Curb Management Practices and Effectiveness in Improving Safety

November 2022 | Final Report

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TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. 05-096	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Curb Management Practices and Effectiveness in Improving Safety		5. Report Date: November 2022 6. Performing Organization Code:
7. Author(s) Todd Hansen Zachary Elgart Stephen Bell Zhiheng Hu Nick Wood Andy Alden		8. Performing Organization Report No. 05-096
9. Performing Organization Name and Address: Safe-D National UTC Texas A&M Transportation Institute The Texas A&M University System College Station, TX 77843-3135 Virginia Tech Transportation Institute 3500 Transportation Research Plaza Blacksburg, Virginia 24061		10. Work Unit No. 11. Contract or Grant No. 69A3551747115/ Project 05-096
12. Sponsoring Agency Name and Address Office of the Secretary of Transportation (OST) U.S. Department of Transportation (US DOT) State of Texas		13. Type of Report and Period Final Research Report; Start Date: 1/1/21 End Date:11/30/22 14. Sponsoring Agency Code
15. Supplementary Notes This project was funded by the Safety through Disruption (Safe-D) National University Transportation Center, a grant from the U.S. Department of Transportation – Office of the Assistant Secretary for Research and Technology, University Transportation Centers Program, and, in part, with general revenue funds from the State of Texas.		
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17. Key Words Curb management, curbside management, safety, vehicle safety, pedestrian safety, conflicts, encounters, curbside zones, passenger pickups and dropoffs, pickups and dropoffs, freight loading and unloading	18. Distribution Statement No restrictions. This document is available to the public through the Safe-D National UTC website, as well as the following repositories: VTechWorks, The National Transportation Library, The Transportation Library, Volpe National Transportation Systems Center, Federal Highway Administration Research Library, and the National Technical Reports Library.	

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 46	22. Price $0

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Abstract

Curbside access has been a growing concern in cities over the last decade as on-demand passenger or goods transportation services have proliferated. Increased activity at key loading and unloading points may increase the risk of crashes and collisions between vehicles or with nearby active travelers as vehicles maneuver to access curbside spaces and others maneuver around them. This research project investigated linkages between curb management practices and safety among travelers as vehicles navigate to and from designated curb zones within a multimodal urban environment. The project analyzed the effectiveness of curb management practices in improving safety through reduced collisions between vehicles and other travelers. The project also investigated existing curb management practices across the United States to understand safety considerations and related perspectives of cities, community stakeholders, and industry organizations. The team collected video data of curbside zone utilization in Roanoke, Virginia, and synthesized observed interactions for analysis of a small city curbside zone site. The results include interview and focus group discussions on curb management and safety considerations as well as discussion of the approach and method for primary data collection in measuring curbside safety.

Acknowledgements

The project team would like to extend a thank you to the staff from the following agencies and firms for sharing their knowledge and experience to inform this research:

City of Roanoke, Virginia

San Francisco Municipal Transportation Agency

Transportation For America

City of Columbus, Ohio

Greater Williamson Road Area Business Association

Pebble

EasyMile

City of Louisville, Kentucky

City of Hollywood, Florida

Chattanooga Area Regional Transportation Authority

This project was funded by the Safety through Disruption (Safe-D) National University Transportation Center, a grant from the U.S. Department of Transportation – Office of the Assistant Secretary for Research and Technology, University Transportation Centers Program, and, in part, with general revenue funds from the State of Texas.

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Introduction

Vehicle uses at the curb such as parking, loading and unloading goods, or fixed-route transit service have always been important for curbside management planning. However, the recent proliferation of on-demand passenger transportation and goods delivery services have created increased demand at the curbside. Increased activity at key loading and unloading points may increase the risk of crashes and collisions between vehicles or with nearby active travelers as vehicles maneuver to access curbside spaces and others maneuver around them. Without further understanding of what constitutes effective curb management, safety outcomes at busy intersections and pedestrian activity centers may worsen through increased vehicle crashes or near-misses with other vehicles and active travelers (such as ambulatory pedestrians, pedestrians with mobility devices, cyclists, scooter-riders, and people riding transit and other shared mobility services). This project explored how agencies can use curb management to improve safety for all pedestrians, micromobility travelers, and vehicles by investigating linkages between curb management practices and traveler safety as vehicles navigate to and from designated curb zones in multimodal urban environments. The research reviewed existing curb management practices within the United States, focusing on technology, temporal management, street design and infrastructure, zoning for mode uses and prioritization, traffic monitoring, policies and regulations, permitting and monetization, and enforcement. The team also gathered data and insights on curb management practice safety outcomes via secondary data collection and primary video collection and data synthesis of activity at a small city curbside zone site. The report highlights key findings from interviews with city transportation staff members, community stakeholder organizations, and private industry, along with findings from focus groups with local business vehicle drivers, business owners near curbside zones, and local travelers in two case study cities. While further development of safety goals and measurement practices is needed to increase understanding of safety at the curb, this report provides information uncovered on the topic during the project.

Background

This section provides background on curbside and parking management practices in U.S. cities and their relation to safety considerations and outcomes.

Curb Management Overview

The curb, by definition, is a public space along the street between travel lanes, where the vehicles move, and the sidewalk, where pedestrians walk—the nexus between the roadway and pedestrian realms (*1*). This connecting point of public space is increasingly attracting the attention of city leaders and private industry for how to use it safely and efficiently. Curb space serves many functions, including parking for vehicles, safe separation for pedestrians, bus landing pads for transit service, adjacent travel paths for bike lanes, access to water drainage, and pickup and dropoff locations; this last use has increased over the past decade as more ride-hailing, freight,

goods delivery, and related activities have grown in cities across the country. In addition, curb use by emerging transportation modes such as shared mobility and micromobility influences the role of curbside space within the greater transportation system. Recently, many cities have piloted curbside management programs to balance accelerating demand and limited public space. Curbside management aims to improve the mobility and safety of all users by developing an organizational scheme that considers space constraints. However, curbside management also intersects with political and economic challenges to determine priorities for mobility access while ensuring safety for travelers.

Safety is an essential topic at the curb due to its various functions playing a role in today's transportation system. There are numerous potential ways to judge the safety issues for curbside space, including curb access events, near-misses, curb-related collisions among pedestrians, bicycles, and vehicle violations (*2*). A pilot for a dynamic curbside management system in Washington, DC, measured the safety implications of curbside zones by logging incidents of double parking and illegal turns. A similar pilot in Columbus, OH, surveyed drivers on these behaviors; crash incidents were notably low in both locations during the pilots, but near-misses were not recorded (*3*). Designated ride-hailing pickup and dropoff zones can provide travelers with safe waiting sites at designated landmarks with appropriate signage (*4*).

Policies, Regulations, and Planning

Regulation and enforcement allow cities to manage curbside spaces better, requiring vehicle operators to park in legal zones and adhere to efficient loading times or practices. In areas with high demand for loading, there can be an undersupply of loading zones (leading to double parking behavior). Curbside zones can help drivers find a temporary parking space for short-term use. On-demand pricing based on zone utilization is another option to manage demand (*5*). Several cities have implemented programs to help manage short-term loading and pickup/dropoff zones.

- In 2008, the San Francisco Metropolitan Transportation Agency's (SFMTA) Color Curb Program created loading and short-term parking zones using three colors to note passenger loading, commercial loading, or short-term parking uses (*6*, *7*).
- The Seattle Department of Transportation (SDOT) developed their "Final 50 Feet" concept for urban freight to improve the efficiency of the street network and the city's vertical spaces, reduce truck dwell times, and reduce failed first deliveries (*8*).
- The District Department of Transportation (DDOT) in Washington, DC, developed their K Street pilot program in response to issues generated by a lack of available curb space. Under the pilot program, carriers can obtain information about loading zones using an interactive map and can pay the loading zone fee (*9–11*). Subsequently, DDOT's Nightlife Restriction Pilot developed curbside zones in key high-demand areas (*12*).
- The New York Department of Transportation implemented the "Clear Curb" program at three pilot locations. Under this program, commercial loading is prohibited during morning

and afternoon rush hours on weekdays, while rapid loading/unloading of passengers at the curbside are allowed (delivery of goods must occur at off-street loading locations) (*13*).

- Columbus, OH, implemented an intelligent parking network that dynamically changes pricing and time limits for parking meters based on observed demand. The city also piloted loading management zones to measure commercial vehicle activity in priority areas (*3*).

Policy and Planning Initiatives

On-street parking is a vital component of developing residential areas and commercial districts. It provides space to park near residences and businesses while also allowing transportation services to pick up or drop off their customers. Additionally, on-street parking offers a buffer between pedestrians and motorized traffic, helping to increase safety and reduce noise for sidewalk users. Cities can also use off-street parking availability to decrease on-street parking on congested streets or high-demand locations (*14*). In areas with significant demand, agencies may use time-of-day restrictions to reduce traffic and emissions caused by vehicle cruising (*2, 15*).

The interplay of different travel modes around the same space can lead to crashes and congestion in dense urban cores. Layered networks and priority classifications for different roadway segments can ensure all users are served effectively (*2*). Tactical urbanism (i.e., "pop-up urbanism" or "living previews") is another tool planners use to test the viability of proposed improvement projects via temporary installation; these implementations allow residents to interact with the project and leverage direct experiences while enabling real-time modification to ensure the proposal operates well. For example, part of San Francisco's Vision Zero Plan improved curb access by implementing loading zones, separating bike lanes from vehicle traffic, and testing parklets at temporary locations along a corridor segment (*2*). The COVID-19 pandemic allowed cities to implement new temporary curbside uses such as restaurant pickup zones, essential service provider parking, and expanded sidewalks while relaxing payment and enforcement at spaces (*16*).

Infrastructure and Geometric Design

Areas with high-demand transit volumes may need to eliminate potential conflicts between motor and non-motorized vehicles for safety concerns. Protected bike lanes can encourage transit ridership while lowering the risk of crashes (*17*). For example, a 2011 project in Seattle grew bus ridership by 40 percent and decreased collisions by 19 percent while overall traffic increased (*18*). Cities can also optimize road lanes in corridors to reduce the conflicts among motorized vehicles. For example, a longer peak-period transit lane can extend the queue jump lanes on some streets where multiple transit lines come together, allowing buses to park at off-peak times while still avoiding the queue jump lanes. SDOT initiated a road diet program that converted a busy four-lane street into one lane with the center left-turn lanes and parking, improving pedestrian safety and providing an opportunity for riders to use short curbside lanes during peak times (*8*).

Curb Management Practices

This section outlines some examples that provide valuable lessons for good curb management strategies, including the latest transportation technologies and commonly used treatments.

Dropoff or Flexible Zones

Dropoff or flexible curbside zones can allow cities to allocate curb use by priority and local context. For example, SDOT implemented flex zones to serve different purposes at different times, such as serving commercial and passenger loading in the same location or separating other functions along the curb block (*2, 8*). In addition, agency staff in Washington, DC, implemented pickup and dropoff zones within the Dupont Circle neighborhood to address increased traffic from ride-hailing vehicles; this included reallocating parking spaces as passenger loading zones and improved signage (*10*, *13*, *19*, *20*). Boston implemented a program in key areas that replaced metered parking with designated passenger loading zones between 5 p.m. to 8 a.m. every day, working with transportation network companies (TNCs) to geofence these zones in their digital platforms and decreasing passenger pickup and dropoff activity in local active travel lanes (*21*).

Parking and Pricing

Cities have also utilized new technologies in parking monitoring, payment, and customer information. SF Park in San Francisco adjusts the metered parking rate according to real-time parking demand and provides parking information (pricing and availability) on their smartphone app; this system decreased congestion while parking availability increased (*22*). The parkDC pilot program expanded the city's desired usage of block faces by 10 percent while reducing illegal parking in loading zones through pricing adjustments in these spaces (*23*, *24*). Older parking management solutions such as residential parking permit programs maintain access for residents by displaying a decal in the vehicle (*25*). However, permitting programs must be cautious not to overcommit available parking by issuing too many permits beyond curbside capacity (*26*).

Curb and Safety Data Sources

Cities have also used data science on traffic and curbside utilization, some of which can be provided through agreements with private technology companies to create more robust curbside management practices. This section offers descriptions of some of these companies and public initiatives in the curb data space as examples (not endorsements):

- CurbFlow coordinates commercial operator activity at designated pickup/dropoff zones (*27*).
- SharedStreets is a shared digital platform for data exchange of street information, including curb space regulations (*2*).
- Pebble (previously named Coord) provides a digital platform for cities to manage curbside areas through collected data (*28*).
- The Los Angeles Department of Transportation uses a public digital inventory of its parking meters and regulations for planning (*10*, *29*).
- The Open Mobility Foundation digitizes data of curbs and developed an application programming interface for curb regulations (*30*).
- Automotus uses video analytic technology to collect the data for curbside spaces for city management in the planning and enforcement of commercial vehicles (*31*).

- In Santa Monica, CA, DTSM and Open Curbs provide a digitalized map of curbside information and utilization by different vehicle types in curbside zone locations (*32*).

Technology Deployments and Infrastructure

Emerging technology will continue to revolutionize traditional urban management planning and regulations strategies. At the curbside, planners and engineers will connect curb zones to autonomous vehicles (AVs) and connected infrastructure such as monitors, sensors, and other technologies. In anticipation of an AV future, engineers and planners have launched pilot blueprints of AVs for better city management to address traditional transportation problems such as congestion and crash incidents. Though uncertain, AV fleets could potentially result in decreased road congestion compared to traditional vehicles (*33*). In addition, AV cruising capability could reduce parking demand in critical locations in concert with peripheral parking after dropoffs at curbside zones (*34*). These activities would increase the need for limited curb space and detailed curb management (*35*). The evolution of AV technology has the potential to release curb space currently dedicated to parking for improved land uses and travel (*36*).

Research Questions:

This research attempts to fill this gap by addressing the following questions:

- What specific safety issues occur at curb areas with pickups and dropoffs?
- How have curb management practices and technologies addressed identified safety issues?
- What are the differences in safety outcomes between well-managed and poorly or unmanaged high-demand curb areas?
- What municipal regulations, permitting, and enforcement actions help enable safer curbside areas?
- How do municipalities identify key curbside areas for intervention and prioritize different travel modes at those locations?
- How are the needs of people with disabilities and marginalized populations addressed and prioritized for safe travel at curbsides?
- What are the differences in curb management between larger and smaller urban areas?

Method

This section presents an overview of the methodology. Additional details appear in the appendices.

Literature Review and Industry Scan

A literature review identified the current curb management practices and technologies that municipalities and regions have imposed on public and private vehicle fleets in the U.S., concurrently serving as an industry scan of cities with relevant pilots or programs. The research team reviewed published research, documentation, and guidance on curbside management and any information on the safety of travelers at the curb or in the adjacent sidewalk or roadway areas. This

review established further background on curbside management and identified current gaps in techniques or data sources in measuring safety. The research team also tracked city practices in curbside management identified in an industry scan.

Case Study Selections

The research team used the information from the industry scan to determine key cities of interest for a further case study based on evidence of different regulatory, technological, and operational approaches to curb management. The research team reached out to contacts in these cities for informal discussions about their practices, pilots, and programs concerned with curbside management, available reports and data, and interest in participating in this research project. Staff members from SFMTA in San Francisco provided additional information on their efforts as a large city example. Meanwhile, staff members at the City of Roanoke, VA, participated as a small urban area case study and approved further data collection for the research project.

Data Collection and Analysis

The research team worked with staff from the Transportation Department at the City of Roanoke to gather available traffic and safety secondary data over the previous three years (2019, 2020, and 2021) and additional information on curbside zones in downtown Roanoke. This section discusses the secondary data sources used to select the primary data collection location, methods used for primary data collection, and processes for the data analysis.

Site Selection for Small City

The research team looked at historical traffic volumes and crash incidents over the past three years on Roanoke roadways, either from data provided by the city or available through the Virginia Department of Transportation. The traffic volume data included average daily vehicle counts and scooter usage, while crash incident data was available for specific street locations, dates, and vehicle types. Next, the research team compared this data to locations of curbside pickup, local public transit services, sidewalks, intersections and traffic controls, and neighborhood activity centers. Ultimately, the research team and city staff selected a curbside pickup location with two loading spaces on Campbell Ave (Figure 1) due to its proximity to local dining and market establishments and relatively high daily traffic volumes. The two loading spaces at the location are available to be used for free up to 15 minutes; other street parking is available on Campbell Ave at pay meters, while off-street parking is available at area surface lots and garages. Park Roanoke is responsible for enforcing parking rules, periodically conducting on-foot patrols, and taking pictures of vehicle license plates with time stamps.

Figure 1. Curbside zone on Campbell Ave in Roanoke.

Primary Data Collection

After site selection, the research team placed cameras aimed at the site roughly 10 to 11 feet above the roadway on nearby street light posts with powered outlets. Site recording occurred for seven days to capture traffic and curbside pickup location usage in a typical week. The research team set the cameras to record once motion was detected in the field of view. Several criteria influenced camera locations, such as weather resistance and dynamic video recording (instead of continuous).

Data Coding and Dictionary

The data coding for this video analysis was distinct to the project and different from efforts in other cities such as Washington, DC, and Columbus, OH (*3*), focusing on potential safety conflicts between different types of travel modes (vehicles or pedestrians) while recording the times of vehicles utilizing the curbside spaces. Data on pedestrians and micromobility users (cyclists or scooter riders) was recorded in cases of individuals or groups of people crossing the street at the midblock or riding their vehicle inappropriately (i.e., this data does not represent full counts of pedestrians and micromobility users during the observation period). Within broad topic categories (vehicles/travelers, zone, and street information) are data categories for coding observations. The data categories are outlined below, with more detail on category definitions in Appendix A.

- Vehicle/Traveler Information
    - Date: month, date, and year of the event logged
    - Day: day of the week of the event logged
    - Vehicle/Traveler Ref #: internal reference number for the vehicle or traveler in the event logged; typically done in sequence for a given day using an alphanumeric combination
    - Type: the type of vehicle using the curbside zone
- Zone Information
    - Zone Spot: indicates which space in the curbside zone was used
    - Parking or Temporary Use: indicates whether a vehicle parked in the curbside zone space for an extended period
    - Zone Placement: indicates whether the vehicle was parked entirely within the space

    - Zone In Time: starting time for use of the curbside zone
    - Zone Out Time: ending time for use of the curbside zone
    - Zone Event Type: indicates a conflict or encounter between the vehicle in the curbside zone and another party
    - Zone Event Severity: indicates the level of severity in the conflict or encounter
        - A – conflict with contact
        - B – conflict no contact
        - C – encounter only (not close enough for conflict)
    - Other Party Type: indicates whether the other party in the conflict or encounter was a pedestrian or used some type of vehicle
    - Other Traveler #: internal reference number for the vehicle or traveler representing the other party in the conflict or encounter
- Street Information
    - Lane or Sidewalk & Direction: traveling direction of the other party on either the sidewalk or in the street/throughlane
    - Ped/Bike Event: indicates the direction of the other vehicle in the conflict or event
    - T-l or Sw Event: indicates the type of unsafe travel behavior in the throughlane (i.e., T-l) or on the sidewalk (i.e., Sw)
    - T-l or Sw Start Time: indicates the start time for the other traveler
    - T-l or Sw End Time: indicates the end time for the other traveler

Once the recording was completed, the research team retrieved the cameras from the sites and saved the footage to a secure server. Using the data coding designed for this study, the footage was saved for data collection. The data coding for vehicles consisted of recording the time a vehicle entered and exited the zone, the location within the zone, the type of vehicle, the vehicle's purpose of using the zone, and what events and/or conflicts may have occurred to or by that vehicle. Other observations recorded included pedestrians/groups who crossed from either side of the road, automobiles performing unusual or unsafe maneuvers in the road (e.g., swerving or U-turning), and micromobility vehicles riding on the sidewalk or driving the wrong way. If any conflicts were to occur (either vehicle-vehicle or vehicle-pedestrian), the event was assigned a level of severity based on observations during the event.

Analysis

Researchers analyzed video data collected from the Campbell Ave location for information on space utilization at the curbside zone and possible unsafe activity from local travelers (either vehicles or pedestrians) around the site, using the data coding method developed to capture the number of instances by time of day and day of the week to determine any patterns in the use of the curbside spaces, frequent occurrences of vehicle types involved, or unsafe travel actions.

Expert Interviews

To learn more about the efforts to manage the curb area, the research team interviewed government staff and regulators, service providers and technology companies, and related entities (e.g., business improvement districts) in San Francisco and Roanoke. After collecting contact information for potential interview participants, the research team emailed each person to explain the project and invite them to meet with the research team. In total, the research team conducted 14 interviews. Appendix B presents the discussion guides used with each cohort.

Focus Groups

Focus group participants were recruited in multiple phases beginning with a list of contacts provided by city partners in Roanoke, VA, and San Francisco, CA. After the research team contacted these potential participants, the identification of additional potential participants occurred via internet searches of pedestrian and bicycle membership organizations, business organizations, and online forums for vehicle operators. Any potential participants identified through the search received invitations to participate. The research team also placed advertisements on Craigslist about the opportunity to participate in focus groups. In total, 30 people expressed interest in participating in one of the focus groups, and 15 people participated.

The research team facilitated discussion in each focus group in four broad categories with slight variations according to participant experience (e.g., Local Travelers, Business and Property Owners, and Vehicle Operators), as presented in Table 1. Appendix C presents each focus group discussion guide, and Appendix D presents a complete focus group summary.

Table 1. Focus Group Discussion Themes and Questions

Theme	*Local Travelers Questions*	*Business and Property Owners Questions*	*Vehicle Operators Questions*
Travel Environment	– What is it like to travel in the area you call home?	– What is the area around your site like?	– What is it like where you typically work?
Travel Mode Choices	– First and second mode choices? – Comfort as a pedestrian? – Ever used taxi, ridesourcing, or scooter/bike-share? – Did COVID-19 alter your mode choices?	– How people typically arrive? – Incentivize the use of non-auto modes? – Provide parking (cars, bikes, or scooters)? – Know about the curb zones nearby?	– What type of driving job do you currently do? – Have you ever worked as a driver in another role?

Theme	*Local Travelers Questions*	*Business and Property Owners Questions*	*Vehicle Operators Questions*
Access and Delivery Needs	– Experience around the curb when using ridesourcing or delivery? – Specific knowledge of your city's curb policies?	– Site access needs? – Describe deliveries (if at the curb, what could be better)? – Ever worked with local entities to coordinate transportation service? – What impact might AVs have on access to your location?	– Curb access needs? – Ever worked with another entity (city, venue, etc.) to facilitate transportation to a specific destination (if so, how did it work)?
Safety Concerns	– Any safety concerns related to navigating the curb area or intersections? – Concerns change when traveling in other areas? – Would AVs change your safety perceptions (how)?	– Concerns about customers/tenants navigating curb area or nearby intersections? – Would AVs change your safety perceptions (and how)? – How should the curb be managed (ad-hoc or formalized)?	– Concerns when navigating the curb area or intersections? – Will AVs affect your role in the industry? – Would you prefer to act in an AV support capacity? – How should the curb be managed (ad-hoc or formalized)?

Results

This section discusses the results and key findings, including information from interviews with city and industry stakeholders, outcomes from virtual focus groups in San Francisco and Roanoke, and analysis of data collected at the Roanoke curbside pickup location during June 2022.

Cities and Industry

Interview discussions with city staff members at Roanoke, San Francisco, and other cities engaged in parking and curbside management in the U.S. generated key findings on current curbside management and safety practices. Further interviews were conducted with technology companies, local organizations, and advocacy groups to get additional perspectives on curbside safety. The following section presents key takeaways from these discussions; further information synthesized from these interviews appears in the supplemental brief to this project report.

Safety Integration

- Many cities do not have a comprehensive set of safety goals beyond implementing safe design practices and minimizing injuries/fatalities on roadways. Vision Zero initiatives have been adopted by some cities/DOTs, aiming to improve roadway safety to the point of zero vehicle collision fatalities occurring in a year.

- Cities are challenged with a lack of resources to provide consistent and up-to-code infrastructure across their street and sidewalk networks. Lack of available space on a given street can also create challenges in implementing the best designs or complete streets that will improve safety and accessibility for all travelers.
- Looking for places with higher amounts of pedestrian crossings can identify key places of interest for safety. Space allocations for certain types of parking and loading activity should also be measured to ensure vehicles can safely enter and exit the curbside.
- Tracking locations and attributes of data for fatalities and incidents in traffic collisions is a common but reactive practice. Likewise, activity data on double parking, illegal parking, and vehicle violations can help identify potentially unsafe areas.

Prioritizing Access and Improvements

- Priorities for parking access can vary at different times of day in key traffic attractor areas, particularly where different types of commercial and private vehicles use the space in the morning versus the afternoon or evening.
- Businesses and other property owners are critical to the conversation of curbside areas to receive input, facilitate buy-in of determined locations, and increase understanding of curbside management policies.
- Data inventories are helpful planning tools for knowledge of current resources and areas where either infrastructure improvements or curbside interventions can be targeted. Digitizing regulations as part of these inventories can also be helpful for this process.
- Implementations of technologies for parking (i.e., smartphone apps and parking pay zones) need to be sensitive to the population groups that would use said technology to access the curb space (ex., lower income individuals).
- Quick-build projects at curbs and sidewalks can be a way for cities to make needed improvements to the pedestrian pathway sooner rather than waiting to include them in larger capital corridor improvement projects.

Planning and Decision-Making Challenges

- Obstacles on sidewalks (either temporary or fixed) and infrastructure for other modes of travel (i.e., micromobility) can decrease accessibility for pedestrians with disabilities.
- Dynamic parking rates and the removal of parking meters can affect low-income individuals' curb access. However, cities can proactively create reduced rates and alternative payment options for these groups.
- Safety challenges resulting from sidewalk space used by people experiencing homelessness can be addressed in alternative methods to citations and barriers, including sidewalk widening and resources for housing and immediate needs.
- Cities should also consider the effects of construction, special events, holidays, and types of businesses on street corridors on planned curbside access to determine if additional mitigations are needed to manage traffic and safety.

Curbside Policies and Pricing

- Higher pricing and time limits at parking/curbside spaces are typical tactics for cities to encourage vehicle turnover. Additionally, offering free parking at off-street locations is a way to encourage vehicles to move away from higher demand areas.
- Often cities have different departments that determine the locations and policies of curbside zones and parking spaces versus the enforcement of those polices. In some cases, better coordination between different groups may be needed to achieve access and safety goals.
- On-foot enforcement of curbside use by vehicles is typical but sometimes ineffective if not applied consistently (throughout the day, to different areas, etc.). Newer technologies can be beneficial for vehicle monitoring and collecting data for planning purposes.

User Perspectives

Focus group and interview discussions with Local Travelers, Business and Property Owners, and Vehicle Operators generated detailed information about each group's experience interacting with the curb environment, as presented in Appendix D. The following sections present key takeaways from each group of participants.

Local Travelers

The local traveler interview participants present four unique perspectives and lived in different parts of Roanoke—however, some commonalities emerged:

- Use of taxis and ridesourcing in the Roanoke area was not a common mode choice for any of the participants.
- Three of the four participants have either experienced or witnessed issues and safety concerns during ridesourcing pickup/dropoff.
- All participants agreed that safety in Roanoke is a significant concern both on sidewalks and at intersections.
- Three of the four participants feel unsafe using shared scooters in Roanoke.
- All participants could imagine safety benefits from AVs, but each also had some concerns about reliably safe performance (e.g., identification and avoidance of people on bicycles).

Business and Property Owners

Only one entity—a restaurant in downtown Roanoke—agreed to participate in the focus group process, but the business was well established and able to draw from many years of experience.

- Curbside pickup/dropoff spaces are helpful for the business in concept; however, current spaces are not located in useful places, and the managing entity for the spaces did not conduct meaningful outreach with the businesses that could use such spaces.
- Due to a lack of bicycle parking and fear of theft, the business allows bicycle riders to park inside the restaurant.

- AVs seem to present the opportunity to help people get around town who do not have other options, either due to transit gaps or lack of a personal vehicle.
- Restaurants throughout downtown would have benefited from conversion of curbside parking to dining areas during the COVID-19 pandemic, but this was not permitted.

Vehicle Operators

Participants in the vehicle operator focus groups shared their experiences working in delivery, ridesourcing, and limousine transportation jobs. As with the local traveler group, despite diverse experience and perspectives, some commonalities emerged:

- Additional time, patience, and awareness are often required to operate safely in the curb area.
- Dedicated curb space for pickup/dropoff of both passengers and goods is limited in San Francisco and Roanoke, and vehicle operators would benefit from additional curb access in both markets.
- It is helpful to study the area of operation ahead of time to understand traffic patterns, good and bad times to be in certain areas, and the rules/regulations that govern traffic, intersections, and curb areas.
- All participants agreed that blocking other vehicles while working results in other road users exhibiting frustration and aggressive behavior.
- Nine participants were cautious about the potential safety improvements from AVs (citing issues such as sensor failure or overly cautious/unpredictable driving), and all acknowledged that their jobs are at risk because of AV technology.
- Clear communication about policies that govern the curb is critical for their success.

Curb Zone Usage and Impacts

The observations from the video data collected at the curbside site in Roanoke yielded the following results on curb zone usage and possible impacts on safety behavior. The results in this section do not represent a statistically significant sample but rather a snapshot of one zone.

Overall Utilization

The research team logged the number of vehicles, vehicle types, and purposes of those vehicles in using the two curbside 15-minute parking zone spaces (as could best be determined based on visual evidence) for the equivalent of a one-week period. Figure 2 shows the daily usage of the two curbside spaces by day of the week; the curbside area was accessed at the greatest levels on Wednesday through Friday, with slightly lower levels of parking or loading/unloading on Saturday. Unsurprisingly, Sunday had the lowest number of vehicles using the two spaces, though Monday was not much higher in utilization, which may be a symptom of some local restaurants and businesses on the street block being closed early in the week.

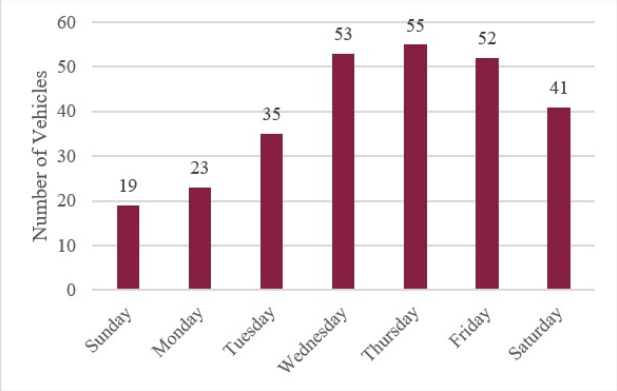

Figure 2. Total vehicles in curbside zone, by day.

Error! Reference source not found. shows the percentage breakdowns and average time parked in the two curbside spaces according to vehicle type and observed parking or temporary use by the vehicle driver during the one-week equivalent period; percentages are calculated based on the total 277 vehicles parked.

Table 2. Vehicle Types and Uses in Curbside Zone Observations

Vehicle Type	Percent of Vehicles	Average Time (min)	Parking or Temporary Use	Percent of Vehicles	Average Time (min)
Emergency	0.7	0:05	Food Delivery	1.5	0:26
Food Delivery	0.4	0:02	General Delivery	0.7	2:52
Freight	1.4	0:15	Parcel Delivery	2.6	0:15
Other Business	1.8	0:38	Parcel Pickup	0.7	0:08
Package	0.7	0:12	Parked	54.1	0:58
Personal	88.4	0:41	Passenger Dropoff	3.4	0:01
Specialty	0.7	0:01	Passenger Pickup	2.2	0:02
TNC	5.8	0:04	Restaurant Pickup	34.7	0:08
Total Vehicles	**277**	**0:37**	**Total Vehicles**	**268**	**0:37**
-	-	-	No Use Determined	3.2	1:07

The vehicles using the curbside spaces most frequently were personal vehicles, meaning privately owned automobiles that did not appear to be associated with a business or other organizational entity; these vehicles accounted for 88 percent of overall users in the observations. The next highest group was TNCs at nearly 6 percent, which points to the spaces being successfully used for safer passenger pickups and dropoffs. Freight vehicles and other general business vehicles each made up around 1 to 2 percent of the curbside zone users. TNC usage may be higher than observed, but without any visual method to determine whether a vehicle's zone use is TNC or personal, such as a company logo or branded carryout bag, some TNCs may have been entered as personal vehicles. The personal vehicles category likely includes unconfirmed TNC passenger trip and delivery services. For parking or temporary uses, over half of the observed vehicles (54 percent) were

parked in the spaces for an extended period and did not appear to either pick up or drop off any goods or passengers (though the former may have occurred off camera). Pickups for to-go/takeout orders from local restaurants were also a frequent use of the curbside zone (around 35 percent of vehicles), which points to the spaces successfully helping people access area businesses for a temporary period. Delivery of food, freight, or parcels also occurred using the spaces, but to a lesser extent than the aforementioned use categories.

The research team also measured space utilization time from when a vehicle parked to when it left, keeping in mind that the curbside zone allows for up to 15 minutes of occupancy at all times of day. Figure 3 shows total parking time in the curbside zone during the observation period by 15-minute increments; around three quarters of all users were within the allowable 15-minute maximum, meaning the average utilization time was skewed by the minority; this points to overall good compliance by vehicles. Average time for space utilization varied depending on vehicle type or purpose; personal vehicles and other business vehicles averaged around 40 minutes of space utilization. Passenger pickup and dropoff were notably short in average utilization time, around 1 to 2 minutes each. Restaurant and parcel pickups were both around 8 minutes each. During the video analysis, the research team did not identify any parking enforcement for the curb zone.

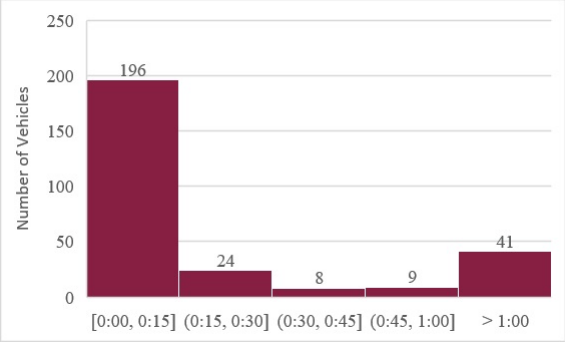

Figure 3. Total parking time, by time increments.

Trends in Compliance

The research team looked at average parking time by day of the week and by time ranges in 15-minute increments. Figure 4 shows the average parking time by day for all vehicles, with the overall average being higher than 15 minutes for any day (Sunday being the highest).

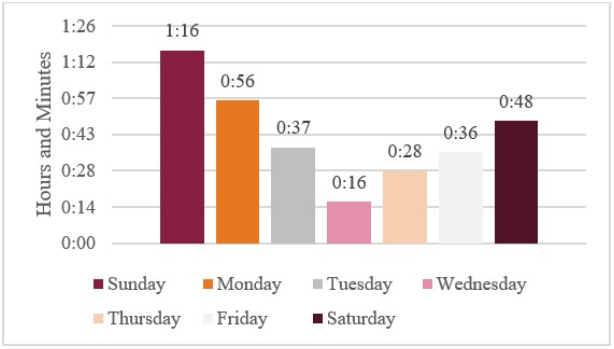

Figure 4. Average parking time in curbside zone, by time ranges.

Active Travelers

The research team logged only pedestrian, e-scooter, and bicycle travelers who were traveling unsafely or illegally in the study area around the curbside zone. For pedestrians, this generally consisted of crossing the throughlanes in the middle of the street instead of using crosswalks at the nearest intersection; Figure 5 reflects logged instances of unsafe pedestrian activity, which is higher in the afternoons (similar to vehicle utilization).

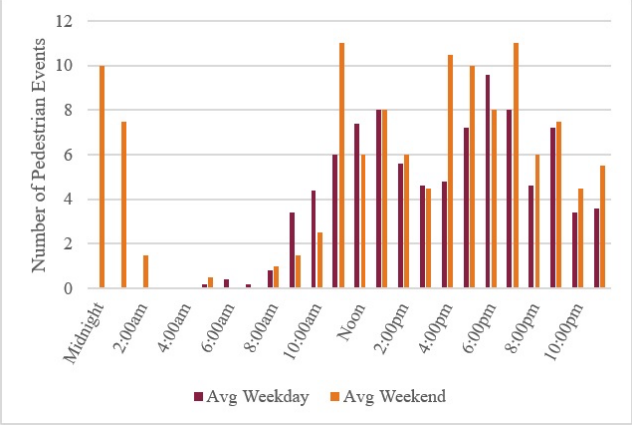

Figure 5. Average of pedestrian/pedestrian group events (unsafe activity), by hour.

Similar to pedestrians or groups of pedestrians, e-scooter and bicycle travelers were only logged in the data set in instances when there was unsafe/unlawful travel behavior. Only 27 e-scooter events were logged, most of which involved riding on the sidewalk next to the curbside zone in either direction; some instances were wrong-way travel by the scooter in the throughlane, and other instances involved people crossing the street at the midblock with their scooter. Notably, there was only one instance of a bicyclist illegally riding on the sidewalk.

Safety Impacts

During the one-week observation period, there were a few instances noted each day in which either the curbside zone vehicle, passing pedestrians and other active travelers, or other vehicles in the throughlane encountered unsafe situations. The research team graded instances of either a zone event or throughlane/sidewalk event on an A, B, C scale; some events occurred without close

enough proximity for an encounter with the curbside vehicle. Table 3 shows the results of these observations and severity ratings; no A-rated events (conflicts with contact) occurred during the one-week period. Some conflicts or potential conflicts (i.e., encounters) occurred as vehicles were maneuvering into and out of the spaces, often while a pedestrian(s) was crossing the street and walking past the vehicle. There were also some instances of an encounter that happened from the curbside parked vehicle opening their door to the throughlane street traffic, which could cause stops or swerves across the road centerline (i.e., median). The research team also observed several instances of sidewalk-riding by e-scooters and U-turning by vehicles to the other side of the street (sometimes to park in the observed curbside zone).

Table 3. Safety-Related Observations at Curbside Zone Area

Event Category	Description	Event Severity A	Event Severity B	Event Severity C	No Conflict or Encounter	Grand Total
Zone	Backing In Conflict	-	2	2	-	4
Zone	Pulling In Conflict	-	-	5	1	6
Zone	Pulling Out Conflict	-	2	1	-	3
Zone	Throughlane Door	-	-	2	-	2
Throughlane or Sidewalk	Attempted Parking	-	-	-	1	1
Throughlane or Sidewalk	Continued Stop	-	-	-	2	2
Throughlane or Sidewalk	Sidewalk Riding	-	-	-	22	22
Throughlane or Sidewalk	Sudden Stop	-	-	-	1	1
Throughlane or Sidewalk	Swerve Across Median	-	2	2	17	21
Throughlane or Sidewalk	U-Turn	-	-	-	20	20
Throughlane or Sidewalk	Wrong Way Traveling	-	-	-	2	2

Discussion

The research effort set out to examine levels of safety around activity at curbside zone areas and ways that the curbside zone attracted vehicle activity and created potential safety conflicts between vehicles accessing the zone spaces and other vehicles or active travelers. The original intent was to merge existing data sources of traffic activity, safety incidents, and curb management implementations to measure how safety had improved around curbside areas following these implementations. However, working with city case study partners revealed that existing data on crashes and safety incidents could be limited and/or inaccurate in measuring the locations and

crash levels at certain locations. Additionally, existing data sources do not typically have information on near misses or other encounters between vehicles and travelers that avoided collisions but were still the result of an unsafe situation.

The research effort pivoted to focus on discussing curbside management practices and challenges with different parties and conducting primary data collection and analysis at a key curbside zone location with the small city case study partner. The research team gained valuable insights from conversations with city departments, industry stakeholders, and community organizations about curbsides, parking and access, and safety considerations. The interviews or focus groups with drivers, businesses, and local travelers also provide perspectives from residents and local stakeholders on their key challenges.

The method developed for primary data collection and synthesis was helpful for measuring utilization and user types of the curbside area, despite safety outcomes and conclusions being limited due to the relatively small observation period (one week). The analysis still showed that behavior from active travelers (particularly pedestrians) creates potential conflicts with vehicles accessing the curbside area. Concurrently, vehicles on the street either trying to maneuver to and from these spaces or going around other such vehicles create unsafe situations for all parties in the immediate area. Further application of the primary data collection method used for the curbside zone in Roanoke would be beneficial to develop a statistically significant sample and gain further insights into safety in curbside management.

Conclusions and Recommendations

This section provides a handful of key topical takeaways from the research project as observed from stakeholder interviews, focus groups, and data analysis on curbside safety.

Takeaway 1 – Improving Infrastructure

Safe pedestrian infrastructure on the sidewalk and for crossings or intersections is a key component of safety around curbside zones. Without safe crossings that encourage pedestrian use, additional safety conflicts between vehicles accessing the curbside and active travelers will occur. Cities should include pedestrian infrastructure improvements as part of curbside management efforts.

Takeaway 2 – Communication and Enforcement

Many cities may lack enforcement practices to make curbside zone policies effective. Whatever enforcement method the city transportation department or parking management entity uses, consistent turnover of designated curbside zone spaces helps achieve access for different vehicle uses and creates separation of short-term activities (dropoffs/pickups, deliveries, etc.) from longer term parking. Manual or technologically aided monitoring of curbside spaces and micromobility travel is needed to make policies effective. Additionally, active communication with property

owners and community members during the planning and engagement processes is valuable for buy-in and observance of curbside access policies.

Takeaway 3 – Develop Safety Goals

Developing safety goals that are specific to curbside management and/or corridors with curbside zones is an area of need for cities and regional governments. Current safety measurement tends to be general to vehicle collision numbers and not tied to specific zone or corridor implementations. Cities should consider developing safety goals around curbside management efforts that are measurable, defined by specific time periods, and consider all traveler types.

Takeaway 4 – Better Safety Measurement

Cities and their partners should implement better practices for measuring safety around curbside areas, starting with data inventories of current curbside and pedestrian infrastructure. Measurement of crashes and collisions also needs to be standardized in some communities to makes sure that reliable and accurate data on safety is being collected. The need remains to better understand and capture near misses or potential unsafe encounters between vehicles and travelers; further development of this method using permanent placements of collection technologies or primary data collection deployments should be pursued.

Takeaway 5 – Future Automation Impacts

AVs will be game-changing for travelers and the way cities consider vehicle access at the curbside. While these vehicle technologies could improve safety through better driving behavior, the mass deployment/ownership of AVs is currently too far in the future to truly understand their impacts. In the meantime, curbside management practices including good location of curbside zone (e.g., strategically locating passenger pickup/dropoff zone near the most common destinations) and infrastructure for all area travelers (e.g., accessible sidewalks/crossings and safe/comfortable facilities for bicycles and e-scooters) will help cities improve current safety and prepare for a future with more short-term curb access by vehicles.

Additional Products

The Education and Workforce Development (EWD) and Technology Transfer (T2) products created as part of this project can be downloaded from the Safe-D website here. The final project dataset is located on the Safe-D Dataverse.

EWD Products

The EWD Plan established for this project includes the following components:

1. Two graduate students were hired at different points of the project to assist with different tasks. The first was a master's and PhD. student from Texas A&M University School of Landscape Architecture and Urban Planning who assisted with Tasks 2, 3, and 4. The

second was a master's student from the University of Texas at Austin School of Architecture who assisted with interviews in Task 5. Both were Texas A&M Transportation Institute (TTI) employees during their involvement with the project.

2. A research packet was developed that includes all project materials such as the report, brief, and dataset. It also includes a slide deck that lecturers can use to provide an overview of the report and dataset, highlighting useful information and providing context for the data coding method used for the dataset. The slide deck contains links to online resources referenced in the report and summarizes lessons learned from the research effort to encourage further investigation into the topic area.

T2 Products

The research produced the following products:

- Brief – A document summarizing best practices from research findings.
- Database – The final dataset developed from this project work.
- Final Report – The report documents the work performed, models and results, lessons learned, conclusions, and recommendations.
- PowerPoint slide deck – The presentation summarizes the work performed and the results of the analysis and explains how the database can be used in similar analyses.

The main consumers of research products include federal, state, tribal, metropolitan planning, and other local public agencies associated with traffic and vehicle management, along with research institutes and private entities. Urban planning and civil engineering students may also benefit by using the data methodology and dataset example to perform data-driven safety analyses.

The research team will look for opportunities to publish components of the project research as an academic paper in a relevant journal such as the Transportation Research Record, with the goal of publication along with presentation at the TRB Annual Meeting. TTI and VTTI will also feature the research in presentations within their agencies and to other external audiences.

Data Products

The dataset uploaded to the Safe-D Dataverse for this project contains observations of curbside zone use and nearby traveler behavior for a curbside pickup location with two loading spaces on Campbell Ave in Roanoke, Virginia. The observations in the dataset were logged from analysis of video collected at the site from June 14-15, 2022, and June 22-28, 2022. The dataset uses a data coding method developed by the research team to log vehicle/traveler, zone, and street activity information for each observation.

Data coding includes timestamps for events along with a range of options for vehicle types, uses of the curbside zone, and unsafe travel maneuvers in the area. The dataset includes observations for all vehicles that parked in the curbside zone for any period during the video collection period.

The dataset also includes observations for other vehicles and active travelers (such as pedestrians, bicyclists, and scooter-riders) who exhibited potentially unsafe or illegal walking/riding behavior; observations for these vehicles/travelers are not intended to represent a full count of these groups during the video collection period. In total, 1,038 vehicle or active traveler observations were recorded in the dataset from a one-week period.

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Appendix A: Specification Descriptions for Dataset

Table 4. Specification Terms and Descriptions for Safe-D 05-096 Dataset

Information Type	Term	Description
Vehicle/Traveler	Personal Vehicle	Private automobile, not appearing to be used for business/delivery purposes
Vehicle/Traveler	TNC	Automobile with identified transportation network company (TNC) branding
Vehicle/Traveler	Taxi	Automobile with identified taxicab company name/branding
Vehicle/Traveler	Paratransit	Transit vehicle used for ADA complementary paratransit service
Vehicle/Traveler	Pedestrian	Single pedestrian or group of pedestrians
Vehicle/Traveler	E-Scooter	Single e-scooter traveler or group of e-scooter travelers
Vehicle/Traveler	Transit Bus	Transit bus used for fixed-route service
Vehicle/Traveler	Package	Automobile used for package delivery
Vehicle/Traveler	Emergency	Emergency vehicle (such as an ambulance or fire department vehicle)
Vehicle/Traveler	Freight	Freight delivery vehicle (such as a cargo truck)
Vehicle/Traveler	Police	Police vehicle
Vehicle/Traveler	Bicycle	Single bicycle traveler or group of bicycle travelers
Vehicle/Traveler	Other Business	Other automobiles branded with business/company names
Vehicle/Traveler	Specialty	Other types of specialty automobiles not included in one of the previous categories
Zone	Front	Parking or loading in the front space of the two-space curbside zone
Zone	Back	Parking or loading in the back space of the two-space curbside zone
Zone	Middle	Parking in the middle of the two-space curbside zone
Zone	Parked	Vehicle parked and remained in the curbside zone for an extended period
Zone	Passenger Dropoff	Vehicle dropped off a passenger (or group of passengers) using the curbside zone
Zone	Passenger Pickup	Vehicle picked up a passenger (or group of passengers) using the curbside zone

Information Type	Term	Description
Zone	Parcel Delivery	Vehicle delivered a parcel/parcels using the curbside zone
Zone	Parcel Pickup	Vehicle pickup up a parcel/parcels using the curbside zone
Zone	Restaurant Pickup	Vehicle picked up to-go/takeout orders from a nearby restaurant using the curbside zone
Zone	Food Delivery	Vehicle delivered food dropoff using the curbside zone
Zone	General Delivery	Vehicle performed another delivery type (not included in the previous categories) using the curbside zone
Zone	Entirely Within	Vehicle temporarily parked/parked entirely within the curbside zone area
Zone	Mostly Within	Vehicle temporarily parked/parked mostly within the curbside zone area (a small portion of the vehicle may have been outside the zone)
Zone	Partially Within	Vehicle temporarily parked/parked partially within the curbside zone area (a portion of the vehicle being outside the zone)
Zone	Backing In Conflict	Conflict or encounter between the curbside vehicle another vehicle/traveler occurred from vehicle backing in to the curbside space
Zone	Pulling In Conflict	Conflict or encounter between the curbside vehicle another vehicle/traveler occurred from vehicle pulling in to the curbside space
Zone	Pulling Out Conflict	Conflict or encounter between the curbside vehicle another vehicle/traveler occurred from vehicle pulling out of the curbside space
Zone	Sidewalk Door	Conflict or encounter between the curbside vehicle another vehicle/traveler occurred from curbside vehicle opening a door towards the sidewalk
Zone	Throughlane Door	Conflict or encounter between the curbside vehicle another vehicle/traveler occurred from curbside vehicle opening a door towards the throughlane
Zone	A - conflict with contact	Conflict between the curbside vehicle and another vehicle/traveler in which contact was made between the two parties (does not detail whether injury occurred)
Zone	B - conflict no contact	Conflict between the curbside vehicle and another vehicle/traveler in which contact was not made between the two parties (e.g., a “near miss”)
Zone	C – encounter	Minor encounter between the curbside vehicle and another vehicle/traveler, not close enough for potential contact
Zone	Pedestrian Crossing	A pedestrian or group of pedestrians crossing in the throughlanes via the middle of the street (not at a crosswalk)
Zone	Pedestrian Sidewalk	A pedestrian or group of pedestrians walking on the sidewalk adjacent to the curbside zone (marked if a conflict or encounter occurred)

Information Type	Term	Description
Zone	Vehicle	Another automobile travelling in one of the throughlanes near the curbside zone (marked if a conflict or encounter occurred)
Zone	Scooter	A scooter traveler or group of scooter travelers riding illegally (either on the sidewalk or the wrong direction in a throughlane)
Zone	Bicycle	A bicycle traveler or group of bicycle travelers riding illegally (either on the sidewalk or the wrong direction in a throughlane)
Zone	Other Traveler #	Reference number to other involved vehicle/traveler in a conflict or encounter
Street	Cross NB	Pedestrians, bicycle-travelers, or scooter-travelers crossing the street in the throughlanes via the middle of the street (not at a crosswalk); specifically crossing in the Northbound direction
Street	Cross SB	Pedestrians, bicycle-travelers, or scooter-travelers crossing the street in the throughlanes via the middle of the street (not at a crosswalk); specifically crossing in the Southbound direction
Street	Cross NB & SB	Pedestrians, bicycle-travelers, or scooter-travelers crossing the street in the throughlanes via the middle of the street (not at a crosswalk); specifically crossing in both the Northbound and Southbound directions (either simultaneously or one direction first, then the other)
Street	Sidewalk EB	Bicycle-travelers or scooter-travelers riding illegally on the sidewalk adjacent to the curbside zone; specifically traveling in the Eastbound direction
Street	Sidewalk WB	Bicycle-travelers or scooter-travelers riding illegally on the sidewalk adjacent to the curbside zone; specifically traveling in the Westbound direction
Street	Sidewalk EB & WB	Bicycle-travelers or scooter-travelers riding illegally on the sidewalk adjacent to the curbside zone; specifically traveling in the Eastbound and Westbound directions (either simultaneously or one direction first, then the other)
Street	Throughlane WB	Automobiles, bicycle-travelers, or scooter-travelers riding in the Westbound throughlane nearby/adjacent to the curbside zone (marked if a conflict or encounter occurred)
Street	Throughlane EB	Automobiles, bicycle-travelers, or scooter-travelers riding in the Eastbound throughlane nearby/adjacent to the curbside zone (marked if a conflict or encounter occurred)
Street	Vehicle Passing WB	Pedestrians, bicycle-travelers, or scooter-travelers passing the vehicle in the curbside zone in the Westbound throughlane (marked if a conflict or encounter occurred)
Street	Vehicle Passing EB	Pedestrians, bicycle-travelers, or scooter-travelers passing the vehicle in the curbside zone in the Eastbound throughlane (marked if a conflict or encounter occurred)

Information Type	Term	Description
Street	Vehicle Streetside	Pedestrians, bicycle-travelers, or scooter-travelers passing next to the vehicle in the curbside zone on the street-side (marked if a conflict or encounter occurred)
Street	Vehicle Front	Pedestrians, bicycle-travelers, or scooter-travelers passing next to the vehicle in the curbside zone on the front-side (marked if a conflict or encounter occurred)
Street	Vehicle Curbside	Pedestrians, bicycle-travelers, or scooter-travelers passing next to the vehicle in the curbside zone on the sidewalk/curb-side (marked if a conflict or encounter occurred)
Street	Vehicle Back	Pedestrians, bicycle-travelers, or scooter-travelers passing next to the vehicle in the curbside zone on the back-side (marked if a conflict or encounter occurred)
Street	Sidewalk Riding	Bicycle-travelers or scooter-travelers riding illegally on the sidewalk adjacent to the curbside zone
Street	Excessive Speeding	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that appeared to be travelling at an excessive speed well over the speed limit
Street	Sudden Stop	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that came to a sudden stop in the throughlane, possibly due to another vehicle using the curbside zone
Street	U-Turn	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that did a U-turn maneuver in the middle of the street (either to travel or park in the other direction)
Street	Swerve Across Median	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that swerved across the median into the other throughlane, possibly due to another vehicle using the curbside zone
Street	Attempted Parking	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that attempted to park (but ultimately did not) in either the curbside zone or one of the adjacent parking spaces
Street	Continued Stop	Automobile in one of the throughlanes nearby/adjacent to the curbside zone that came to a continued stop in the throughlane, possibly due to another vehicle using the curbside zone or activity further ahead in the throughlane
Street	Wrong Way Traveling	Automobile, bicycle-traveler(s), or scooter-traveler(s) in one of the throughlanes nearby/adjacent to the curbside zone that rode in the wrong direction in the throughlane

Appendix B: Expert Interview Discussion Guides

Interview Guide: Government Staff and Regulators

Safety Goals

1. Does your organization have a comprehensive set of safety goals? What are the goals and how are the goals measured?
2. Do any goals address curb management practices directly? Indirectly?
3. How does your organization determine liability for incidents on the curb?
4. Can you describe how the agency prioritizes enhancements and modifications to the curb? Does a schedule exist for making physical and operational adjustments to the curb?

Decision-Making and Planning

5. What is the process for assessing and selecting strategies to address safety challenges?
6. How does your organizations integrate physical accessibility challenges and ADA requirements into the curb space?
7. Does your organization have a low-income program that provides rebates as part of its parking system? If so, can you provide details on that program?
8. What considerations are made for people experiencing homelessness in managing the curb space?

Outreach Efforts

9. How do you inform and educate road users about your curb area policies and safe practices? Is it different from business and property owners?
10. What feedback have you received from road users? Business and property owners?

Enforcement and Pricing

11. How do you enforce curb policies?
12. How was the pricing structure, if one exists, developed? How often are curb pricing policies adjusted?

Effects of Curb Policies

13. How have the curb management policies you've implemented affected road users? Transit operators? Ridehail and scooter providers?
14. Was the local transit operator included in the development/discussion of your curb policies?
15. Have you conducted any before/after studies?

Opportunities for Additional Learning

16. Has your organization ever conducted pilot curb interventions (e.g., pop-up or tactical urbanism)? If so, what was the outcome of the project? Were the studied modifications implemented systemwide?

17. What issues need to be addressed by further information or guidance (i.e., national guidebook)?

Interview Guide: Service Providers and Technology Companies

Safety Goals

1. How does your organization integrate safety into your services?
2. What safety considerations are present at the curbside?

Decision-making and Planning

3. How does your organization approach curb-area physical accessibility challenges and ADA requirements?
4. How does your organization address affordability so that your use of a public good does not result in exclusionary outcomes?
5. What considerations are made for interacting with people experiencing homelessness? How do you provide service to customers within this community?
6. Is there anything unique done to look at interactions in and around the curb area?

Current Needs and Prioritization

7. From your organization's perspective, what are the current opportunities for improving safety in and around the curb area?
8. How does your agency interact with public agencies with respect to safety?

Outreach Efforts

9. How do you educate and inform your drivers about relevant curb policies? *[for TNCs, taxis, and intercity carriers]* What about riders?
10. How do you educate and inform business or property owners adjacent to the areas in which you operate? What about government entities?
11. Do you every coordinate with these groups to either offer trips incentives or establish pickup/dropoff locations? Something else? If yes, please explain.

Enforcement and Pricing

12. How do curb management policies and fees impact your operations?

Opportunities for Additional Learning

13. Has your organization ever participated in pilot curb interventions (e.g., pop-up or tactical urbanism)? If so, what was the outcome?
14. What issues need to be addressed by further information or guidance?

Interview Guide: Other Related Entities

Safety Goals

1. Does your organization have a comprehensive set of safety goals related to transportation? What are the goals and how are the goals measured?

2. Do any goals address curb management practices directly? Indirectly?
3. What goals do you feel need to have a higher priority by the agencies that manage the curb space?

Decision-making and Planning

4. What is the process for identifying safety challenges within the communities you serve?
5. How does your organization advocate for improvements to curb-area physical accessibility challenges and ADA requirements?
6. Does your organization advocate for affordability as part of priced parking programs?
7. What considerations should be made for people experiencing homelessness and their access to the curb area?
8. Is there anything unique done to look at interactions in and around the curb area?

Current Needs and Prioritization

9. From your organization's perspective, what are the current opportunities for improving safety in and around the curb area (particularly at designated curb zones)?

Outreach Efforts

10. How do you inform and educate road users about their rights, curb area policies, and safe practices? How do you inform business and property owners? It is any different?
11. What feedback have you received from these stakeholders?

Enforcement and Pricing

12. What is your organization's perspective on enforcement for curb area policies?

Effects of Curb Policies

13. How have curb management policies and practices influenced your community?

Opportunities for Additional Learning

14. Has your organization ever conducted or participated in pilot curb interventions (e.g., pop-up or tactical urbanism)? If so, what were the outcomes?
15. What issues need to be addressed by further information or guidance (i.e., national guidebook)?

Appendix C: Focus Group Discussion Guides

Project Introduction

This research project seeks to learn about how vehicles in a multimodal environment are managed and prioritized at curb loading and unloading zones. We're particularly interested in differences between public and private vehicles and/or use cases to analyze the effectiveness of curb management practices to improve safety for all pedestrians and vehicles in multimodal environments.

So far, we've looked at current curb management practices across large and small urban areas in U.S., including use of technology, temporal management, street design and infrastructure, zoning for mode uses and prioritization, traffic monitoring, policies and regulations, permitting and monetization, and enforcement.

Today we're excited to talk to you because of your real-life expertise about the curb area.

This discussion will be recorded but the recording will only be used to supplement our written notes and will not be published or presented in any manner.

Icebreaker

Before we get into the project specific questions, I'd like to make sure each of our connections is working. So, I'll call out names from the list of participants showing on my screen – when you hear your name, please say hello and tell us your favorite thing to do in your free time.

I'll start—my name is Zach Elgart and when I have free time, I really enjoy either running or reading.

*****Call out participants one by one*****

Focus Group Guide: Local Travelers

Travel Environment

1. How would you describe the area where you live? *e.g., Urban, suburban, or rural* | ***[for San Francisco]*** *Downtown, neighborhood, mixed use*

Travel Mode Choices

2. What is your primary mode when traveling within the city? Why?
    a. What secondary modes do you typically use?
3. Have you ever used a taxi or ridesourcing company like Lyft or Uber?
4. How comfortable do you feel walking on sidewalks in your neighborhood and/or the downtown business district?
5. For any of the previous questions, has your opinion changed due to COVID-19?
6. *What about bike- or scooter-share? For what kinds of trips?*

a. ***[For people that use bikes and scooters]*** How has your experience in a bike lane been impacted by other road users access to the curb?

Access and Delivery Needs

7. When using a transportation provider, how has the curb area experience been? *For example: Was it confusing locating your driver? Ease of entering/exiting the vehicle? Comfort waiting for the vehicle?*
    a. What about your experience receiving deliveries (either traditional delivery like pizza or on-demand services like UberEats, DoorDash, Postmates, etc.)?
        i. How often have you used delivery services? At what times of day do you usually use them?
        ii. Do you meet them outside? If so, how has that experience been?
8. Are you specifically aware of your city's curb zones or curb rules?
    a. If yes, how did you learn about them?

Safety Concerns

9. When navigating the curb-area do you ever have any safety concerns? *For example: fast-moving traffic, opening doors, pedestrians crossing mid-block, parked scooters/other obstacles, uneven thresholds, or lack of edge definition.*
10. What about navigating intersections – do you have safety concerns in these environments? *For example: limited visibility to see oncoming traffic or crossing pedestrians, poor lighting (at night), or not enough time to cross.*
11. Do your safety concerns, in either the curb or intersection areas, change when traveling away from a familiar place? If so, how? What could be better?
12. Would your safety perceptions change if automated vehicles were used? How?
    a. Any benefits or concerns related to the curb area specifically?

Focus Group Guide: Business and Property Owners

Travel Environment

1. How would you describe the area where your business/facility is located?

Travel Mode Choices

2. How do your customers, employees, or tenants typically arrive?
3. Do you incentivize the use of non-auto modes?
4. Do you provide parking for cars? What about bikes or scooters?
5. Do you know about the curb dropoff zone located outside of your property?

Access and Delivery Needs

6. What types of access does your business/facility require? *For example: loading unloading (either goods or passengers), short term parking, pedestrian access*
7. How are deliveries currently received?
    a. If at the curb, what could be better?
    b. If not at the curb, would curb access be beneficial? Would you be willing to contribute financially for improved access?

8. Have you ever worked with the local transit agency or another transportation provider to coordinate service/access to your location? If yes, how did that work?
9. What impact do you expect automated vehicles to have on access and delivery to your location? How will that change the way you address access?

Safety Concerns

10. When considering customers or tenants navigation of the curb-area, do you have any concerns?
11. What about intersections – do you have any concerns about customers or tenants navigating nearby intersections?
12. Would your safety perceptions change if automated vehicles were used? How?
    a. Any benefits or concerns related to the curb area specifically?
13. Do you want improved or formalized curb management, or should governance of the curb area remain ad-hoc?

Focus Group Guide: Vehicle Operators

Travel Environment

1. How would you describe the area where you typically work? *e.g., Urban, suburban, or rural* |***[for San Francisco]*** *Downtown, neighborhood, mixed use*

Travel Mode Choices

1. What type of driving job do you currently do?
2. Have you ever worked as a driver in another role?

Access and Delivery Needs

3. What types of curb access does your service require?
4. Has your company ever worked with another entity (city, venue, etc.) to facilitate transportation to a specific destination? If yes, how did that work?

Safety Concerns

5. When considering riders' navigation of the curb-area, do you have any concerns?
    a. ***[For people making deliveries]*** What about when you have to leave your vehicle to deliver something?
6. What about intersections – do you have any concerns about riders navigating nearby intersections?
    b. ***[For people making deliveries]*** What about yourself?
7. How do you think automated vehicles will affect your role in the transportation industry?
    c. Would you prefer to act in a support capacity for riders/customers of such a vehicle?
8. Do you want improved or formalized curb management, or should governance of the curb area remain ad-hoc?

Appendix D: Focus Group Findings

Introduction

To expand on the lessons this research project has already gleaned from literature reviews, expert interviews, and site observations, the research team conducted focus groups with three types of curb users: Local Travelers (e.g., the general public), Business and Property Owners, and Vehicle Operators (e.g., professional drivers). The following sections present a summary of findings from each group.

Local Travelers

The recruitment process for local traveler focus group participants identified four potential participants, but each person had different availability. Therefore, instead of a group discussion, a member of the research team met with each person in a one-on-one interview (using the same discussion guide) at a time that worked well for them. Each of the four participants in the local traveler interviews lived in the Roanoke, VA, area.

Travel Environment

Discussions with local travelers began by reviewing the environment around their home location and their first choices for transportation. Table 5 presents a summary of the responses from each of the four focus group participants.

Table 5. Local Travel Environment and First-Choice Travel Modes

Participant	Responses
1	– Old suburb of Roanoke - built in 1910s with single family homes – Tries very hard to avoid driving their car, but uses it more than other modes due to children – Loves to ride the bus and walk when possible, though curtailed bus use temporarily during COVID-19 to avoid taking space from people without other options – Owns an electric bike – Works in adjacent town (about seven miles away) and feels biking to work is not safe
2	– Suburban apartment outside of central Roanoke – Travels back and forth between there and parents – Wishes they lived in a more rural part of the area – Has to take a car to get anywhere – COVID-19 was initially concerning, but after learning more it became less worrisome. Found the reduced traffic to and fewer people walking to make things feel safer—now that people have returned to pre-pandemic travel patterns it seems none of them are paying attention and it makes the travel experience feel unsafe.
3	– Lives in Roanoke City, in a neighborhood with a dense street grid – Mostly car dependent area - to travel more than a mile you need a car

Participant	Responses
4	– Old streetcar suburb of Roanoke built in the 1920s and 1930s – Single family homes – Uses biking or walking around home but requires a car to do large errands or visit family/friends – Bike parking is limited and often riders must use infrastructure (e.g., street signs) to secure a bicycle. Williamson Road was identified as particularly difficult to park a bicycle, requiring a long walk from a secure location to one's destination (along low-quality sidewalks)

Other Travel Mode Choices

After discussing first-choice travel modes, the discussion with local travelers explored their use of other modes such as taxis or ridesourcing, walking, and bike- or scooter-share. Table 6 through Table 8 present summaries of the responses from each of the four interview participants.

Table 6. Taxi or Ridesourcing Use

Participant	Responses
1	– Has used these services, but not frequently
2	– Has used ridesourcing twice – once to return from downtown after drinking and once to return from the airport
3	– Rarely uses ridesourcing but they are available
4	– Rarely uses ridesourcing unless traveling away from home

Table 7. Sidewalk Comfort

Participant	Responses
1	– Some sidewalks are blocked (including by poor placement of utility poles), but sidewalks are available in most places and the feel, "probably 85 percent comfortable"
2	– In downtown, sidewalks are not very comfortable—they are busy with people that are not paying attention and vehicle traffic moves quickly and frequently mounts the curb – Near home there are no sidewalks –to walk the participant would first have to drive to a location with sidewalks or go to a local church for recreational walking
3	– Feels very safe walking locally and to get to downtown, though incidents of unsafe driving seem to have increased during the COVID-19 pandemic
4	– In the neighborhood sidewalks are very comfortable – Downtown sidewalks are mostly comfortable due to narrow one-way streets, but parked cars limit visibility

Table 8. Bike- or Scooter-Share Use

Participant	Responses
1	– Used scooter share a few times but did not feel safe. Prefers bikes and does not use bikeshare because they own a bike

Participant	Responses
2	– Used a scooter share once in downtown Roanoke. This was an uncomfortable and scary experience. They did not know how to operate the device well and were harassed both for using the sidewalk and the street to travel. Resorted to switching between sidewalks and streets according to the level of traffic to avoid conflicts.
3	– Never used scooter share because it does not seem safe. Additionally, they clutter the sidewalk and the police issue citations for riding on sidewalks instead of the street.
4	– Uses scootershare in downtown Roanoke

Access and Delivery Needs

To understand local travelers' interactions with transportation or delivery providers in and around the curb area, the research team asked participants to discuss their experience using such services as well as their understanding/awareness of curb rules that might influence such experiences, as summarized in Table 9.

Table 9. Experience with Transportation/Delivery Services and Curb Rules

Participant	Responses
1	– Due to a lack of an appropriate loading zone, a ridesourcing driver was once forced to block traffic with their vehicle during loading. This caused anxiety for the participant. – Some bus stops do not have curbs/sidewalks, ramps, or other accessible facilities. – Home location is adjacent to a parking lot which makes delivery receipt easy. – Participant is aware of 15-minute limits for pickup/delivery zones and the fact that parking in a bus stop is illegal; learned about these rules by observing signage.
2	– In one instance, it was difficult to find the right ridesourcing driver because so many were operating. Once the correct vehicle was found accessing it was easy because the driver was able to park right next to the curb and the sidewalk was free of anything that might impede access. – Delivery services are used twice per month in the evenings and delivery access to the door is easy once the driver locates the correct apartment – From signage, the participant knows of a store-specific loading zone downtown but, because of a one-way street, the driver's door must be opened into traffic. Also knows of some restaurants and grocery stores with dedicated pickup zones.
3	– Never experience issues accessing or egressing from a vehicle – Does not receive a lot of deliveries, but the neighborhood association will cite delivery vehicles for parking on the grass between the sidewalk and the curb
4	– Has not struggled to identify ridesourcing driver but has experienced pickups/dropoffs where the driver has to double park or stop in the road—easy for them but would be a challenge for others – Depending on the part of Roanoke, waiting for a ride could be uncomfortable due to missing sidewalks

Safety Concerns

With the understanding of each participant's experience with navigating the curb area and with using transportation and delivery services, the research team transitioned to a discussion of safety

to learn more about concerns in the curb and intersection areas as well as participants' perceptions of AVs' impact on safety. These findings are presented in Table 10 through Table 13.

Table 10. Curb Area Concerns

Participant	Responses
1	– Storm litter creates trip hazards due, in part, to low curb heights (debris washes onto sidewalks) – Shared scooters often block sidewalks – Large restaurant crowds cause challenges for sidewalk uses
2	– Crowded sidewalks and lack of attention paid by other users (both drivers and pedestrians) makes the experience uncomfortable – factors that are exacerbated when travelling with a family member with disabilities
3	– There is a huge problem with people speeding and running stop signs as well as nonexistent pedestrian infrastructure
4	– Sidewalks often either do not provide enough space (in terms of width) or end abruptly forcing users to use the road or backtrack to a safe path – recent work [by the city] to make connections has only been partially successful – Sidewalk pavement quality varies significantly and has forced wheelchair users into the street because the sidewalk was impassible

Table 11. Intersection Concerns

Participant	Responses
1	– It is difficult to safely cross wide streets especially when pedestrians are not assisted by curb bump outs or visibility is blocked by cars – It is often not clear whether people making right turns will first stop for a red light and then check that the crosswalk is clear – Drivers do not seem to understand that pedestrians have the right of way
2	– Often there is not enough time to cross, crossing signals appear to contradict traffic lights in some locations – Cars parked close to the crosswalk force pedestrians into the street to see oncoming traffic – As a user of a mobility device, intersections without curb cuts and/or with tactile feedback for people with visual difficulties are challenging – Drivers frequently run red lights
3	– Pedestrian crossings do not have countdowns to help users understand how much time they have to get across the street – Pedestrians often cross midblock or in other locations not designated for crossing – Many intersections lack marked crosswalks and pedestrian signals – People run stop signs making crossing intersections as a pedestrian more dangerous
4	– Intersections do not consistently have marked stop lines for vehicles or marked crosswalks which is intimidating for pedestrians – Pedestrian countdown signals are in place in some intersections but not widespread in the city, so the benefit [of signals] is spotty – Method of mounting traffic lights (strung at an angle difficult for pedestrians to see) makes it hard for pedestrians to gauge right of way at intersections

Table 12. Concerns When Away from Familiar Places

Participant	Responses
1	– Concerns vary depending on location – Higher numbers of pedestrians make the experience feel safer – Once the patterns of behavior of a location are learned (e.g., whether people respect pedestrian right of way) comfort levels adjust accordingly – Physical separation (bollards, walls, etc.) between traffic and pedestrians, as experienced in other places, helps with the feeling of safety
2	– Safety concerns are the same in unfamiliar places – people are distracted by smartphones regardless of how they are traveling or where they are
3	– Always cautious when walking regardless of location
4	– *Not discussed*

Table 13. Impacts of Automated Vehicles (AVs) on Perceptions of Safety

Participant	Responses
1	– Eye contact with drivers is a key component of feeling safe as a pedestrian – this is impossible with AVs – AVs seem to be reinventing the bus, which is not needed – AVs could improve vehicle-to-vehicle communication either through visual or virtual signaling – AVs could introduce issues with equity, inclusion, and justice, and any implementation of the technology should account for these factors – Resources for all modes need to be carefully considered with preference for people
2	– Concerned about the technology failing and whether it would be possible to confidently tell when it was safe to cross in front of an AV – If AVs were forced to only operate in the curbside lane, it might make the sidewalk feel safer due to the buffer the vehicles could provide from human drivers
3	– AVs could help make pedestrians safer, but they also inspire skepticism because it seems like current pedestrians are test subjects for the technology – Requires more refinement before the technology can be trusted – From a driver perspective there is concern about AVs stopping randomly and creating dangerous situations or causing crashes
4	– Hopeful that AVs would help reduce speeds because their programming would require following speed limits – Concerned that AVs will struggle to identify bicycles – In Roanoke, circling for parking is very common and AVs could curtail this practice by dropping people off at destinations and then parking in a garage

Business and Property Owners

The research team also reached out to business and property owners in the case study locations for their perspectives on curb management. Only one organization (a business in Roanoke) volunteered to participate in the focus group process and sent two representatives to the discussion. A summary of the findings from the research team's discussion with this organization is provided in the following sections.

Travel Environment

The business—a restaurant—is located near the center of downtown Roanoke around the intersection of Campbell and Jefferson and sits next to a surface parking lot.

Travel Mode Choices

Most people that come to the restaurant (and, according to the participants, anywhere in downtown Roanoke) choose to drive a car. Prior to the COVID-19 pandemic, many people would walk from their offices to the restaurant; currently, the majority of customers (around 70 percent) drive directly to the restaurant and either park on the street or in the lot next door. Because of a lack of bike parking and high rate of bike thefts, customers who arrive via bicycles are told that they may either bring their bicycle into the restaurant for storage during their meal or that the restaurant staff will bring their to-go order out to the sidewalk (the same policy is available for dog owners). Historically, there was a city-provided bike rack down the street from the restaurant, but it was hit by a car and has not subsequently been replaced. Parking downtown can be challenging; street parking is free, which results in slow changeover of spots, while parking garages are difficult to use and costly. Additionally, the participants have noticed that there are challenges with parking perceptions in downtown; many people think it is hard to park and, therefore, do not go downtown.

To facilitate pickup of to-go orders at local restaurants during COVID-19, Downtown Roanoke Inc. (DRI) installed 15-minute pickup zones throughout downtown. However, according to the participant, these zones were never codified by the city and, therefore, parking limits are not enforceable. Additionally, the location of the zones is such that they do not provide convenient pickup locations for their restaurant—it would be better, according to the participant, to place such zones at either end of a block. The participants stated that DRI did not conduct meaningful engagement with downtown businesses during the development of the pickup zones program and that the information about the program is not helpful for users (e.g., specific zones are not identified as best for specific businesses).

Access and Delivery Needs

The restaurant currently receives deliveries at the curb because the only entrance to the facility is the front door. To make the delivery process easier, the restaurant owner schedules deliveries in the early morning. Other businesses in downtown, according to the participants, struggle with deliveries because they do not schedule them before street parking fills up for the day—often deliveries that occur later in the day for the participant and other downtown businesses require that the delivery vehicle is parked multiple blocks away and the goods are transported to the business by hand truck.

When discussing the possibility of AVs for use in accessing the restaurant, the participant stated that this type of service could "help a lot of people access places and fill in the gaps of transit in Roanoke," especially if the service is provided curb-to-curb. The participant also acknowledged that AVs could help people get around Roanoke (such as third shift workers) after transit stops running—"the more people that have access to jobs the better it will be for everyone." Instead of

pickup zones, according to the participant, "All restaurants would have benefited from using the curb parking area for outdoor dining and the city wouldn't even consider it [for downtown]," despite allowing outdoor dining to occur in southern Roanoke.

Safety Concerns

The participant mentioned specific curb and intersection safety concerns including:

- Very low curbs in front of the restaurant—about 2 inches high—are very easy to mount with a vehicle and could allow crashes during parking.
- It is often difficult to transition from streets to sidewalks due to uneven/low-quality pavement caused by deferred maintenance and street trees.
- Safety in front of the restaurant is fine, but it is not the same everywhere in Roanoke.
- Downtown parking garages paint the curbs in front of their locations yellow, but the paint that is used is very slippery after it dries and offers less traction than the adjacent curb and sidewalks.
- Crossing the street is dangerous because intersections "are awful and people don't pay attention."
- The participant has nearly been hit when crossing a busy intersection and frequently sees wrong-way drivers on downtown one-way streets.
- Frequent road/utility work causes issues with safe travel through downtown.

Regarding AVs, the participant feels that they can improve safety in town and on higher speed roads and freeways, but intersections need to have more built-in control (e.g., pedestrian sensing).

When discussing curb management policies, the participant explained that it would be helpful to have one concept for curb management that is implemented where appropriate throughout the city.

Vehicle Operators

Following advertisements for focus group participation to vehicle operators in both case study locations, the research team organized the focus groups based on respondents' experience in operating vehicles as part of their profession and availability in scheduling. The vehicle operators focus groups consisted of 1 professional driver from the Roanoke area and 10 from the San Francisco area. This section summarizes the information collected from these drivers, organized according to the area where they work.

Travel Environment and Modes Operated

To begin, the research team asked vehicle operator focus group participants to describe the area(s) where they work and the type of work they engage in. The findings from these discussions in Roanoke and San Francisco are presented in the following sections.

Roanoke

The focus group participant in Roanoke operated a limousine service in the evenings and worked as a moving truck driver during the day. Both the limousine and the moving truck vehicles measure approximately 26 feet in length and typically require three parking spaces to safely maneuver up to and away from the curb; this frequently results in needing to circle the block multiple times and/or wait extended periods for spaces to clear. Additionally, the participant noted that these vehicles present additional challenges when navigating the one-way streets common in downtown Roanoke. Regarding time of day, the participant from Roanoke noted that earlier in the day is better because traffic and demand for parking are lighter—traveling in Roanoke in the moving truck or limousine is more difficult after noon and on weekends. An additional challenge for the moving truck is ramp placement (sometimes requiring blocking pedestrian traffic and/or mounting the curb to properly position the ramp) and reverse driving.

San Francisco Area

Of the 10 participants in the San Francisco vehicle operator focus groups, four worked as ridesourcing drivers (one of whom also worked for an on-demand delivery company) and six worked as drivers for companies distributing goods (e.g., ice cream or baked goods), general pickup/delivery services (e.g., furniture moving), and UPS/FedEx (seasonally). Those who work in ridesourcing focused on the City of San Francisco, targeting neighborhoods including SOMA, Noe Valley, Outer Mission, Financial District, Sunset District, and Downtown. The other participants work in all parts of San Francisco as well as other areas throughout the San Francisco Bay Area.

Access and Delivery Needs

Vehicle operators require access to the curb to do their jobs. The research team asked vehicle operator focus group participants to describe their interactions with the curb area, including the type of space required for their purposes and whether they had ever worked in a coordinated service scenario (e.g., a special event shuttle between a parking area and a venue). The findings from these discussions in Roanoke and San Francisco are presented in the following sections.

Roanoke

The respondent's limousine business initially started by contracting with businesses to provide transportation services (e.g., local hotels); therefore, passenger loading areas were pre-defined by the client at both pickup and dropoff. As the business grew, it began offering service to the general public, which introduced more variables to the pickup and dropoff situations. For example, instead of a dedicated loading area at a hotel, service to the general public requires pickups and dropoffs in residential neighborhoods and at multiple destinations in one evening (e.g., barhopping). Without dedicated pickup and dropoff spaces, light poles, trash cans, and other sidewalk furniture introduce additional challenges to limousine service requiring the driver to perform a "constant balancing act between providing access and safety" for their customers.

As described above, the moving truck operated by this participant requires similar vehicle space to the limousine but does not need space to accommodate passenger pickup and dropoff. Instead, the moving truck requires space to deploy a ramp and transport goods to/from the vehicle. Sometimes this requirement impedes safe pedestrian flow, but the moving staff strive to provide safe passage for pedestrians as much as possible.

San Francisco Area

Each of the participants in the San Francisco focus groups agreed that access to the curb to facilitate either passenger or goods pickup/dropoff is much more difficult in the City of San Francisco than the other parts of the Bay Area, due to significantly limited parking and high demand from both single-occupancy vehicle drivers and other professional drivers. Some highlights of the discussion are listed below, as quoted from participants:

- *There is big difference between driving in San Francisco versus Oakland and the suburbs. Very little parking in San Francisco for loading and unloading. It would be great if there was dedicated parking for trucks, so you do not have to double park.*
- *I don't depend on access to the curb…I put my blinkers on to alert drivers if I need to park in an odd space.*
- *Curb access is a big safety issue…I see pedestrians being hit all of the time.*
- *We sometimes need more than one spot.*
- *You have to know by memory which businesses have loading zones, which permit double parking, etc.… Unless you have a dedicated route every day, you have to keep track of all types of different scenarios.*
- *You have to take the initiative to park illegally sometimes. Sometimes, you take a big risk in getting a ticket to make a delivery.*
- *[Location] plays a major part in any type of delivery in the Bay Area. Sometimes, before I accept a new contract, I scope out the areas where the deliveries occur to see if it can be done.*
- *When you are just a contractor, receiving a long-term or short-term contract, you are held liable for any tickets issued for improper parking.*

Safety Concerns

Finally, the research team asked vehicle operator focus group participants to describe their safety concerns when working in the curb area and in intersections before exploring their perceptions of AV safety and how to best manage curb areas from a policy perspective. The findings from these discussions in Roanoke and San Francisco are presented in the following sections.

Roanoke

When navigating intersections in either their moving truck or limousine, the participant in Roanoke identified challenges with communication and right-of-way—during turning movements, the vehicles they operate often require another vehicle to proceed through the intersection so that they

can safely navigate the turn without collision. Communication with pedestrians, especially when operating the moving truck, is hard because the drivers cab sits much higher than pedestrian line-of-sight. In traffic, shared scooters operate quickly and unpredictably, which makes it difficult to safely navigate in areas where these vehicles are common.

Regarding AVs, the participant in Roanoke expressed concerns related to sensor failures and whether the vehicle is capable of discerning true safety issues and non-critical movements (e.g., a plastic bag blowing across the road), implying that an AV might stop abruptly without good reason and create unsafe situations for other road users. Additionally, this participant was concerned about the potential of AVs to desensitize people to safety issues.

When discussing management of the curb, the participant from Roanoke felt that comprehensive policy solutions would be most appropriate in large markets, but likely overkill in small markets such as Roanoke.

San Francisco Area

Ridesourcing drivers in San Francisco described safety concerns related to passenger pickup and dropoff, including passenger confusion that leads to dangerous situations (e.g., exiting the vehicle into traffic or before it has completely stopped and crossing mid-block before/after service); availability of space along the curb that does not conflict with buses or force passengers to navigate street furniture or trees; and being forced to double park. Delivery drivers described unique challenges, including the need to be sure the vehicle is securely parked (e.g., parking brake applied and wheels curbed) to avoid rolling away on hills; parking on the right side of the street when working with UPS/FedEx due to vehicle exiting rules; and parking locations that are well-lit and secure when delivering using personal vehicles/sedans due to theft risk related to visually exposed packages.

All participants in the vehicle operator focus groups agreed that any action that blocks traffic (e.g., double parking or careful/slow navigation) causes frustration and sometimes aggression among other road users.

Participants expressed concerns related to intersections including:

- Difficulty safely navigating heavily congested areas due to vehicle size
- High numbers of pedestrians require extra diligence
- Blind spots occur due to street furniture, other vehicles (driving and parked), and trees
- Turning conflicts often occur because of the size of some delivery vehicles—other road users do not understand or anticipate the space/time required to turn large vehicles
- Speed limits are not intended for large trucks, but most road users do not understand this and can become frustrated or pushy when large vehicles travel slower than other traffic
- Time of day is critical in intersections due to vehicle and pedestrian congestion levels at peak travel times—avoiding peaks makes intersections safer

Opinions among vehicle operators focus group participants regarding AVs were mixed. Some participants embrace the technology and believe that the sensors and processing power will allow AVs to operate more safely than humans and allow professional drivers to focus on other tasks such as inventory during pickup/delivery and customer service—one participant is even pursuing work with an AV company to stay current in the industry. Other participants (the majority) were more skeptical of the technology, citing concerns related to job loss, slow speed driving (and the associated road rage from human drivers), interactions with other road users at intersections (e.g., communication regarding right-of-way), and issues associated with hacking and cybersecurity threats.

When discussing curb management policies, the vehicle operators focus group participants agreed that intersections and curbs should be made more similar throughout a city/region with lane striping and signage. One participant suggested that a comprehensive set of policies throughout a city would be best, but it should start with small changes. Another saw benefits for comprehensive policies and for ad hoc situational policies—San Francisco has many unique conditions that require special consideration, but there are also many instances where a standardized practice is appropriate. Regardless of the policies, the participants agreed that clear communication about the policies themselves and the rationale behind them is critical, as is flexibility to change things when it is determined that a certain decision is not working as planned.