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Improving Future of the Commonwealth's Curb

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16. Abstract

Demands for use of the curb space (curbside lanes and the adjacent sidewalk space) are evolving quickly across the Commonwealth of Massachusetts as municipalities of all sizes juggle the competing needs of pedestrians, cyclists, transit, transportation network companies (TNCs), in addition to conventional uses for parking, goods delivery, and emergency access. The problem is further complicated by the potential deployment of e-bikes, scooters, and automated vehicles. Guidance for curb management is needed for communities of all sizes across the Commonwealth where the context can vary from dense urban environments to small town centers. Whereas curb management policies in the past have typically focused on vehicles and parking, future curb policies must recognize the diverse ways that people use the curb in a multimodal transportation system. This study addresses two objectives: 1) to explore the demands on the curbside lane and identify strategies for curb management for municipalities across the Commonwealth of Massachusetts, and 2) to identify future demands on the curbside lane and how these demands can be accommodated. The guidance in this report is based on a review of recent literature on curb management practices and focus group interviews with stakeholders from across Massachusetts.

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Future of the Commonwealth's Curb

Final Report

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Executive Summary

The curb is the edge of a roadway, representing an interface between mobility (movement of people and goods) and access (getting people and goods to and from the places that they need to be). Curb space management requires consideration of demands and activities in the curbside lane, the adjacent sidewalk, and the interactions between the two. Historically, the default designation use of curb space has been on-street parking, with exceptions made where access is required for infrastructure like bus stops or fire hydrant. Curb space has many other uses, including pedestrian access to buildings, passenger loading/unloading (e.g., ride-hailing services), loading/unloading of goods, and non-transportation uses such as outdoor dining.

In recent years, there has been increasing attention on the competing needs at the curb as ride-hailing services increases pick-up and drop-off activities, e-commerce increases package delivery, and other non-transportation uses have gained popularity. Existing resources for developing curb management strategies focus on urban contexts where the curb space is congested with competing uses. This report presents a review of existing literature, a summary of findings from stakeholder outreach, and recommendations for curb space management practices and considerations that apply to communities throughout the Commonwealth of Massachusetts.

Review of Curb Space Management Policies and Practices

There are four important trends that are affecting the use of curb space and drawing widespread attention to conflicts and congestion at the curbside:

1. *Increased Use of Ride-Hailing Services* – The advent of app-based ride-hailing services (e.g., Uber, Lyft, Via) have dramatically increased demand at the curb for pick-up and drop-off activities. In Massachusetts, the ride-hailing services are most heavily used in the inner core communities of the Boston Region, but the services are also highly utilized in smaller communities, such as Provincetown (Cape Cod), Nantucket, and Edgartown (Martha's Vineyard). Increases in passenger pick-up and drop-off activity are a phenomenon across many parts of the Commonwealth.
2. *Increased E-Commerce (Online Shopping and Food Delivery)* – The increasing popularity of online shopping for goods, groceries, and meals has increased the number of delivery vehicles and the number of times that delivery vehicles stop to load and unload goods at the curb. Illegal parking by commercial vehicles is widespread in cities where the phenomenon has been studied (e.g., more than half of goods deliveries in four California cities were associated with illegal parking in no-stopping zones or blocking a lane traffic).
3. *Increased Interest in Multimodal Transportation (Walking, Cycling, Transit)* – Two initiatives have gained popularity across the United States as communities look to shift travel by private car toward active transportation modes. *Vision Zero* programs aim to eliminate traffic fatalities by making safety improvements that protect vulnerable road

users. *Complete Streets* programs promote the design of streets that prioritize safety, comfort, and access for all users rather than focusing on the movement of cars.

4. *Active Management of Curb Space* – There is a trend toward implementing policies that are responsive to changing conditions and demands at the curb rather establishing a static policy or curb designation that remains in place indefinitely. Examples of active management are policies to manage supply and demand for curb space through pricing or scheduling different curb space uses for different time periods in the day.

The first step to establishing coherent and effective curb space management practices is to understand what is happening at the curb. There are many possible metrics of curb space use and performance related to mobility, livability, accessibility, safety, efficiency, and economic vitality. Measurement of existing activities at the curb are important for establishing appropriate policy goals. Measurement of curb space performance is necessary for monitoring and evaluation to ensure that curb space management is optimized for these goals. A common challenge is to collect data on curb use, and methods range from infrequent manual observations to crowdsourced data from mobile phones and GPS devices. There is an emerging need for data standards related to curb space that 1) are open to allow integration across multiple sources; 2) utilize apps that provide platforms for gathering, sharing, and managing information, and 3) include data identifiers to allow actors to interact on a digital platform that manages things like payment, permissions, and scheduling.

Next, it is important for communities to consider how curb functions should be prioritized in defining goals for curb space management. These functions may include: support for modal plan priorities, access for people, access for commerce, activation, greening, storage, emergency access, repair and maintenance access, and waste management. The order of prioritization may vary from one community to another, or over time commensurate with the increase in demand for curbspace, or for different land uses (left side of Figure 1). Strategies for managing curb can be broadly categorized as relocation, flexibility, and conversion. Policies also require different levels of ranging from signage to technology to hard infrastructure investments (right side of Figure 1).

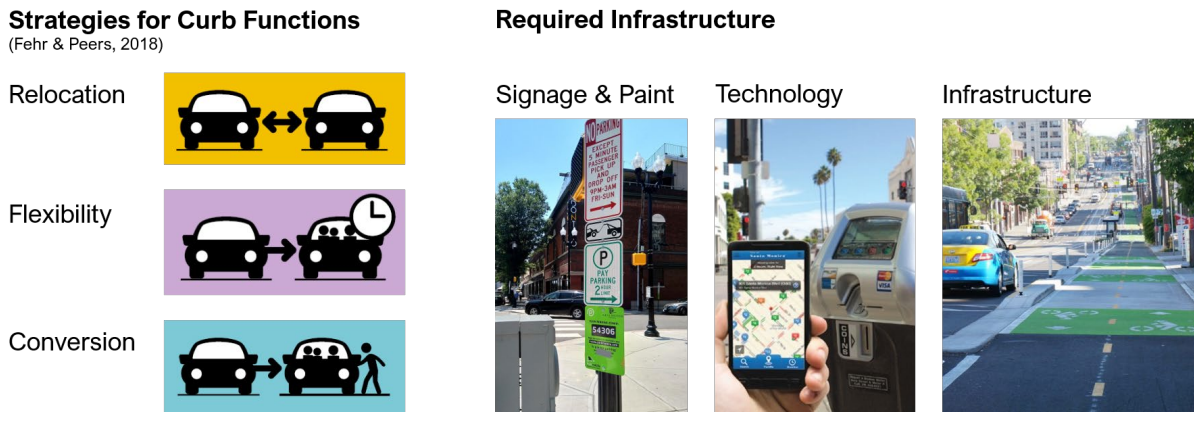

Figure 1 Categories for strategies and tools for curb space management, including a) strategies for curb functions, and b) required infrastructure various implementations.

The COVID-19 pandemic accelerated many changes that were already happening at the curb. In many communities, the need to support public health gave authorities a mandate to think openly about prioritization of curb functions and the importance of curbside pick-up and delivery, outdoor dining, and slow streets for safe multimodal use. The pandemic pushed many smaller cities and towns to embrace curb space management in order to address local needs. The lessons learned during the pandemic are also applicable to communities considering how to manage curb space as the pandemic ends:

1. Allocate the curb equitably
2. Improve the curb flexibility
3. Make the curb a place of innovation

Stakeholder Perspectives in Massachusetts

This study incorporated input from 15 stakeholders during 7 focus group meeting, which was recorded and analyzed to identify common themes and important insights for curb space management across the Commonwealth of Massachusetts. Four main themes emerged from the comments of stakeholders:

1. *Primary Users of the Curb*
   - Dining – "…the pop-up dining areas that … repurpose the curbside… during the pandemic"
   - Pedestrians – "they've set up cones on the parking lane …to widen the sidewalk area for pedestrians [and] bicycles"
   - Parking for Businesses – "We hear a lot from our business owners about the importance of [parking and] their unwillingness to deviate"
   - Accessibility – "The curb belongs to the cars…It's not always accessible for people getting in or out or dropped off "
   - Repurposing – "The City tried out taking the parking spaces [and] using those for additional restaurants [and] eating, and everybody loves it."; "geofencing [for] some of the Uber and Lyft drop-off areas [and] delivery"
2. *Data*
   - Cameras – "we can go out [and] setup counters…we've got these little video cameras."
   - Location Based Apps – "We do have a couple of [location-based services] tools that aggregate data from cell phones as well as connected vehicle fleets"
   - GIS Data – "When a bus lane turns into a bike lane …then overnight parking, the dynamic uses within that line segment and the points that make up the assets along the curb [are] crucial to understand"
   - Artificial Intelligence – "Verizon has a product …that …essentially [uses] AI to look at the curb…[it] also measures the productivity of the curb"
3. *Needs and Policy Changes*
   - Flexibility – "general enthusiasm for trying something new and the regulations made it easy for them to do it"; "Earlier, the process of outdoor dining involved

professional engineers, lawyers, and 10's of thousands of dollars just to get an outdoor dining cafe zone [and now it doesn't]"

- Business Considerations – "We had a shared street project [and] I thought we were going to be tarred and feathered from the businesses"; "Businesses [are] expanding their storefront to the sidewalk… understanding [where the dropoff] locations are relative to [the business], is very important info "
- Advocacy Groups – "we are not trying to push one group against the other. Sometimes it all does not fit, and it is a balance between all of us; statewide and municipalities"; "We have public health planners or public health components in our office…they chime in on projects"
- Safety - "Safety is always the bottom line"; "It is good to get an idea of more vulnerable populations, not just the average college student who can zip across the street"

4. *Future Needs*
   - Connected Infrastructure – "we know that more connectivity is coming, or autonomous vehicles are coming and [we need to change] how the infrastructure …will talk to those vehicles"
   - Safety and Security – "how can the municipality itself revert infrastructure for [automated] vehicles…[to] increase the safety along the curb …obviously there will be security issues"
   - Curb Data – "how do we digitize information about the curb, the location, the regulations…[how do we get] better data about how the space is being used"
   - Effect on Parking – "we are not going to see as [much] demand …for long-term personal vehicle storage, it's going to be more …pickup and drop-off"

Recommendations for Massachusetts Communities

Although the literature on curb space management focuses heavily on urban contexts with large, dense cities, there are insights that are relevant to communities of all sizes throughout Massachusetts. Furthermore, the stakeholder interviews provide insights about gaps in the literature and special considerations that cities, towns, and villages in Massachusetts should be aware of in planning and implementing curb space management policies.

Identifying & Prioritizing Curb Functions

- Recommendation 1 Curb uses should be identified and prioritized based on the context of the community.

Measuring Curb Use

- Recommendation 2 Despite the difficulty, data on curb use should be collected to support the selection and implementation of curb space management policies.
- Recommendation 3 Open data standards should be embraced so that public authorities control data and policy-making.

Changes in Curb Use in Response to Repurposing

- Recommendation 4 Implement new curb policies as pilots or demonstrations to gauge demand and build public support.
- Recommendation 5 Measure and compare benefits against losses when policies change curb functions.

Impacts on Business

- Recommendation 6 Removal of on-street parking can be contentious, but other uses may be more productive in supporting businesses.
- Recommendation 7 Dynamic policies, which can vary the curb use over time, provide flexibility to serve many competing needs.

Input from Advocacy Groups

- Recommendation 8 Recognize that ADA requirements do not address all challenges experienced by people with impairments.
- Recommendation 9 Stakeholders representing a wide range of perspectives should be engaged throughout the planning and implementation process.

Safety Considerations

- Recommendation 10 Safety impacts of a curb intervention should always be carefully considered in context.

Coordination among Multiple Jurisdictions

- Recommendation 11 Effective curb management policies require coordination among public agencies and private entities, especially regarding ongoing maintenance (e.g., snow removal).

Future Needs

- Recommendation 12 Technologies for curb management should be viewed as tools to support policy goals for curb functions.
- Recommendation 13 Policies should be flexible to adapt to evolving demands, especially with uncertainty about the specific requirements around technologies like autonomous vehicles.

Resources

MassDOT has published two documents that provide communities in Massachusetts design guidance that supports prioritization of active transportation modes, which is relevant to the

design and management of curb space. The *Separated Bike Lane Planning and Design Guide* (2015) includes a chapter that focuses on the design of bike lanes around on-street parking, loading zones, and transit stops. The *MassDOT Municipal Resource Guide for Walkability* (2019) provides general guidance for communities across the Commonwealth to improve walkability. An important and useful part of the guide is a section on "ADA and Accessibility," which provides detailed design guidance for making pedestrian spaces accessible for all users.

There are also funding programs that provide communities in Massachusetts with support to improve transportation infrastructure, which can include improvements to the curb space. The MassDOT Complete Streets Funding Program provides technical assistance and construction funding to municipalities to support policies that include facilities for pedestrians, bicycles, transit, and other modes (e.g., cars, freight traffic, emergency vehicles, etc.). In 2020, MassDOT launched the Shared Streets and Spaces Program to provide funding support for municipalities that needed to make changes to their street and curb space in response to the COVID-19 pandemic.

Best Practices for Curb Space Management

Best practices for curb space management are summarized by a cycle of steps as shown in Figure 2. These practices create a loop in which curb use and performance are assessed in an ongoing manner so that policies respond to the evolving needs of the space. The diversity of community contexts across the Commonwealth of Massachusetts makes it difficult and inappropriate to make a blanket recommendation for specific curb management tools or strategies. Instead, each community must engage in a policy development process for curb space management.

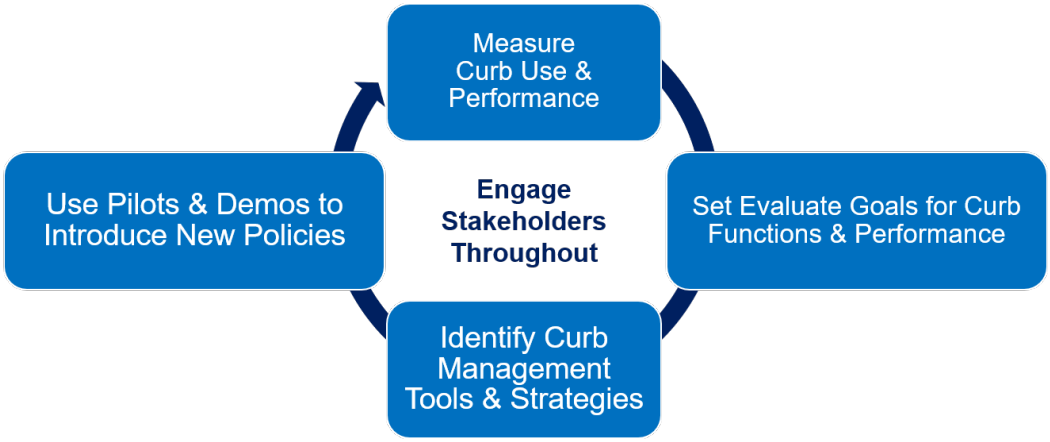

Figure 2 Recommended Practices for Curb Space Management

The most general conclusions from the literature review and stakeholder inputs may be summarized as following insights and recommendations:

1. Effective curb space management starts with data.

2. Policies should promote the “best” use of curb space, which depends on context and the goals of the community.
3. Engage stakeholders throughout planning and implementation of new curb policies, especially from those who can provide insight on the needs of vulnerable users.
4. Use pilots and demonstrations to gather information and build public support.
5. Embrace active and flexible curb space management practices.

The recommendations from this study are intended to draw attention to challenges and opportunities that each community should consider in selecting appropriate curb

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List of Acronyms

Acronym	Expansion
ADA	Americans with Disabilities Act of 1990
AI	Artificial Intelligence
COVID	Coronavirus Disease
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
GPS	Global Positioning Systems
MassDOT	Massachusetts Department of Transportation
MPO	Metropolitan Planning Organization
TNC	Transportation Network Company

1 Introduction

Demands for use of the curb space (curbside lanes and the adjacent sidewalk space) are evolving quickly across the Commonwealth of Massachusetts as municipalities of all sizes juggle the competing needs of people on foot, cycling, using transit, ride-hailing and transportation network companies (TNCs), in addition to conventional uses for parking, goods delivery, and emergency access. The problem is further complicated by the potential deployment of e-bikes, scooters, automated vehicles, micro-freight, and unforeseen modes of transport. The Boston Region Metropolitan Planning Organization (MPO) performed a *Future of the Curb* planning study (Clark, 2019), but guidance for curb management is needed for communities of all sizes across the Commonwealth where the context can vary from dense urban environments to small town centers. Whereas curb management policies in the past have typically focused on vehicles and parking, future curb policies must recognize the diverse ways that people use the curb space in a multimodal transportation system.

1.1 Project Overview

In most communities, the default designated use for the curbside lane is on-street parking. Curbside lanes and the adjacent sidewalk space have many other uses, including space for pedestrians to access buildings, passenger loading/unloading (e.g., ride-hailing services), loading/unloading of goods, and non-transportation uses such as outdoor dining. The curbside lane is sometimes used for dedicated bicycle lanes or transit lanes. In low-density areas, there may be ample curb space for all uses. In urban environments or during special events, however, there is often congestion at the curb as the demands for multiple uses exceed the available space. This has led to a variety of policies for parking (e.g., pricing, time limits, permits) and designations for other uses. Curb uses are changing with increasing density of uses, emerging technologies and changing traveler behaviors, all of which add to the demands of limited curb space and driving the need to identify strategies to manage the curbside lane for future needs.

Management strategies for the curb space are gaining increasing attention across the United States. A Boston Region MPO *Future of the Curb* planning study (Clark, 2019) focuses on the management of curbside lanes in an urban context. There is a need to identify policies and designs for curbside lane management that are appropriate for a variety of contexts that exist across the Commonwealth of Massachusetts. This includes considering village and town centers, and suburban neighborhoods, where challenges of curbside lane and sidewalk management may be more driven by the need to accommodate different types of users and functions than alleviating congestion. Specifically, there is a need for a resource that communities can use to identify curb space management practices that are likely to be successful to meet specific objectives related to transportation modes, population groups, and demand levels while recognizing implications for changing future technologies. For example, some curbside lane management policies require only paint or signage for implementation and could, therefore, be changed at low cost in response to changing needs. Other designs may require construction of barriers or roadside hardware that could be less flexible to re-purpose or costly to change.

The purpose of this study is to review existing curb space management policies and practices with particular attention to identifying strategies that are appropriate for diverse contexts; serve the needs of people walking, people cycling, people with a disability, and other vulnerable users; and anticipate changing future needs associated with new technologies (e.g., connected and automated vehicles) that will likely change the ways that people use the curb space. The goal is to provide forward-looking guidance for public authorities across the Commonwealth of Massachusetts that seek to improve curb space management to better serve communities' needs.

1.2 Study Objectives

This project has two main objectives:

1) To explore the demands on the curbside lane and identify strategies for re-purposing and managing the curbside lane in municipalities across the Commonwealth of Massachusetts.

2) To identify future demands on the curbside lane and consider how the curbside lane could be re-purposed and managed to accommodate these new demands.

This report presents recommended practices and considerations for communities to implement effective curb space management policies that are appropriate for their contexts. The intent is to create a forward-looking reference that identifies potential strategies for curbside lane design and management, recognizing that some strategies offer more flexibility over time while others may require infrastructure investments to fully realize benefits.

2 Research Methodology

The research approach for this study consists of three main components: a literature review to assess the current state of practice for curb space management, especially in the United States; engagement of stakeholders to understand current uses and emerging needs in Massachusetts; and an analysis comparing the two. The following subsections describe the research approach for each of these parts of the project. The culmination of these three sections is guidance for curb management across the Commonwealth of Massachusetts.

2.1 Literature Review

Physical curbs have been built at roadsides since ancient times, like in Pompeii, Italy. Curbs first appeared in the US in the late 18th century. Policies to manage the use of the curbside lane and adjacent sidewalk spaces have developed rapidly in recent year as competing needs and technologies change the way that the curb is used. A review of the literature on curb management practices focuses on the most recent developments in curb management policy and practice. The review makes use of publications by national-level organizations that review curb management practices in cities across the United States and synthesize guidance for:

1. Defining Curb Space and Functions
2. Identifying Trends in Curb Use and Management
3. Development of Curb Management Policy
4. Deploying Curb Management Tools and Strategies
5. Identifying Future Needs

The review also includes guidance developed during the COVID-19 pandemic for cities of all sizes to repurpose curb space for changing needs (e.g., outdoor dining, recreation spaces, delivery pick-up/drop-off).

Insights from the literature review, as they related to communities across the Commonwealth of Massachusetts, are identified. Notably, most of the documented curb space management studies and pilot projects have been in very large cities. These cities are an appropriate model for Boston and the urban communities at the center of the Boston Metropolitan Area, but there are smaller cities, towns, and rural communities throughout Massachusetts that also have curb space management needs. Particular attention is given to identifying the relevant lessons learns and literature gaps related to the diverse communities across the Commonwealth.

2.2 Stakeholder Engagement

To gain insights about the needs of Massachusetts communities, stakeholder input was solicited through targeted focus groups. There are two types of information that are gained by including stakeholder engagement in this project:

1. Current practices and challenges regarding data collection and curb space management in communities across Massachusetts; and

2. Insights regarding future needs and anticipated behaviors at the curb.

Since the goal of stakeholder engagement is to gain a comprehensive understanding of current practices and needs in Massachusetts, this part of the project involved recruiting participants with diverse perspectives, affiliations, and geographic representation (e.g., size of town, region of the state). The goal was to recruit individuals who could provide the prospective of public authorities, businesses, and road users (including cars, transit, bicycles, pedestrians, people with a disability, goods delivery). Ultimately 15 stakeholders were recruited to participate (see Table 2.1). Their identities are anonymized in this report in order to encourage participants to speak candidly about their experiences and perceptions regarding curb management.

Table 2.1 Stakeholder Participants

ID	Job Description	Geographic Area Served
1	Freight Program Manager	Eastern Massachusetts
2	Transportation Planner	Eastern Massachusetts
3	Highway Division	Massachusetts Statewide
4	Project Manager	Massachusetts Statewide
5	Senior Transportation Engineer	Massachusetts Statewide
6	Transportation Analyst	Eastern Massachusetts
7	Transportation Planner	Western Massachusetts
8	Policy	Massachusetts Statewide
9	Transportation Planner	Central Massachusetts
10	Planning and Sustainability	Western Massachusetts
11	Transportation Planner	Massachusetts Statewide
12	Senior Transportation Planner	Central Massachusetts
13	Senior Planner	Western Massachusetts
14	Transportation Planner	Eastern Massachusetts
15	Support Specialist	Massachusetts Statewide

All stakeholders were recruited through the emails, and 15 stakeholders agreed to participate in the study. All stakeholders were required to complete an online consent form and a demographic questionnaire. Out of the 15 stakeholders, 4 were female and 11 were male. The average age was 46 years and 6 months (SD = 14 years 9 months). All stakeholders were actively working in the field of transportation with their job roles ranging from Transportation Planning, Transportation Engineering, Director of Policy, Project managers, and disability advocacy. They represent 10 organizations:

- Berkshire Regional Planning Commission
- Boston Transportation Department
- Cambridge Systematics
- Central Massachusetts Regional Planning Commission
- Central Transportation Planning Staff
- City of Northampton
- Massachusetts Commission for the Blind
- Massachusetts Department of Transportation
- Merrimack Valley Planning Commission
- Old Colony Planning Council

All stakeholders were familiar with curb space management policies to varying degrees, where apart from 2 stakeholders, the other 13 were aware of the transportation from familiar to extremely familiar. With regards to their mobility patterns, most stakeholders drove multiple times a week, and used public transportation only a few times a week. Only 5 stakeholders reported using ridesharing apps a few times a week.

Stakeholders were interviewed in small focus group meetings with about two participants at each meeting. Due to the COVID-19 pandemic, all focus group meetings were conducted remotely by video teleconference. In total, 7 focus group meetings were scheduled across December 2020 and January 2021. Each meeting lasted roughly one hour and was structured as an interview with follow-up questions, allowing for discussion between participants. Four main questions or themes were addressed in each focus group:

1. Who is using the street and the curb?
2. What data are available to measure the activities on a street or in a community?

3. What are the needs of the users with respect to the street, sidewalk, and curb?

4. What are anticipated future trends that are likely to affect theses needs and the ways that users interact with the curb space?

To follow up on these main themes, additional probing questions were used to help encourage participants to think broadly about curb use and the types of insights that would be useful for thinking about curb management policy. These follow-up and probing questions include:

- How do policy changes impact curb usage?
- How does curb usage vary based on location?
- How do the seasons or weather influence usage of the curb?
- How does the curb policy differ according to user group (e.g., pedestrians, bicyclists, other micro-mobility users, age, gender, ability, socio-economic status)?
- How can and will curb usage be restricted based on user type?
- How do you see curb use evolving as businesses and communities use curbs more actively in urban areas?
- How do local governments and public health programs impact curb usage?
- How do advocacy groups impact the design and management of curbs?
- Does increased curb use affect other areas of roadway safety and traffic policy?
- What are the techniques for gathering data for curb usage?
    - Who has the data?
    - Where is it housed and is it virtually accessible?
    - When is it collected, and is it collected regularly?
    - What area is the data applicable to?

Following each meeting, a transcript was prepared from a recording of the meeting in order to create a comprehensive record of all of the stakeholder comments. Along with the notes from the meetings, these transcripts were analyzed to identify common themes that arose throughout the focus group meetings.

2.3 Analysis of Curb Management for Massachusetts

The third part of this research is to compare the findings from the literature review, which synthesized current guidance on curb management at a national level, with the stakeholder feedback from the focus groups. Since the goal of this study is to develop guidance for curb

management that is applicable to communities across the Commonwealth of Massachusetts, this part of the study entails analyzing the extent to which existing literature already cites relevant experiences and provides useful guidance. This comparison focuses on identifying two types of themes:

1. *Alignment between the literature and focus group themes* – To the extent that the issues raised by the stakeholders are already addressed in the literature, these references are useful resources for Massachusetts communities. Specifically, guidance for policy planning and implementation of curb management tools and strategies that are described in the literature are identified.

2. *Gaps between the literature and focus group themes* – There are two types of gaps that are worth identifying. First, issues and challenges that are raised by stakeholders from Massachusetts but not adequately addressed in the literature represent a gap in guidance. The goal here is to identify these gaps, synthesize the insights from the stakeholders, and at least present issues that communities in Massachusetts should be aware of and consider in planning and implement curb management practices. Second, any insights from the literature that are relevant to Massachusetts communities (especially those outside the urban center of Boston) that do not relate to stakeholder comments are also presented to draw awareness to issues that should be considered.

Finally, this analysis goes beyond the literature review and stakeholder engagement to identify resources that are specifically available to Massachusetts communities for curb space management. These include funding programs that can be used to pay for planning and implementations as well as existing design guidance that is relevant to curb management.

3 Results: Literature Review

For most of history, the curb space has primarily been designed for the purpose of managing drainage from the roadway, and its use in urban areas has tended to default to on-street parking. Within the last five years, there has been increasing attention on the competing needs at the curb as ride-hailing services increases pick-up and drop-off activities, e-commerce increases package delivery, and other non-transportation uses have gained popularity.

This review summarizes the findings and guidance of recent reports that assess the competing needs at the curb, propose best practices for establishing effective curb management policies, and review the various treatments to achieve specific objectives. Most of the recent reports build on policies laid out by the City of Seattle Department of Transportation (Seattle DOT, 2017) and a report from the National Association of City Transportation Officials (NACTO) called *Curb Appeal: Curbside Management Strategies for Improving Transit Reliability* (Roe and Toocheck, 2017). The *Curbside Management Practitioners Guide*, published by the Institute of Transportation Engineering (ITE) (Mitman et al., 2018), builds on the Seattle and NACTO reports to provides guidance for optimizing curb space to achieve outcomes that are broader than just transit reliability. The International Transportation Forum's report called *The Shared-Use City: Managing the Curb* (ITF, 2018) provides an international perspective on the current state of curb management and future needs. These studies focus on curb management in large cities where the challenges of curb management are characterized by rapidly growing and changing demand competing for tightly constrained curb capacity. A useful synthesis of these studies, with identification of lessons and opportunities for the Boston Region, is presented in a technical memorandum for the Boston Regional Metropolitan Planning Organization called *The Future of the Curb* (Clark, 2019).

A report by Transportation for America entitled *COVID and the Curb* (T4America, 2021) was prepared during the pandemic and provides insights for how cities (large and small) have approached curb management to address dramatically changing needs. Although the shutdowns associated with the COVID-19 pandemic have suppressed certain types of demand as many people work, shop, and dine at home, other trends in curb use have accelerated. E-commerce (e.g., online shopping, food orders, grocery delivery, etc.) became widespread as people opted to stay home have goods delivered. Outdoor spaces or dining and recreation became increasingly important for allowing safe spaces to eat and move outside of the home. The City of Boston was a contributor to this report. Ultimately, many of the lessons learned during the pandemic will have general applicability as cities and communities move toward a new post-pandemic normal.

This review is structured in five parts. First a brief definition of the curb space and its functions is provided. Second, a synthesis of guidance for the necessary steps that agencies should take in developing and implementing curb management strategies. Third, a summary of the different types of curb uses and relevant management tools and strategies is presented. Fourth, a review of literature on emerging and future needs of the curb is presented. Finally, an

assessment is provided of what is lacking in terms of relevant guidance for communities across the Commonwealth of Massachusetts, especially locations that are not typical urban corridors.

3.1 Defining the Curb

The conventional definition of the *curb* is the formal edge of the roadway, typically constructed of stone or concrete to separate the space for moving vehicles from sidewalks, building, and landscaping on the roadside. Historically, the purpose of the curb was to manage drainage from the roadway; keeping sewage and storm water from flowing into buildings (Schaller, 2019). An added benefit is that the curb demarcates a safe space for pedestrians by physically separating space for walking (sidewalks) from space for moving vehicles (curbside lane). Due to the cost of curb construction and the fact that it serves a primarily urban function, curbs are less commonly built in rural and suburban environments where water can simply drain to the roadside and walking paths are either set back from the roadway or non-existent. Design guidance for the physical curb is mostly related to physical dimensions (AASHTO, 2018), marking for visual delineation (FHWA, 2009) and requirements for curb cuts, ramps, and textures to be accessible by people with disabilities, as required by the Americans with Disabilities Act of 1990 (ADA, 1990).

3.1.1 Right-of-Way Zones

The uses of the curb space are much broader than simply drainage, because it is the interface between mobility (movement of people and goods) and access (getting people and goods to and from the places that they need to be). Therefore, when we talk about curb space management, we need to consider not only the physical curb itself as an edge but also the spaces adjacent to that edge. The City of Seattle has been a leader in establishing frameworks for curb policy and implementing curb management strategies to achieve policy goals. The Seattle DOT defines three distinct zones as shown in (Seattle DOT, 2021).

- *Pedestrian Realm* – The space between the property line and flex zone, including sidewalk, plantings, bus shelters, bike racks, and sidewalk café dining
- *Travelway* – The lanes used for mobility, including general traffic lanes and dedicated transit or bicycles
- *Flex Zone* – The interface between the travelway and pedestrian realm serving multiple uses along the street, including on-street parking, deliveries, passenger pick-up/drop-off, and parklets; it may be converted to mobility at certain times of day

For the purposes of this study, we will use the term *curb space* to refer to the space spanning the pedestrian realm and flex zone, which runs along the edge of every street. This is consistent with the literature on *curb management* or *curbside management*, which addresses policies and strategies that can be implemented in various parts of this space. Even on streets with curbless designs, such as the Dutch *woonerf* or *living street* intended to calm traffic by sharing space

for vehicles with pedestrians (Ben-Joseph, 1995), the concept of curb zones remains relevant for thinking about management of the activities along the street.

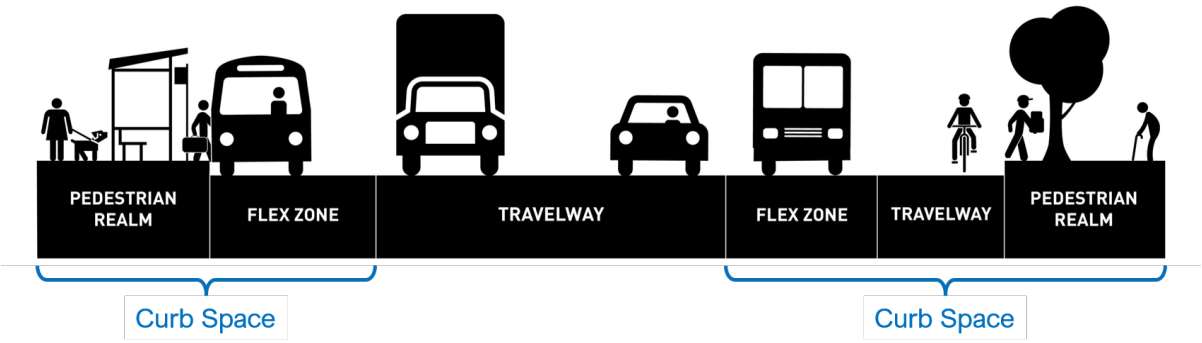


Figure 3.1 Street Right-of-Way (ROW) Zones (Adapted from: Seattle DOT, 2021)

3.1.2 Functions of the Curb

The curb serves many functions, and these can be categorized in many different ways. The six categories of functions defined by Seattle DOT (Seattle DOT, 2021) are widely cited and have influenced guidance from ITE and the Boston MPO.

1. *Mobility* – Movement of people and goods; e.g., sidewalks, general purpose traffic lanes, dedicated turn lanes, dedicated transit lanes, and bike lanes

2. *Access for People* – People arriving at their destination or transferring between different modes of transportation; e.g., transit stops, bike parking, passenger loading zones, short term parking, taxi zones

3. *Access for Commerce* – Goods and services reaching their customers and markets; e.g., commercial vehicle loading zone; truck loading zone

4. *Activation* – Offering vibrant social space; e.g., food trucks, parklets, outdoor dining space, public art, street festivals

5. *Greening* – Enhancing aesthetics and environmental health; e.g., plantings, rain gardens, and bio-swales

6. *Storage* – Providing storage for vehicles or equipment; e.g., long-term parking, bus layover, reserved spaces (such as police or government use), construction

The ITF report identifies functions that do not fit neatly within these 6 categories (ITF, 2018).

7. *Emergency Access* – Allowing emergency equipment and personnel to respond quickly to needs; e.g., fire hydrants and fire lanes

8. *Repair and Maintenance Access* – Allowing access for maintenance of infrastructure and utilities; e.g., sewer and telecommunications access, snow removal

9. *Waste Management* – Providing a space for waste to be collected

Many of these curb functions are not new, but the relative demands of each of these functions is changing with society and technology. While parking has been a prominent function of the curb for as long as there have been cars, curb space has also served transit, passenger pick-up and drop-off for taxis, and goods delivery as long as there have been streetcars, taxis, and delivery wagons or vans.

3.2 Trends in Curb Use

In recent years, a number of trends have affected curb use and drawn widespread attention to the conflicts and congestion at the curbside.

3.2.1 Increased Use of Ride-Hailing Services

Although taxis have picked-up and dropped-off passengers at curbs for as long as they have existed, the advent of app-based ride-hailing services (e.g., Uber, Lyft, Via) have dramatically increased demand at the curb for pick-up and drop-off activities (ITF, 2018; Schaller, 2019).

Ride-hailing companies promote their services as an alternative to car-ownership, but several studies suggest that they draw demand from public transit (Martin et al., 2010; Clewlow and Mishra, 2017; Schaller, 2016; 2017). A study of ride-hailing services in Denver, Colorado, found that 22% of users would have taken transit if the ride-hailing service were not available (Henao, 2017). The study also found that ride-hailing increases the vehicle miles traveled per trip served by 84% when taking into account empty distance traveled and comparing to the mode that would have been taken. In Boston, 59% of ride-hailing trips would have been completed by transit, bicycle, or walking (Gehrke, et al., 2018), and 45% of vehicle miles traveled by ride-hailing vehicles were empty (Balding, et al., 2019). The Metropolitan Area Planning Council estimates that lost transit ridership may cost the MBTA as much as $20 million per year in reduced revenues (MAPC, 2019). Schaller (2017) shows compelling evidence that ride-hailing services (namely Uber and Lyft) are responsible for increased that vehicular traffic and slower traffic speeds in Manhattan.

In Massachusetts, ride-hailing has grown most prominently in the inner core municipalities of the Boston Region. Figure 3.2 shows how the number of ride-hailing trips per person in each municipality of Massachusetts. In addition to Boston, there are also high rates of ride-hailing utilization per person in Provincetown (Cape Cod), Nantucket, and Edgartown (Martha's Vineyard); Amherst and Springfield rates of ride-hailing are comparable to suburban Boston communities (Mass DPU, 2019). Therefore, increases in passenger pick-up and drop-off activity are a phenomenon across many parts of the Commonwealth. There are, however,

places in the Berkshires and rural Central Massachusetts where ride-hailing services are not as accessible and have historically been utilized at very low rates.

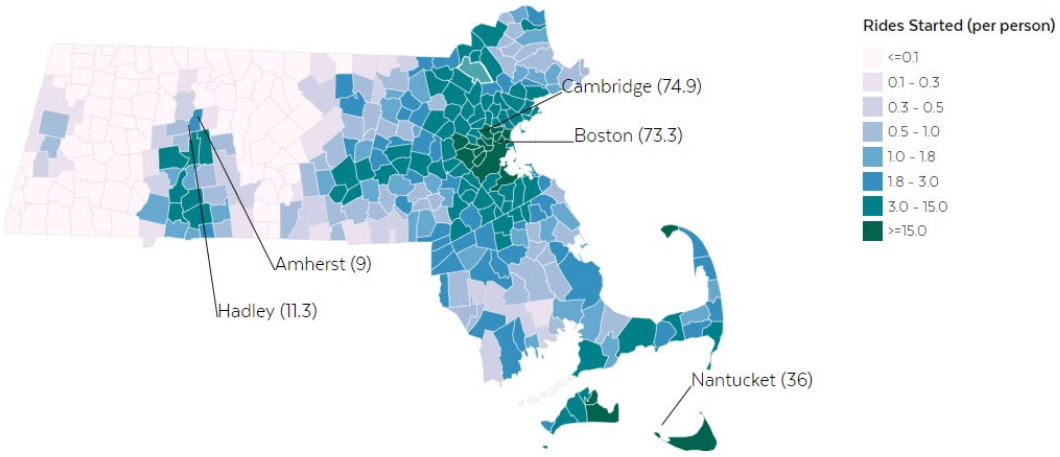


Figure 3.2 Total ride-hail rides started per person (Source: Mass DPU, 2019)

3.2.2 Increased E-Commerce (Online Shopping and Food Delivery)

Like the ride-hailing services, delivery of goods is not a new phenomenon. What has changed in recent years is that people are increasingly purchasing goods, groceries, and meals online rather than shopping at brick-and-mortar establishments (ITF, 2018). The result is an increase in the number of delivery vehicles and the number of times that delivery vehicles stop to load and unload goods at the curb.

The transportation planning literature is dominated by attention to the movement of people, but streets are also critical to the movement of goods. Commercial vehicles make up an estimated 7% of urban traffic (Schrank et al., 2015). In commercial districts, and their presence at the curb is increasing as consumers order goods, groceries, and meals online. In commercial districts, trucks stop to deliver the goods that stock the shelves and pantries of stores and restaurants. In residential areas, the United States Postal Service is no longer the only carrier making regular deliveries, as online orders are delivered by services like FedEx and UPS as well as individual contractors.

Most of the attention on goods delivery and the curb are focused on West Coast cities and New York City. The lack of available loading space at the curb, has led to widespread rates of illegal parking by commercial vehicles at "red zones" where no stopping of any kind is allowed (e.g., at fire hydrants) and double-parking, which blocks a lane of traffic (Schaller, 2019). A study by the California Department of Transportation in Los Angeles, Santa Monica, Oakland, and Berkeley found that only 40% of commercial vehicles parked legally (Komanduri et al., 2019). A study in Seattle found similar levels of illegal parking, noting that inadequate space for on-street and off-street loading forces commercial drivers to parking in unauthorized spaces (Girón-Valderrama et al., 2019). Even in places where policies have banned deliveries during

certain hours, such as New York City's Clear Curbs program, vehicles continue to flout the rules (Simon and Conway, 2019). Double parked commercial vehicles are detrimental to the efficient traffic flow, because they block the movement of vehicles, especially transit and bicycles that are more likely to be traveling in the shoulder lane (Han et al., 2005; Cherrett et al., 2012; Keegan et al., 2018). The lane changes that are required to maneuver around double parked vehicles also pose a safety hazard (Ambrosini and Routhier, 2004; Visser et al., 2014).

Researchers at the University of Washington identified significant heterogeneity in the types of commercial vehicles parking in Seattle (e.g., location, duration, vehicle size, curb access requirements) which suggests that appropriate policies for curb management must be developed with site-specific data (Girón-Valderrama et al., 2019). The same research group noted that a particular challenge for goods delivery is getting items "the final 50 feet" from the vehicle to the final customer, noting that for every 20 minutes stopped at the curb 12 minutes were spent negotiating sidewalks, curb cuts, building security, and moving between tenants for multiple deliveries (Goodchild et al., 2019).

3.2.3 Increased Interest in Multimodal Transportation: Walking, Cycling, Transit

Cities and towns across the United States are looking for ways to encourage alternatives to travel by private car, especially for short trips that could shifted to active transportation modes, like walking and bicycling. In the interest of reducing traffic congestion and pollution, reducing traffic related injuries and fatalities, improving public health, and making communities generally more livable, there is increased attention on designing and managing streets to facilitate transit, bicycles, and pedestrians. Two initiatives are relevant to this trend: Vision Zero and Complete Streets.

Vision Zero programs are aimed at improving traffic safety with the goal of eliminating traffic-related fatalities altogether. On the streets of cities and towns, this means making safety improvements that protect vulnerable road users, namely those riding bicycles or walking. Noting that 13% of streets accounted for 75% of severe and fatal injuries, San Francisco focused safety improvements on targeted corridors (SFMTA, 2021). Boston's Vision Zero policy guides transportation design decisions and programs for Neighborhood Slow Streets (reducing speeds to 20 mph) and improved bicycle infrastructure (City of Boston, 2021a, b).

Complete Streets are an initiative promoted by Smart Growth for America (Riverón, 2018) to design streets that prioritize safety, comfort, and access for all users. The idea is to move away from street design and traffic policy that prioritizes movement of cars to also consider the needs of people who walk, bicycle, use transit, or move with assistive devices. The idea of slowing traffic to make space for other users has gained even greater popularity during the COVID-19 pandemic, with cities and towns looking to repurpose streets in order to better serve community needs (Descant, 2020). In addition to Boston's own Complete Streets guidelines (Boston Transportation Department, 2013), MassDOT helps communities across the Commonwealth pay for infrastructure improvements through the Complete Streets Funding Program (MassDOT, 2016). Complete Streets projects have been funded in all parts of the Commonwealth.

3.2.4 Active Management of Curb Space

There is a trend toward implementing policies that are responsive to changing conditions and demands at the curb rather establishing a static policy or curb designation that remains in place indefinitely. The idea of *active management* is for public agencies to proactively design, measure, price, and manage their curb space (Mitman et al., 2018). The use of active management is endorsed as an approach to implement the types of flexible policies that will adapt to changing needs and be most beneficial for communities (ITF, 2018; Schaller, 2019).

Active management can take many forms, but the most developed experience has been in the realm of parking, where there is a large body of literature on the policies that can be used to manage the parking supply in the face of variable demands and raise revenues for municipalities. Economists have endorsed the idea of pricing transportation infrastructure, such as parking spaces at least since Pigou (1920), and of varying this price by time-of-day (Vickrey, 1954). Despite the theoretical benefits, the practice of pricing street parking has been controversial since the first parking meters were installed in Oklahoma City in 1935 (ITF, 2018). What has evolved significantly in recent years is the flexibility that technology now gives public authorities to manage parking in an active, dynamic way.

Current thinking on the management of curbside parking builds heavily on Shoup (2005), which argues that underpriced street parking contributes to significant social cost in terms of wasted time, pollution, and traffic congestion. This is due to the phenomenon of people cruising streets in search of a cheap place to park, may typically make up 30% of street traffic in congested urban neighborhoods and sometimes well over 50% (Shoup, 2006). Shoup (2005) argues that cruising for parking would be eliminated if prices were set high enough to keep one space vacant on each block (about 85% occupancy). This often-cited target occupancy was the motivation for the dynamic parking pricing program in San Francisco called sfPark, which used smart parking meters to detect occupancy rates and periodically revise parking prices between minimum and maximum values. The reported benefits of this active parking management were 43% reduction in search time for parking, 30% reduction in vehicle miles traveled, 22% drop in double-parking, and 4-5% increase in bus speeds (Roe and Toocheck, 2017). This active management through app-based pricing is now being expanded to freight loading zones as well. Demand priced parking and freight zone pricing in Washington, DC, resulted in increased meter revenues as well widespread approval from businesses, customers, and delivery drivers (ITE, 2018).

When expanded beyond the scope of parking, active curb management includes policies that allow curb use to change by time of day. Figure 3.3 shows what this might look like. Morning and evening rush hours may prioritize transit and ride-hailing pick-up/drop-off in order to move commuters. The middle hours of the day may allow for more varied uses including parking and street vending. The late night hours may be devoted to goods delivery, at a time when other demands of the curb are lower.

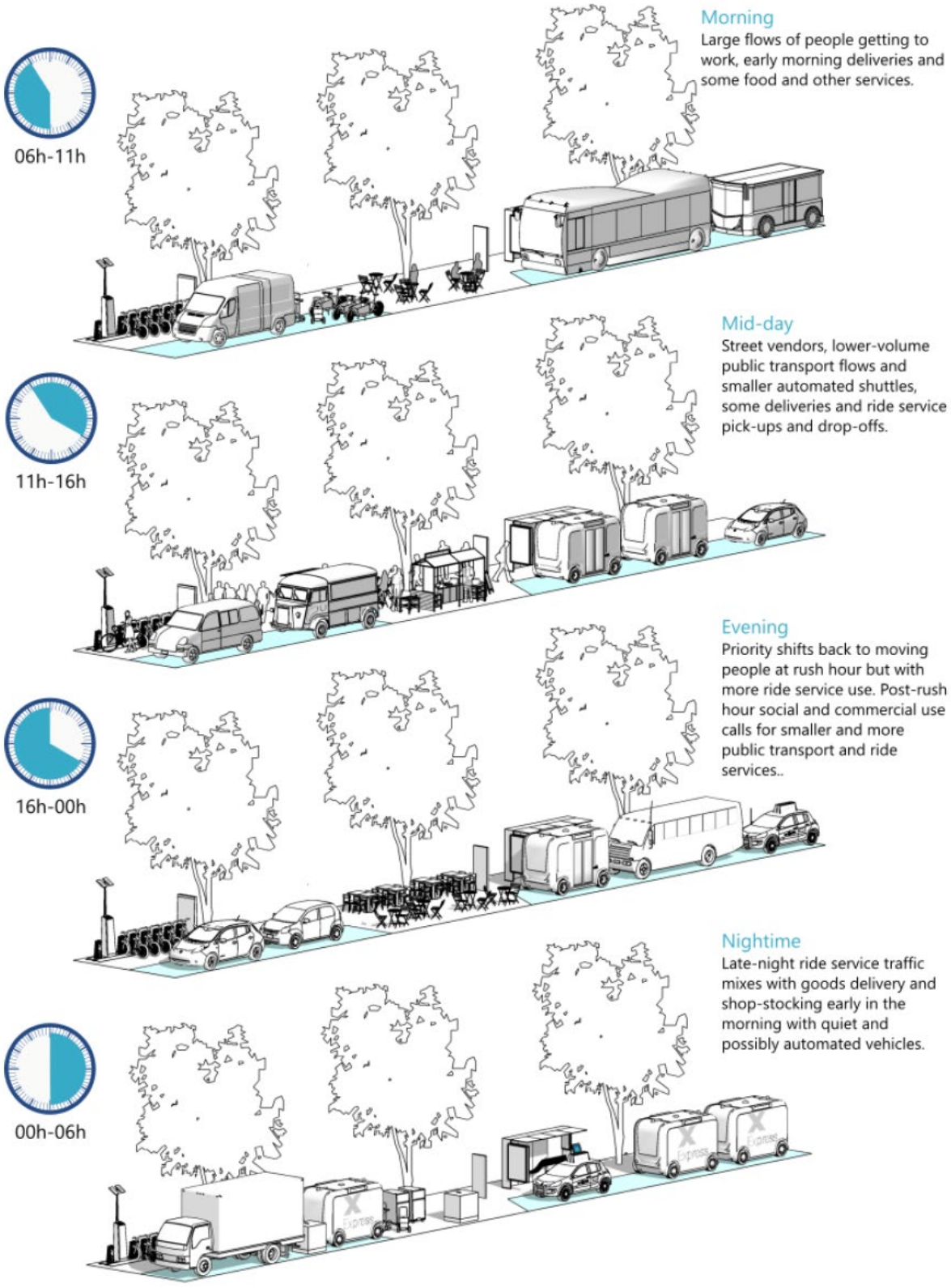


Figure 3.3 Dynamic use of the curb over the day (Source: ITF, 2018)

3.3 Development of Curb Management Policy

Recognizing that curbs have value for multiple (often competing) uses, there is consensus among curb management experts that cities need coherent policies to manage these functions. The conventional 20th Century approach to curb space management was to allow curbside lanes to be used on a first-come-first-served basis, which typically resulted in parking for cars displacing other uses (deliveries, passenger pick-up/drop-off, and access for transit, bicyclists, and pedestrians), (Roe and Toocheck, 2017).

3.3.1 Framework for Decision Making

The ITE *Curbside Management Practitioners Guide* (Mitman et al., 2018) advocates adopting a decision framework along the lines of Seattle's 6-step treatment selection process (Seattle DOT, 2021). The idea is that policy goals must be established before appropriate treatments can be identified, because the policy decisions should guide the selection and evaluation of the tools or technologies used for curb management.

1. Inventory Existing Conditions
2. Identify Land Use and Activity Consideration to Develop Modal Prioritization
3. Identify Appropriate Treatment Alternatives
4. Assess and Present Alternative for Public Feedback
5. Refine and Implement Treatments
6. Evaluation

3.3.2 Measuring Use and Performance of Curb Space

The first step to establishing coherent and effective curb space management practices is to understand what is happening at the curb. Knowledge of curbs is generally poor, with many public authorities lacking appropriate data and metrics to support decision making (ITF, 2018). Several references identify the need to start by measuring what is happening at the curb (Roe and Toocheck, 2017; Mitman et al., 2018; Schaller, 2019). The purpose is twofold: First, it is necessary to measure existing activities at the curb to establish appropriate policy goals (e.g., alleviate conflicts, provide access for underserved users, etc.). Second, measurement of performance is necessary for monitoring and evaluation to ensure that curb management is optimized for these goals over time.

Table 3.1 Measures of Effectiveness for the Curb (Adapted from Mitman et al., 2018)

Category	Quantitative Measures	Qualitative Measures
Mobility	Blocked bike facilities Blocked transit facilities Loading zone utilization Loading zone turnover rate Transit reliability Transit ridership Occupancy of TNCs Cruising for parking (e.g., average time) Vehicle Level of Service (LOS) Emergency response time Private vehicle ownership Parking demand Congestion (e.g., travel time)	Wayfinding and user experience
Livability	Bicycle parking spaces Public seating	Parks/green space provided Community gather space Activation of public space (e.g., calendar of events)
Accessibility	Illegal use of disability loading and parking spaces Number of disability loading and parking zones Number of ADA lawsuits	Feedback from people with disabilities
Safety	Number of near-miss incidents Number of curb-related crashes Number of ped/bike conflicts with trucks Number of moving vehicle citations	Consequences of curb access events (e.g., swerving, illegal u-turns)
Efficiency		Streamlined data collection Technology for real-time efficacy monitoring High-functioning, public-private stakeholder body meeting regularly
Economic Vitality	Amount of café/restaurant seating Staff time dedicated to coordinating deliveries Sales tax receipts Funding for streetscape and façade improvements	Convenience of loading zones

Category	Quantitative Measures	Qualitative Measures
	Availability and turnover of parking near businesses	

There are many metrics for curb space performance. Table 3.1 provides a summary of measures (Mitman et al., 2018). These can be broadly categorized as either quantitative or qualitative measures. With limited resources, it is not expected that cities will monitor all of these measures, but a selection can be identified based on the policy goals. Such measures are useful for establishing a baseline of existing curb performance and communicating to stakeholders about the problems that proposed changes are intended to address. In some cases, measuring activity at the curb can surprise even those stakeholders that are familiar with it. Business owners often over-estimate the role of private cars and parking for their customers; on Cesar Chavez Street in Los Angeles, merchants thought 36% of customers arrived by private car, when in fact it was only 7% (Roe and Toocheck, 2017).

It can also be important to quantify the capacity of the curb space to support different types of uses. The NACTO guide (Roe and Toocheck, 2017) provides examples of curb productivity for many different functions, see Table 3.2. Two Uber-funded studies conducted by Fehr & Peers measured curb productivity in San Francisco (Fehr & Peers, 2018) and Cincinnati (Fehr & Peers, 2019), with a focus on measuring the people served per hour by different curb configurations. On-street parking is shown to be the least productive curb use by far, with a single space serving perhaps 1 person per space-hour (e.g., one vehicle with two passengers parked for two hours). By comparison, a pick-up/drop-off zone for taxis or ride-hailing services may serve as many 191 passengers per space-hour, and a bus stop may serve 242 passengers per space-hour. Productivity values like this are clearly very context-dependent, but they at least provide some insight about the relative capacity of the curb to support different uses. The consensus among several experts is that the productivity of different curb uses should be considered so that curb management practices realize the curbs highest and best use (Mitman et al., 2018; ITF, 2018; Schaller, 2019).

Table 3.2 Measures of Curb Productivity (Source: Roe and Toocheck, 2017)

Curb Use	Productivity
Metered Parking Space	15 vehicles/day
Passenger Pick-Up/Drop-Off Zone	100 passengers/day
Freight/Goods Loading Zone	20 deliveries/day; $10,000 daily sales
Bus Stop	1,000 passengers/day
Bike Share Station	40 riders/day
Paratransit and Accessible Loading	serves ~19% of US population
Food Truck	150 meals/day; $800-$1800 income/day
Parklet	100 visitors/day; 10-20% revenue boost

There are different levels of technology involved in traffic and curb data collection. These methods vary in terms of the types of data that can be collected, the equipment required for collection, and the cost.

1. *Manual Counts* – The conventional method of data collection for traffic, parking, bicycle and pedestrian counts, loading zone turnover, etc. is to observe the street in-person and manually record observations. This is time-consuming, so data is usually collected for only a few hours at targeted locations. It is too costly to collect data in this manner for long periods of time or extensively across large parts of the network.

2. *Dedicated Counters* – Depending on the type of measurements that are to be made, there are dedicated tools that can be installed to measure relevant traffic data. These are typically costly to install but can provide continuous observations for ongoing measurement. Due to the costs, they are typically limited to targeted locations.

    a. *Inductive Loops* – Loop detectors that are embedded in the pavement are commonly used to detect the presence of vehicles (or even bicycles) for actuated traffic signals. With proper equipment in the signal control cabinet, these loops can also be used to record vehicle counts.

    b. *Parking Detectors* – Sensors embedded in parking spaces can be used to detect the presence of a vehicle. These can be used for automated parking enforcement in addition to measuring overall occupancy and turn-over rates. This is useful for understanding how parking is used and to support dynamic strategies (like variable pricing) to manage the curb in response to real-time demands.

    c. *Bicycle and Pedestrian Detectors* – There are a number of different technologies specifically designed to count the numbers of bicyclists and/or pedestrians passing a location. These include devices that detect weight using a strain gauge, inductive loops to detect the metal in a bicycle, infrared beams such as those used for automatic door chimes in stores, and radar. These devices are often costly to install and work best in environments where pedestrian flow is channeled into specific corridor (e.g., hallway in a train station).

3. *Video Image Processing* – Automated image processing algorithms have developed significantly in recent years to the point that many vendors now provide products that collect measurements by analysis of existing or dedicated video feeds. For example, image processing can be used to track vehicle and pedestrian movements at an intersection, monitor occupancy and turn-over of parking spaces, and support automated enforcement of double-parking (e.g., by mounting a forward looking camera on the front of a transit vehicle). Although the hardware for these implementations is typically much less costly than other dedicated detectors, the algorithms for image processing are usually proprietary and require ongoing payments to a vendor for services.

4. *Crowdsourced Data* – Several companies use aggregated data from mobile phones and Global Positioning Systems (GPS) devices to provide network-level traffic data. This can include origin-destination data and measurements of traffic speeds and travel time reliability. Although these data sources are too coarse for many types of curb-level activity measurements, ride-hailing services are app-based and, where extensively used, can provide useful information about the locations of passenger pick-up//drop-off activities. Crowdsourced data is almost always managed by 3rd part vendors who retain ownership of the data, so this is another data source that typically requires ongoing payments for service.

3.3.3 Prioritizing Curb Functions

Before appropriate curb space management practices can be selected and implemented it is necessary for communities to set goals for their curb functions and frame these within larger policy goals for the community (Schaller, 2019; Clark, 2019). The guidance from ITE suggests that the tools for curb management should match policy goals, and these goals are almost always more important than the tool or technology used to implement it (Mitman et al., 2018).

Again, the City of Seattle has been a leader in framing how to think about prioritizing curb functions. Seattle's policy is to rank the importance of curb functions (see listing in Section 3.1.2) based on the dominant land use along the street as shown in Figure 3.4 (Seattle DOT, 2021). Across all uses, Seattle prioritizes city-wide modal plan priorities. Locally, the curb management can be targeted to the needs that represent the highest and best use for the context. For example, activation of space for commercial and social uses (e.g., outdoor dining, social gathering) may be an important benefit in retail districts, but a low priority in residential and industrial areas.

Generally, guidance in the literature advocates for prioritizing most curbside uses over the private car, including public transit, bicycles, and pedestrians (Roe and Toocheck, 2017), pick-up and drop-off space for passengers and goods (Schaller, 2019); and, in the COVID-19 pandemic, space for dining and recreation (T4America, 2020). It is noteworthy that this literature is heavily focused on curb management in large cities where alternatives to traveling by private car are abundant and competition for scarce curb space is intense. Priorities in small towns, suburban communities, and rural areas should consider the needs and context of those communities.

	Residential	Commercial & Mixed Use	Industrial
1	Support for Modal Plan Priorities	Support for Modal Plan Priorities	Support for Modal Plan Priorities
2	Access for People	Access for Commerce	Access for Commerce
3	Access for Commerce	Access for People	Access for People
4	Greening	Activation	Storage
5	Storage	Greening	Activation
6	Activation	Storage	Greening

Figure 3.4 Flex zone functions prioritized based on land use (Source: Seattle DOT, 2021)

3.4 Curb Space Management Tools and Strategies

There are many ways that curb space can be managed. The strategies for managing the curb can be categorized as shown in Figure 3.5 (Fehr & Peers, 2018):

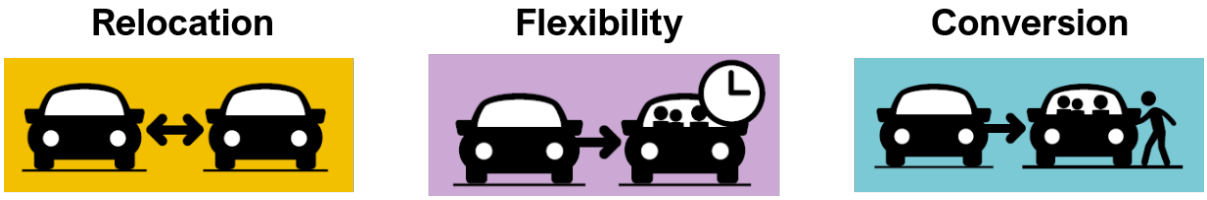


Figure 3.5 Strategies for curb functions: relocation, flexibility, and conversion (Source: Fehr and Peers, 2018)

1. *Relocation* – Changing where an activity happens, either by moving it to a different street, a different part of the block, or re-arranging the alignment of the pedestrian realm, flex zone, and travelway.

2. *Flexibility* – Allowing the use of a space to change at different times; e.g., scheduled by time of day or an active management strategy that can change in real time.

3. *Conversion* – Changing curb demands so that people use the curb differently; e.g., converting a parking space into a passenger loading zone

Furthermore, not all tools for curb space management require the same level of investment. Lower cost investments are typically the ones that are easier to change, whereas costly infrastructure is likely to remain in place for a long time. Broadly speaking, the types of infrastructure investments can be categorized as shown in Figure 3.6.

1. *Signage and Striping (Low Cost)* – Paint (or thermoplastic) and signage is relatively cheap to change, and the low monetary costs allow changes to be made even as a pilot.

2. *Technology (Medium Cost)* – Curb management interventions that require the development or adoption of an app or the installation of technology (e.g., sensors, signals) requires some planning and investment. For an app-based tool, the cost of expanding a system once it is up and running can be low.

3. *Hard Infrastructure (High Cost)* – The cost of building physical structures and laying concrete is the highest both in terms of money and disruption during construction. The interventions are typically designed to last a long time, although a pilot implementation may be conducted with portable barriers and planters.

Figure 3.6 Required infrastructure for curb space management: signage and paint; technology; hard infrastructure.

Most of the tools and strategies for managing the curb have been envisioned and tried in large urban corridors. The tools and strategies available for curb management can be organized in six categories, based on the structure of Mitman et al., (2018) and Clark (2019), as shown in Table 3.3. The table provides a list of interventions with an indication of the type(s) of strategies and the type(s) of infrastructure required. The following subsections provide some more details about the types of interventions and examples of implementation.

3.4.1 Passenger Pick-Up/Drop-Off

Policies for passenger pick-up and drop-off have been implemented for many years to manage transit vehicles and taxis. The rise of ride-hailing services has made these activities even more

common in many places, bringing about policies to manage where and when passengers can be pick-up and dropped-off.

1. *Dedicated Pick-Up/Drop-Off Zone* – A part of the curb space can reserved for passenger pick-up and drop-off activities by either posting a sign or painting the physical curb. Dedicated space for specific modes at transit stops or taxi stands are a well-established example of this type of zone. In recent years, dedicated zones for ride-hailing services have become common at locations with high ride-hailing demand (e.g., airports, train stations, shopping malls).

Table 3.3 Tools and Strategies for Curb Management

Tool	Strategy			Infrastructure		
	Relocation	Flexibility	Conversion	Signage	Technology	Construction
Passenger Pick-Up/Drop-Off						
Dedicated Pick-Up/Drop-Off Zone			•	•		
Time-Dependent Pick-Up/Drop-Off Zone		•	•	•		
Moving Pick-Up/Drop-Off Around the Corner	•			•		
Geofencing for Ride-Hailing Vehicles	•	•			•	
Freight/Goods Loading/Unloading						
Freight Zone Pricing		•		•	•	
Off-Peak Delivery & Congestion Charging		•			•	
Off-Street Vehicle Staging Zones	•			•		
Moving Loading Zone Around the Corner	•			•		
Urban Consolidation Center for Last Mile	•					•
Parking						
Time Limits		•		•		
Time-of-Day Restrictions		•		•		
Priority or Permit Programs			•	•		
Demand-based Pricing			•	•	•	
Reduced Occupancy Targets			•		•	
Include Off-Street Parking in Plans and Guidance	•			•		
Transit						
Dedicated Transit Lanes	•					•
Bus Queue Jump Lanes	•					•
Bus Bulbs or Boarding Islands	•					•
Permit Commuter Shuttles		•			•	
Automated Enforcement of Transit Spaces			•		•	
Bicycle						
Protected Bike Lane (a.k.a. “cycle track”)	•					•
Bicycle Storage			•			•
Shared Mobility Storage			•		•	•
Pedestrian and Activation						
Curb Extensions	•					•
Wider Sidewalks	•	•				•
Parklets			•			•
Dining Space			•			•

2. *Time-Dependent Pick-Up/Drop-Off Zone* – For locations where pick-up and drop-off activities are concentrated in certain times of the day or days of the week, a dedicated space for passenger pick-ups and drop-offs can be scheduled. A pilot program in Washington, D.C., implemented a ride-hailing pick-up/drop-off zone near Dupont Circle from 10:00 pm – 7:00 am Thursday through Sunday in response to evening congestion. The dedicated zone was considered so successful that it was made permanent, and additional ride-hailing pick-up/drop-off zones were implemented in other parts of the city (ITE, 2018).

3. *Moving Pick-Up/Drop-Off Around the Corner* – In locations with high ride-hailing demands, congestion at the curb can result passenger pick-up and drop-off activities conflicting with each other or with other uses of the curb. Requiring passenger pick-ups and drop-offs to move off a busy main street and onto a less busy side street can reduce congestion while keeping passengers within a block of their preferred origin or destination.

4. *Geofencing for Ride-Hailing Vehicles* – Geofencing, enabled by GPS in customers' smartphones and ride-hailing vehicles, can allow cities to designate areas for safe pick-up and drop-off activities. This is technical method for moving pick-ups and drop-offs, which can also be implemented dynamically. A successful example of geofencing is in San Francisco's Mission District, where the city worked with Lyft to define dedicated pick-up and drop-off sites on less congested side streets.

3.4.2 Freight/Goods Loading/Unloading

Goods have been loaded and unloaded at the curb for as long streets have existed. The increasing popularity of e-commerce has led to increased curb activity as people order everything from books to groceries to prepared meals for delivery. For many goods, the items originate in warehouses and the curb activity is associated with delivery to the final destination. For prepared meals, each delivery is associated with curb use when prepared food is picked up from a restaurant and when delivered to the customer.

1. *Freight Zone Pricing* – Dedicated zones for loading and unloading goods can be managed, like parking, using pricing or an app-based reservation system. A pilot program in Washington, D.C., required commercial vehicles to purchase a daily or annual permit to use designated loading zones. The smartphone app used to collect payments also provides real-time information to drivers about the locations of available space. Despite some initial resistance, the program is now popular because the managed loading spaces are more reliable for delivery companies (FHWA, 2017).

2. *Off-Peak Delivery and Congestion Charging* – In an effort to reduce congestion on city streets and at the curb, freight movements can be shifted to off-peak hours, when space is otherwise underutilized. Off-peak delivery programs incentivize delivery companies and the businesses that receive shipments to schedule deliveries at night, allowing trucks to move more quickly and reduce competition with other users of the curb space. The off-peak delivery program in New York City was popular with delivery companies,

which value the reliability and time savings of working on uncongested streets. However, participation was constrained by businesses that prefer to receive deliveries during regular working hours, because a late-night delivery requires keeping a business staffed when it would otherwise be closed (Holguin-Veras et al., 2011).

3. *Off-Street Vehicle Staging Zones* – Where off-street space is available (e.g., alleys), dedicating space for freight vehicles to park reduces the need for dedicated delivery zones at the curb where there is competition with other uses. This solution is most effective in dense city centers, where an off-street staging area can be located in close proximity to many delivery destinations (Goodchild et al., 2019).

4. *Moving Loading Zone Around the Corner* – Like the policy to move passenger pick-up/drop-off activities from a busy main street around the corner to a less congested side street, loading zones can also be moved. The challenge is that moving a loading zone further from an origin or destination increases the time associated with each delivery. This solution can work well where blocks are short so that the added distance to/from the delivery zone is not onerous. If loading zones are too far from delivery origins or destinations, truck drivers are more tempted to park illegally.

5. *Urban Consolidation Center for the Last Mile* – One way to reduce congestion at the curb in areas with dense delivery demand is consolidate goods into fewer vehicles. Although there is an extra cost associated with unloading and reloading items into vehicles for local delivery, a consolidation center can allow large shipments from multiple suppliers to be grouped into small loads that are organized by destination. Instead of having each supplier send their own vehicle to local food store or restaurant (resulting in multiple delivery stops at the curb), the goods could be consolidated into a single load for each business or block, allowing for smaller vehicles to make deliveries and fewer delivery stops at the curb.

3.4.3 Parking

On-street parking is one of the most common uses of the curb, and it has been studied and regulated for decades. When demand exceeds supply, there are a wide range of policies that can be implemented to manage parking depending on the demands and needs of the community.

1. *Time Limits* – Businesses want nearby parking to be available to their customers. A time limit on parking prevents residents or workers from using a prime parking space all day and forces turn-over to keep spaces available to new customers. Time limits can vary, depending on the intended use, from a few minutes for quick loading (e.g., dry cleaners or take-out restaurant) to a few hours (e.g., retail shopping or dine-in restaurant). The limits may be imposed by limiting the time that can be purchased on a parking meter or by periodic enforcement.

2. *Time-of-Day Restrictions* – In some cases, there are competing demands for the curbside lane so that parking is only allowed during certain hours. For example, a busy

arterial may ban parking during the morning and evening commuting hours to allow the space carry traffic. In other cases, the parking may be banned overnight to allow for delivery of goods or street cleaning.

3. *Priority or Permit Programs* – In places where demand for free or underpriced parking outstrips supply, certain users can be prioritized over others. Permit programs are common for allowing residents of neighborhoods near large attractors (e.g., university, hospital, sports arena) to park on the streets in front of their homes and restricting others to parking designated facilities or to travel by other modes. Permit programs can be blended with other policies, for example by exempting permit holders from time limits or time-of-day restrictions.

4. *Demand-Based Pricing* – Although parking pricing is widespread, the price that is charged is most often set as a static policy. Demand-based pricing links the price of parking to occupancy of the space so that increased demand leads to greater prices. Data can be collected to adjust prices periodically (on the order of days or weeks) or a real-time system can allow prices to fluctuate in real-time in response to demand. The smart parking system in San Francisco, called sfPark, works with sensors that detect parking occupancy and a smartphone app to communicate parking information with drivers. The program has been expanded from a pilot program to the entire city and has resulted in increased parking revenue as well as reduced traffic congestion from vehicles searching for parking (Roe and Toocheck, 2017).

5. *Reduced Occupancy Targets* – One of the problems with high demand for on-street parking is that it is difficult for drivers to find an available parking space, which leads to additional vehicle-miles of travel as drivers search for space. A common target for on-street parking is to limit occupancy to 85% of total spaces, which leaves about one vacant parking space per block. At this reduced occupancy, drivers are able to quickly find a vacant space (Shoup, 2005). While making parking spaces easier to find may encourage some people to drive, the policies that are implemented to achieve reduced occupancy (e.g., pricing, time limits) should make other modes of travel more attractive by comparison.

6. *Include Off-Street Parking in Plans and Guidance* – Although on-street parking is almost always managed by municipalities, because it on public right-of-way, off-street parking may be managed by municipalities, business owners, or a private parking company. Parking plans should account for all available parking options. If parking spaces at the curb are repurposed for other uses, the needed parking capacity may be accommodated in off-street facilities.

3.4.4 Transit

Transit vehicles typically use the curbside lane for travel and use curb space to stop for boarding and alighting passengers. Curb space management policies can have a significant impact on the reliability of transit operations, and this was the focus on the NACTO's *Curb Appeal* report (Roe and Toocheck, 2017).

1. *Dedicated Transit Lanes* – A lane that is dedicated only to the movement of transit vehicles allows them to operate without interference from other vehicles. The effect is to make transit operations faster and more reliable, because vehicles stop only for passengers and at traffic signals. In most cases, a dedicated transit lane is adjacent to on-street parking or at the curbside. Right-turning vehicles, cars that are maneuvering into and out of on-street parking spaces, bicycles, and double-parked vehicles all encroach on this space and impact the effectiveness of a dedicated lane.

2. *Bus Queue Jump Lanes* – On streets where space is constrained, a dedicated transit lane can be provided only on the part of the street immediately upstream from a traffic signal, where cars queue when the signal is red. This allows transit vehicles to bypass traffic queues by "jumping" all the way to the intersection stop bar during a red signal. The queue jump lane is typically at the curbside, where space would otherwise be used for on-street parking or loading.

3. *Bus Bulbs or Boarding Islands* – Buses lose time whenever they pull to the curbside for passengers to board or alight and then must merge back into traffic. A bus bulb extends the curb out to the travel lane so that the waiting area for passengers in space that would otherwise have been curbside parking and a bus stops in the lane of traffic. The stopped bus blocks the lane of traffic while serving passengers, but in so doing holds the lane open so that it can proceed without waiting once all passengers have boarded. A boarding island is a similar design in which there is a travelway between the passenger waiting space and the sidewalk. Example include designs in which a separated bikeway is located between on-street parking and the sidewalk or when transit operates in the median of a street.

4. *Permit Commuter Shuttles* – Public transit agencies are not the only operators of high-capacity passenger vehicles. In locations with dense employment, a privately operated commuter shuttle can serve a similar role in moving people without relying on private cars and space for parking. Commuter shuttles operated by tech companies, such as Google, are common in San Francisco, where the municipality has had work to balance the needs of private operators and the public transit agency. In Boston, shuttles operated by hospitals reduce the demand for parking adjacent to hospital facilities.

5. *Automated Enforcement of Transit Spaces* – One of challenges for successful implementation of dedicated transit lanes or queue jump lanes is keeping the space clear for transit vehicles. Vehicles that queue or double park in transit lanes are particularly problematic, because they require transit vehicles to stop, contributing to poor travel time reliability. Image processing technologies allow license plates to be automatically read and identified in video footage, so cameras that are mounted at the roadside or onboard transit vehicles can be used to implement an automated enforcement program that issues to tickets for violations.

3.4.5 Bicycle

Bicycles are an important active mode of transportation, and many communities are seeking ways to encourage bicycling by making infrastructure safer and more inviting.

1. *Protected Bicycle Lanes* – A protected bicycle lanes (a.k.a., separated bike lanes or cycle tracks) are bicycle lanes that are designed with a physical separation from the travelway for motorized vehicles. These facilities are typically located in the curbside flex space and have a significant impact on the physical infrastructure at the curb. The *Separated Bike Lane Planning & Design Guide* (MassDOT, 2015) provides detailed guidance for communities in Massachusetts.

2. *Bicycle Storage* – Bicyclists need a space to park and lock their bicycles when not in use. It is common to position bicycle storage at the curbside, but placement can block other interactions between the street and sidewalk, such as passenger pick-up/drop-off and good loading/unloading.

3. *Shared Mobility Storage* – In some communities, shared mobility services allow people to travel with shared vehicles (e.g., bike share, e-bike share, scooters). Docked services have dedicated infrastructure where vehicles are pick-up and dropped-off, and these facilities are typically located near the curbside where they are easily accessible from the street and sidewalks near points of interest. Some systems (especially scooters) operate as dock-less systems in which vehicles can be left anywhere at the roadside, and communities have faced challenges with shared vehicles accumulating on streets and sidewalks that block pedestrians and other road users (Gössling, 2020).

3.4.6 Pedestrian and Activation

The pedestrian realm is the space that is dedicated to the movement of people as well numerous other uses. This is the public space that serves more than just a transportation purpose, because the design can allow for recreation, social interaction, and economic activities.

1. *Curb Extensions* – At intersections, the curb can be extended past the edge of a curbside lane used for parking or loading and up to the edge of the travelway. The result is a shorter crosswalk, which allows pedestrians to cross the street more quickly. The curb extension also allows pedestrians to wait closer to the travel way where drivers can see them more easily and allows the curb to be built with a tighter radius. These physical changes to the infrastructure improve safety by forcing vehicles to slow down and positions pedestrians to be more visible to drivers, both of which improve road safety. This change to the infrastructure does not allow the curbside lane to be used as a travel way, which is a limitation of the design.

2. *Wider Sidewalks* – Increasing the width of sidewalks makes the space more functional for many users. From a mobility perspective, wider sidewalks allow more people to use the space comfortably and the sidewalk becomes more accessible for people using a mobility device like a wheelchair or power chair. Wider sidewalks also allow more

space for: people to meet and socialize, vendors to sell things, buskers to perform, etc. The impact is a more inviting streetscape that encourage walking and engages the community.

3. *Parklets* – A parklet is a small, landscaped space that extends into the curbside lane. This may be as simple as a bench with some plantings that provide space to rest. A parklet may also provide a space for tables, public art, bicycle parking, etc. This creates a space that can serve recreational needs while providing some greenery in an urban environment.

4. *Dining Space* – Sidewalk dining contributes to the economic productivity of restaurants and grocery stores by increasing the capacity to serve customers. In warmer months, outdoor dining has been popular in many communities, with permits from the municipality typically required for setting tables out on the sidewalk. During the COVID-19 pandemic, restrictions on indoor dining made dining space at the curb an economic necessity for many businesses in small towns and villages as well as large cities. In response to the pandemic, many communities experimented with converting on-street parking in the curbside lane into space for dining (T4America, 2021).

3.5 Future Needs

Although much of the literature is focused on the current management practices at the curb space and examples of tools and strategies that have been implemented, there are a number of emerging challenges and future needs that are presented. The first has to do with the emerging roll of data and communications in curb space management. There are also new uses that are expected to present new demands for curb space.

3.5.1 Standards for Coding Curb Management

Most cities have limited data on the use and performance of existing curbs, and this lack of knowledge is a barrier to developing and implementing policies that will serve a communities needs (Schaller, 2019). Measurement tools and data on the curb are increasingly being provided by third party entities, so ownership of this information is shifting away from public entities (ITF, 2018). Although the involvement of private companies in the digital aspects of curb management does support innovation, but there is growing recognition that an open source data format for coding streets and the curb is necessary for consistent collection of data and integration across different users. The ITF Report (2018) identifies three important implications for open data standards for the curb:

1. *Open Data* – open-source data references and open data are ways to bring multiple actors together on a common platform.

2. *Self-Communicating Curb* – Third party apps that work on open data standards can provide platforms for gathering, sharing, and managing information

3. *Digital Identifiers* – In order for actors to interact on a digital platform, digital identifier (e.g., a digital license plate) could link vehicles to platforms to manage payments, permissions, scheduling, etc.

An example of an open data initiative for curb space data is CurbLR, which is supported by an independent non-profit organization called Shared Streets. The idea is create an open platform for communicating curb regulations and curb data in a way that is referenced to the street network. For example, a data standard like CurbLR would support maps of curb activity data as shown in Figure 3.7, which could be used by public authorities to make policy decisions or implement context-specific curb management practices. Private companies have also developed curb management tools that integrate curb data with apps for implementing smart loading zones, managing ride-hailing pick-up/drop-off, and demand-responsive parking pricing. COORD, a company backed by Alphabet, Inc. (Google's parent company), is one of the most prominent of these players, and it's services have been adopted in more than a dozen cities from New York to Aspen, Colorado (see Figure 3.8).

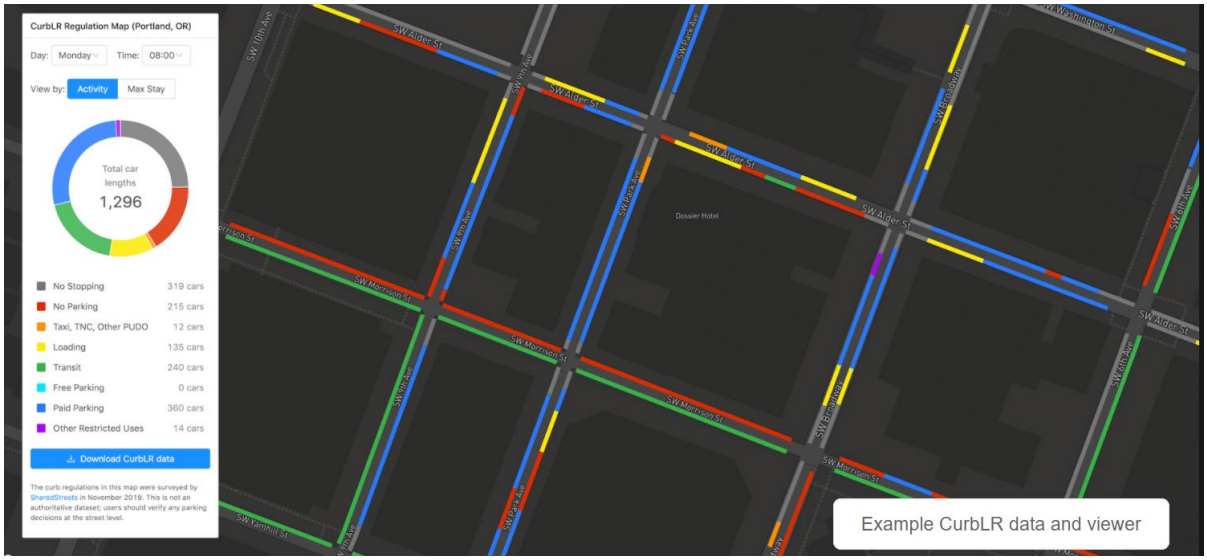


Figure 3.7 CurbLR is an open spatial data standard (Source: SharedStreets, 2021)

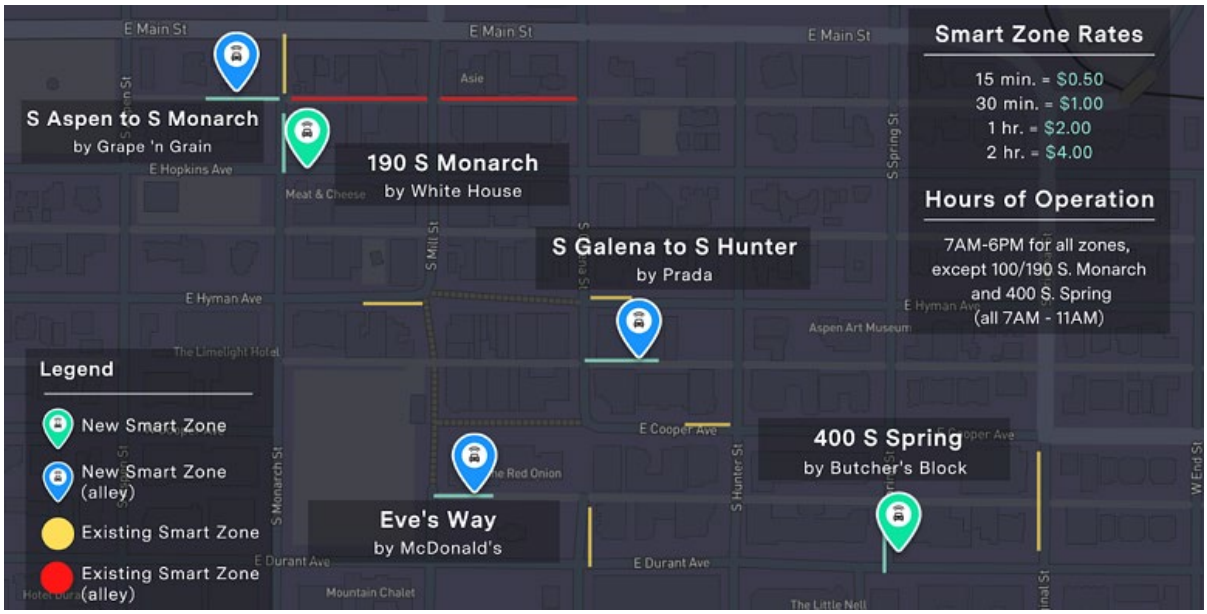


Figure 3.8 COORD is a proprietary product for implementing smart curb management policies (Source: COORD, 2021)

A report from Transportation for America called *Principles for Universal Curbside Language and Standards (UCLS)* (T4America, 2020) notes that it is difficult for governments to set policies, communicate with users, coordinate among jurisdictions, and be savvy in working with private companies unless UCLS are developed and implemented. The report presents five principles for UCLS:

1. *Local public agencies set policy*
2. *Equitable*
3. *Open and Publicly Viewable Data*
4. *Easily Transferable*
5. *Clearly Communicated*

A data standard that adheres to these principles would empower communities to establish and implement their own curb space policies. Advocates for a universal data standard argue that this is a necessary requirement to realize the potential of technologies to lead to curb management that benefits society. The alternative to a universal standard would be for individual entities (likely private companies) to develop proprietary data standards that work only with their own systems. Such an outcome would likely restrict the access that public authorities have to data and lock authorities into service agreements with specific providers.

3.5.2 Automated Vehicles

There is a lot of anticipation about what the era of automated vehicles will bring. The prediction that automated vehicles will impact curb space use commonly appears in the literature on curb management (Mitman et al., 2018; Clark, 2019).

The Society of Automotive Engineers (SAE) J3016 defines six levels of vehicle automation, in order to communicate the range of technical capabilities that are associated with automated vehicle systems (SAE, 2021). Figure 3.9 shows for each of these levels the role for a human and the driving features that may be automated. At lower levels of automation (SAE Levels 1 and 2), automated features support a human driver, who is in control of the vehicle. The curb requirements of these vehicles is similar to the requirements for a conventional vehicle (SAE Level 0), because the human driver must remain engaged in the driving task. Even a vehicle with parking assistance (SAE Level 2), which can perform the parking maneuver automatically, requires the driver to drive to the parking space and stay in the driver's seat.

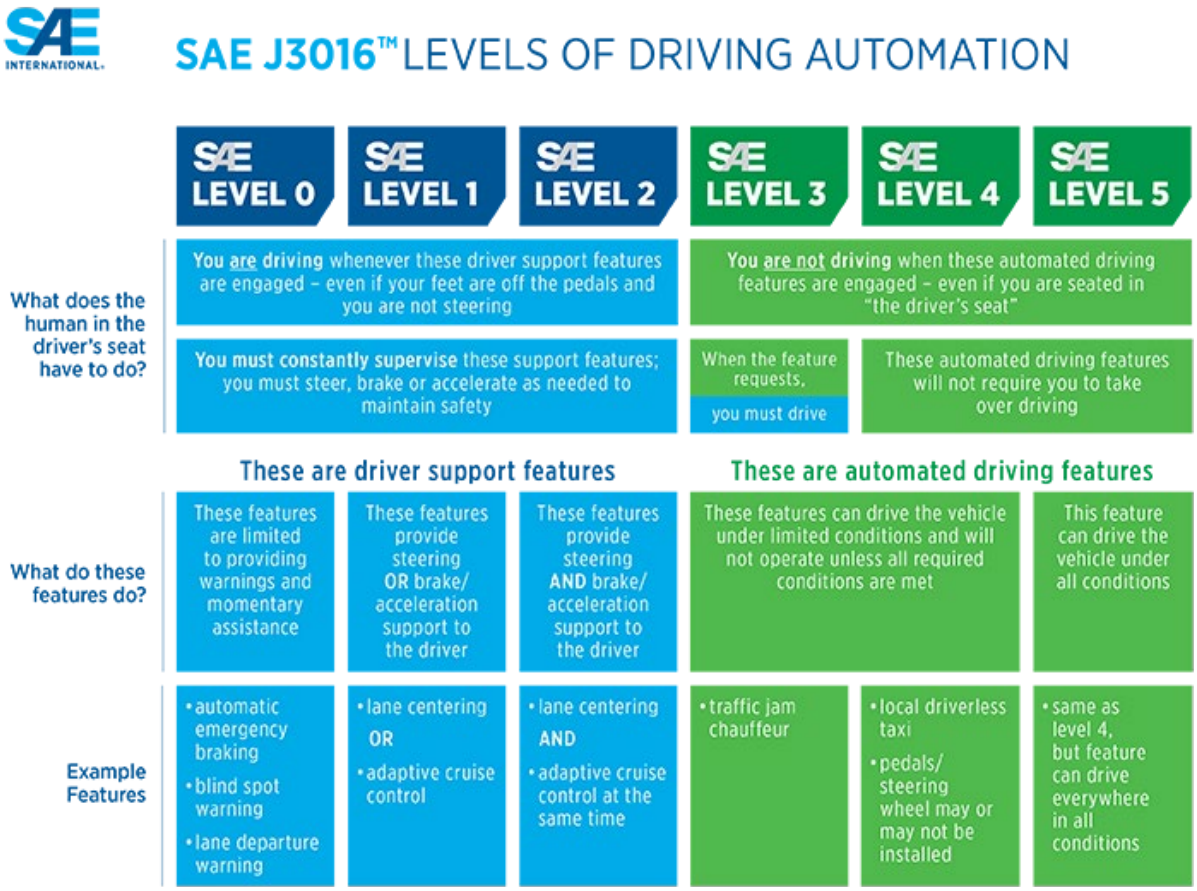


Figure 3.9 SAE J3016 Levels of Driving Automation (Source: SAE, 2021)

At the higher levels of automation, vehicles can operate without a driver in either limited environments (SAE Level 4) or through the road network in all conditions (SAE Level 5).

Although the technologies for automated vehicles are developing quickly, these levels of vehicle automation are not yet in operation. Not only is there is uncertainty about when such systems will be available, but also about what the impacts will be on travel behavior. The expectation is that SAE Level 4 and 5 automation, which would allow for driverless taxis, would reinforce the current trend toward more pick-up and drop-off or loading activities at the curb while reducing the demand for parking in close proximity to destinations (Soteropoulos et al., 2019). Essentially, it will no longer be necessary to park cars at prime curb locations. By eliminating the need for parking at the congested curbs closest to businesses and points of interest, there is an opportunity to convert that space to more productive uses. There is also the potential for SAE Level 4 and 5 automated vehicles to bring about increased vehicle miles of operation as empty vehicles circulate between drop-offs and pick-ups (Chai et al., 2020).

3.5.3 Shifted Focus to People over Vehicles

Until recently, most of the design guidelines for streets and curbs came out of agencies and organizations that focused on highways as a means to move vehicles (e.g., AASHTO, 2018). While this makes some sense in terms of design of the curbside lane travelway, there is now widespread recognition that streets, especially in cities and towns, need to serve people. Clark (2019) anticipates that the changing technologies and innovations in real-time information for curb management will have a lot to do with improving safety and prioritizing the movement of people over the movement of cars. This is well-aligned with the general advice that curbs should be managed to realize their most productive use (Roe and Toocheck, 2017; Mitman et al., 2018; ITF, 2018; Schaller, 2019)

3.6 Curb Space Guidance for Implementation

3.6.1 General Implementation

With increased competition for curbs, any changes are likely to benefit some users and disadvantage others and may therefore become contentious (ITF, 2018). The best way to move forward is to develop sound curb space policies based on data and measurements and to build community support for changes that are to be made. Mitman et al. (2018) and Schaller (2019) summarize some guidance for making successful changes to curb space management practices:

1. *Evaluate policy and implementations* – Quantitative measurements and qualitative assessments are useful for understand the needs of the curb and the performance of any tools or strategies used for curb management.

2. *Engage stakeholders and the public often* – The roadway and parking tend to be sensitive to the public, and building some consensus or political support for changes in curb policy is critical for success

3. *Use pilot projects for demonstrations* – Pilots are useful for gathering data about how a curb management strategy will work and for educating the public about how the street

will change. This is critical for building community support and choosing the right interventions.

4. *Prioritize productive activities* – Use of the curb for loading and unloading has a greater productive capacity than parking. Once identified, more productive uses should be prioritized.

3.6.2 Lessons from the COVID-19 Pandemic

In March 2020, the COVID-19 pandemic brought major changes to economic and social activities in communities of all sizes, which was reflected in changing demands for the curb. In cities and towns across the United States and around the world, these changes required rethinking curb space management policies and procedures to accommodate new functions. A report entitled *COVID and the Curb* was compiled by Transportation for America (T4America, 2021). The report includes input from cities and towns across the United States to describe how communities used the curb to respond to the pandemic and present ideas to ensure that curb serves the public good. An overarching theme noted in the report is that in many cases the COVID-19 pandemic accelerated changes that were already starting to happen at curbs around the country. Suddenly, the need to support public health gave authorities a mandate to think openly about curb functions and the importance of curbside pick-up and delivery, outdoor dining, and slow streets for safe multimodal use (Descant, 2020). Many communities that had not previously taken a very active approach to curb management were thrust by the circumstances to take action (Pochowski et al., 2020).

Many of the challenges that public authorities faced in trying to define curb management policies during the pandemic were the same kinds of challenges that cities had faced prior to the pandemic. Some of these challenges include (T4America, 2021):

- Balancing equitable community engagement with pressure to provide quick solutions
- Identifying pilot locations
- Revising permitting processes to be less arduous and more equitable
- Communicating clearly new regulations and policies
- Locating staff capacity to implement and maintain pilot projects
- Determining when and how to make pilots sustainable in the long term

An important difference from curb space management literature prior to the pandemic is that experiences and examples from smaller cities and towns are included in the reports on curb management under COVID-19. Almost all the examples of curb space management tools and strategies prior to the pandemic were in the largest cities where demands of the curb far exceeded the capacity. In smaller communities, congestion at the curb is not necessarily the primary challenge, and the changes made during the COVID-19 pandemic had more to do with

accommodating diverse functions. A couple relevant examples from smaller cities include (T4America, 2021):

- *Ann Arbor, Michigan* – The city made changes to curb designations in order to support businesses that could no longer serve customers indoors. These changes included:
    - Converting parking into 15-minute loading zones near restaurants;
    - Waiving permitting fees for all downtown businesses to use sidewalk space;
    - Allowing restaurants to repurpose parking in front of their business for dining at no cost; and
    - Planning street closures to allow businesses to expand their outdoor footprint even further.

  The main challenge reported in Ann Arbor was in communicating new policies, especially around conversion of parking to loading zones. Until clear signage could be posted, the policy was not considered to be enforceable.

- *Bellevue, Washington* – A healthy streets initiative closed streets to traffic in order to make safer space for socially-distanced recreation. The program was organized as a series of pilots. In one location, there was negative feedback, and the street was re-opened to traffic. In another location, the closed street was so popular that there are now plans to make the change permanent. The lesson from this experience is that first implementing controversial changes as a temporary pilot allows of adjustments based on the community response, which sometimes cannot be reliably predicted.

Experiences from Boston's outdoor dining program were highlighted in the report as well (T4America, 2021). These included changes to process of setting curb policy, which provided an example for how public authorities can respond more quickly to evolving needs:

- *Waiving or Reducing Outdoor Permitting Requirements* – Some of the permitting requirements for businesses to use outdoor spaces, such as sidewalk dining, were considered too onerous or time-consuming for the demands of the pandemic. The City of Boston is considering if some of the permitting requirements that were waived for the pandemic need were ever necessary at all.

- *Expediting Design and Implementation* – In order to make outdoor spaces accessible for alternative uses, funds were allocated to rapidly install ADA accessible ramps.

- *Recognizing Continued Needs for Other Functions Alongside Dining* – Curbside activities related to goods delivery, and movement of buses and bicycles. Along Brighton Avenue, conversion of parking to 5-minute loading zones accommodated goods delivery functions, which dramatically reduced double-parking that impacted a new bus-bike lane.

Some of the approaches used to address these challenges can serve as lessons for success that are likely to be useful after the pandemic. The *COVID and the Curb* report (T4America, 2021) presents three main policy ideas for local authorities to take away from the documented experiences of cities and towns during the pandemic:

1. *Allocate the curb equitably* – Prioritizing space appropriately for transit and vulnerable users; addressing inequitable enforcement; ensuring that curb signage is understandable and accessible; and utilizing the curb to incentivize more just economic activity (e.g., ensuring that small and minority-owned businesses have an opportunity to benefit from utilization of curb space).

2. *Improve the curb flexibility* – Allow demand-based curb management; consider pricing the curb; set up city-specific curb guidance; coordinate curb management across jurisdictions; and monitor curbs to develop a curb inventory

3. *Make the curb a place of innovation* – Identify new ways to allow for piloting outside of the traditional procurement or permitting processes; update land use policies; and make space for non-traditional entrepreneurs

Similar guidance comes out of a Kittleson & Associates report on *What COVID-19 Has Taught Us About Curbside Management* (Pochowski et al., 2020). That study looked at trends across cities during the pandemic, especially the shift in reallocating space to outdoor dining and commerce. Five recommendations for long-term approaches to curb management are made for communities as they come out of the pandemic:

1. *Collect data before the pandemic is over* – While indoor dining was closed, it is possible to tell exactly how much restaurant revenue is associated with the curb (outdoor dining, delivery, and take-out), although the attractiveness of some of these options may change with the return to indoor dining.

2. *Define return-on-investment of curb uses by location and time* – Relevant metrics may be economic returns, public health considerations, equity considerations, and proximity of curb space to destinations.

3. *Collaboration across jurisdictions* – Where multiple agencies or entities are involved, collaboration will be necessary

4. *Allow for dynamic curb management* – This is necessary to address competing uses and objectives; for example, real-time parking availability information and dynamic pricing combines data with policy

5. *Prepare for new curbside demands* – Now the communities are thinking about the curb more than ever before, it is a good time to plan for vehicle-curb communications that can support the proliferation of ride-hailing, e-commerce, and new technologies that are ultimately expected to include automated vehicles.

4 Results: Stakeholder Engagement

The input received from 15 stakeholders during 7 focus group meetings was analyzed to identify common themes and important insights regarding curb management across the Commonwealth of Massachusetts. The analysis resulted in identification of four main themes, each described in the following subsections.

4.1 Primary Users of the Curb

Throughout the interviews, all stakeholders acknowledged the need for repurposing the curbside for more than its use for parking and delivery. With that considered, the intended purposes of curb usage, and the primary users of the curb differed across the state.

Stakeholders from areas in and around Boston emphasized the need for the city to repurpose the curb for more dynamic, on-demand usage. The acceptance of non-traditional uses of the curb was prevalent among the stakeholders. Outdoor dining, for instance, was acknowledged as a currently acceptable usage of the curb. Additionally, stakeholders acknowledged the increasing spaces for pedestrians and bicyclists as a non-traditional use for the curb. One participant summed up this in their quote:

> *It's really interesting just seeing all the pop-up dining areas that … repurpose the curbside… during the pandemic. I know they've repurposed the parking to be a dining area for outdoor dining, and in Brookline, for example, they've set up cones on the parking lane as well to widen the sidewalk area for pedestrians [and] bicycles to get a wider sidewalk area.*
>
> *—Senior Transportation Planner, Massachusetts Statewide*

Another participant spoke about recent efforts to repurpose the expanded curb space for bus and bike lanes. The emerging use of the curb was the use of ride-hailing services. The use of curb for bike stations was mentioned, however, it was not pointed out as a major use.

Stakeholders from areas outside Boston, including Merrimack Valley, Western Massachusetts, Berkshire County, and Worcester, spoke about more traditional uses of the curb. Stakeholders spoke about residential parking, transit activities, and overnight storage and delivery loadings as primary uses of the curb. While stakeholders did point out the need to repurpose parking spaces for alternate usage, some observed pushback from within their communities. One participant spoke about the importance of street parking in their quote:

> *We have a lot of free, unrestricted on-street parking. We hear a lot from our business owners about the importance of that in their unwillingness to deviate from that platform. So those are the first users that come to my mind.*
>
> *—Transportation Planner, Western Massachusetts*

Among the 15 stakeholders, one stakeholder who belonged to an advocacy group for the blind reported that the primary users of the curb were cars, emphasizing on the lack of accessibility of curbside usage for the blind. They spoke of a lack of accessibility in existing and emerging uses of the curb and how it does not consider the needs of the visually impaired, which is a cause for concern.

> *The curb belongs to the cars, because it depends on which side of the curb you're talking about – it does define a sidewalk, usually. The curb for blind people usually impacts them when they get to the corner to cross the street, so there are different parts of the curb. It seems that for the roadside of the curb is all for cars; it has either parking or it's all cars with some bicycles. It's not always accessible for people getting in or out or dropped off places [or] that need to get off a bus to get to the curb.*
>
> *—Support Specialist, Massachusetts Statewide*

4.2 Increased Use of the Curb Space Upon Repurposing

All stakeholders reported that their cities have adopted some level of repurposing, which was accelerated by the COVID-19 pandemic. A major effort around repurposing parking lots into restaurant spaces has been implemented throughout the state. One stakeholder succinctly summarized the emphasis on restaurant seating in this quote:

> *The City tried out taking the parking spaces [and] using those for additional restaurants [and] eating, and everybody loves it. So, we are already talking about making that just a thing that we do year-round, which we… had previously seen in New York City. We have places in Somerville, downtown Boston, but not anything widespread… We want this like all over the place … It has sort of forced people to look at things that [they] wouldn't have otherwise.*
>
> *—Project Manager, Massachusetts Statewide*

As pointed out earlier, the demand of TNC companies and delivery vehicles have informed the policy around repurposing the curb:

> *I know the City of Boston is looking at geofencing [for] some of the Uber and Lyft drop-off areas pre-COVID. So, I imagine that would continue to be looked at, depending on how things roll out with COVID, but just kind of defining the space, but also looking at deliveries. We have examples of delivery vehicles parked in bike lanes for the majority of the time.*
>
> *—Senior Transportation Engineer, Massachusetts Statewide*

Stakeholders spoke about how there is still pushback on repurposing parking spaces. City residents are mostly in favor of accessibility to closer parking lots.

A lot of towns have street parking, and municipal lots probably have enough parking. But generally, people are lazy and do not want to go for walks. People don't want to park in the municipal lot and then walk 500 yards or something to where they're going.

—Transportation Planner, Central Massachusetts

Community members from the Pioneer Valley region agreed to the repurposing of the curb spaces, but there was resistance from the larger business community, which is a concern for future policies that are enacted suddenly.

People are willing to support some of the new treatments and removal of parking spaces on a small scale, but do it on too large of a scale or do it in front of the wrong business who's losing the parking and all of a sudden it's no longer viewed as a positive… what people have been able to gain versus probably the very little that they've lost in terms of implementation.

—Transportation Planner, Western Massachusetts

While there is pushback from different cities, there has been a sense of acceptance from those who understand the importance of how these changes can have an impact on the larger community in the long run. A stakeholder from Berkshire county described their experience of how repurposing for ride-hailing service activities and repurposing spaces for dining have changed the larger community, and there are chances of sticking to this new repurposing even in a post-COVID environment.

People in the Berkshires… are pretty conservative about who can use the sidewalk and trying to preserve parking for our visitors. But I think seeing that it has been successful and how easy it was, I think it would be hard to go back… With that said, I think some towns may have like quadrupled [ride-hailing] over the last two or three years. Then we see [that] there are some Uber and Lyft trips in some of the more rural locations, but it is mostly Pittsfield that's been driving that. So, there are some drop-off spots for Uber and Lyft in downtown Pittsfield.

—Senior Planner, Western Massachusetts

Additionally, the stakeholder mentioned how planning for bike lanes in the city is something that the local community will incorporate in the near future.

The Berkshires is a big tourist location. They put in a very, very large dining space that was shared by four or five different restaurants, or something to that effect… In Great Barrington, they're planning on changing the one-way system, and they asked about putting in bicycle lanes.

—Senior Planner, Western Massachusetts

4.3 Inputs on Curb Space Management

4.3.1 Measuring Curb Space Use

The stakeholders reported various measures to quantify curbside usage activity. They reported primary measures, including turnover times and the type of vehicle accessing the curb. Additionally, looking at parking meters as a measure of the duration and frequency of usage is often considered. Like parking, measures from ride-hailing services and delivery companies help understand the hotspots and demand areas that have greater activity. The importance of these measures is mostly to help companies understand productivity and help implement better asset management practices, along with repurposing different curb spaces for different types of uses.

In addition to different usage tracking, pedestrian activity is usually tracked in locations with counters. However, not every region tracks pedestrians and bicyclists. A participant was quoted as relying on specific setups to count using counters and cameras to get a measure of activity.

> *For a project-level basis, if we know we're looking at a specific corridor, we can go out [and] setup counters. We've got these little video cameras that will track the number of vehicles, bicycles, [and] pedestrians moving through or making turns at intersections.*
>
> *—Project Manager, Massachusetts Statewide*

For future trends, a few stakeholders shared suggestions on measures of curbside usage. One participant suggested the use of location-based data (with anonymized users) and GIS data measure the usage. They also suggested how existing data can be used to establish volume.

> *We do have a couple of [location-based services] tools. The ones that we use are Radius and Streetlight. Both of those aggregate data from cell phones as well as connected vehicle fleets, and they use that to take an estimate. Streetlight has more penetration with several users. It's getting data so they can also get us an estimate of the number of people using the roadway. It'll also include people walking and people biking.*
>
> *—Project Manager, Massachusetts Statewide*

> *I just want to reiterate the importance of GIS data when it comes to management and understanding the curb. When a bus lane turns into a bike lane during other hours and then overnight parking, the dynamic uses within that line segment and the points that make up the assets along the curve [are] crucial to understand.*
>
> *—Senior Transportation Engineer, Massachusetts Statewide*

Additionally, another stakeholder pointed out tools that can be used to understand curbside activity using camera analytics.

Verizon has a product out there that we're testing now, but essentially looks at using AI to look at the curb. The product also measures the productivity of the curb, which means how many people are parking, or how many vehicles can access that over a certain period.

—Transportation Planner, Eastern Massachusetts

4.3.2 Impact of Curb Space Policy Changes on Businesses

Like findings from previous sections, while there has been acceptance for curbside changes across the Commonwealth, there has been pushback observed in certain regions. Stakeholders believed that repurposing the curbside added support to businesses that have been struggling during the pandemic. One stakeholder stated:

Everybody was just trying to get creative to make things as normal as possible and help support the businesses that are already struggling. So, a lot of flexibility was granted to have space for users…

—Senior Planner, Western Massachusetts

Additionally, with regards to repurposing for outdoor seating, it helped their cities by adding vibrancy to the town and helped businesses overall. The stakeholder added:

Generally, for a lot of these old mill cities with downtowns, we have not been built for outdoor dining. I know a few specifically built out a few bump-outs, which ended up seating people. Those were for crossings, but they ended up being able to put seats out there, and it is nice to add vibrancy to downtown and seeing people out there as opposed to being in dark old buildings where you really cannot see people. It is not like Boston, where they have windows that open up to the outdoors.

There's some general enthusiasm for trying something new and the regulations made it easy for them to do it. I think that's always nice for businesses.

—Senior Transportation Planner, Central Massachusetts

Earlier, the process of outdoor dining involved professional engineers, lawyers, and 10's of thousands of dollars just to get an outdoor dining cafe zone. So, this is ideally changing that process

—Transportation Planner, Eastern Massachusetts

In comparison to the Boston region, community members in western Massachusetts observed pushback when they repurposed the curb spaces for seating and dining. They observed that before COVID, the non-restaurant businesses were ok with a few outdoor seating spaces, as the access to their businesses was not compromised. However, during COVID, those businesses wanted dedicated parking access for their customers on the curbside. This was done

to ensure that pedestrians do not keep away from the spaces that have been repurposed for restaurants.

> *It seems that a lot of times [the businesses are] interested in making sure that there's ample parking for their customers to be able to pull in right away and get to their store.*
>
> *—Transportation Planner, Central Massachusetts*

> *We had a shared street project this summer with MassDOT Shared Streets funding. I thought we were going to be tarred and feathered from the businesses that we were single-handedly changing the streets. However, it had no impact on them, but it seemed we were destroying the entire universe.*
>
> *I've worked in a lot of communities, and it is often that there's not enough parking, no matter how much parking there is. So, the business pushback was phenomenal. It had a lot to do with the kinds of businesses. Pre-COVID, restaurants did not mind that people had a walk because you're going to a restaurant for a couple of hours. Who cares if you walk 300 feet? Using parking, either street parking or lot parking for other uses will be much, much more acceptable to people than it was before. You know when you can use the lane and you are not going to be negatively impacting, say a business, by not allowing parking or by having a loading zone at a certain time. Knowing what time of day makes the most sense and communicating that, I think, is job number one. You [also need to] know [what] each community is willing to accept to a certain extent.*
>
> *—Planning and Sustainability, Western Massachusetts*

> *We need to get the space out there for the restaurants, and there wasn't too much thought given to what the impact on the curb is going to be, so we took a more responsible approach. So, if we heard concerns (for example, no pedestrian access) in certain areas, we would respond and address it.*
>
> *—Transportation Planner, Eastern Massachusetts*

In addition to the policy updates, the stakeholder who works with the mobility of visually impaired people found that these changes do not necessarily consider the new assets might require them to navigate them differently, without much assistance or design considerations. They were quoted as following:

> *Businesses [are] expanding their storefront to the sidewalk. The buses, in accessing a place to drop-off that's convenient to where a person needs to travel to a store, or if Uber has an area that they can only drop off, then the blind person needs to know where they are being dropped off [relative to] the location of the store. Sometimes that's a little difficult to negotiate; from where you think you are and then getting your landmarks and finding the store that you want to*

go to. So the drop off areas, and understanding [where] those locations are relative to, is very important info.

—Support Specialist, Massachusetts Statewide

People in wheelchairs using the sidewalk don't like the transitions. The transitions are too upsetting and sometimes they get stuck. If they're going across the street, they just stay on the street because it's all flat, and they compete for that space.

—Transportation Planner, Massachusetts Statewide

4.3.3 Inputs from Advocacy Groups

All stakeholders noted the importance of advocacy groups and their inputs that would inform policy decisions. However, stakeholders noted that final policy decisions lie with the directives from their parent organizations and the government. Different stakeholders talked about these points in the following statements:

You know, that [advocacy inputs during COVID were] coming in pretty heavy, but we didn't [make policy changes] because we just didn't see the demand. It was not coming from the businesses. It was not coming from the Main Street… so we did not consider the advocates representing that main street. We consider the businesses. We did not listen to what [the advocates] were saying [earlier, before COVID]. Fortunately, in Boston we have the Go Boston 2030 plan, which was, from my understanding, a comprehensive engagement process. That's what we're working from so we can keep pointing back to that.

—Transportation Planner, Eastern Massachusetts

It is tough, because [in] some areas where people are looking for a transit lane, people might also want wider sidewalks for accessibility. They also might want bike accommodation, and we are not trying to push one group against the other. Sometimes it all does not fit, and it is a balance between all of us; statewide and municipalities. It is just how do we hear their concerns but know that maybe it is a bus/bike lane in some areas, or maybe it is not as wide of the sidewalk and we are fitting in a shared-use path? There's a lot of balancing that we do on every single project.

—Senior Transportation Engineer, Massachusetts Statewide

I think, concerning MassDOT, most of what we would have in that space is covered in our Complete Streets guidance.

—Policy, Massachusetts Statewide

Stakeholders pointed out that local government has a role in listening and considering advocacy groups as well. Two examples of these were quoted by stakeholders. The statements are as follows:

> *There are walking and biking advocacy groups and recently we've been talking a lot with the Worcester Disability Commission, which focuses on disabled people in their usage of sidewalks and curb ramps.*
>
> *—Transportation Planner, Central Massachusetts*

> *There are increasingly bike-friendly city councils over the last few years because of advocacy from the community. So now they are talking about implementation, or I should say they passed a resolution. There is an emphasis on forcing the city to install protected bike lanes anytime a street is reconstructed. The wording of the resolution was extremely problematic, and the actual implementation has not gone as well as the advocates hoped that it would, but I think the intent is still being honored to some extent by city staff. That is a situation where you have safety and comfort for folks. Biking is the intent, above all other things, but it varies... [In] some corridors, the politics or the demand for parking is such that you won't see bike facilities.*
>
> *—Transportation Planner, Massachusetts Statewide*

> *The city of Newburyport has an advocacy group called Newburyport Livable Streets and they have been very good about advocating for some Safe Routes to School and bicycling and walking in the city.*
>
> *We have the Regional Coordinating Council for transit, and they are looking at transit access for people who are low-income, disabled, and elderly. The Cancer Society has been very good about organizing some problem solving about getting people to appointments.*
>
> *I worked on a plan for the MVRTA [Merrimack Valley Regional Transit Authority] for the City of Haverhill, well not for the city, but for a group of nonprofits who work with a lot of low-income people and elders. They were looking for ways to get people to a variety of things: getting people to Alcoholics Anonymous for the evening meetings, people to doctors' appointments, jobs, all sorts of things. They did get a grant recently, and they have started using the taxi service. They started a specific extra transit program to get people to places that they can't easily get to, especially during the pandemic.*
>
> *—Senior Transportation Planner, Central Massachusetts*

In addition to policy decisions, a stakeholder pointed out that the local community has a role in deciding priorities for a region. The stakeholder from Berkshire county spoke about the importance of advocacy for public health, designing for older people, and other inputs for road sharing. They stated:

I think in our most rural communities, people using the road for biking and walking has increased. I think a lot of that was due to second homeowners coming from New York and Boston and basically turning their second home into a year-round home. Then they're all just hanging out at home, working from home, working remotely, and then getting out on the street and biking and walking every day. It wasn't as noticeable in Pittsfield and North Adams and some of the more downtown areas, but we heard about it a lot in our more rural communities.

It [has] just increased demand for bike lanes or sidewalks and things. Doing ADA assessments and doing advocacy for disabled people. I think in general, a lot of our communities that do have sidewalks struggle to maintain them.

Community members who would have trouble walking around could provide a lot of advocacy there to make changes and make sure that [they] have a safe way to get from place to place. We have public health planners or public health components in our office. So, I think we have four or five public health staff, and they chime in on projects, and we try to integrate public health as a component of transportation in general.

—Senior Planner, Western Massachusetts

4.3.4 Safety Considerations While Repurposing Curb Spaces

Stakeholders have emphasized that safety is the bottom line when considering any curbspace design or policy measures. This was emphatically stated by a participant who worked at the Massachusetts department of transportation.

Safety is always the bottom line at MassDOT.

—Highway Division, Massachusetts Statewide

Stakeholders stated that the safety of vulnerable road users must be considered, including older and people with disabilities. While repurposing efforts of the curb spaces are important and welcomed, considering the safe maneuvering of vehicles around these spaces has to be considered. One stakeholder suggested that transit spaces need to be considered because of the enhanced risk of crashes while buses are pulling out.

Having the bus stop in the [shoulder] lane with a curb extension after the bus stop has safety issues. The bus pulls out [and] creates a greater risk of crashes, and that's, frankly, our most common bus crash.

—Planning and Sustainability, Western Massachusetts

While most stakeholders were happy with the emphasis on safety, the disability advocate found that safety culture needs to consider the newer feature designs with mobility issues. The usability of such features needs examination while considering efforts to repurpose curb spaces. They stated:

I think a lot of times designers have a good design [for roundabouts], but they don't look at the functionality or how it works for the individuals [that] are using the roundabouts.

I do not like roundabouts, personally. For our teaching orientation and mobility [to people with vision-impairment], you must depend on yielding of the traffic when you add a crosswalk, and in Massachusetts yielding isn't a common occurrence. But you need to get around and find where the crosswalk is. [At a roundabout] it is not at the corner anymore; it's usually around the corner, and locating where that crosswalk is and how people cross streets regarding traffic yielding, anticipating the gaps [is a challenge]. How far I must walk now around an intersection can cause concern for certain people. It is fatiguing to walk further than I normally do at a plus shape intersection, so understanding how people are using the intersection and how functionally [it] is being used may vary from area to area.

It is good to get an idea of more vulnerable populations, not just the average college student who can zip across the street or get in between cars and then run to a mid-street crossing and jaywalk. And, focus on those other groups that take longer, and they may not be the ones who are studied. The assumption is just [that] people with disabilities have somebody to help them or they do not go out.

—Support Specialist, Massachusetts Statewide

4.4 Future Needs

Stakeholders shared interesting perspectives on what they feel the impact of AVs would be on the future of the curb. It was important for all the stakeholders to consider the consistency in the implementation of curb space policy

Consistency in the community-wide implementation would be needed.

—Senior Transportation Engineer, Massachusetts Statewide

One stakeholder spoke about the importance of connectivity with AVs. They shared an interesting example of how connectivity would have a practical application on infrastructure communicating with AVs and informing how they would seek parking. They stated:

We're all in the transportation sector, we know that more connectivity is coming, or autonomous vehicles are coming and [changing] how the infrastructure of the curb will talk to those vehicles. You mentioned public health, so let us say the use of ambulances: will there be any connectivity?… 'Hey, I must stop at this building, but it is completely packed so where can I park?' The curb is talking to the ambulance saying, 'Hey, there is a space here, you could brake there you can move there.' I think that would also be a possibility.

—Transportation Analyst, Eastern Massachusetts

In terms of the implementation of safety, a stakeholder spoke about the importance of safety and anonymity in the implementation. They shared their perspective in this statement:

> *I'm in the consultant realm with agencies, whether they're statewide agencies or municipalities, and the signal is that [automated vehicles] will be coming. So how can the municipality itself revert infrastructure for the vehicles? That would increase the safety along the curb and then obviously there will be security issues. People care about their independence, and ... that's a whole different issue of security and anonymity.*
>
> *—Transportation Analyst, Eastern Massachusetts*

Another stakeholder who had previously pursued the idea of connected infrastructure with AVs spoke about how digitizing curb spaces can help their interactions with AVs:

> *There's the sort of digitizing of the curb, which has been considered for research, and so I won't go into that one. But how do we digitize information about the curb, the location, the regulations at that space? I think the other piece of it that is interesting is measuring usage of the curb. I think more and better data about how the curb space is being used would add value. A future state that we'd like to get to [would] be how we use this data to improve limited road space; street space that we have currently.*
>
> *—Policy, Massachusetts Statewide*

Another stakeholder was not sure about the idea of AVs in the public spaces, and how transit would look:

> *I'm kind of ambivalent about self-driving cars... I feel that the influence will be on transit, for example take [the AV] from my house to the train station and then I take transit, it could be great. But [using AVs] certainly in midtown Manhattan, would be crazy and scary.*
>
> *—Planning and Sustainability, Western Massachusetts*

A stakeholder from Western Massachusetts pointed out that the problem was not about AVs, it was more about how it would have an impact on the community. They stated that the shift towards ridesharing, and AVs would be pretty much in the same line of thinking. They stated:

> *We essentially already have autonomous vehicles. They're just piloted by humans, rather than by artificial intelligence.*
>
> *—Planning and Sustainability, Western Massachusetts*

Their opinion is to repurpose curbside spaces and consider interaction with AVs as an afterthought if they can be thought of them as an artificially intelligent taxi service. They stated:

People like coming in the door, depending on what type of businesses, and some of them would buy it. Most of them would not, but I think now with COVID and an expansion of outdoor seating into parking areas, a lot of them were like 'oh my gosh yeah this is what matters,' especially, in an area that is already walkable. They are finally starting to recognize that their customers were already primarily pedestrians.

So, I think we are going to continue to see that expanded use of parking space for bars, restaurants, that kind of thing, especially in some places where liquor laws have been relaxed a little bit more. You can get takeout alcohol from some places, which I think helps the outdoor seating. I think, in general, we are not going to see as many demands in those areas for long-term personal vehicle storage, it's going to be more and more pickup and drop-off and some of those other users that were saying.

—Transportation Planner, Massachusetts Statewide

4.5 Summary

The findings from the interviews have been critical for understanding the emergent needs resulting from the repurposing of the curb space. All stakeholders recognized the importance of repurposing the curb space for other purposes. However, they expressed the importance of consistency in curbside management policy and considering the needs of the communities including businesses and residents. Additionally, the stakeholders report the future of the curb to be ready for the varying needs while emphasizing the need for safety and considering the inputs from community advocates.

5 Results: Curb Space Management for Massachusetts

The findings from the literature review (Section 3) are now compared with the insights from the stakeholder engagement (Section 4). This analysis identifies the current practices, challenges, and needs across the Commonwealth of Massachusetts that are addressed in the existing body of literature on curb management. It also identifies gaps between the experience in Massachusetts and current state of practice for curb management in the United States. Both areas are important. Where the existing literature provides guidance and examples of implementations, there are direct references for communities in Massachusetts to look toward. Where gaps exist, there is value in drawing attention to challenges that are not currently addressed in the literature but that communities will need to consider in planning and implementing curb management practices.

This section is organized in four parts. Section 5.1 briefly describes the relevance of the literature to the contexts across the Commonwealth of Massachusetts. Section 5.2 synthesizes the guidance from the literature that addresses or directly relates to themes that emerged from the stakeholder input. Section 5.3 identifies gaps between the literature and the practices, challenges, and needs for communities across the Commonwealth. In some cases, the guidance is as simple as drawing attention to an issue that should be considered during the planning and implementation process. In other cases, there may be a lack of knowledge or experience that will require some research or experimentation to address. Section 5.4 highlights funding and opportunities and resources to support innovative curb management that are specific to Massachusetts.

5.1 Relevance of Literature to the Commonwealth of Massachusetts

Most of the literature is focused on dense urban communities where competition for curb space is intense, and congestion at the curb has forced public authorities to take action. Cities that have played a leading role in planning and implementing curb management strategies include Seattle, Washington; Portland, Oregon; San Francisco, California; Los Angeles, California; Washington, DC; and New York City (all large coastal cities). Many of the innovations in curb management have been piloted in California, where seasonal weather patterns have less effect on behaviors and pressures at the curb. Taking this all together, the existing body of literature appears to be most relevant to urban communities, such as those at the center of the Boston Metropolitan Area. In fact, Boston MPO compiled a report on the *Future of the Curb* (Clark, 2019), specifically identifying relevant examples and implications for Boston. Within Massachusetts, the cities of Boston and Cambridge have been most prominent in experimenting with curb management implementations.

Nevertheless, there are insights from the literature that have relevance to communities throughout Massachusetts. The Commonwealth is a diverse state including a large coastal city

(Boston); extensive urban and suburban communities across Eastern Massachusetts; regions with significant seasonal demand associated with tourism on Cape Cod, the islands, and parts of the Berkshires; smaller and mid-sized cities in Central and Western Massachusetts; and numerous small towns with compact historic centers across the state. Although most of the communities outside of central Boston do not have the types of urban corridors often described in the literature, there are certain functions and demands are in common.

- Ride-hailing is a quickly growing mode of travel and a significant contributor to curb demands in some communities outside of Boston, such as Martha's Vineyard (as shown in Figure 3.2).

- Gateway Cities have dense urban cores, many of which are being revitalized, which is bringing activity back to the streets of these neighborhoods (e.g., Union Station in Worcester; MGM Casino in Springfield). These Gateway Cities are located across the Commonwealth (Figure 5.1).

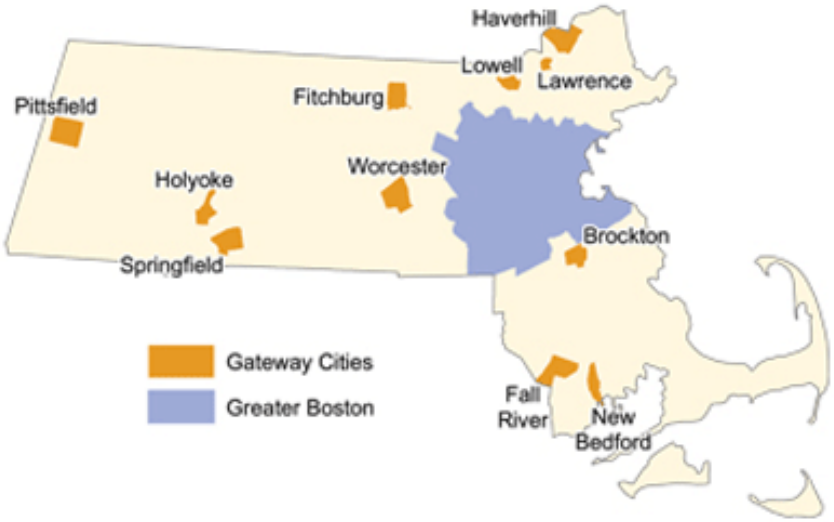


Figure 5.1 Gateway Cities in Massachusetts

- Constrained parking is a challenge in many communities across the Commonwealth, not only where the population density is greatest. This can result from a combination of a couple factors: 1) In many cities, high demand at certain locations (such as historic town centers) is driven by a concentration of activities in a small area; and 2) most communities outside of Boston are served by minimal public transit service and leave people largely dependent on their cars, which then need to park.

Although experiences from Boston's curb management practices appear in the literature, little is said about what is happening in the rest of the state. The following sections present the results of analyses to compare stakeholder input with guidance in the body of literature, with a view toward highlighting guidance is relevant to communities outside of Boston.

5.2 Curb Space Management Guidance that is Aligned with the Literature

The stakeholders that provided input through the focus groups represented organizations in communities within the Commonwealth of Massachusetts, as opposed to the national scope of references on curb management in the literature. Despite the differences from many of the cities in which innovative curb management practices have been demonstrated, there are many aspects of the literature that are well aligned with the issues in Massachusetts.

5.2.1 Identifying and Prioritizing Curb Space Functions

Stakeholders acknowledged the relevance of defining the curb to broadly include the edge of the street as well as adjacent spaces related to the travelway, flex zone, and pedestrian realm (). There is widespread agreement that curb management policies should be developed to reflect the uses and prioritized functions for the curb. This includes a general movement toward recognizing the role of streets and curbs for serving all modes of transportation (including pedestrians, bicycle, transit, ride-hailing, and goods delivery).

While stakeholders from the Boston area generally embraced the idea of repurposing curbs for more dynamic uses and alternatives to parking, stakeholders from the rest of Massachusetts expressed more concern about pushback in their communities toward reallocating space from parking. An important consideration is that the communities within Boston are served by an extensive public transit system, and there is already significant travel by modes other than private cars. Communities outside of Boston are more likely to be reliant on private cars as a dominant transportation mode, although this is not uniformly the case. Competition for curb space in Northampton mirrors the challenges faced in Boston and Cambridge. Ride-hailing in Martha's Vineyard is so prevalent during busy summer months that island communities face rampant double-parking challenges.

Across the Commonwealth there is acknowledgement that there is value in considering curb uses other than parking, especially with increasing rates of ride-hailing use and the increasing implementations of complete streets.

Recommendation 1 Curb uses should be identified and prioritized based on the context of the community. Beneficial curb management policies will be those that serve the needs of existing curb users and support a community's goals and visions for the future. This may look very different in an urban neighborhood than in a smaller town.

5.2.2 Measuring Curb Space Use

Stakeholders spoke about the same challenges and opportunities associated with measurement and data that are described in the literature. In general, obtaining data about curb use is challenging. Conventional traffic data collection methods have focused on monitoring the flow of vehicles, and the process of counting bicycles or pedestrians is more challenging.

There is widespread agreement across the Commonwealth that measuring curb use is critical for the process of identifying appropriate curb management policies and for monitoring their effectiveness. There are also significant differences in how curb data is collected in different parts of Massachusetts. In central Boston, innovative data sources are used, including video processing with artificial intelligence and aggregated cell phone data from third part providers. In more smaller towns and more rural areas of the Commonwealth, there is limited access to these state-of-the-art data sources, and it is more common to rely on manual counts.

Recommendation 2 Despite the difficulty and expense, communities should collect data on curb use to support selection of appropriate curb management policies and continue to monitor the curb to so management policies can be adjusted as needed.

Recommendation 3 Public authorities should make an effort to embrace open data standards and pursue agreements with vendors that allow cities and towns to retain as much ownership and access to data as possible. This will give communities the most control over their own curb policies so that decisions can be made that prioritize the public interest.

5.2.3 Changes in Curb Space Use in Response to Repurposing

All stakeholders recognized that the COVID-19 pandemic has brought changes to the curb use that would not have likely taken place otherwise. Curbs have been repurposed for dining, pick-up/drop-off for deliveries and ride-hailing, and bicycle facilities in communities across the Commonwealth. Stakeholders from Central and Western Massachusetts noted that these changes, which took space away from street parking, would have been very difficult to implement without the impetus of the pandemic.

Now that curb use has changed in many communities, it may not be necessary to role back changes in curb policies as the pandemic ends. A key to gaining public support for changes to curb management was the fact that these changes were initially implemented as temporary solutions. Once curbs are repurposed, and people start using the space differently, and demand for the curb can change to fit the new policy. For example, creating spaces for dining and recreation can increase the number of people using the curb for these purposes.

Recommendation 4 Implement new policies as temporary pilots or demonstrations to gauge demand and build public support. Curb management strategies that succeed in a temporary implementation can be made permanent.

Recommendation 5 When curb functions are changed through the implementation of a curb management policy, it is useful to measure and compare the benefits against losses. For example, converting on-street parking to outdoor dining has a benefit in more space to serve customers but a potential negative impact in making the business more difficult for customers to access by driving.

5.2.4 Impacts on Businesses

Businesses are reliant on the curb in many ways. The street, curb, and sidewalk are the gateways through which customers access businesses, such as stores and restaurants. In urban areas and town centers, goods are typically delivered to businesses from the curb. The public space in front of a business is often beneficial in attracting customers (e.g., sidewalk dining at a restaurant. All of these are important functions that are of interest to businesses, but perhaps no function is more sensitive than on-street parking. Businesses are often vocal and powerful constituents, advocating for curb management policies that they perceive to be to their bottom line. Stakeholders, especially from communities outside Boston, cited examples of businesses insisting on maintaining street parking near their doors.

The COVID-19 pandemic brought significant challenges and stresses to businesses in all communities across the Commonwealth and around the country. With indoor dining spaces closed and people choosing to order food and goods for delivery to their homes, on-street parking was no longer as important for supporting businesses. Instead, businesses needed access for delivery pick-up and drop-off as well as outdoor spaces where customers could safely dine while socially distanced. Making changes from parking to loading zones and outdoor dining spaces represented a shift toward more productive functions.

Recommendation 6 Removal of on-street parking is often contentious, but reallocating curb space to other uses, such as ride-hailing pick-up/drop-off, freight loading, and outdoor dining or recreation space have the potential to attract more customers or make businesses operate more efficiently. Measuring curb use, productivity, and even sales tax receipts provide data on which to base rational curb policy decisions.

Recommendation 7 Curb management policies that can vary over time and include multiple functions within a block provide the flexibility to serve many competing needs. For example, the curb space along a block may include some space allocated to outdoor dining and a dynamic curb lane that may be designated for parking, ride-hailing, or freight loading at different times of the day (Figure 3.3).

5.3 Gaps Between the Literature and Massachusetts Experiences

There are a number of issues that were raised in the focus groups with stakeholders that are not sufficiently addressed in the literature. Although some of these issues are related to the local contexts of smaller communities in Massachusetts, by and large, the stakeholders draw attention to issues that are not only relevant to the Commonwealth but other cities and towns across the country as well.

5.3.1 Inputs from Advocacy Groups

The literature advises public authorities to involve stakeholders and advocacy groups from early in the process of establishing curb management policies with the goal of building public support for changes (Mitman et al., 2018). There are numerous references to the perspectives of businesses, transit operators and users, and people traveling by active modes (bicycles and pedestrians). Although there is mention of vulnerable groups, such as people with a disability, their needs and challenges are not explicitly recognized or discussed.

The ADA specifies design criteria for sidewalks and curb cuts to make facilities accessible to people with a disability such as a vision impairment or use of mobility device (e.g., wheelchair). The recent curb management literature makes brief mentions of the need to serve people with a disability, but the assumption seems to be that if designs comply with ADA standards, these needs are met. The stakeholders provide some insights about the diverse range of perspectives and needs that these vulnerable users may have when interacting with the curb and the challenges that new curb uses pose, even when the infrastructure complies with ADA design standards. Examples of challenges for people with a disability include:

- People with a vision-impairment rely on tactile surfaces to understand where the edge of the curb and designated crosswalks are located. This infrastructure typically exists only at intersections, leaving mid-block curb areas without features to help the vision-impaired get oriented. This posed challenges for people who want to use a ride-hailing service that makes a pick-up or drop-off at a midblock location.

- People who rely on a mobility device, such as a wheelchair or powerchair, require a sufficient lateral clearance and curb cuts to be able to move safely on sidewalks. Mid-block activities, such as transit or ride-hailing pick-up and drop-off can pose a significant challenge for these people, especially if parked cars force a space between a physical curb step and the vehicle. A consequence is that wheelchair users are sometimes forced to move in the travelway with motorized traffic in order to get to an intersection with a curb cut. Even where the physical infrastructure is designed in an accessible way, use of the street for dining, commerce, or landscaping can encroach on the required clearance for passage, making it difficult or impossible for the person to use the sidewalk.

Recommendation 8 Planners and policy-makers should recognize that ADA requirements do not address all challenges users with impairments. People with vision and mobility impairments are particularly vulnerable, but there are a wide range of disabilities that can make the roadside difficult to navigate.

Recommendation 9 Stakeholders should be recruited to represent a diverse a range of perspectives. Although it is not possible include representation of every possible advocacy and interest group, limiting involvement puts policy-makers at risk of overlooking important stakeholders in the community.

5.3.2 Safety Considerations

Safety is the primary responsibility of public authorities in managing public infrastructure, even more important that efficiency and equity. The insights from stakeholders draw attention to the need consider safety implications of every policy intervention. For example, a curb extension at an intersection that shortens the length of a crosswalk is intended to improve pedestrian safety. However, when that extension is constructed in front of a curbside bus stop, the infrastructure forces buses to maneuver back into the travel lane in a way that increases vehicle-bus crash risk.

Recommendation 10 The safety impacts of a curb management intervention should always be carefully considered in context. Changes to the curb infrastructure of policies for use can have both positive and negative impacts on safety that should be considered and monitored.

5.3.3 Coordination Among Multiple Agency Jurisdictions

The reality is that streets, curbs, and sidewalks are not controlled and managed by a single public authority. For example, a state highway may run through the heart of a town's commercial center where a planning for curb policies and sidewalks are handled by one department, but maintenance is handled by another. Implementing effective curb management policies requires that there be adequate coordination between the entities involved.

One way that this plays out in many communities in Massachusetts is in the handling of snow removal during winter months. Snow plowing on the street may be the responsibility of a different agency or department than snow clearance of sidewalks. It is not always clear who is responsible for keeping the curb itself clear. The problem is complicated by the fact that snow storage is an intended function for the curb in many places. Just as some communities ban street parking during snow events, it may be reasonable to dedicate the curb to snow storage in these cases, but this challenge that is not described in the existing literature.

Recommendation 11 Effective curb management policies require that authorities work to coordinate their activities and overcome compartmentalization of responsibilities. This particularly relevant for curb maintenance, including plans for snow removal.

5.3.4 Future Needs

The stakeholders from across the Commonwealth acknowledged that uses of curb are changing and are likely to continue changing in the future. This is especially true as vehicles are increasingly equipped with connected technologies, and automation appears to be on the horizon. There remains uncertainty about what these changes will actually bring. In the realm of connected vehicles, the opportunities of vehicle-to-curb communications for dynamic and active curb management are already being realized through app-based pricing and reservation systems. The expectation is that automated vehicles will be a development on the ride-hailing model, leading to increased pick-up/drop-off demands and decreased need for parking.

The stakeholders also raised the idea that priorities in the future will change, with the focus of curb management policies moving away from cars towards serving people. Although the future is shrouded in uncertainty, there is a clear need for flexibility in curb management policies so that the use of the curb can evolve with changing demands and technologies.

Recommendation 12 Technologies for curb management should be viewed as tools to support policy goals for curb functions. Therefore, technologies should only be adopted when appropriate for the context.

Recommendation 13 Curb management policies should be designed to be flexible so that they can change in response to evolving demands. As automated vehicle technology matures, there will likely be more clarity on the specific requirements of this new user case. Based on existing knowledge, all of the projected future trends support the idea of active curb management and flexibility to change curb use by location and over time.

5.4 Resources for Massachusetts

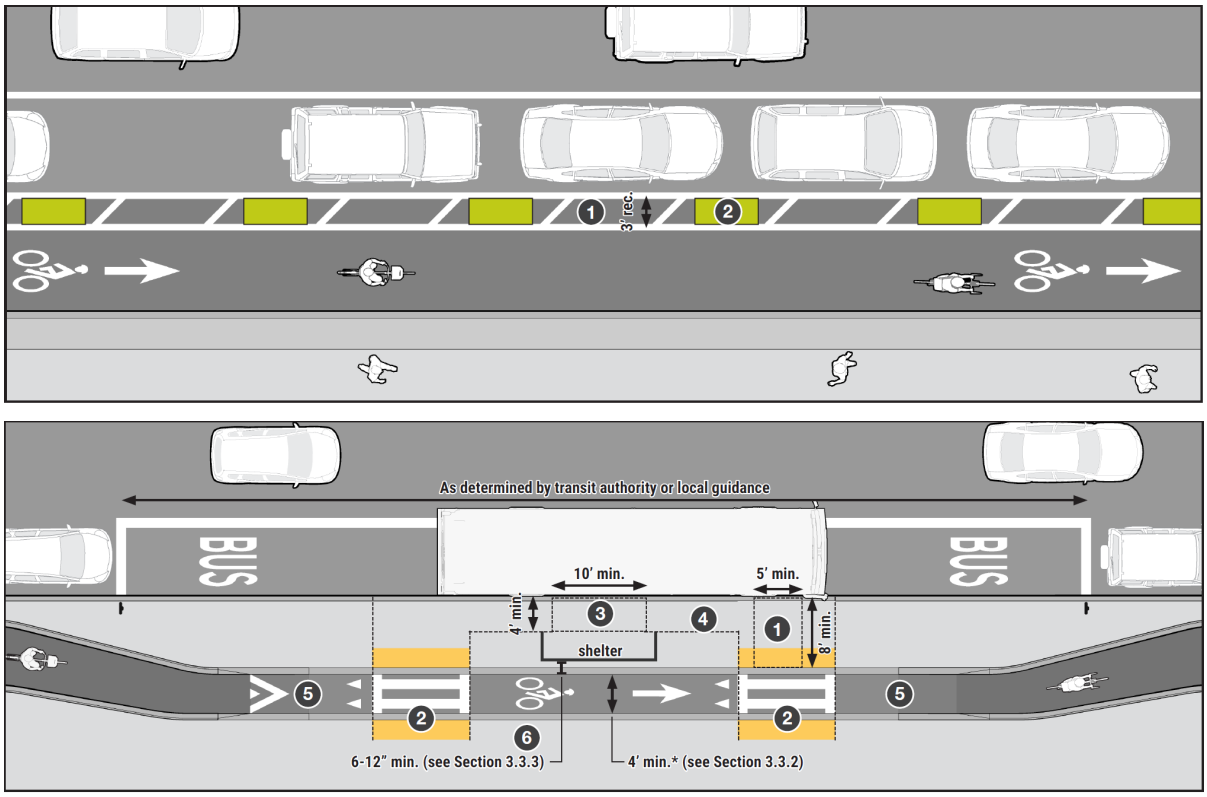
Communities in Massachusetts have several opportunities for funding support and guidance related to improvement of the curb. These programs are state-level initiatives that support prioritization of active transportation modes and holistic design in Massachusetts, which are intended to improve transportation sustainability, equity, and quality of life.

5.4.1 Separated Bike Lane Planning and Design Guide

The *Separated Bike Lane Planning and Design Guide* was published by MassDOT (2015) to provide design guidance for the implementation of separated bike lanes along streets. The document provides guidance on general design considerations and specification on things like the width of bikeways, materials, signage, and lighting. Chapter 5 of the design guide specifically focuses on design guidance for bike lanes around on-street parking, loading zones, and transit stops; examples shown in Figure 5.2. This detailed design guidance includes recommendations for positioning and dimensions of infrastructure to support bicycle use.

Chapter 7 of the design guide also provides recommendations for maintenance of separated bike lanes, many of which are applicable to curb management more generally. The design guide draws attention to the need for authorities to plan for:

- Maintenance plans and agreements (including clarifying responsibilities between public authorities and adjacent land owners)
- Sweeping and debris removal
- Trash collection
- Snow removal and de-icing in winter
- Repair and replacement
- Construction zones



* A bike lane width narrower than 5 ft. requires a design exception.

Figure 5.2 Separated bike lane design guidance for on-street parking (above) and transit stop (below), (Source: MassDOT, 2015)

5.4.2 Municipal Resource Guide for Walkability

The *MassDOT Municipal Resource Guide for Walkability* (2017) provides general guidance for communities across the Commonwealth to improve walkability and explains reasons why this is important. Guidance is provided for contexts from rural to densely populated urban areas. Although some guidelines are provided for preferred dimensions of pedestrian infrastructure, most of the guidance addresses planning-level considerations for what makes a community walkable and how to improve conditions for pedestrians to make walking safer and more attractive.

An important and useful part of the guide is a section on "ADA and Accessibility," which provides detailed design guidance for making pedestrian spaces accessible for all users. Design guidance is provided on surface materials, widths of clearances, allowable slopes and cross-slopes, driveways, and obstructions.

5.4.3 Complete Streets Funding Program

The idea of Complete Streets is to design street spaces that serve all users. The MassDOT Complete Streets Funding Program provides technical assistance and construction funding to municipalities across the Commonwealth that have had a municipal employees complete a

Complete Streets course and that have passed a Complete Streets policy. As of 2020, more than 90% of municipalities in Massachusetts have at least one employee that has received the required training. Submitted policies are scored, and those that include pedestrian, bicycle, transit, and at least two other modes (e.g., cars, freight traffic, emergency vehicles, etc.) receive the highest rating for "users and modes" (MassDOT, 2016). Under the Complete Streets Funding Program, the reward for eligible communities is $50,000 in technical assistance for developing a Complete Streets Prioritization Plan and $400,000 for construction.

In essence, a comprehensive curb management policy is consistent with the tenets of Complete Streets, because policies to manage the interactions at the curb can benefit all modes and road users of all ages and abilities. Communities that are already developing and implementing Complete Streets plans can incorporate curb management into these efforts.

5.4.4 Shared Streets and Spaces Program

In the summer of 2020, MassDOT launched the Shared Streets and Spaces Program to provide a total of $10 million funding support for municipalities that needed to make changes to their street space in response to the COVID-19 pandemic. An additional $10 million was made available through a second round called the Shared Winter Streets and Spaces Program, launched in November 2020. Curb improvements are one of the eligible uses of these funds, so this is an example of MassDOT providing funding support for curb management that adapts to the needs of the community.

6 Conclusions

6.1 Curb Management Practices and Recommendations for Massachusetts

Curb space management is something that every community should be thinking about. In some communities the need to act is urgent, driven by competing demands and congestion that affects the safety, economic efficiency, and quality of life. In other communities, changes that may not have been recognized or addressed were accelerated by the COVID-19 pandemic. The pandemic forced public authorities to respond quickly but also provided an opportunity for communities to rethink how their curbs are used now and in the future.

The guiding principles around curb space management are applicable across the Commonwealth and could serve as recommended practices for developing and implementing curb management policies, in general. Best practices are summarized by a cycle of steps to actively manage curbs as shown in Figure 6.1. These practices create a loop in which curb use and performance are assessed in an ongoing manner so that policies respond to the evolving needs of the space. This is a process that will help communities to identify the most appropriate curb management practices for their own context, which in some cases may be to make no changes at all.

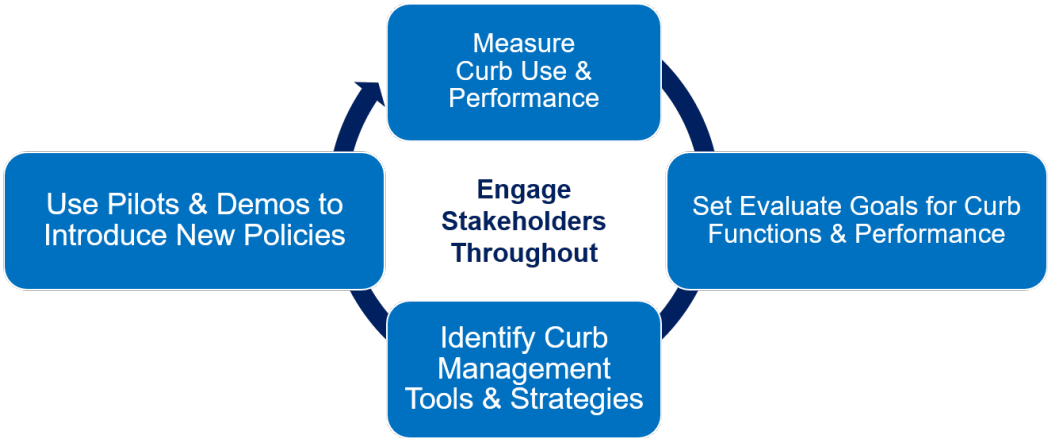


Figure 6.1 Recommended Practices for Curb Space Management

The diversity of community contexts across the Commonwealth of Massachusetts makes it difficult and inappropriate to make a blanket recommendation for specific curb management tools or strategies. The list of curb management tools presented in Table 3.3 includes solutions that are suitable for different settings, depending on the goals of the curb space. The lack of a one-size-fits-all solution requires each community to engage in a policy development process for curb space management.

The recommendations that come out of this study are intended to draw attention to challenges and opportunities that each community should consider in selecting appropriate curb management interventions. The most general conclusions from the literature review and stakeholder inputs may be summarized as following insights and recommendations:

1. *Effective curb management starts with data* – This requires identifying the curb's functions and measuring its performance.

2. *Policies should promote the "best" use of the curb space* – This depends on the context and the goals of the community. This will often include prioritization of uses other than on-street parking.

3. *Engage stakeholders* – Input and participation from stakeholders should be included throughout the process of planning and implementing new curb management strategies, especially those who can provide insight on the challenges and needs of vulnerable users.

4. *Use pilots and demonstrations* – Piloting changes on a limited space or timeframe allows information to be gathered about the effectiveness of new curb management strategies and build public support for successful interventions.

5. *Embrace active and flexible curb management practices* – This requires ongoing monitoring, evaluation, and modification of curb management strategies. This will position communities to adapt curb management to evolving demands.

As demands of the curb space change, communities are challenged to change curb space management practices as well. The trends at the curb, including increased ride-hailing activity, freight and goods delivery associate with e-commerce, and growing need to serve users other than cars have become apparent in communities across the Commonwealth, not only the Boston Metropolitan Area. Acute demands in the largest urban areas have forced cities like Boston to take curb management seriously and think creatively about solutions. Smaller towns in Massachusetts are not experiencing these changes uniformly, but the changes are coming none-the-less. Sooner or later each community will need to consider how their curbs are used and define curb management policies.

6.2 Future Research Needs

The scope of this study included review of the existing literature and analysis of stakeholder perspectives to identify best practices and guidance for curb space management that applies to communities across the Commonwealth of Massachusetts. Several research needs emerged through this analysis, which warrant additional investigation. The following research needs are related to understanding how the curb space is likely to be used in the future and how curb space management can adapt to meet those needs.

1. *Integration of Multiple Data Sources for Curb Space Management* – Effective planning and management of curb space requires data, and the relevant data comes from many different sources (see Section 3.3.2). There is a need for methods to integrate data from multiple sources into a common format that can be support decision-making in multiple contexts. With many communities of differing sizes and available resources, consistent methods of data collection and metrics of performance are needed to support the design, implementation, and evaluation of curb space management policies. Furthermore, the details of data ownership and access also have implications for the cost and functionality of curb space management systems.

2. *Additional Stakeholder Perspectives* – This study included perspectives from several stakeholders representing Transportation Planning, Transportation Engineering, Director of Policy, Project managers, and disability advocacy (see Section 2.2). There are additional perspectives that would also be useful for understanding the complete picture of curb space use, including public transit operators, waste collection, freight and delivery services, and event management.

3. *Connected Infrastructure* – Technologies, including GPS and internet-enabled smartphones, now allow for data be collected and information to be communicated between road users, the infrastructure, and the managing agency. It will be important to understand how peoples' attitudes and behaviors affect the implementation of these technologies and related policies for curb space management. These technologies already exist in some forms, such as smart parking systems, but there is potential for connected infrastructure to be used to implement policies that are adaptive and dynamic in handling diverse demands at the curb.

4. *Automated Vehicles* – The development of automated vehicle technologies is changing the driving experience, and the impacts of high levels of automation (SAE Levels 4 and 5, see Section 3.5.2) are still unknown. As technologies increasingly take over driving tasks from humans, peoples' attitudes and behaviors toward driving, parking, and use of other transportation modes will have implications for how curb space is used. Additional research is needed to understand how automated vehicle technologies will affect passenger pick-up and drop-off activities, deliveries, and interactions between AVs and other road users. Future curb space management policies and practices will need to account for these changes.

The existing literature on curb space management includes a variety of policies and technologies that have been implemented to handle the diverse demands of the curb. Although much of the recent innovation has been in large urban areas, cities and towns of all sizes are beginning to rethink curb space policies to meet the evolving needs of the community. One common theme is the need for curb spaces that can adapt as demands change, which was made clear as communities were compelled to engage in active curb space management during the COVID-19 pandemic. As technologies change the ways that people travel and goods are delivered, activities at the curb will continue to change as well. With open minds and a spirit of innovation, the future of the Commonwealth's curbs will be adapted to serve communities across Massachusetts.

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