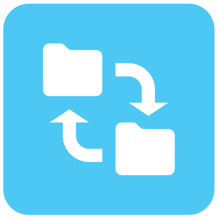
Once the data needs for a project have been identified, practitioners typically examine existing data their agency has on-hand before devoting resources to the collection of new data. Besides identifying the existence of data, it is important to evaluate the quality and applicability of data and processes for updating data. For example, data which is out-of-date or does not represent the critical study time periods for the project in question may need to be replaced with more useful data. This will identify which new data needs to be collected.

After determining if new information is required, potential methods for obtaining the relevant datasets are evaluated. A number of sources may be useful in helping secure the required new data, most of which generally fall into the following four groups. These groups are generally classified based on their relation to the agency practitioner:

1. **Manual data collection** – this represents the collection of new information through in-person, onsite observations and direct review of written policies, guidance, and procedures. These data sources require a person to collect data directly or manually deploy data collection equipment in the field. However, data collection may still involve sophisticated technical equipment such as apps, imagery processing algorithms, and digitization tools. Manual data may be skewed by in-person bias, collection fatigue, and limitations for extended durations.

2. **Automated data collection** – this includes the collection of new information through the deployment of temporary or permanent electronic equipment that do not require a human operator. Automated data collection may still require human review, interpretation, evaluation, analysis, or enforcement.

3. **Third-party data providers** – these are non-governmental sources from which new aggregated datasets can be obtained, sometimes for a fee. Some third-party data providers are purveyors of aggregated data collected via manual or automated data collection, but this group also includes mobility providers, goods and freight carriers, and other specific-use data providers.



4. **Interagency data** – information obtained from other agencies, typically without significant cost, falls into the category of interagency data. The agencies holding these datasets are typically other government entities, including departments which oversee areas such as economic development, public safety, parking, and transit operations.

Note that the same data can often be obtained using more than one of the methods described above, and the most desirable method is often influenced by the scope and size of the project being evaluated. For projects which are taking place in small areas or may require small datasets to evaluate, manual data collection may be an efficient solution. Datasets pertaining to larger geographic areas or requiring continuous data collection of activities for long periods may often be more effectively obtained through automated methods or third-party sources. Information related to mobility provider activities will often be most accurately obtained through direct coordination with those providers where feasible. Some of the advantages and disadvantages are listed in the table below.

Table 7. Advantages and Disadvantages of Different Data Collection Methods

Method	Advantages	Disadvantages	Common Applications
Manual data collection	Allows for human/subjective judgments Collect data with more fine-grained detail Lower cost of technology	Labor intensive Time intensive Data consistency and quality	Smaller scale projects Projects requiring subjective judgments and/or complex contexts that might not be suited to automated methods Projects with customized or specialized data collection
Automated data collection	Can generally collect more data (e.g., more frequently and/or over a larger area) more efficiently than manual collection Allows long-term record of observations (e.g., video or image captures) Might allow for the automation of data analysis	Higher initial cost Risk of equipment malfunction Issues with algorithm used in automated methods could cause consistency errors If human effort is needed to process or digitize results, could still be labor-intensive May be difficult to customize some automated data collection methods to fit project needs For detailed surveying, automated methods might not result in sufficiently precise location accuracy Need for further analysis	Large scale projects Projects which may require a stored video record of observations Projects that may not require customization in data collection Projects that do not require precise location data

Method	Advantages	Disadvantages	Common Applications
Third-party data providers	Can provide information that is not easily observable (e.g., mobility use, ridership, transportation routes) Can provide data over a longer time period than is feasible for data collection (e.g., annual data by month to reveal temporal trends)	Initial costs for some sources may be too high for use in small, target efforts Mobility providers may simply be unwilling to provide the data or provide it at a level of disaggregation such that it is useful for evaluation purposes Sometimes requires more rigorous legal negotiation between agency and mobility providers Third-party providers, other than the specific mobility service provider, sometimes have insufficient sample sizes to draw conclusions Claims that don't hold up on coverage and accuracy	Projects requiring the examination of temporal or longitudinal trends Projects which benefit from quantitative understanding of third-party mobility provider activity
Interagency data	Can provide information that is not easily observable Can provide data over a longer time period than is feasible for data collection (e.g., annual data by month to reveal temporal trends) Typically lower cost than obtaining data via new collection or third parties	Data might be stored in a way that is difficult to analyze (e.g., not digitized, not synthesized, etc.) Obtaining data from other agencies can sometimes be quite onerous Data can sometimes be in different formats between agencies	Supply of information on background context, existing conditions, planning and zoning, transit, and other components overseen by public agencies Projects requiring the examination of temporal or longitudinal trends

Some data collection solutions may not exactly fit any of the four categories above. An example of this is app-based data collection, which involves a person manually operating an electronic device to collect data but typically then having the data itself processed and transmitted to the practitioner by a third party (e.g., 311 app to report micromobility devices blocking sidewalks). Similarly, automated data collection typically involves the installation of a sensor device. Data may also be captured from a vehicle-mounted sensor that typically requires a human to operate the vehicle. In such cases, the data itself is typically post-processed using one of the methods discussed in the Automated Data Collection section or provided to a third-party vendor for processing.

It is also important for practitioners to examine their agency's current process for updating asset data as changes are made or requested by planners and public works staff. Practitioners should consider what sustainable processes could be put in place to ensure that inventory data will be kept up to date over time. Some interagency data will come in the form of agency plans such as bicycle master plans, ADA transition plans, or list of capital projects.

The following section discusses the evaluation of existing in-house data as well as the four typical sources of new data and information. There are many platforms that collect and inventory curb space. Notable platforms and commonly used tools at the time of this report are summarized below and expanded upon later in the report:

Table 8. Evaluation Tool Descriptions

Tool Name	Tool Description	Tool Function
Coord API	Dynamically model curb rules and allocations	Data management
Coord Collector	Augmented reality smartphone application that data collectors can use to assist with the collection of curb data Includes license plate recognition features to assist with parking occupancy and turnover counts	Data collection (in-person)
Coord Driver	Helps drivers find and pay for curb space	Dynamic loading zone wayfinding
Curb IQ	Digitizes curbside regulation data Makes curb regulations from agencies available as a trip planning tool for the public	Data management and sharing
INRIX Road Rules	Tool to digitize, manage, and communicate rules about roadways, curbs, and sidewalks	Data management and sharing
Mapillary	Uses crowdsourced or privately-provided street-level imagery to identify and map the features of signs, sidewalks, and traffic signals Imagery is processed using computer vision	Data collection (automated)

EXISTING IN-HOUSE DATA

Data can often be difficult to acquire for sharing and use among different agencies and departments or even between divisions within a single organization. Before beginning data collection, an open data policy creating a data committee with responsible data stewards for each department should be established. These stewards would be responsible for curating, updating, documenting (e.g., creating metadata, see below), and sharing the data for their respective areas of expertise. Shared data often has little use and application in its current state but can become more meaningful with manipulation, especially when combined with other relevant data.

Metadata

Existing data resources should be inventoried and ideally contain metadata. Metadata is defined as a set of data which describes and provides information about other data. The International Organization for Standardization (ISO) has metadata standards for many types of data, including geospatial information which are important to curbside management projects (ISO, 2014). Often, in open data policies, jurisdictions will define their metadata standard preference. At minimum, the date collected, date updated, and responsible party should be included along with applicable attributes concerning the specific asset or item of data.

Figure 17. Photo. Image of curbside allocation with signage for car sharing in Seattle, Washington, USA. While this example demonstrates parking for Zipcar, the same treatment can be applicable for any car-share providers and can potentially be agnostic to any specific provider. *Source: Seattle Department of Transportation/Flickr.*

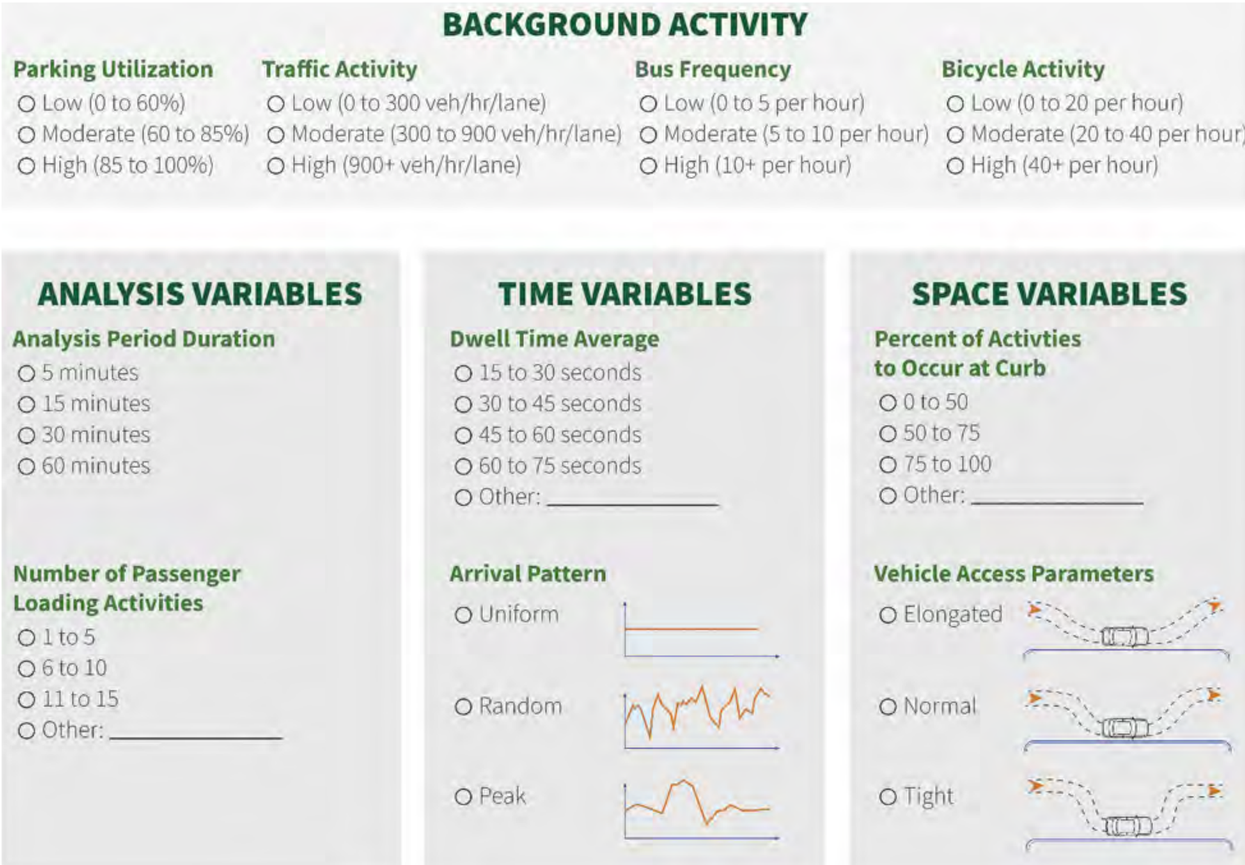


Figure 18. Graphic. Curbside analysis can depend on many variables, whether collecting manual or automated data. Identification of curb variables is critical in curbside analysis. Some sample metrics displayed below, note that definitions of low, moderate, and high activity should be defined for each project based on local context. *Source: Fehr & Peers.*

Data Validation

Ideally, the metadata serves as a point of data validation to ensure data quality. However, in the case of rapidly-evolving infrastructure and changing uses, validation is often required to ensure uses are catalogued and current. Often, data shared between agencies may require clarification and validation. Ideally, all partners involved support open data and maintain similar open data policies that facilitate data sharing and validation.

Data Single Source of Truth

Data portals and project management data repositories can be viewed as a single source of truth, such that each piece of data is only edited in a single place. Data portals are a direct product of many open data policies. Project management data repositories are often established to provide designers, builders, and managers a single authoritative repository of existing data and data under development. These portals and repositories are invaluable, un-siloed, truthful resources accessible to jurisdictional staff and ideally to the general public and any mobility partners.

MANUAL DATA COLLECTION

This section discusses the collection of new information through in-person, on-site observations and direct review of written policies, guidance, and procedures. In general, manual data collection efforts are best deployed when the desired data cannot be collected through another method, when automated methods do not lead to sufficient precision or quality (e.g., many automated methods struggle to achieve location precision), or when the scale of the dataset required does not result in increased efficiency with the application of automated methods.

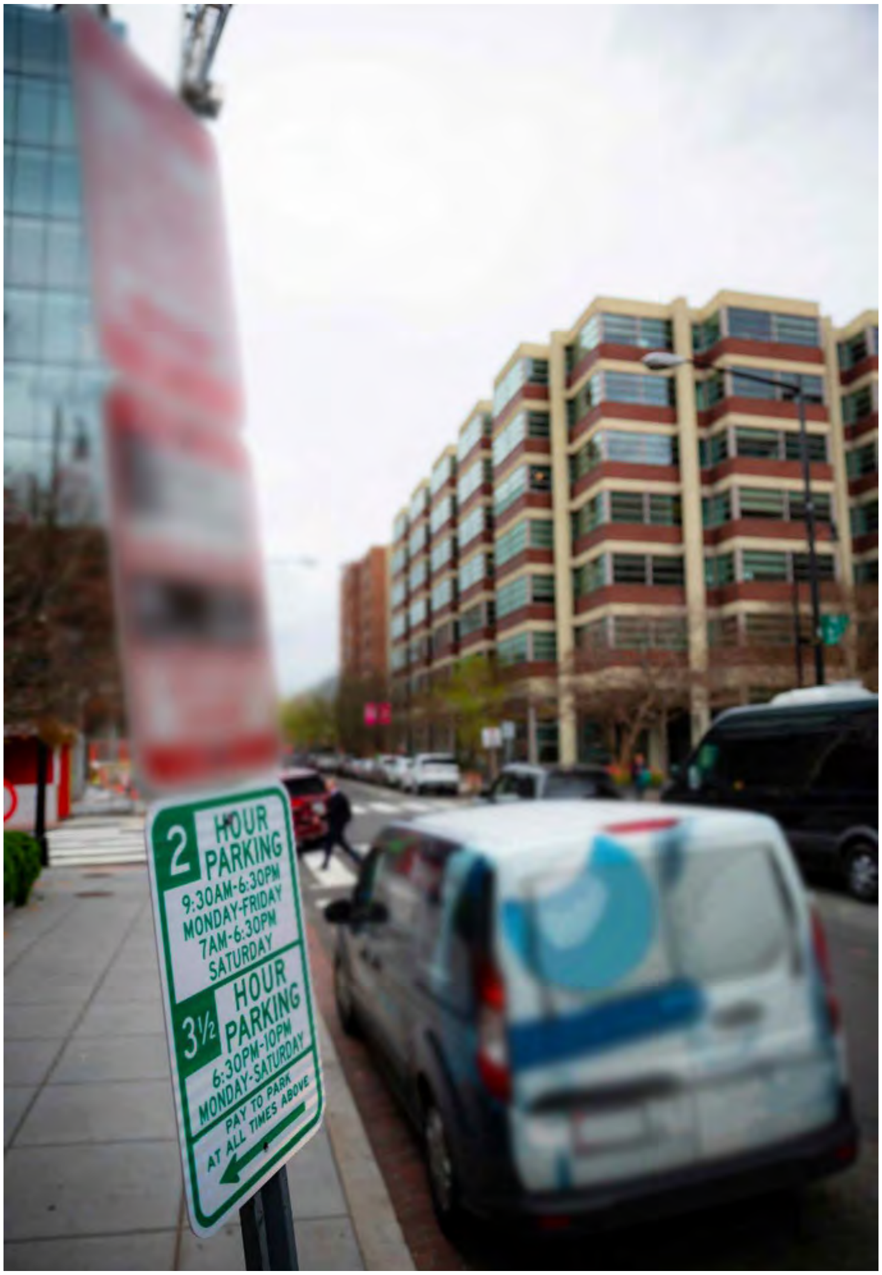


Figure 19. Photo. Parking policies related to designation of space, temporal assignments, pricing, or enforcement are sometimes codified at the local level.
Source: District Department of Transportation.

Review of Applicable Agency Policies and Codes

Applicable agency policies and codes should be reviewed to understand how the curb is regulated. This can provide insight into which functions of the curb are permitted, what restrictions exist for different types of curb use, and how changes are made to curb zones. In general, national standards help communicate how curbside management regulations are understood to the road user, if applicable. Additionally, State legislation should be reviewed to determine how existing regulations are defined relative to curbside management. For example, State legislation will often lay out rules for what behaviors qualify as parking or passenger loading and where passenger loading zones are permitted. There may also be strict requirements in order to designate curb space as commercial or passenger loading zones.

Practitioners should also review city policy to identify any specific regulations that may be in place or need to be revised as part of a comprehensive curbside management program. For example, certain locations have city-wide laws about overnight parking, where large vehicles may park, or the maximum stay that is permitted so that vehicles are not stored indefinitely on city streets. One might find that the city lacks code enabling certain curb uses that should be encouraged or uses that should be prohibited.

This information can be found on city or agency websites and in city or State codes. Additionally, this information can be obtained by interviewing public officials. Review of agency policies and codes should document permitted curb uses, restrictions on curb use, who has jurisdiction over the roadway, and which agencies regulate which curb functions. It can be difficult to determine who has authority over the curb, as authority over the curb might be spread across multiple local and state agencies. Even within a single agency, curb regulations and decisions might be divvied across different departments or divisions in ways that are not transparent even to members of that agency.

Figure 20. Graphic. An example of quantitatively visualizing the inventory of various curb uses on a typical block in San Francisco, CA, USA. *Source: Fehr & Peers/Uber Technologies*.

In-Person Observations and Counts

In-person observations and counts can inform assessments of supply and demand for different uses of the curb. This assessment of existing conditions informs how the curb is used and managed, which can provide insight into the need for curb changes or whether proposed changes are appropriate for the site. Additionally, metrics regarding curb use can serve as MOEs to measure the effectiveness of curb projects.

Existing Curb Uses and Supply

Inventories of existing curb uses and supply should be conducted on a block-by-block or corridor-by-corridor basis. This inventory should document the location, length (e.g., driveway, space for accessible van lift, or point (e.g., fire hydrant, streetlight, etc.) of curb zones designated for different types of uses at the curb, including but not limited to parking, loading, transit stops, bicycle and micromobility parking, street trees, seating, utilities, accessible curb ramps, and traffic signal poles. Additionally, any other physical assets that communicate curb regulations or restrictions or define what activities are permitted or restricted (as indicated in street signage) should be noted. Additionally, curbside inventories should identify land uses adjacent to the curb, which will dictate curb space needs and usage, both in absolute terms and in time of day and day of week terms. This could include parking restrictions (e.g., parking is metered or limited to those with residential parking permits), day and time restrictions for parking or loading zones (e.g., curb space is earmarked for passenger loading from 5 PM to 12 AM and reverts to vehicle parking at other times of the day), and information about parking prices (e.g., hourly cost of parking). It is also very important to observe how persons with disabilities are utilizing the existing curbside. For example, are drivers with lift-equipped vans deploying the lift directly onto the sidewalk? This understanding of the existing usage is critical to evaluating the potential impact of changes to the curbside on individuals with disabilities.

A priority level may be one method established to resolve conflict between regulations that may apply at the same time and location (e.g., a snow emergency zone or street cleaning zone that overrides day-to-day residential parking). The SharedStreets CurbLR open data specification provides a template for what type of information should be collected for a complete curb supply inventory, and how it can be stored in a consistent, uniform way.[1] This open data specification allows jurisdictions to use an established resource which is compatible with data in its initial states, but does not have an open governance model. The CurbLR data specification is built upon the Shared Street Linear Referencing system, which is used with Open Street Map, a commercial basemap or a city-managed basemap as a linear reference. Another standard is the Alliance for Parking Data Standards (APDS) standard.[2] APDS is more off-street centric, where CurbLR is on-street centric, but may be combined for overall curbside management specifications.

1 *https://github.com/sharedstreets/curblr*
2 *https://www.allianceforparkingdatastandards.org*

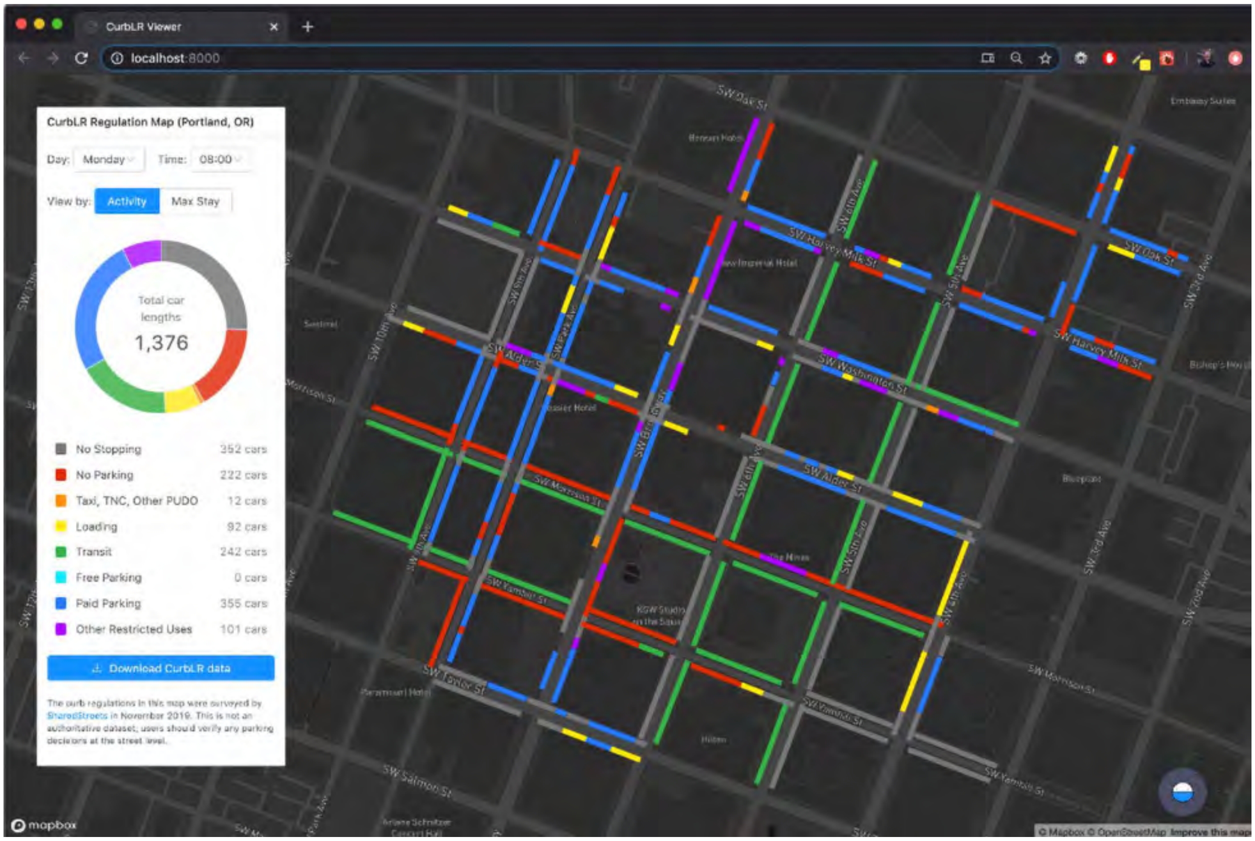


Figure 21. Graphic. An example of the CurbLR Regulation map showing different curb regulations in Portland, OR, USA. *Source: SharedStreets*.

Additionally, transportation infrastructure should be characterized and cataloged to inform considerations of travel behavior along the corridor. This could include the number of travel lanes in each direction, peak-hour tow-away lanes, the presence and type of bicycle facilities, what transit routes serve the corridor, and the presence of dedicated bus or transit lanes.

Some of this information might be available in online or internal databases such as GIS shapefiles or CAD drawings. However, digital databases of curb designations and restrictions are often limited to specific types of curb use (e.g., only transit stops) or are not updated regularly; for some types of curb use, agencies might lack digital databases altogether. To supplement any digital data or create new digital data, practitioners may need to inventory curb assets and regulations in areas of interest. Practitioners could conduct in-person surveys on blocks or corridors under study. Surveyors should annotate street drawings to mark the locations and measurements of the different curb zones and features discussed above as well as document any signage regarding restrictions of use.

Transportation infrastructure should be characterized and cataloged to inform considerations of travel behavior along the corridor.

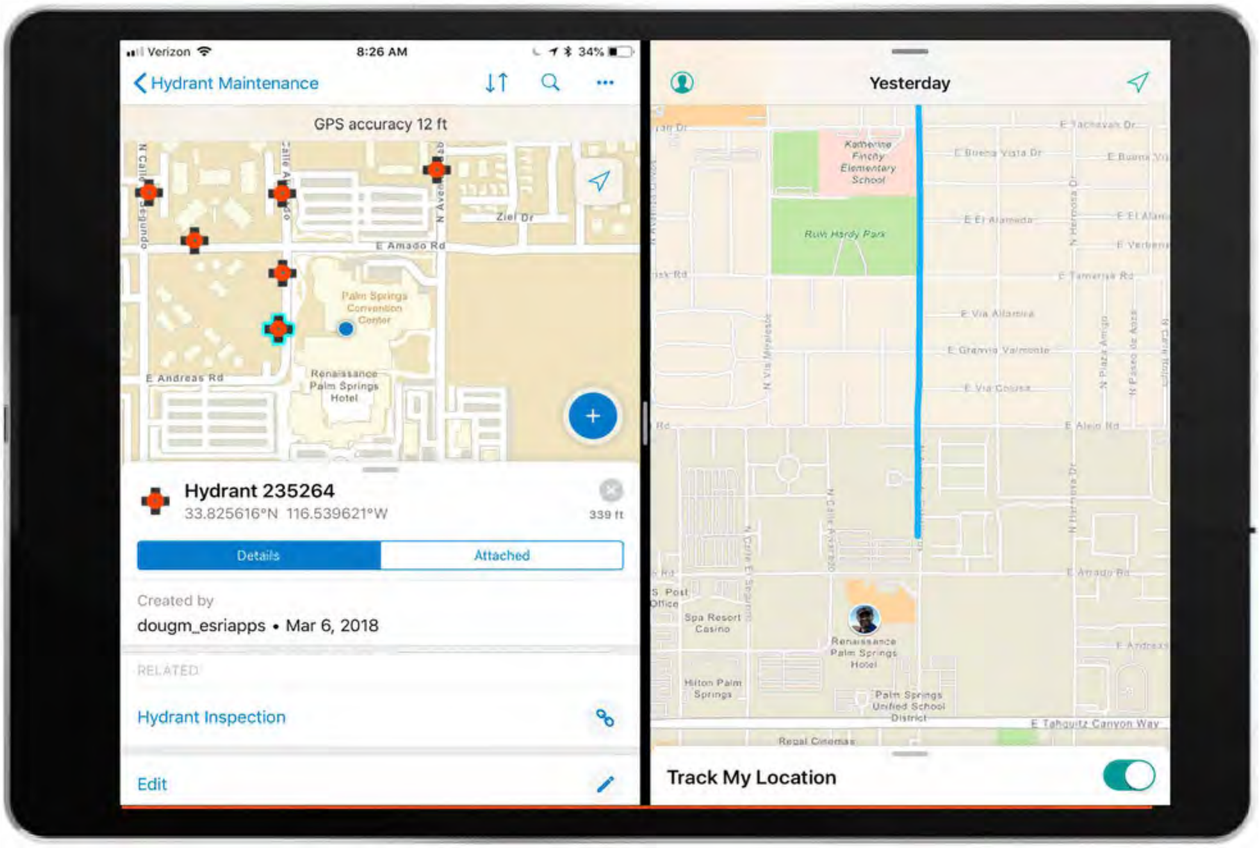


Figure 22. Graphic. The Esri Collector for ArcGIS app digitizes curbside features, including location, photographs, and description. *Source: Esri.*

Alternatively, practitioners can use tools available from third parties such as the Esri Collector for ArcGIS app, Field Papers or other open source tools, or Coord's Collector application to assist with data collection. The Coord Collector App, discussed further in the Third-party Data Providers section below, is a hybrid in that it requires human collection via an augmented reality device app, but is then synthesized by Coord and provided to the practitioner as a curb asset dataset, which can be exported to GIS software (Coord, 2019). Coord is a curb asset and regulation inventory that has a digital dataset of what is physically on the curb (assets), but also permits dynamic uses which vary by time (e.g., hour of day, day of month, month of year).

When contracting a third party for data collection services, cities should consider the license terms on any data products that are created (e.g., who owns the results, what uses are permitted or restricted, and how the results may be shared). It is important to make sure you are using the latest methods and not overpaying for costly, outdated collection methods.

Observed Curb Use Demand

Additional observations should be conducted to determine demand for different types of curb use. These observations should capture who are the different users of the curb, how frequently each user uses the curb, whether there are conflicts between different types of users, and whether there is demand for a curb function that lacks curb space (or lacks sufficient curb space).

By comparing how usage patterns for different users vary by time, regulations can be designed to become more flexible. Regulations can be designed in response to when demand for each use peaks. Then, instead of serving a single use at all times, the same curb space might be able to serve different users at different times of day.

Manual observations are typically collected through in-person visits. When collecting data in-person, it might be possible to conduct counts of some types of curb events; in other cases, data collectors might record qualitative observations of behavior. Manual data collection can be limited in the ability to efficiently identify conditions over longer periods of time or larger geographic areas due to the need to integrate data collected using different staff who may have different perceptions of activity.

Data should be collected throughout the day and night and on different days of the week. For certain uses, curb demand might vary significantly by the time of day or day of the week. For example, commercial loading might peak in the mornings on weekdays, whereas passenger loading might occur most frequently in the evenings on weekends. By comparing how usage patterns for different users vary by time, regulations can be designed to become more flexible. Regulations can be designed in response to when demand for each use peaks. Then, instead of serving a single use at all times, the same curb space might be able to serve different users at different times of day.

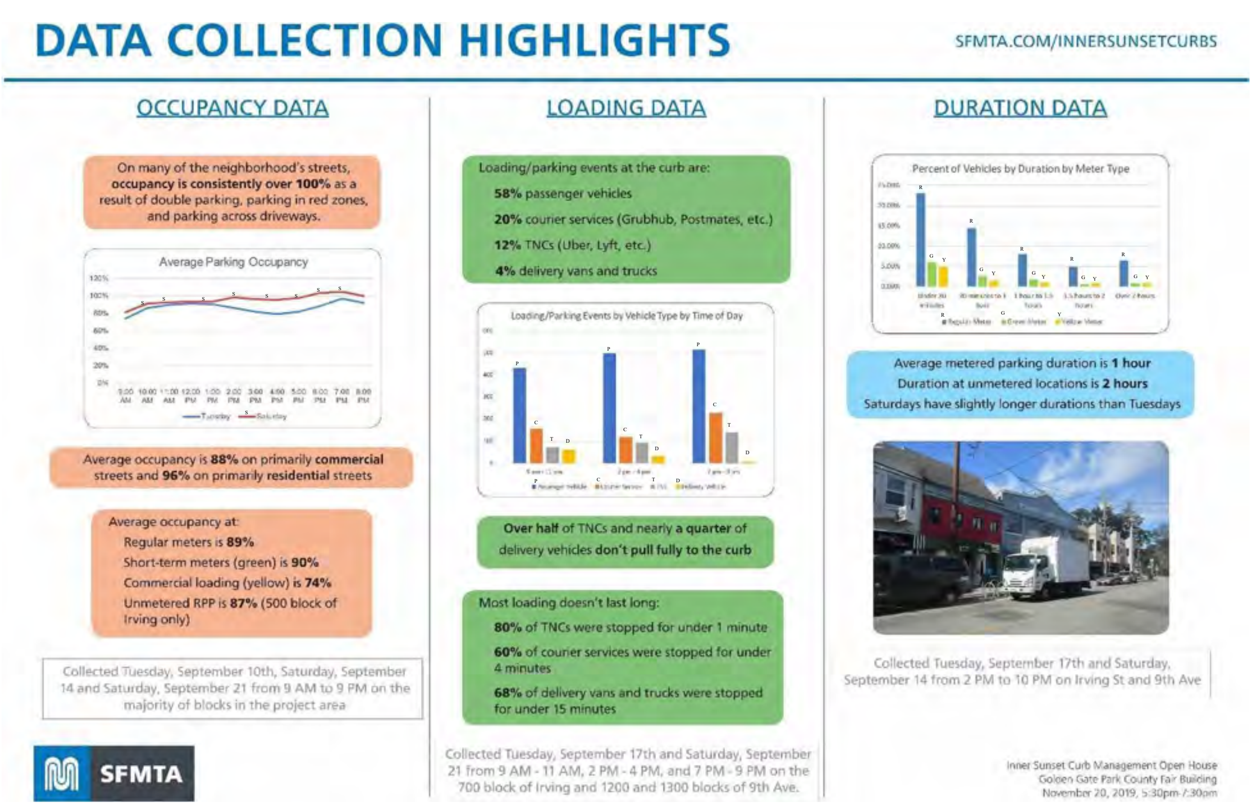


Figure 23. Graphic. San Francisco Municipal Transportation Agency performed extensive data collection and observations of parking and loading activity for the Inner Sunset Curb Management Project in San Francisco, CA, USA.
Source: San Francisco Municipal Transportation Agency.

Figure 24. Dynamic Curb Space Management is a means to accommodate multiple uses, like bicycle lanes, car sharing, and freight based on peak demand. *Source: Seattle Department of Transportation.*

In-person observations of curb demand may include the following:

- **Parking occupancy counts** – Vehicle parking occupancy can be used to quantify parking demand and determine when parking demand peaks. If data on license plate numbers is collected in addition to counting the number of vehicles present, this data can further be used to determine duration of stay and parking turnover to depict parking behavior in more detail. Parking occupancy data may be collected through in-person observations or through video recordings.

- **Cruising behavior** – Observers might record when vehicles appear to be cruising in search of parking; this behavior can cause conflicts with others on the street as well as indicate a need to better manage the availability of parking and access. Cruising can be recorded through qualitative observations of vehicles from in-person observations or video recordings.

- **Commercial and passenger loading** – Data collection should include the location of any loading events (e.g., at the curb in a loading zone; at the curb outside of a loading zone; in a bicycle lane; in a travel lane, etc.); the duration of the loading events; the type of vehicles engaging in loading (e.g., passenger vehicles, ride-hailing vehicles, courier services, delivery vans, etc.). Count and location of loading events can be collected from in-person observations or video recordings. Depending on the frequency of loading events, it might be easier to code duration from video recordings.

Figure 25. Graphic. Dockless small vehicles are a new use that needs to be managed at the curb. The dockless vehicle parking shown here at sidewalk grade in Seattle, Washington, USA is one potential solution. *Source: Seattle Department of Transportation*.

- **Bicycle or pedestrian conflicts** – Data collection should include all instances of conflicts between vehicles and bicyclists or pedestrians such as vehicles blocking bicycle lanes or crosswalks, instances of bicyclists swerving into traffic due to conflicts with vehicles, blockages in the sidewalk, or pedestrians crossing the street outside the crosswalk. This can take the form of qualitative observations or a count of observed conflicts from in-person observations or video recordings.

- **Transit conflicts** – Any instances of conflicts between public transit vehicles and other road users, such as private vehicles double-parked in transit stops or blocking transit lanes, should also be noted. This can take the form of qualitative observations or a count of observed conflicts from in-person observations or video recordings.

- **Vehicle, bicycle, and pedestrian counts** – Data collection should include counts of the number of vehicles, bicycles, and pedestrians traveling the corridor, either from in-person observations, counts from video recordings, or pneumatic tubes. These counts can be used to determine the volume of activity along the corridor by mode (to help determine modal priorities) as well as identify when there are periods of peak activity.

Figure 26. Photo. Surveyor uses CurbWheel and smartphone app to inventory curb assets and regulations. *Source: SharedStreets.*

Additionally, details about characteristics of land use along the corridor should be collected in detail (e.g., occupancy and/or zoning certificates identified by the jurisdiction by parcel and/or building. This should include the type of land use (e.g., residential, commercial, etc.), land use densities, and whether the corridor contains any destinations that cause notable patterns in travel behavior (e.g., churches, which generate parking and loading demand only at specific times and days of the week). In areas with commercial activity, information about the types of businesses present and their hours of operation should also be noted. Different land uses have different demands for curb space, which could influence proposed changes to the curb. In the case of commercial development generating many curbside movements, data collection should also identify where the commercial parking/ loading zones are located relative to the businesses they are serving. Many passenger-focused curbside uses, such as bus stops and ride hailing, will also benefit from examining the spatial relationship between the curb spaces and the nearby land uses they serve.

One available tool to measure and take photo inventories of curbside management signs is CurbWheel from SharedStreets. CurbWheel is an open source data collection instrument that combines the precision of a measuring wheel with the efficiency of a smartphone app that can be used to map a city's curb assets and regulations and create a CurbLR data format. To use CurbWheel, a surveyor walks down a street, rolling a standard digital measuring wheel hardwired to a Raspberry Pi computing device to calculate distance and using his or her phone to take photos and of street signs, paint, and other markings. After completing street surveying with the wheel and app, users can process the data in a digitizer web app to produce a CurbLR data format.

User Feedback (Surveys or Focus Groups)

User feedback via surveys or focus groups can provide further insight into how the curb is used and may be a key component on the establishment of project goals. Surveys can be collected from local merchants, residents, and visitors to the corridor in the form of intercept surveys.The surveys should be available in formats to meet the communication needs of the all persons being surveyed. Alternatively, groups of merchants, residents, or visitors could be assembled for a focus group. Additionally, depending on project goals, surveys or focus groups could be collected from specialized groups (e.g., people with disabilities, transit riders, etc.). Surveys and focus groups allow users of the curb to provide their perspectives on issues with current curb allocations beyond what might be visible from observations or other forms of quantitative data collection.

Local merchants can provide insight into commercial demand for the curb. Merchants and delivery drivers should be interviewed about when and how often they receive commercial deliveries (e.g., frequency and time of day), what types of vehicles they use for deliveries and pick-ups, where they conduct loading activity, and their broad perception of issues regarding loading or travel behavior. Additionally, merchants should be asked their perception of how customers, visitors, and employees travel to their businesses.

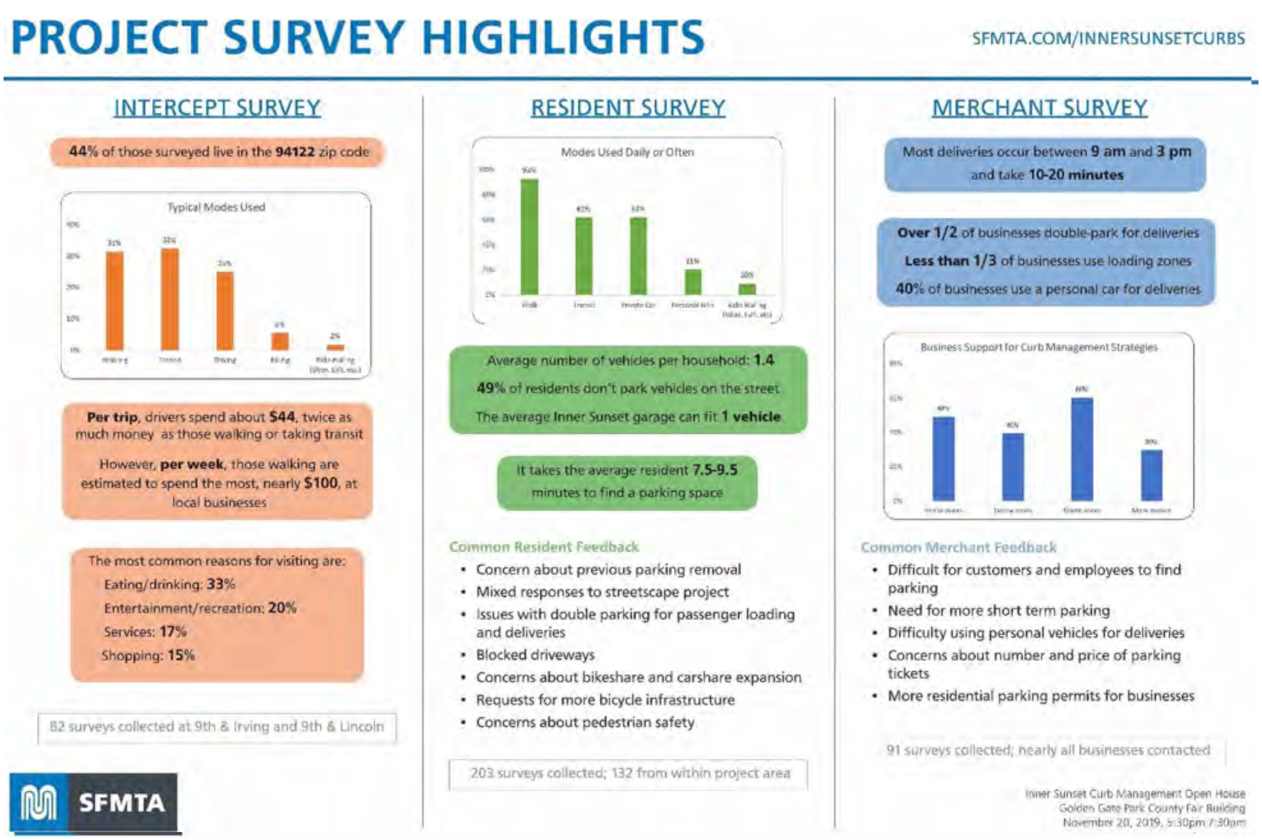


Figure 27. Graphic. San Francisco Municipal Transportation Agency collected intercept, resident, and merchant surveys to understand stakeholder needs as part of the Inner Sunset Curb Management Project in San Francisco, CA, USA.

Source: San Francisco Municipal Transportation Agency.

Figure 28. Photo. Intercept surveys conducted with attendees at a living preview event provide valuable feedback on treatments under consideration in San Francisco, CA, USA. *Source: Fehr & Peers.*

Local stakeholders should be surveyed about their own travel behavior, their concerns about current curb allocations, and perception of proposed changes to curb space. Additionally, they could provide insight into their general user experience along the corridor.

Metrics and thresholds should be determined by individual agencies based upon the type of project and local context.

Finally, intercept surveys can capture how non-residents travel and what they do along the corridor. Intercept surveys might include questions about how the individual traveled to the corridor, where they live, and why they traveled to the corridor. The mode split of travelers to the corridor can help inform decisions about how to prioritize different types of curb space. Visitors can also identify issues with wayfinding or comprehensibility of curb regulations.

The Curb Observation Worksheet Template can serve as a sample form to assist public agencies and consultants with conducting on-site curb observations if a practitioner does not have access to enhanced collection methods such as apps. Metrics and thresholds should be determined by individual agencies based upon the type of project and local context.

Table 9. Curb Observation Worksheet Template for possible public agency use. Definitions of low, moderate, and high activity should be defined for each project based on local context. *Source: Fehr & Peers.*

Curb Event On-Site Observation Worksheet

Date	**Weather**
Time Period Observed	**Technician**
Location	

Traffic Activity	**Transit Frequency**
☐ Low (0-300 vehicles/lane/hour)	☐ Low
☐ Moderate (300-900 vehicles/lane/hour)	☐ Moderate
☐ Heavy (900+ vehicles/lane/hour)	☐ Heavy

Bicycle Activity	**Pedestrian Activity**
☐ Low	☐ Low
☐ Moderate	☐ Moderate
☐ Heavy	☐ Heavy

Location Sketch

Indicate North

Parking Stalls	**Parking Occupancy**

Observations

Activity Observed	Time	Dwell Time	Occurred at Curb?	Illegal Maneuver?	Pass or Freight?	Number of Pass	Notes

AUTOMATED DATA COLLECTION

Automated data collection refers to the use of electronic equipment, either temporarily or permanently installed, to obtain information about activity occurring in the field, without the need for human operation. Video recording is the most common tool used in automated data collection though a variety of other tools exist, ranging from simple pneumatic tubes for the collection of traffic data to more sophisticated wireless sensing and communication devices. Timelapse cameras, for example, are an entry-level and low-cost form of automated data collection. This does not include human-operated data collection tools, such as mapping apps or automated photography for collection of street-level imagery.

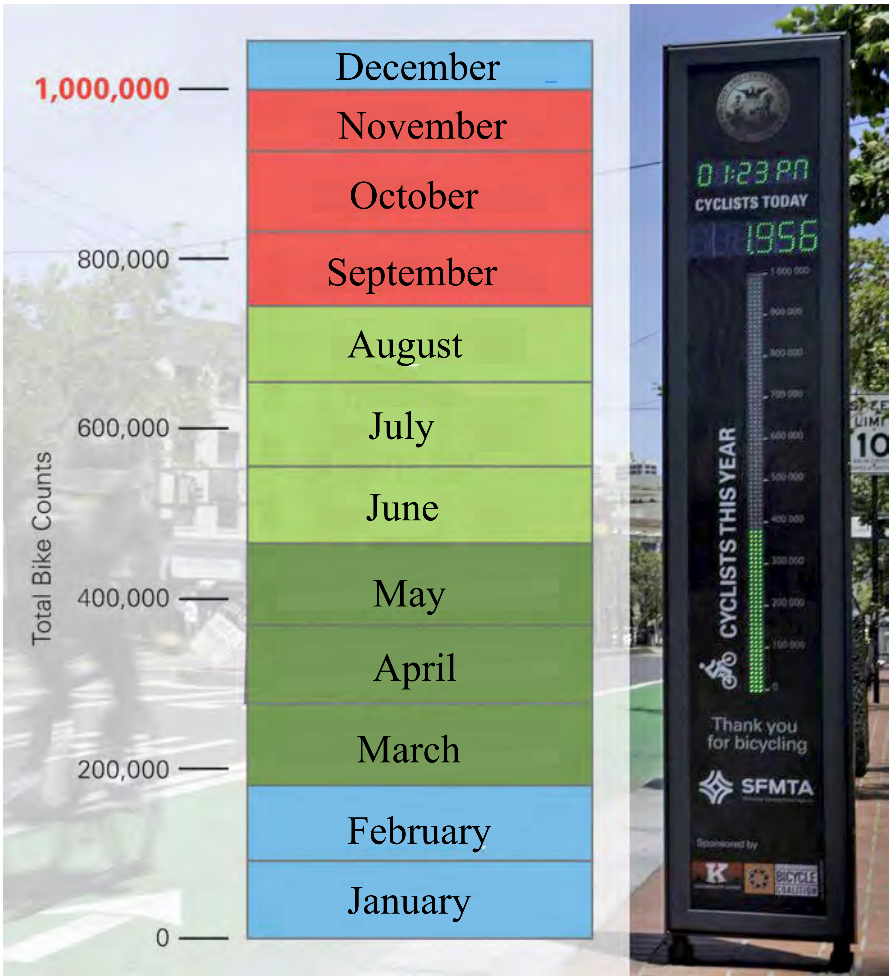


Figure 29. Graphic. Automated bicycle counters in San Francisco, CA, USA collect continuous volume data on key corridors. The data shown here reflect cumulative bicycle counts on Market Street in 2015, exceeding one million bicycles.
Source: San Francisco Municipal Transportation Agency

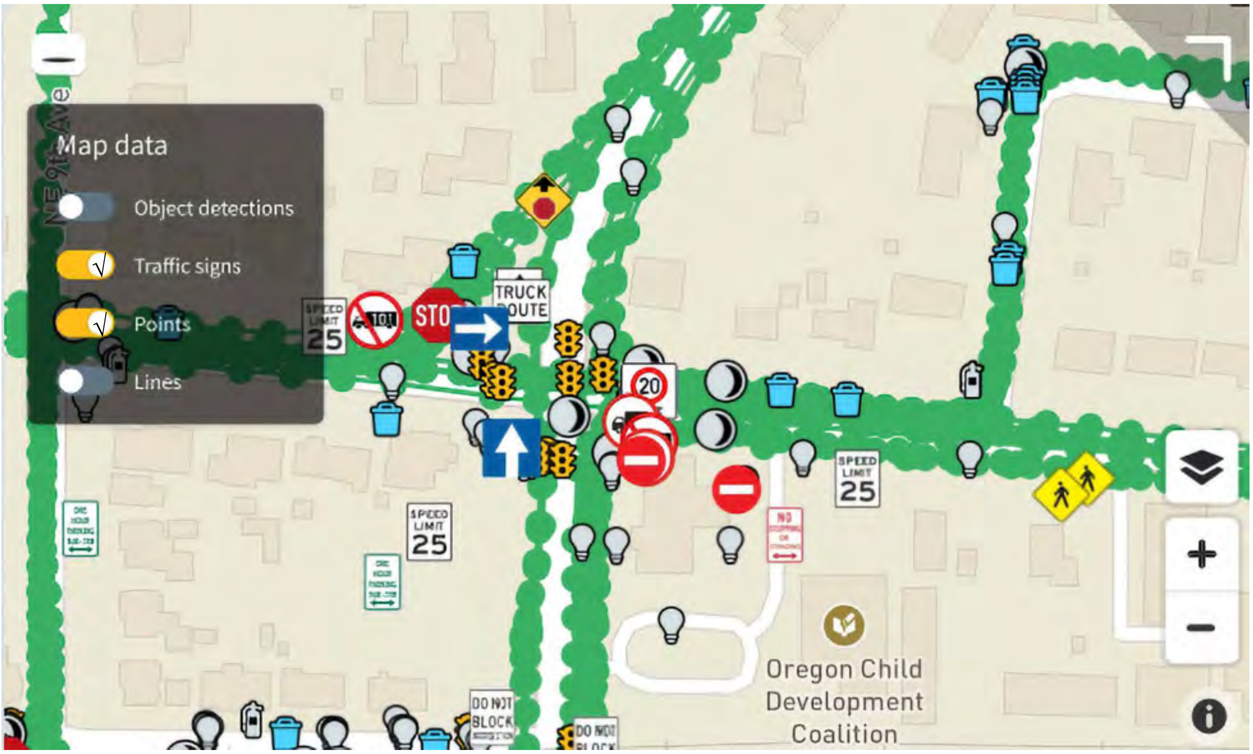


Figure 30. Graphic. A map showing the location of physical features in the right-of-way created by Mapillary utilizing machine learning and still images captured from a vehicle-mounted camera. *Source: Mapillary*.

The primary benefit of automated data collection methods is that they typically allow the collection of larger data sets while requiring fewer overall person-hours of effort. This is especially true as advances in machine learning and computer vision increasingly allow information to not only be collected, but also analyzed in an automated fashion.

When considering an automated method for data collection, practitioners should consider whether human effort is needed to process or digitize the results, which is sometimes the case with computer vision technology. In addition, for very detailed surveying, such as a curb supply inventory, practitioners should consider the resulting location accuracy to ensure the level of precision meets their needs.

Video Sensing

In general, video sensing can be used to collect most data that might otherwise be collected via in-person, on-site observations provided there is adequate placement and volume of video cameras. One major benefit of video sensing is the ability to retain digital files of the observations without degradation of data quality, rather than relying upon a translation of the observed activity into written notes.

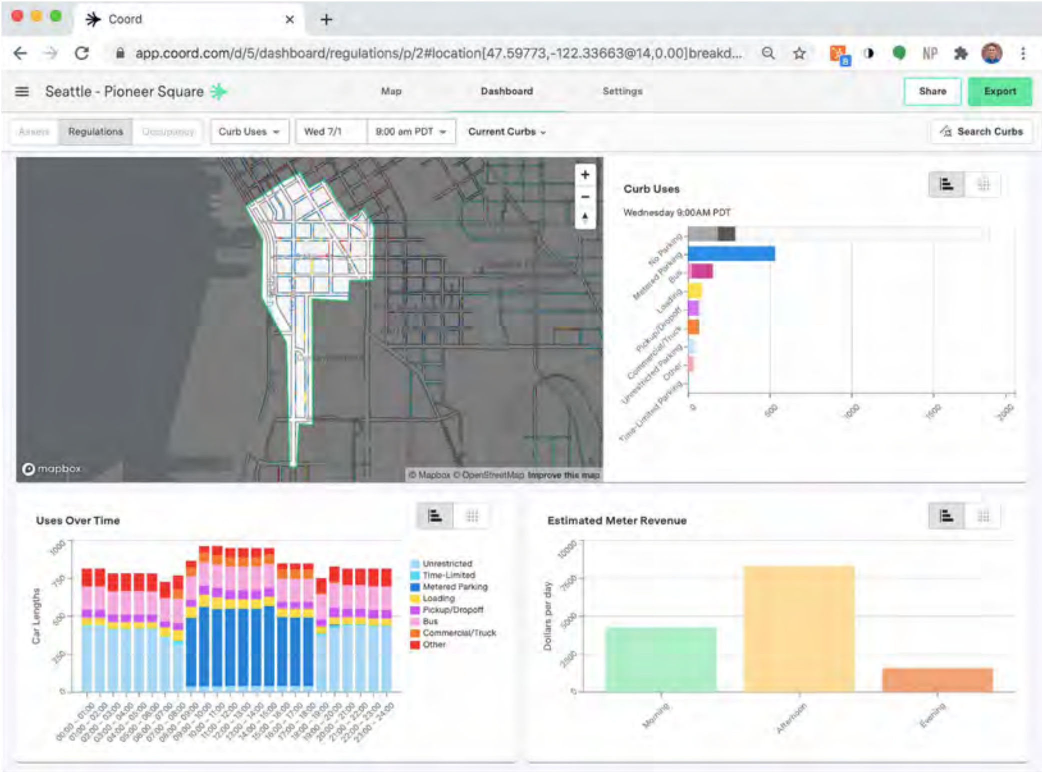


Figure 31. Graphic. Map and graphs generated from Coord app is another approaches to representing curb inventory collection and categorization of curb data. *Source: Coord.*

When data is collected via video recording, data collectors might be able to analyze curb conditions more comprehensively over longer periods of time. Additionally, video can allow for greater precision and detail, particularly for metrics like duration of loading events, which may be easier to time from a video recording. However, depending on the type and quality of video equipment available, this approach might only be successful during daylight hours.

At its most basic, video sensing allows the same activity to be viewed, but provides the flexibility for the practitioner to view the video at any time and potentially view the same activity multiple times — and, if multiple sensors are used, from multiple angles — to better interpret the activity. However, the emerging fields of machine learning and computer vision are making it increasingly possible to reduce the amount of time spent by practitioners on reviewing of video data.

Computer vision describes the development of systems which allow machines to gain understanding from digital images or videos in an attempt to automate tasks for which humans rely upon visual senses. Machine learning refers generally to a method of data analysis that seeks to automate analytical decision-making based on the computer system learning from data, identifying patterns in the data, and making decisions with minimal direction from an operator. The largest advantage of using computer vision for data collection is how rapidly data may be collected and transformed into an analyzable format. However, the quality of the output is only as good as the quality of the algorithm used to translate images into data. As development continues in these fields, digital images or video data can increasingly be reviewed and analyzed with greater precision, automatically, and without direction from the practitioner.

Current examples of computer vision include Coord Collector and Mapillary (discussed further in the Specific-use Data Providers and Tools section below). Coord Collector uses computer vision and augmented reality to validate images collected by the users. Mapillary uses computer vision and machine learning to automatically translate street-level images into maps of curb and street features. The figures below show an example of a machine-generated map created by Mapillary and Coord.

The application of video data with these emerging technologies can result in the ability to process much larger datasets, allowing some types of curb uses to be counted or coded quantitatively as opposed to relying on qualitative or anecdotal observations. For example, the automated identification of near-misses and other conflicts using repeatable parameters applied through algorithms and computer vision may allow the number of conflicts meeting certain criteria to be more precisely quantified, whereas a strict reliance on manual practitioner observations — whether they be in-person or via video review — would be reflective of a series of independent qualitative judgments by the practitioner.

A thorough investigation of applicable privacy and video recording policies and regulations is necessary to verify the legality of video sensing in a given jurisdiction. Note that, where allowed, video sensing equipment can often serve multiple purposes for the public agency simultaneously. Permanently-installed cameras that observe curb activity, for example, could potentially also be connected to an agency's transportation management center and used to assist with incident response, public safety, or other governmental uses.

Radar Sensing

Radar sensing is predominantly used to collect data pertaining to the real-time location of vehicles, with the most common applications being the deployment of radar sensors to identify vehicles' presence or passage for parking occupancy, traffic counts, or various Intelligent Transportation Systems that rely upon large volumes of vehicle location data. These sensors are able to continually report the occupancy status of parking stalls, thereby facilitating evaluations of parking occupancy over long time periods as well as potentially allowing the dissemination of real-time parking availability information to the agency or the public.

Communications-based Sensing

Communications-based sensing devices detect the presence of uniquely-identifiable devices broadcasting communications signals, including Bluetooth from vehicles, mobile phones, or computers. This technology is most frequently used to identify the same device passing multiple sensing locations, allowing the identification of presumed travel routes and travel times/speeds. When applied at a large scale, this can help with the identification of travel patterns and average speeds across a roadway network. The use of communications-based sensing, however, naturally captures data only from members of the public who have the applicable communication signals active; this can lead to underreporting portions of the population who are less likely to own or use a suitable device.

THIRD-PARTY DATA PROVIDERS

In addition to manual or automated data collection arranged by the practitioner, third parties such as mobility providers, goods and freight carriers, and specific-use data providers have emerged as a viable source for a variety of data ranging from existing curb designations to roadway and curb uses. In some cases, third-party data will provide data from the same origin or collection methods as manual or automated data collection but may be available as a synthesized dataset from a third-party provider.

Mobility Providers

New third-party mobility providers have emerged as an additional transportation option in some jurisdictions. These mobility providers offer services such as ride-hailing, car-share, bike-share, and scooter-share, all of which might use the curb. When ride-hailing vehicles lack loading zones, they might block bicycle lanes or travel lanes while dropping off or picking up passengers. Car-share vehicles might use dedicated on-street parking spaces. And, as dockless bike-share and scooters have grown in popularity, some agencies have reported issues with bicycles and scooters being parked in the sidewalk, blocking pedestrian access.

Historically, there has often been a limited amount of data available to the public from mobility providers. Companies value the privacy of their data and may limit public information available about their operations in order to protect user privacy and competitive trade information. In some cases, mobility providers might be particularly hesitant to distribute data to public agencies as such data can then be made public through Freedom of Information Act requests. More recently, mobility providers have begun to investigate additional methods to provide data that can assist practitioners with planning and project development while protecting user privacy and business sensitive information. For example, public agencies can partner with third parties (such as academic institutions or private firms) to complete data analysis.

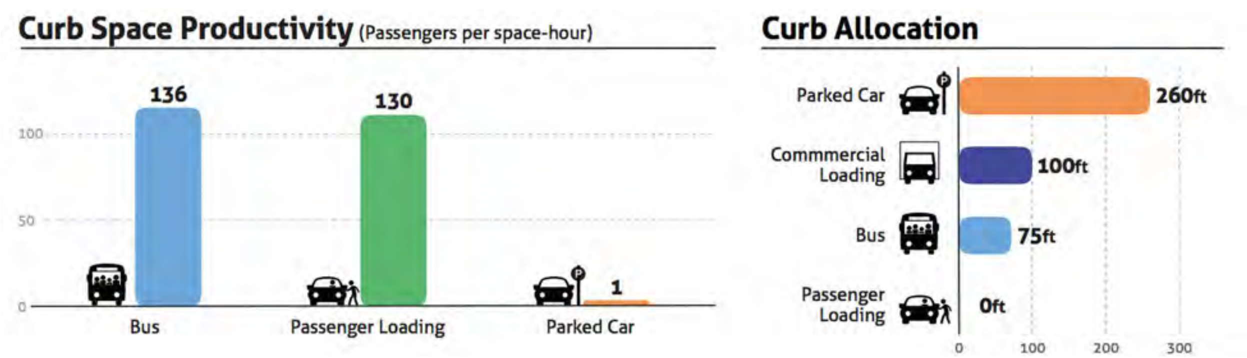


Figure 32. Graphic. Pick-up/drop-off data from Uber helped with the identification of study locations for the San Francisco Curb Study, with subsequent manual and video data collection allowing the development of more robust metrics.
Source: Fehr & Peers/Uber Technologies.

Figure 33. Photo. Bicycle and scooter share information along with ride-hailing and car-sharing data can be helpful in allocating curb space. *Source: Sarah Abel/ITE.*

However, information about ride-hailing activity can be critical to inform curb allocation for uses like passenger loading. Uber and Lyft have voluntarily shared data with agencies in some cases, including identifying the top destinations along a corridor for pick-ups and drop-offs or providing the average number of pick-ups and drop-offs per block face, by time of day and day of the week. In some cities, curbside data from mobility providers can be accessed in aggregated form through third parties such as SharedStreets (discussed further below). SharedStreets has used data from Uber and Lyft to analyze average pick-up and drop-off information by blockface. To date, cities such as Toronto, Washington DC, Minneapolis, Pittsburgh, and Los Angeles have received and analyzed this type of data (Pelon, 2019).

Such information can inform where and when there is the highest demand for ride-hailing services and therefore more demand for passenger loading zones. Demand for passenger loading might vary by time of day or the day of the week. For example, there might be a large demand for passenger loading space in the evening or weekends and very little during the day on weekdays. As cities adopt more flexible curb regulations, the amount of curb allocated to passenger loading could vary by time of day to match demand patterns.

Additionally, ride-hailing companies can potentially provide data on metrics like average vehicle occupancy to determine the extent to which travelers use shared rides, which could further calibrate the amount of curb needed for passenger loading. In this way, coordination with mobility providers can be mutually beneficial and potentially facilitate ongoing sharing of relevant data and information.

More information is frequently available to the public from bike-share and scooter-share providers. Some of these services are contracted by public agencies, whereas others agree to report data in order to receive a permit to operate within a given jurisdiction. Areas in which bike-share and scooter-share are popular might benefit from allocating some sidewalk or curb space for use as a shared mobility parking zone. To the extent that bike-share and scooter-share data is available, it can be used to identify how and where people are parking their micro-mobility devices as well as popular destinations for travel. This information can then serve to determine appropriate locations for shared mobility parking and operation. Safety and usage data including crash and property damage can be shared with agencies to provide context for improving multimodal safety.

Goods and Freight Carriers

Online retail and delivery services have also become more prevalent in recent years. There has been an increase in the quantity of goods ordered online and delivered by traditional delivery services such as UPS and FedEx (CityLab, 2017). Additionally, delivery activity has further increased due to the advent of courier network services (CNS), which are companies that pair delivery requests generally sent via smartphone app for food or other goods to couriers (e.g., contracted gig workers). Couriers then make deliveries by personal vehicle, foot, or bicycle. CNS companies include Amazon Flex, Postmates, Grubhub, DoorDash, and UberEats. Another emerging delivery method is the use of robots and/or small autonomous vehicles for urban deliveries, though those technologies have not been widely deployed yet.

Figure 34. Photo. Data pertaining to freight and goods delivery pick-up/drop-off activity can be helpful in implementing loading zones with sufficient capacity and availability to meet the needs of delivery drivers, reducing the number of blockages to adjacent uses as seen here in Washington, DC, USA. *Source: District Department of Transportation.*

As with ride-hailing companies, information about the operations or delivery patterns of delivery companies may not always be readily available to the general public. However, these services represent a growing demand for curb use, and wherever possible, public agencies and practitioners should attempt to collaborate with these companies to better understand their delivery patterns. Agencies might be able to collaborate with third parties to obtain and analyze data from goods and freight carriers. For example, UPS and other companies have worked extensively with the Seattle Department of Transportation (SDOT) and the University of Washington's Urban Freight Lab to supply data.

To identify areas with the most delivery activity as well as the peak delivery hour, useful information could include top generators of pick-ups or drop-offs, number of pick-ups and drop-offs per block face per time of day and day of the week, average duration of pick-ups and drop-offs, the mode split for couriers, and any information on where couriers park when completing pick-ups or drop-offs.

Where possible, agencies should seek collaboration with multiple freight and goods delivery providers in order to pursue a robust dataset.

Where possible, agencies should seek collaboration with multiple freight and goods delivery providers in order to pursue a robust dataset. Data obtained from any individual provider may represent a limited and incomplete picture of delivery activity due to market segmentation across multiple providers.

This data can be used to determine curb allocations for commercial loading as well as appropriate hours for which these zones should be active. For example, it is possible the peak hour for some of these services would not match typical hours for loading zones. Delivery times are often based on when the freight carriers' customers (e.g., the businesses and/or persons receiving the deliveries) are able to accept the deliveries. Freight carriers will try to avoid making deliveries at congested times and prefer off-peak deliveries, if possible. Additionally, in some jurisdictions, depending on code regulations, couriers might be ineligible to use commercial loading zones as they likely make deliveries in personal vehicles without commercial plates.

As with ride-hailing service providers, these companies may be hesitant to share data with public agencies in some cases as such data may then be subject to Freedom of Information Act requests. The number of packages delivered in a given day are major considerations for freight carriers. Package delivery efficiency is why carriers will attempt off-peak deliveries as well. In the absence of collaboration with providers, agencies may be able to use citations issued to delivery vehicles as a proxy for the identification of areas representing greatest service demand or lacking in appropriate delivery loading space. However, as discussed further with respect to citations and police data, policing is highly discretionary, which might cause discrepancies between the frequency with citations are issued and frequency of deliveries.

Specific-use Data Providers and Tools

Some third-party data providers have developed tools to assist with data collection. In some cases, these tools can be used to supplement or replace manual data collection in the field by practitioners. For example, Coord created a tool called "Coord Collector" which allows practitioners to collect curb data using an augmented reality smartphone app. Data collectors mark the beginning of the curb in the app, walk down the street while taking photographs or noting the locations of signs, curb cuts, or curb paint, and then mark the end of the curb in the app. The app tracks the data collector location and uses that information, combined with a city's municipal code and other data sources, like parking rate tables, to create an accurate, digital map of the curb. Per Coord's external marketing, the Coord Collector app can digitize a city block in under three minutes. The Coord Collector app also contains license plate recognition features, which can assist with parking occupancy and turnover studies. Coord Collector is one of the tools in Coord's comprehensive curb management platform. Other tools in the platform include an analytics capability to help cities view, allocate and price curb space and the Coord API to dynamically distribute changing curb regulations to fleets and the Coord Driver app to help fleet drivers find and pay for curb space (Coord).

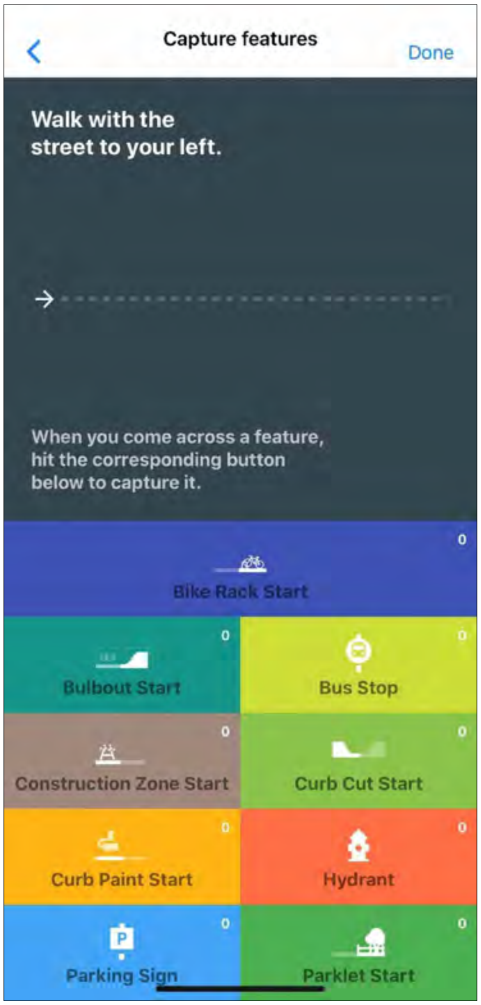


Figure 35. Graphic. Coord Collector is one example of a user-operated smart device app that can be used to capture geocoded images of physical attributes in the public realm. *Source: Coord.*

Curbside data can be collected using a variety of methods, including ingesting information from sources such as Open Data and GIS files, working with regulation data provided by public agencies.

Mapillary is a collaborative platform that uses crowdsourced or privately-provided street-level imagery to identify and map the locations of features such as signs, sidewalks, and traffic signals. Imagery is typically collected utilizing temporary or permanent vehicle-mounted sensors to capture video and/or still images with geospatial references, and is processed utilizing computer vision (Mapillary).

Curbside data can be collected using a variety of methods, including ingesting information from sources such as Open Data and GIS files, working with regulation data provided by public agencies. Regardless of the data collection method, this information needs to then be digitized and standardized to maximize its use in inventories and making curbside management decisions.

CurbIQ is a software solution that helps municipalities collect, display, and manage curbside regulations. An accurate, comprehensive curbside regulation layer can be developed based on a range of inputs including signage inventories, documentation of existing regulations, and in-field data collection methods, such as CurbWheel by Shared Streets. Regardless of the data collection method, CurbIQ generates a digital curb layer in CurbLR format which provides cities with future flexibility and the ability to work with the growing number of curbside management tools and services. The digitized curbside regulation data can then be viewed, updated, and analyzed through various CurbIQ modules and shared with other curbside stakeholders (e.g., TNCs, mapping and wayfinding services, couriers, etc.) via the CurbIQ API which allows third parties to integrate curbside regulation data into their own applications and mobility platforms.

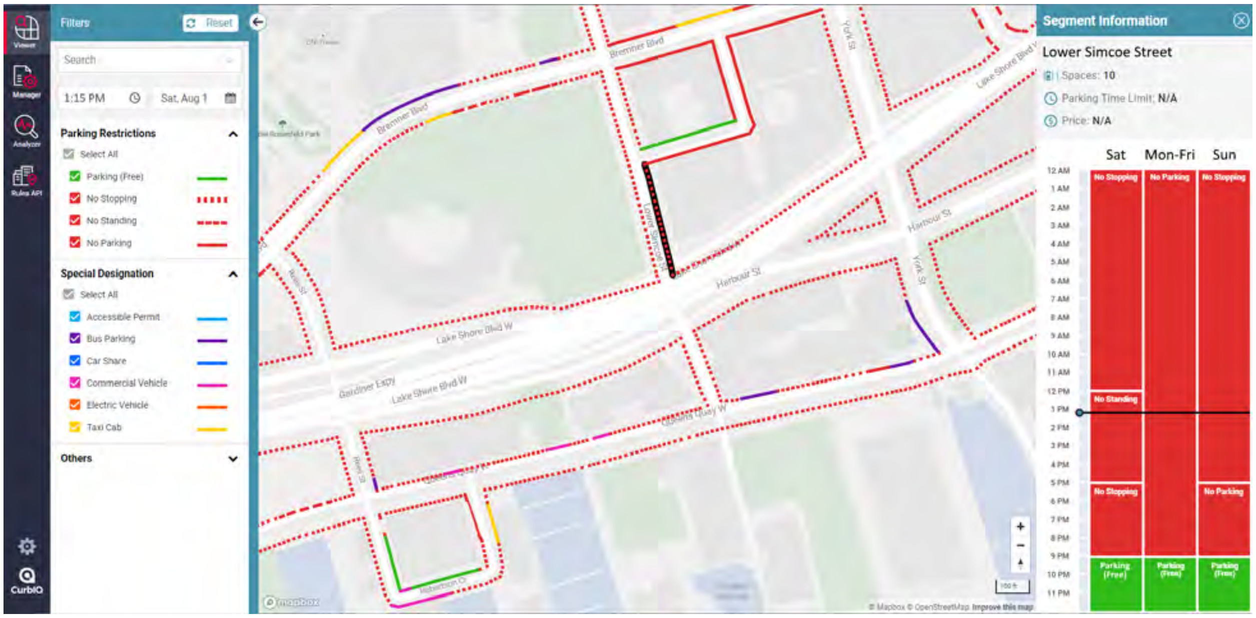


Figure 36. Graphic. digital map of on-street parking restrictions based on time in CurbIQ software on Lower Simcoe Street in Toronto, Ontario, Canada. *Source: IBI Group CurbIQ*.

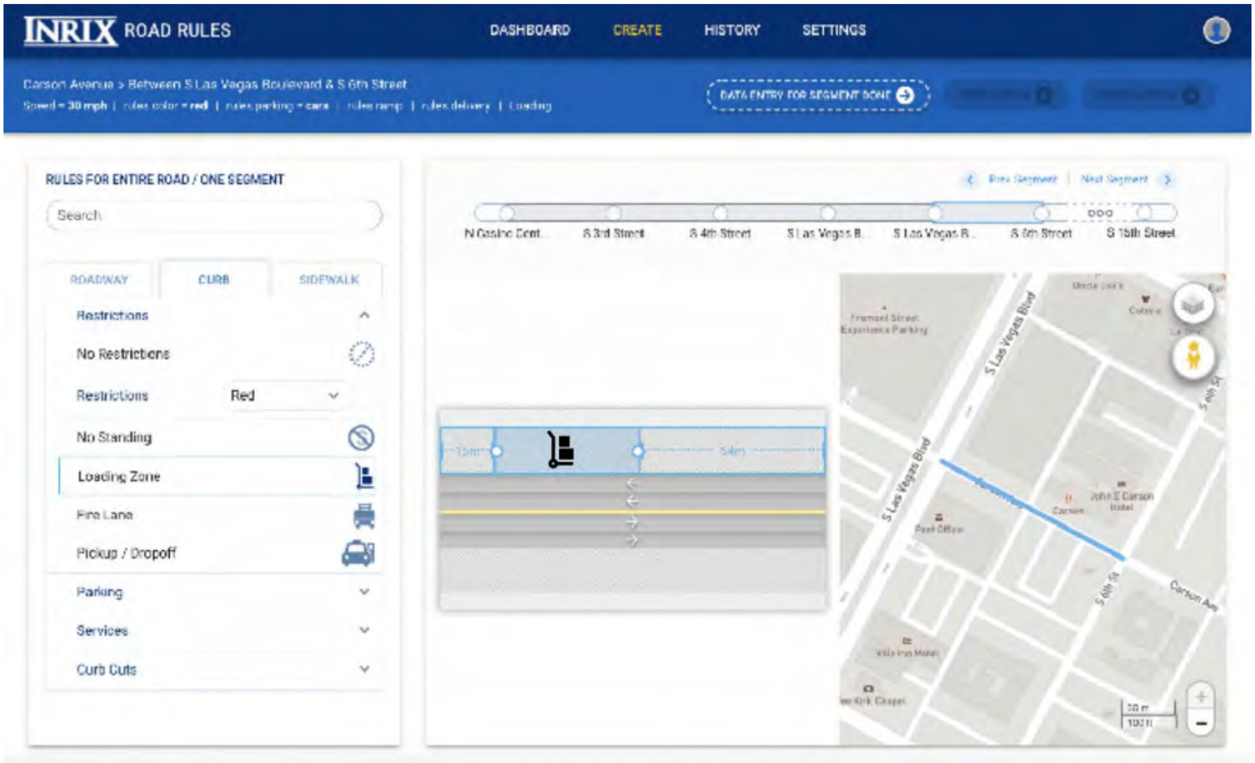


Figure 37. Graphic. INRIX Road Rules is platform that allows practitioners to digitize and manage the curb based on the CurbLR data standard. *Source: INRIX.*

Another example is INRIX, which has created a tool called INRIX Road Rules to serve as a platform for mobility data (INRIX). INRIX Road Rules is intended to help practitioners digitize, manage, and communicate rules about roadways, curbs, and sidewalks. INRIX Road Rules allows users to include road rules (e.g., speed limits, right of way restrictions), bicycle and transit facilities (e.g., bus lanes, bicycle lanes), curb zones (e.g., loading zone locations, transit stops, etc.), curb restrictions (e.g., rules about parking and loading), and any sidewalk assets (e.g., fire hydrants, parking for shared mobility devices like electric scooters). INRIX Road Rules uses the CurbLR data standard and linear referencing system developed by SharedStreets (discussed below) to facilitate data sharing across platforms, companies, departments, and agencies.

When using a vendor's services or platform to create curb data, practitioners should consider how the resulting asset and regulation data will be provided and accessed, as well as the license terms on any data products that are created, such as who owns which datasets, what uses are permitted or restricted, and whether the results may be shared by the agency or used in other platforms. This is important to ensure the agency will have the rights to utilize the data for analyses, evaluations, and engagement processes inherent to curbside management projects. It is also good practice to verify the data collection through random quality control checks.

INTERAGENCY DATA

Interagency data includes data from neighboring jurisdictions, special districts, transit agencies, and any other public entity that operates in or in conjunction with the primary agency. This data could include information about zoning, parcel records, transportation infrastructure, transit operations, business activity, parking occupancy and revenue, or collisions and citations.

Land Use and Planning

Land use data can be used to categorize neighborhood or location type. This information should include the mix of land uses present near the area under evaluation (e.g., residential, commercial, industrial) as different land uses have different patterns of activity at the curb and different modal priorities. Land use should also be used to calculate residential and job density to characterize the intensity of activity along the corridor. However, there might not be a linear relationship between density and curb activity. For example, with the growth of Amazon and other on-demand delivery services, even low-density residential areas might generate significant commercial loading demand. Note that land uses such as hotels and convention centers often have greater impact on curb demand for uses like passenger loading, while special event centers such as concert and sports venues often generate significant peaks of curb demand.

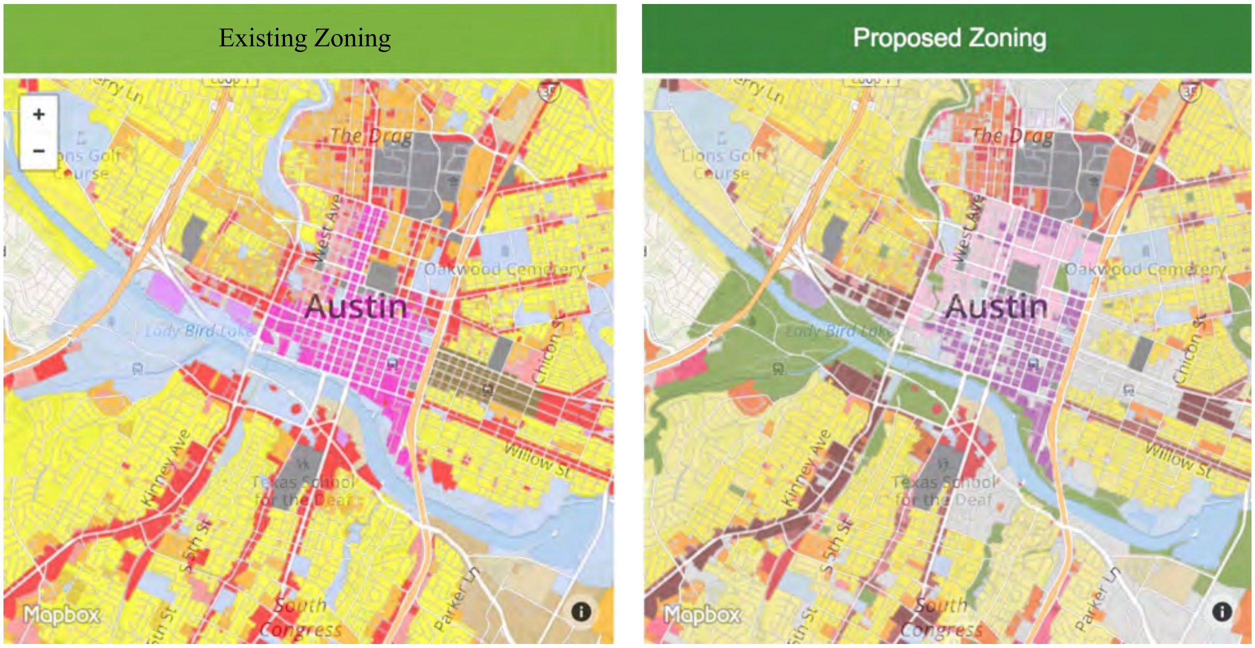


Figure 38. Graphic. Existing and proposed land-use zoning for blocks near the central business district in Austin, TX, USA. *Source: City of Austin.*

Figure 39. Photo. Curb space can be optimized using flex zones, determined based on known land uses and peak user demands, such as curb restrictions for a weekend market in Washington, DC, USA. *Source: Sarah Abel/ITE.*

Data on land use can be obtained from zoning maps, parcel records, and census data. Zoning maps regulate what types of land use and densities are permitted throughout a jurisdiction, although what is built may not match what is permitted under code as jurisdictions rezone previously built-up land. Parcel records include information about what has been built at each property (e.g., building type and size). However, for many jurisdictions, parcel records are not mapped or even digitized, so they might not be to characterize land use along a corridor. Census data can provide supplemental information: census data can be used to calculate residential and job density. Additionally, the census collects data on other population and housing characteristics such as vehicle ownership rates, the types of housing structures present (e.g., single-family houses versus apartments), and occupancy (e.g., renters versus owners).

Planning documents can also be used to investigate future plans for specific corridors or areas. For example, a corridor might fall within a specific plan area with particular goals or visions for future development (e.g., develop a large quantity of additional housing). Additionally, jurisdictions might have developed transportation or freight master plans, which could mark whether the corridor is intended to be a high-quality transit, bicycle, pedestrian, or freight route. Such designations affect the modal priorities of the corridor, which would alter priorities for curb use.

Transit Use and Operations

Transit is particularly important when considering the use of the curb as transit riders primarily access transit vehicles via the curb. Streets with high transit ridership surface transit routes could be prioritized using curbside projects to improve transit operations. Streets with high transit ridership typically coincide with land uses that generate transit ridership. Additionally, there are bus stop demand differences based on the types of land uses along a corridor. In cases of commercial vs residential, commercial or mixed uses typically generate a greater mix of boarding and alighting, while strictly residential tends to be directional based on time of day.

Public transit agencies generally make schedule and routing data available through General Transit Feed Specification (GTFS). GTFS also identifies the location of transit stops (although not their size or type of amenities available, e.g., shelters, benches, etc.). GTFS data can identify the number of transit routes using each stop, headways, and hours of service. Finally, GTFS-RT (GTFS real-time) provides information on real- time vehicle location, trip updates, and system alerts, which can be used to calculate metrics like transit reliability or average speed. Information on transit service can be further supplemented with ridership data. Ridership data is not included in GTFS. Some agencies make ridership data by stop available to the public; in other cases, such data must be requested from each transit provider.

Information on metrics, such as transit delay and dwell times, can be used to identify where there might be conflicts between transit vehicles and other use at the curb.

Additionally, Automatic Vehicle Location (AVL) data provides current vehicle location information. Depending on the transit agency's AVL data fidelity, each vehicle's location is refreshed anywhere from once per second to once per minute. Stored AVL data can provide historical data on transit service that can be used to optimize predictions of transit performance and better understand delay and dwell times. Swiftly, a transit AVL data provider and analyzer, currently leverages historic transit data for predictive arrival information. Information on metrics, such as transit delay and dwell times, can be used to identify where there might be conflicts between transit vehicles and other use at the curb.

Parking Occupancy and Revenue

Transportation/Parking Departments

Parking occupancy and pricing data can be collected from public agencies. Local and State departments of transportation might track parking occupancy, particularly on streets with metered parking. Some agencies use sensors to dynamically detect when a parking space is occupied. Other agencies might be able to approximate parking occupancy based on meter revenues. Meter revenues can identify the number of vehicles that pay for parking. However, such data is imperfect as it's based on the amount of time vehicles pay for, not the amount of time they stay. As such, revenue data cannot detect when parked vehicles depart before their time is up.

Public Safety Departments & Parking Enforcement Agencies

Further information on parking behavior can be obtained from local police departments or parking enforcement agencies. These divisions issue citations for reasons including non-payment of parking meters, violating on-street parking restrictions (e.g., staying longer than posted time limits), and double-parking. This can provide insight into the types of problems present at the curb. For example, a large number of double-parking tickets on a specific block may indicate that demand for loading space surpasses the available supply. The performance of a project, which provides additional loading space, may appropriately be evaluated by the number or frequency of double-parking violations before and after implementation.

Figure 40. Photo. Lack of curb loading space in high-demand areas results in lane blockages and undesirable vehicle movements resulting from tour bus pick-up/drop-off activity in Washington, DC, USA. *Source: District Department of Transportation*.

Figure 41. Photo. In contrast, the provision of ample first-in/first-out curb loading space allows safe and orderly access for tour buses elsewhere in Washington, DC, USA. *Source: District Department of Transportation*.

As with all data, citation data should be viewed through the proper lens due to the discretionary nature of policing. Police and parking enforcement officers might be more likely to issue citations for certain types of traffic and parking violations, such as violations that are easier to observe or, in some cases, violations that generate larger fines (Garrett & Wagner, 2009). Additionally, some research has shown that police might disproportionately patrol particular neighborhoods or disproportionately issue citations to specific groups within the community (Brazil, 2018). Citation data can therefore over-represent or underrepresent certain types of violations and result in a misunderstanding of travel behavior across different geographies and communities.

Multimodal Safety (Traffic Citations and Collision Reports)

Issues with curb access can cause conflicts between pedestrians, bicyclists, and cars, leading to safety issues for different users. For example, when vehicles engaged in passenger or commercial loading lack loading space, they might double-park in bicycle lanes or crosswalks and endanger pedestrians and bicyclists. Public safety citation and collision data can also be used to provide insight into issues with multimodal safety. Local and State police collect reports for collisions involving pedestrians, bicyclists, and vehicles. Additionally, police issue citations for different types of traffic violations to pedestrians, bicyclists, and vehicles. For bicyclists and pedestrians, citations might be issued for behaviors such as bicycling on the sidewalk or jaywalking. For vehicles, citations might be issued for failing to stop at a stop sign or traffic light, crosswalk intrusions, and speeding. Certain types of citations might indicate issues with curb access. However, as discussed above, due to the discretionary nature of policing, citations might not accurately represent differences in collisions or other issues with multimodal safety.

Collision and traffic violation data can be obtained from local or State agencies directly or through collision databases (e.g., in California, the Transportation Injury Mapping System, or TIMS, geocodes and maps all collisions in the state using data from the California Statewide Integrated Traffic Records System, or SWITRS). This data can then be used to identify higher-frequency collision locations involving bicyclists or pedestrians or where vehicles are frequently issued traffic violations. More collisions and violations can indicate a need for managing the curb. However, traffic citation and collision data primarily represents incidents in which an involved party reports the collision to police. Minor collisions in which neither party sustains serious injuries or in which bicycles and vehicles are not damaged, are unlikely to result in a police report.

Sales and Economic Activity

Information on sales and economic activity can be obtained from public agencies, including city or State economic departments and development agencies or districts. Relevant data could include business permits and tax and sales data. Trends in the number and type of business permits issued over time, as well as the frequency of requests for new permits, can shed light onto the type of commercial activity occurring along a given corridor. Sales tax data can further reveal the scale of commercial activity along a corridor. For example, a higher incidence of transactions could indicate a commercial corridor is particularly popular, meaning many visitors to the corridor. Additionally, public agencies can provide information on permit requests for features like parklets and outdoor seating.

DATA STANDARDS AND FORMATTING

When possible, data should be collected and stored in a standard format. Use of standards promotes common and clear meanings that are accessible among different users and organizations. Additionally, data standards help ensure consistency in data meanings and results. Some relevant standards include International Organization for Standardization (ISO), American National Standards Institute (ANSI), General Transit Feed Specification (GTFS), General Bike-share Feed Specification (GBFS), Mobility Data Specification (MDS), Provider Application program interface (API), CurbLR open data specification and SharedStreets linear-referencing system, and Building and Land Development Specification (BLDS). Additionally, the Alliance for Parking Data Standards (APDS) has created a data specification for parking with the assistance of the Intelligent Platform Management Interface (IPMI).

When possible, data should be collected and stored in a standard format. Use of standards promotes common and clear meanings that are accessible among different users and organizations. Additionally, data standards help ensure consistency in data meanings and results.

Figure 42. Photo. Food cart and trucks are a curb side use that may be on either the sidewalk or street. Food vendor street permit issuance and policies are a means to measure and manage the curb. *Source: Seattle Department of Transportation.*

RELEVANT STANDARDS FOR AGGREGATING AND ORGANIZING DATA

ISO and ANSI provide standards around design, engineering, and data structure. Often, ISO standards are referenced within data specifications. For example, for geospatial metadata, the Federal Geographic Data Committee (FGDC) endorses ISO metadata standards.

Relevant data standards for curb management exist through new data specifications. The GBFS is provided by bike-share companies to their host jurisdictions and often shared on jurisdictional open data portals or web sites. The GBFS evolved as the bike-share business model developed and its purpose was to provide locations and updates regarding the quantity of available bicycles at docked bike-share pods. This feed specification is now used by mobile apps and websites to share bicycle availability. However, GBFS has not adapted as bike-share has evolved to include e-bikes and dockless bikes, which recently led to the creation of and updates to the MDS. MDS is intended to help micromobility service providers (e.g., e-scooters, e-bikes, and dockless bicycles) share information about their services, including but not limited to vehicle location and battery level. The Open Mobility Foundation oversees the MDS and has recently started work on a curb data specification that will be forthcoming. Data frameworks enable public-private collaboration and the seamless exchange of transportation data.

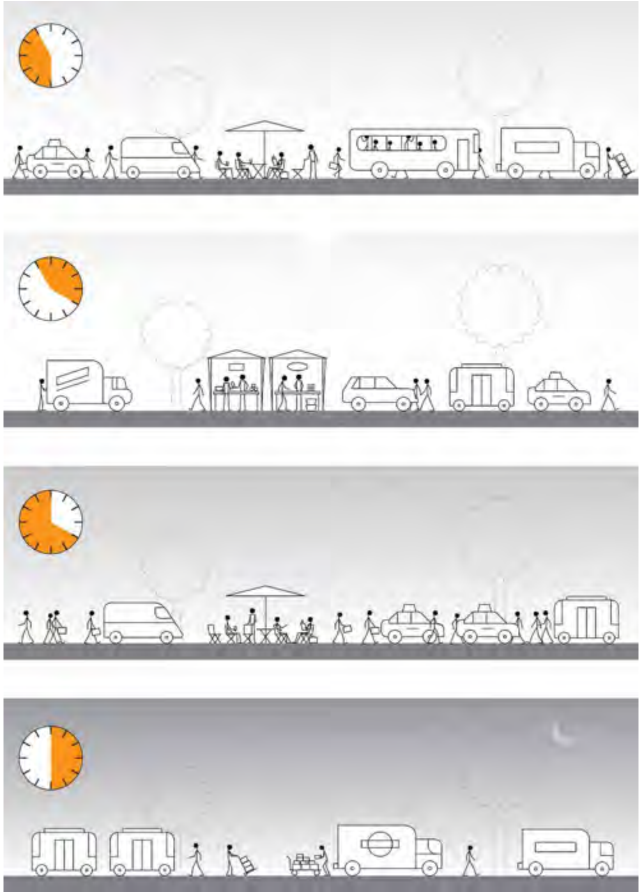


Figure 43. Graphic. The concept of dynamic curbs is evolving and can be adapted based on peak demand of uses at certain times of day. *Source: Haisam Hussein based on NACTO data for Planning Magazine*.

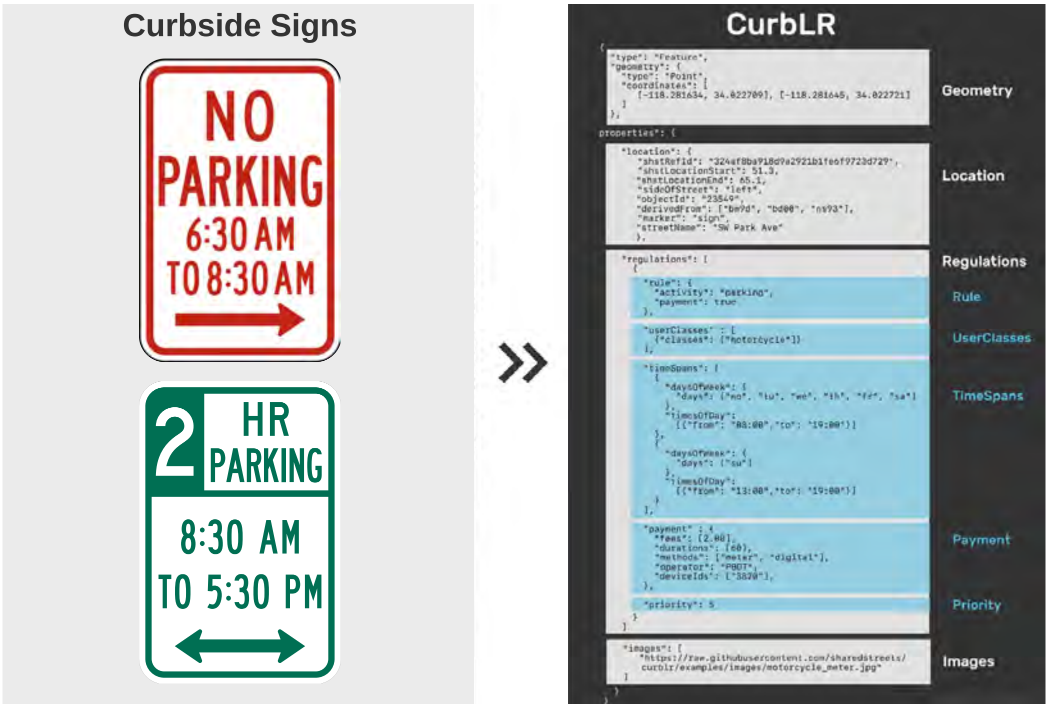


Figure 44. Graphic A and Graphic B. Coding of public realm features, such as parking signs, into suitable data sets allows incorporation into GIS analyses.
Sources: Left: FHWA MUTCD. Right: SharedStreets.

SharedStreets provides an example of an open framework for sharing information about streets across jurisdictions, however it does not have an open governance model. Specifically, SharedStreets provides a linear referencing system that creates a common way to refer to streets between agencies, companies, and others who may all be using a slightly different base map. Users can communicate consistently about where a curb zone is located, for example, without requiring that they agree on a common centerline file. Another example of an open framework is MDS, which is created around a broad community of stakeholders.

For curbside management, SharedStreets has developed a data specification named CurbLR, which provides a format to store essential information about curb regulation. CurbLR provides a format for users to store the location of each curb zone, along with fields to describe the activity, user types, timespans, priority level, and payment terms of the regulation. This data standard allows curb assets to be fully- described and referenced back to the street. It can act as a template for practitioners as they determine what information to collect in a curb inventory and how to store it.

Shared ROW specification is emerging as a cross sectional link to SharedStreets. Eventually, it will link land uses, the sidewalk, the curb, and the roadway from building façade to façade. It uses SharedStreets centerlines and will serve as the mechanism to provide a full street, cross sectional data structure to help determine modal priorities for the curb.

Finally, BLDS is a standard for sharing open data on building and construction permits issued by municipal governments. This data standard references the information needed to assemble a core permits database as well as optional data requirements contractor or inspections data can be connected.

NEXT STEPS

MOVING TOWARD IMPLEMENTATION

The ITE *Curbside Management Practitioners Guide* established a high-level description of the overall treatment selection process involved in implementing curbside management strategies and projects, including the following steps:

1. Inventory existing conditions
2. Identify land use and activity considerations to develop modal prioritization
3. Establish performance measures
4. Identify appropriate treatment alternatives
5. Assess and present alternatives for public feedback
6. Refine and implement treatments

The *Curbside Inventory Report* is a more in-depth technical report pertaining to the collection, inventories, and processing of information relevant to existing conditions, curbside activity, and performance measurement. This provides the practitioner with the tools needed to establish modal priorities within their jurisdiction, paving the way for the pursuit of new projects and strategies.

Figure 45. Photo. Curbside bicycle counting sensor and digital sign installed to inventory use of curbside bicycle facility in San Francisco, California, USA.
Source: San Francisco Municipal Transportation Agency.

Many resources are available to assist with the identification of appropriate treatment alternatives relevant to established modal priorities, including the Available Tools and Treatments section of the ITE Guide. Furthermore, ITE developed a GIS-based Curbside Management Tool that will assist practitioners with the identification of viable treatment options given their identified demands and priorities.

The use of these combined resources will allow agencies to effectively assess potential projects utilizing a repeatable, data-driven approach. The processes position them to include the public in robust engagement that includes identification of goals and values, as well as feedback on the development and implementation of projects.

CURBSIDE MANAGEMENT MOVING FORWARD

The *Curbside Inventory Report* is based upon best practices identified by practitioners who have undertaken extensive data collection and management efforts with a particular focus on lessons learned from implemented curbside management strategies and pilots. It outlines the process of identifying data needs to use a strategic approach to curbside management projects. This approach should incorporate flexibility and productivity to allow the curb to serve more users and more types of needs. Flexibility is important as mobility changes, curbs need to as well.

With the rapid evolution of curbside management practices, data sources, and computer technologies, the best approach to inventorying information related to curbside management is also constantly changing. Advances in automated sensing technologies, machine learning, and computer vision continue to streamline the collection of large volumes of information and create new competitive opportunities for third-party data providers to aggregate that information independent from agencies. These trends are likely to continue improving the efficiency — in terms of both cost and time — with which agencies can obtain large datasets to inform their decision-making. In addition to developing data collection, inventory and assessment strategies based on existing decision-making, agencies should do the following:

- Consider implementing a comprehensive curbside management policy and/or program across multiple departments involved in curbside management
- Ensure that pedestrian features, parking, and passenger loading zones are accessible to and usable by persons with disabilities
- Build in flexibility in design solutions to allow for future modifications
- Be prepared for electrified and connected vehicles and technologies at the curb
- Leverage data sharing and partnerships with all stakeholders internal and external that may be helpful in curbside data collection
- Set standards for threshold decisions under curbside management
- Explore the use of dynamic and flexible curbs as a means to achieving highest and best use based on demand for curb space

Building in Flexibility

To most effectively react to the evolution in curbside management and transportation in general, agencies can benefit from maintaining flexibility for future modifications in the development of projects. This may include ensuring policies and regulations are easily adaptable to a specific context, using adjustable materials or designating flex zones that are intended to be dynamic as part of the original project. Agencies need to consider how the use of flexible spaces will be communicated to pedestrians with disabilities, including vision disabilities. These considerations are useful both for allowing projects to be adjusted not only in the short-term based on performance measurement, but also in the medium- or long-term as curbside demands change.

Electrified and Connected Vehicles and Technologies at the Curb

Electrification and technology advancements of the curb are increasingly important tools for providing flexibility and understanding demand at the curb. An increasingly key element of curbside management strategies is the deployment of electronic devices (e.g., automated sensors, smart meters, information displays, communications equipment) which typically require an electrical service connection to operate, and it is likely that new technologies will result in new devices with similar needs. The strategic deployment of electrical service points with access to key locations along the curb as part of curbside management projects can enhance the agency's ability to consider the full spectrum of solutions as part of both current and future improvements.

Figure 46. Graphic. A depiction of different portions of the right-of-way that may be designated for use by specific modes, including flexible areas that may be used for multiple functions.
Source: Nelson/Nygaard.

Establishing Data Partnerships

Given the importance of data to inform curbside management strategies, agencies would be well served to establish open data policies and pursue relationships to exchange data freely with key partners. Shared mobility providers and freight/goods delivery services represent an increasing proportion of the demand in many jurisdictions, and these partnerships would ideally lead to a collaborative and productive relationship among key curb stakeholders. Sharing synthesized user and asset data could be mutually beneficial to these parties when their application leads to improvements in real-world efficiency.

Sharing Knowledge

The increased emphasis on data-driven approaches to curbside management will directly contribute to continued growth in the number of available before-and-after evaluations of implemented projects. Case studies documenting the successes and lessons learned from these projects will continue to improve the state of the practice in curbside management and inform the development of future projects. As such, it is critical to maintain an ongoing exchange of information between agencies, and the establishment of additional avenues for training and collaboration between practitioners should be considered. Sharing knowledge and understanding demand for curb space also includes the further development and use of flexible and dynamic curbs as a means to provide highest and best use of the curb at all times of day. Additionally, setting national, State, regional, and local standards and threshold decisions in allocating curb space through comprehensive curbside management policies and/or programs will be essential to curbside management moving forward.

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