LAST-MILE FREIGHT CURB ACCESS

DIGITIZING THE LAST-MILE OF URBAN GOODS TO IMPROVE CURB ACCESS AND UTILIZATION

IMPLEMENTATION REPORT

RECIPIENT NAME

CITY OF SEATTLE

FISCAL YEAR OF AWARD

FY22

PERIOD OF PERFORMANCE

09/01/2023—09/01/2025

PREPARED BY

SEATTLE DEPARTMENT OF TRANSPORTATION

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Acronyms

Acronym	Definition
AI	Artificial Intelligence
API	Application Programming Interface
BIPOC	Black, Indigenous, and People of Color
CDS	Curb Data Specification
CVLZ	Commercial Vehicle Load Zone
CLP	Commercial Loading Permit
DCE	Discrete Choice Experiment
GPS	Global Positioning System
HDC	Historically Disadvantaged Community
HDN	Historically Disadvantaged Neighborhood
HVAC	Heating, Ventilation, and Air Conditioning
IPMI	International Parking and Mobility Institute
IT	Information Technology
LTE	Long Term Evolution
NAICS	North American Industry Classification System
NEPA	National Environmental Policy Act
OMF	Open Mobility Foundation
PCI-DSS	Payment Card Industry Data Security Standard
PIPTA	Pacific Interconference Parking and Transportation Association
RDI	Roadway Digital Infrastructure
RFID	Radio Frequency Identification
SDOT	Seattle Department of Transportation
SMART	Strengthening Mobility and Revolutionizing Transportation
TNC	Transportation Network Company
TRB	Transportation Research Board
UFL	Urban Freight Lab
USDOT	United States Department of Transportation
V2C	Vehicle-to-Curb

1. Executive Summary

For over 30 years, Seattle has operated Commercial Vehicle Load Zones (CVLZs) and a Commercial Load Permit (CLP) program to help provide delivery and business access where curb demand is highest. However, Seattle's CVLZ regulations and other management tools have not kept pace with demand and rapid technological advancements in the commercial delivery industry. This has led to congestion, inefficiencies, and safety concerns for Seattle's business community. To address these challenges, the Seattle Department of Transportation (SDOT) launched *Last-Mile Freight Curb Access: Digitizing the Last-Mile of Urban Goods to Improve Curb Access and Utilization* pilot.

Project Location, Goals & Objectives

The Stage One project was guided by two main goals:

- ***Understand commercial vehicle curb access*** through robust baseline data collection and engaging with local businesses and urban freight companies
- ***Improve curb access*** through vehicle-to-curb technology, digital permit, and digital curb monitoring tools built on the Curb Data Specification (CDS) standard

The project was in Seattle's Belltown and Denny Triangle business districts. SDOT prototyped a digital commercial vehicle loading permit by digitizing curb regulations, deployed two vehicle-to-curb technologies, and engaged with local business and urban freight companies. The project tested whether technologies could build a data-driven CLP program by measuring zone usage, identifying vehicle types at these zones, permit compliance, and integration capabilities into a larger digital permit ecosystem that could inform citywide policy.

Partnerships and Engagement

Seattle partnered with the University of Washington's Urban Freight Lab to conduct 1:1 interviews with permit holders and survey commercial delivery operators. Local community engagement specialists focused on speaking to local businesses with in-language outreach to overcome cultural and linguistic barriers. The project was supported by Cambridge Systematics, the Open Mobility Foundation Curb Collaborative, and technology vendors CurbIQ, Umojo, and IPS.

Results and Key Takeaways

The project laid a strong foundation for needing a data-driven, modernized CLP program. Data shows approximately 80% of vehicles using CVLZs were unauthorized. V2C technologies can be an asset in managing CVLZs, however, solar power reliability, configuration, and data integration can be challenging. Using CDS standards made communicating information more efficient but required substantial initial effort to translate SDOT's existing legacy data sets into the latest data structure of CDS.

Moving Forward: Stage Two

Seattle has received a Stage Two SMART grant along with the City of Minneapolis. Stage Two will scale a type of vehicle-to-curb technology(ies) to 500 CVLZs, deliver five data-driven neighborhood curb loading plans, develop a curb data management platform, and adopt a scaled, data-driven approach to updating city policies to improve curb access.

2. Introduction and Project Overview

For over three decades, Seattle has operated Commercial Vehicle Load Zones (CVLZs) and a Commercial Loading Permit (CLP) program to provide efficient urban goods delivery and movement in its business districts. However, over 80% of vehicles using CVLZs today are unauthorized and do not carry valid CLPs, making these load zones unavailable to the intended users and disrupting the safe and reliable flow for transit, bicycle and vehicle movement. In April 2023, the Seattle Department of Transportation (SDOT) was awarded a United States Department of Transportation (USDOT) Strengthening Mobility and Revolutionizing Transportation (SMART) Stage One grant for a Last-Mile Freight Curb Access project, aimed to advance work to provide reliable, modernized access for commercial delivery vehicles at the curb using a collaborative, data-driven approach. In the latter half of 2024, SDOT submitted and was awarded a joint Stage Two grant application with the City of Minneapolis, under the project Smart Curbs for Better Access: A Digital, Data-Driven Approach Across Cities, to expand our Stage One efforts. This Final Implementation Report details SDOT's Stage One project and Stage Two project plans.

2.1. Project Description

Demand for curbspace is growing as more people are living, shopping, eating, going out for entertainment, and starting small businesses in urban business districts in Seattle. All these activities create competing demands on the curb and adjacent right of way, leading to conflicts between modes of travel, congestion, unauthorized parking behavior, and safety issues.

With previous Seattle-specific research, we know that without an adequate and available supply of on-street and off-street load zones, drivers of commercial vehicles are forced either to spend more time looking for parking or to park in unauthorized spaces[1] and that over 80% of commercial buildings in the urban core rely on the curb due to lack of off-street loading area or no nearby alley.[2] This project is intended to address these challenges.

SDOT has not had a scalable way to monitor commercial vehicle curb usage at a citywide level to inform effective policies through modern technology. Having a data-driven and scalable approach to curbspace management for urban goods delivery is a critical lever to enable Seattle to achieve safety and economic development goals. These include the City's Transportation Electrification Blueprint goal that 30% of all urban goods deliveries will be completed with zero emissions vehicles by 2030[3], and our Vision Zero goal to eliminate traffic-related deaths and serious injuries by 2030.[4]

[1] Girón-Valderrama, G. D. C., Machado-Leon, J. L., & Goodchild, A. (2019). Commercial Vehicle Parking in Downtown Seattle: Insights on the Battle for the Curb. Transportation Research Record, 2673(10), 770-780.

[2] The Final 50 Feet of the Urban Goods Delivery System, Executive Summary, 2017.

[3] Seattle's Clean Transportation Electrification Blueprint

[4] Seattle's Vision Zero Action Plan

Seattle chose North Downtown Seattle with two business districts as the Stage One pilot area for vehicle-to-curb (V2C) technologies, data collection, and policy review for the commercial vehicle load zone and permit analysis. SDOT will expand these efforts in Stage Two to all neighborhoods with paid parking and commercial vehicle load zones, starting with five priority business districts.

Figure 1 has three maps showing the deployment areas for Stage One and Stage Two. Figure 1.2 shows the Stage One project area and was in the Belltown and Denny Triangle business districts (approximately 0.5 square miles) just north of the downtown commercial core. Figures 1.1 and 1.3 show the future Stage Two project areas to the north and south of the Stage One area.

FIGURE 1. STAGE ONE AND STAGE TWO DEPLOYMENT AREAS

Land use patterns include dense residential, commercial, and office development that includes the Amazon headquarters and significant employment from other major high-tech companies. Belltown hosts many social service providers and income-restricted affordable housing but is not a historically disadvantaged neighborhood (HDN). The area is served by frequent bus transit and major bicycle corridors for travel into/out of downtown Seattle. The neighborhood business districts are home to many restaurants and nightlife venues dependent upon regular goods deliveries. The area has 150 dedicated CVLZs that vehicles with a CLP holder can use, which represents less than 30% of the city's total CVLZ supply.

In Stage Two, Seattle will expand V2C technology to 500 CVLZs citywide, which represents approximately 80% of the city's total CVLZ zones. SDOT will install the technology in multiple phases, with priority given to five business districts with distinctive characteristics in need of improved commercial curb access.

Each of the Stage Two priority business districts are described below:

- **Pioneer Square:** Seattle's oldest business district with significant history, many restaurants, entertainment venues and dense residential buildings, adjacent to Lumen Field, upcoming 2026 FIFA World Cup events, and downtown office and nightlife activity. (Tract: 53033009200)
- **Chinatown/International District:** Includes a diverse range of languages with a high density of local restaurants as well as wholesale activity serving restaurants throughout the city with frequent large special events adjacent to the stadium district, including the 2026 FIFA World Cup. (Tracts: 53033009100, 53033009000)
- **Capitol Hill/Pike-Pine:** Serves as the busiest restaurant and nightlife activity center in Seattle, and where a separate SDOT-funded project found 98% of vehicles parking in CVLZs were ***unauthorized***. Further, passenger vehicles overwhelmingly used the center turn lane to load (unauthorized activity), especially in the evening. (Tracts: 53033007500, 53033008400)
- **Columbia City**: Targeted growth area in Seattle's long-range plan, serves restaurants, bars, and retail activities in one of the most demographically diverse parts of the city. (Tract: 53033010100)
- **University District:** Adjacent to the University of Washington, with a high density of local restaurants and businesses. (Tract: 53033005302)

Stage One and Stage Two project areas are focused on the densest communities where advanced technology can be most beneficial, supporting curb management and open data Application Programming Interface (API) communications. Technologies such as V2C cameras and sensors, big data from third-party vendors, and better use of existing data from parking, walking, biking, and transit will allow us to communicate real-time and historical information about curb availability to foster public-private partnerships with freight and delivery services. Integrating and standardizing this data into our existing technology systems (such as displaying real-time curb availability in public facing web maps) could allow delivery drivers to quickly find available parking spaces.

SDOT's deployment for the V2C technologies are outlined in **Table 1** to help address the above issues that fall under the SMART Grant Program categories of intelligent sensor-based infrastructure, systems integration, and commerce delivery and logistics. One of the Stage One main goals was to evaluate the V2C infrastructure by seeing if it can identify vehicles at specific CVLZs and use that information to digitally communicate real-time space availability. The two V2C technologies evaluated in Stage One were: 1) single space parking meter using a stereoscopic camera with tap card integration; and 2) Long Term Evolution (LTE) solar-powered snapshot camera using Artificial Intelligence (AI) and computer vision.

TABLE 1. SUMMARY OF V2C TECHNOLOGY DEPLOYMENTS

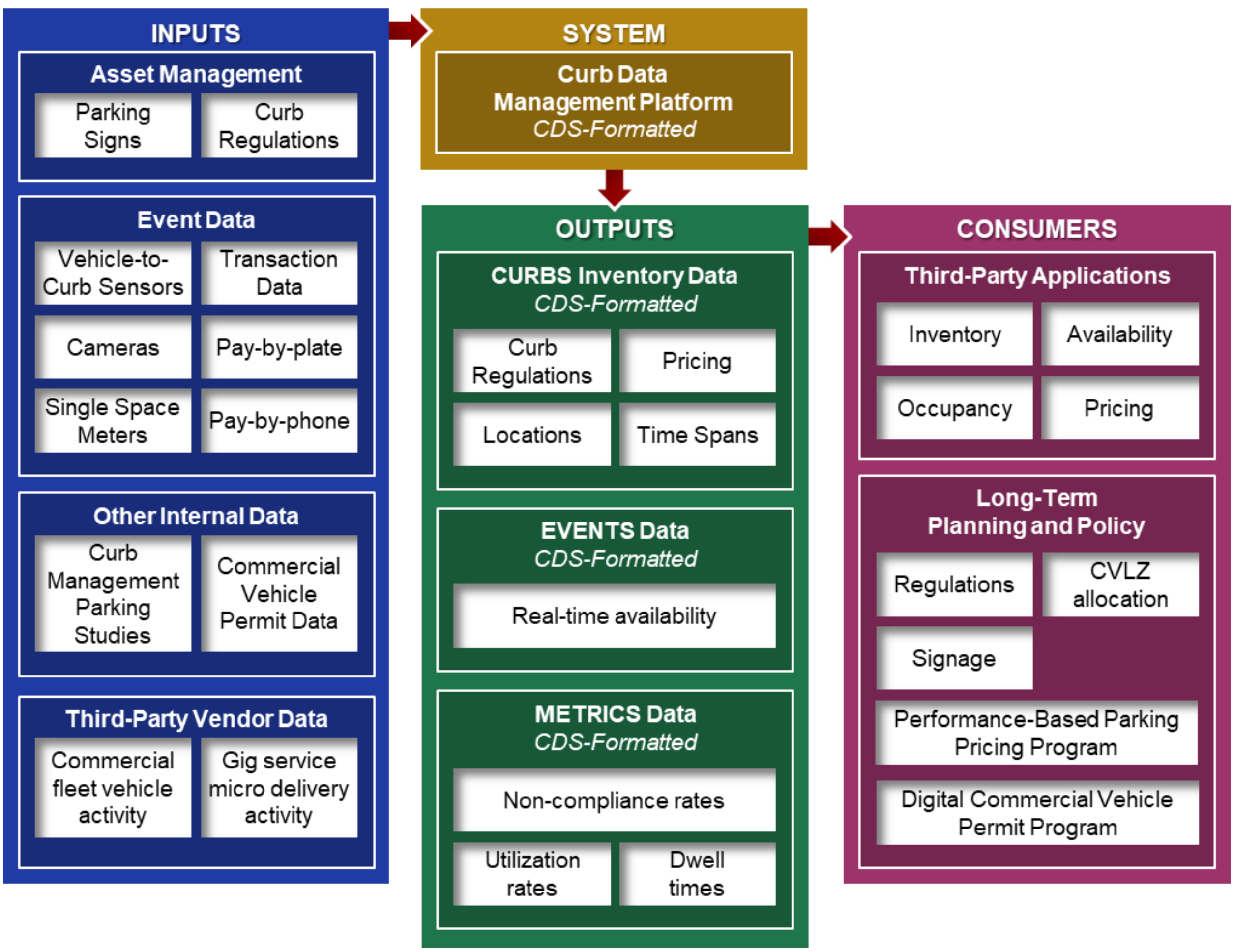
Technology - Vendor	Description of Services	Stage One Scale	Stage Two Scale
Stereoscopic Sensor - IPS Group	IPS Group installed smart parking meters with stereoscopic vehicle detection sensors and tap card technology to gather occupancy, length of stay, and other key metrics to improve the efficiency of CVLZ data collection and gather data for comprehensive analysis.	27	TBD
Camera Sensor - Umojo	Umojo installed solar-powered snapshot cameras to gather occupancy, length of stay, parking behaviors, vehicle type classification, and other key metrics to improve the efficiency of CVLZ data collection and gather data for comprehensive analysis.	25	TBD
Data Aggregator - CurbIQ	CurbIQ was the data aggregator of all data elements in the inventory: the physical curbside space from SDOT inventory (curbs data), existing CVLZ conditions from research conducted by the University of Washington's Urban Freight Lab (UFL) and Cambridge Systematics, and demand/occupancy data from sensors by IPS and Umojo. The CurbIQ platform provides metrics that help inform the utilization and trends reported by SDOT and the lead consultants.	2 dense business districts	30 dense business districts

Stage One's technology analysis (described later in the report) showed benefits and limitations of each technology. With this knowledge, the type of technology and scale will vary by business district in Stage Two. The project team will focus on each area's needs and implement the technology(ies) best suited.

SDOT is fortunate that for over twenty years, sign and curb inventory asset management system data has been collected, stored, and routinely updated. Even though these datasets are stored in a legacy system, the data provided a good starting place for Stage One work. The overall intent was to develop a digital inventory of all Seattle curb regulations within the study area (well over 100 types) in the Curb Data Specification (CDS) format as well as external APIs for digital communications. SDOT is investing in building the necessary foundational components to digitize the curb and to facilitate a future of automated, two-way communication to support more efficient curb management that benefits urban goods delivery and businesses throughout Seattle.

With Stage One stewarding the development of digital tools using national, open-source data standards with support from the Open Mobility Foundation (OMF), SDOT will be able to expand this prototype into a citywide curb data management ecosystem in Stage Two. **Figure 2** shows inputs, system components, outputs and consumer users' benefits for a curb management digital data ecosystem.

FIGURE 2. SDOT'S REPLICABLE CURB DATA MANAGEMENT ECOSYSTEM



The Stage Two project aligns with SMART Grant legislative goals to improve the safety and reliability of all road users impacted by commercial vehicle last-mile operations, promote digital connectivity among roadway infrastructure and commercial curb users, decrease congestion caused by lack of available load zones, foster improved partnerships and coordination with private sector freight and delivery services, and modernize the integration of systems containing curb inventory, events, and metrics.

Stage Two will scale Seattle's efforts in three ways:

1. Install sensor and camera technology to continuously measure curb usage in 30 business districts with focus on five priority business districts to develop data-driven urban goods delivery curb plans.
2. Develop a replicable curb data management software platform to ingest curb asset inventory and usage data and house interactive planning tools and APIs that may provide third-party private-sector applications with real-time availability, occupancy, and pricing information.
3. Adopt a scaled, data-driven approach to improving curb access by leveraging Stage One findings to implement policy and program modification legislation such as updating legal definitions, pricing, and vehicle eligibility to govern modernized curb management and commercial vehicle permit programs.

Communities Impacted by At-Scale Implementation

There are three primary community segments that will benefit from improvements to commercial loading in Seattle: permit holders and local retailers and receivers (those businesses and customers receiving goods). SDOT's CLP program database reveals that permits are used by a wide variety of businesses, including small and locally based companies, who make deliveries throughout the city. Additionally, many small businesses, especially restaurants, are owned or operated by people of color. Put together, these two communities may not be defined by a zip code but interact more fluidly in neighborhoods across the city. The project team engaged with permit holders and business owners, primary communities of impact during Stage One, to better understand their needs and challenges. The Stage One engagement findings and insights are summarized later in the report. With these insights, SDOT plans to expand upon the lessons learned from the Stage One engagement efforts to invest significant resources in the Stage Two stakeholder engagement to make stronger connections between curb efficiency improvements and the benefits to these two main user groups including how to quantify curb improvements.

Benefits for Disadvantaged Communities

The Stage One project area local census data reveals that the area is racially and linguistically diverse and includes a higher percentage of renters compared to the rest of Seattle. Additionally, there are more than 100 Black, Indigenous, and People of Color (BIPOC)-owned businesses in the area[5]. The engagement

[5] Intentionalist Business Directory

focused on these businesses, specifically the in-person outreach, as these groups are often left out of conversations that shape city policy due to linguistic or cultural barriers.

Stage One outreach was led by EnviroIssues, a local specialist in strategic communications and public engagement in the Seattle area. Twelve business owners and managers were interviewed. To accommodate those who prefer languages other than English, the project team provided in-language interviews and translated materials. The goal was to understand how businesses use CVLZs, whether and why they do or do not have permits, how zones and permits could be improved, and how they feel about and whether they would be interested in testing new technologies. The lessons learned from these efforts will inform future SDOT policies and shape a modernized CVLZ permit program that is beneficial to these communities.

Stakeholder Impacts and Program Benefits

The twelve businesses interviewed expressed gratitude to SDOT for seeking their input, as they often feel excluded from City decision-making processes. Most businesses reported challenges with parking for delivery vehicles, and the degree of concern was linked to the frequency of their deliveries. Grocery stores, which receive up to three deliveries per day, were the most frustrated with the lack of reliable curbside loading access. Restaurants, which receive up to six deliveries per week, expressed less frustration. Small businesses receiving the fewest deliveries, such as a tattoo parlor, a dentist's office, and a floral shop, were the least frustrated with access to CVLZs.

Most stakeholders emphasized the need for increased parking enforcement to ensure CVLZs are available for delivery drivers when needed. Freight carriers noted that enforcement and management of CVLZs are seen as a key factor in CLP program valuation (that is, whether they purchase annual permits for their fleet) and would like to see both enforcement and management addressed better citywide. Some businesses indicated a desire for more CVLZs but also want to balance that need with short-term parking for their customers. Nearly all interviewees were supportive of the idea of digital permits and sensors for traffic management and parking enforcement, particularly among restaurants and grocery stores. Many also expressed interest in testing the new Stage One technologies. While skeptical, they expressed a desire to stay informed about the project's progress.

In addition to providing businesses with better access to CVLZs, we aimed to provide digital tools that will allow smaller logistics and delivery businesses to compete on equal footing with larger corporations through access to information on commercial zones and curbspace availability that facilitates efficient operations.

2.2. Project Deployment and Implementation

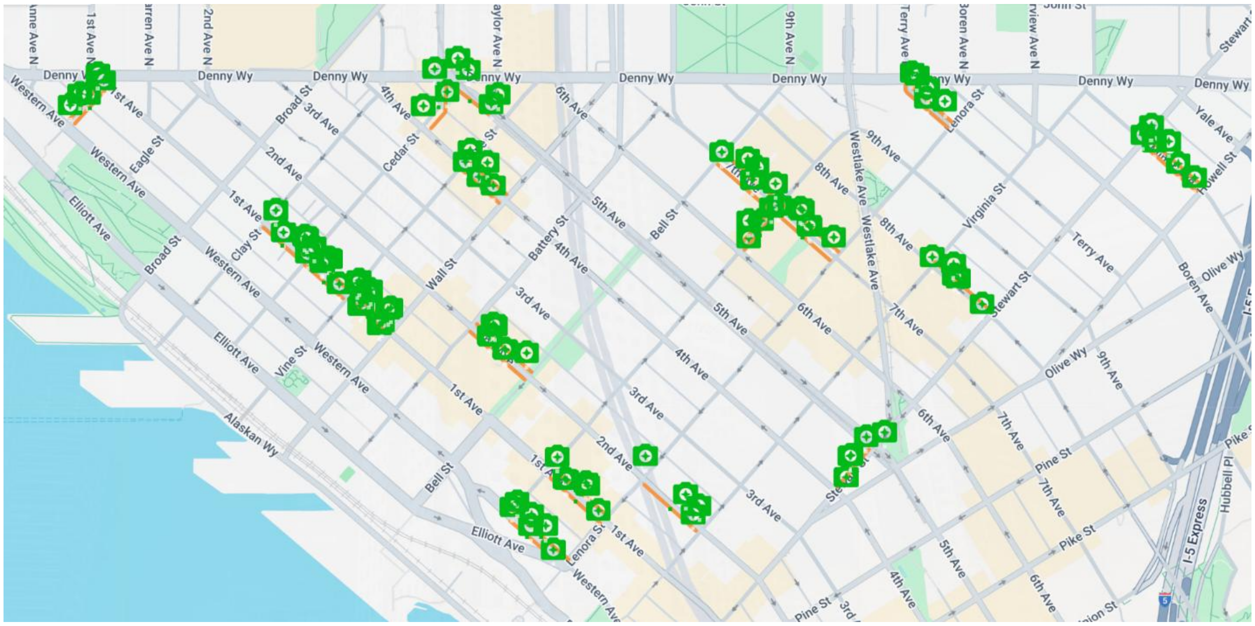
The Stage One project focused on building foundational components for a scalable, citywide deployment of a modernized CVLZ and CLP program, namely:

1. Engaging with local businesses and urban freight companies to understand challenges and build a foundation of trust
2. Prototyping a digital permit and curb management monitoring tools to modernize and scale within the larger curb management ecosystem for SDOT
3. Collaborating with a national cohort of cities led by the OMF to explore how the CDS can help pilot and scale dynamic curb use

Three rounds of analysis were conducted as part of Stage One:

- **Round 1** included a baseline data collection and analysis of 30 blockfaces highlighted in orange and shown in **Figure 3.** Data collection included conventional efforts using video cameras at locations shown by the green camera icons along with technicians to watch and manually record parking events. These efforts were paired with spot data collection efforts to verify vehicle types and presence of CLPs.
- **Round 2** included a smaller focused data collection effort to support the technology assessment. Round 2 data collection included two days of data collection and analysis to compare parking events captured by the Umojo cameras and IPS sensors to data collected using conventional video cameras. During analysis large disparities were discovered between the two data sources. As a result, the project team reexamined the sensor configurations, made a few adjustments, and conducted a third round of data collection.
- **Round 3** included a smaller focused data collection effort to strengthen the technology assessment. The Round 3 data collection included two days of data collection and analysis to compare parking events captured by IPS and Umojo sensors to data collected using conventional video cameras. This was used to provide a high-level assessment of the technologies and an evaluation of various layouts to find the most optimal for accurately measuring CVLZ curb activity.

FIGURE 3. MAP OF BASELINE DATA COLLECTION BLOCKFACES



2.3. Summary of Project Activities

During the first several months of the project, SDOT focused on setting up the project team including, the research lead (University of Washington's Urban Freight Lab (UFL), project management consultant (Cambridge Systematics), data collection consultant (IDAX), and community engagement consultant (EnviroIssues). These partners have worked with SDOT previously and each provides specific niches of expertise valuable to this project.

- The UFL is a leading research cohort working to identify complex urban freight management problems and design solutions.
- Cambridge Systematics is a nationally known transportation planning firm with deep experience in technology project implementation, data standards, and big data analysis.
- IDAX is one of the most well-known Seattle area traffic and parking data collection firms.
- EnviroIssues is a local woman- and minority-owned business with decades of community engagement experience.

Once the project team was established, SDOT focused on procuring V2C vendors and technology installations while the project team focused on baseline data collection, stakeholder engagement, and CDS data translation.

In the latter half of 2024, SDOT submitted a joint Stage Two grant application with the City of Minneapolis, under the project *Smart Curbs for Better Access: A Digital, Data-Driven Approach Across Cities* and was awarded. To better align the Stage One completion date and Stage Two start date, USDOT granted a six-month extension to Stage One.

Outside of the project team, SDOT engaged with and learned from other SMART grant awardees by attending the SMART Grant Summit in Washington, DC, in September 2023 and July 2024 in Boston, MA. SDOT also was involved in a collaboration with OMF as part of the SMART Curb Collaborative, a group of ten SMART grant recipient cities focused on digital curb management projects. The OMF hosted two in-person SMART Curb Collaborative meetings over the course of the project. One in April 2024, hosted in Seattle and one in March 2025, hosted in Portland, OR.

The collaboration identified using a cooperative purchasing agency for procurement called Sourcewell (a state of Minnesota agency), with the goal of providing SDOT and other interested cities with Curbside Management Technologies and Related Services. SDOT used the Sourcewell contract mechanism to procure data management services and curb monitoring devices to support our digital CLP program, which was a large focus of Stage One activities. This is the first time SDOT has used Sourcewell or any cooperative purchasing for curb management procurement.

A framework to achieve the Stage One milestones during the 24-month project timeline was created. **Table 2** indicates the originally planned and actual completion dates for key Stage One milestones along with high-level comments on challenges and issues the project team faced.

TABLE 2. KEY STAGE ONE MILESTONES

#	Stage One Milestones	Planned Completion Data	Actual Completion Date	Milestone Comments
1	Create baseline conditions, maps and data collection plan	Q4 2023 – Q1 2024	Q2 2024	Completed.
2	Develop stakeholder strategic engagement plan	Q1 2024	Q2 2024	Completed.
3	Procure technology services such as data management and V2C infrastructure	Q1 2024	Q4 2024	Completed. Procuring technology services took longer than expected due to technology limitations and procurement challenges.
4	Implement stakeholder communications strategic engagement plan	Q2 2024	Q2 2024 – Q1 2025	Completed. Engaging non-permit holders and some local businesses was a challenge; additional outreach will be required in Stage Two.
5	Finalize baseline conditions analysis	Q2 2024	Q4 2024	Completed.

#	Stage One Milestones	Planned Completion Data	Actual Completion Date	Milestone Comments
6	Finalize CDS digital curb inventory	Q3 2024	Q3 2024	Completed.
7	V2C infrastructure installed and operational	Q2 - Q3 2024	Q4 2024	Completed. Umojo deployment and configuration took longer than anticipated.
8	CVLZ survey results and recommendations	Q4 2024	Q1 2025	Completed. Survey took longer than expected to refine the questions and methodology, identify and recruit participants, and collect enough responses.
9	Deliver V2C technology assessment	Q4 2024	Q1 - Q3 2025	Completed. Assessment took longer than expected due to deployment and reporting issues with camera technology.
10	Submit Final Report	Q1 2025	Q4 2025	Completed.

2.4. Attention Gained from Project

This project has gained attention both locally and nationally. At a national level, OMF developed the SMART Curb Collaborative, bringing together a group of cities, including Seattle, that received SMART grant funding to tackle curb management challenges.

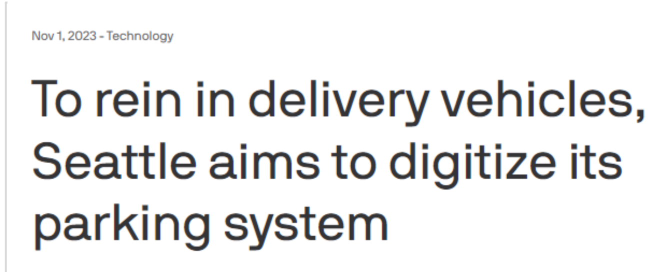
SDOT staff have presented the SMART work at several conferences:

- **Transportation Research Board (TRB) 2023** – Innovations in Freight Data Workshop – Washington, DC
- **Pacific Intermountain Parking and Transportation Association (PIPTA) 2023** – Annual Conference Keynote Panel – Seattle, WA. PIPTA is the Pacific Northwest and Mountain region parking association
- **International Parking and Mobility Institute (IPMI) 2023** – Shoptalk: Curb Management Session – Fort Worth, TX – IPMI is the National Parking + Mobility Conference + Expo and largest attended municipality parking conference
- **CoMotion 'LA 2024** – From Pilot to Program: Lessons in Creating Lasting Change – Los Angeles, CA. CoMotion showcases the latest innovations and trends in multimodal transportation and technology
- **TRB 2025** – Roadway Digital Infrastructure and Cities Panel and Roadway Digital Infrastructure (RDI) Research Charrette – Washington, DC

- **IPMI 2025** – Open Data for Better Curb Access: Implementation Learnings from Three SMART Cities – Louisville, KY

Outside of the SMART grant awardee cohort, SDOT and UFL presented at the OMF Curb Data Specification working group webinars about the project and shared learnings with fellow cities. SDOT, UFL, and Cambridge Systematics shared learnings of the project with fellow cities at conferences. At a local level, SDOT has a publicly available website and blog posts describing the goals for this project and the future of the CLP program at SDOT. UFL is working on several academic papers based on the SMART grant project and their innovative research. This research is expected to be published in the coming years. The Stage One project has also gained attention through on-the-ground community outreach in the project area.

FIGURE 4. AXIOS ARTICLE HEADLINE


Nov 1, 2023 - Technology

To rein in delivery vehicles, Seattle aims to digitize its parking system

Below is a list of websites, articles, and social media posts promoting and explaining this project.

- https://southseattleemerald.com/2023/04/20/sound-transit-and-seattle-department-of-transportation-awarded-federal-grants-for-improvements/
- https://www.openmobilityfoundation.org/smart-curb-collaborative/
- https://www.openmobilityfoundation.org/showcase-seattle/
- https://sdotblog.seattle.gov/2022/01/25/curb-data-specification-update/
- https://www.seattle.gov/transportation/projects-and-programs/programs/parking-program/seattle-smart-grant-digital-commercial-vehicle-permit-project
- https://www.axios.com/2023/11/01/seattle-amazon-delivery-car-digital-parking-system
- https://www.ce.washington.edu/news/article/2024-05-30/urban-freight-lab-expands-impact-beyond-seattle
- https://urbanfreightlab.com/news_announcements/urban-freight-lab-awarded-a-2m-smart-grant-to-digitize-the-curb/
- https://urbanfreightlab.com/research-projects/last-mile-freight-curb-access-digitizing-the-last-mile-of-urban-goods-to-improve-curb-access-and-use/
- https://www.linkedin.com/posts/openmobility_cds-collaboration-smartgrant-activity-7189759402462138368-TZG8?utm_source=share&utm_medium=member_desktop
- https://sdotblog.seattle.gov/2025/01/22/deliveries-upgrade-digital-sensors-curb-data/
- https://www.linkedin.com/posts/seattle-department-of-transportation_smartgrant-urbanmobility-opendata-activity-7322680886712221697-

mEZ0/?utm_source=share&utm_medium=member_desktop&rcm=ACoAAAYhTcoBTY1mXU--Xx41EDTVVPMg7eCvlEk

2.5. Deviations from Original Proposal

The Stage One project was largely consistent with the vision set forth in the original proposal. The main deviations were:

- **Differences in the V2C infrastructure technology to be deployed.** The available technology was not as advanced as SDOT had ***been led to believe***. The team explored a wide variety of technologies with a focus on automated technology that could communicate from a unique vehicle to a unique curb asset in a passive manner. SDOT and UFL engaged with Impinj Inc., IPS Group, eleven-x Incorporated, and Umojo to explore ideas such as Radio Frequency Identification (RFID)-based tolling technology and vehicle-based Bluetooth-enabled sensors. Unfortunately, neither technology was advanced enough to test in the Stage One pilot. SDOT remains interested in these technologies, which we expect will evolve in the coming years and may yield opportunities for interoperability with our Stage Two proposal.
- **Minor schedule delays.** This occurred due to procurement challenges with qualified technology vendors. Some of these challenges are related to the availability of technology options previously mentioned. While we learned early that RFID technologies were not yet ready for deployment, we went far down the path of procurement with a vendor who promised an integrated sensor and Bluetooth solution that would communicate between curb and vehicle, only to learn late in the game that the Bluetooth connection with this sensor technology was in fact not ready for deployment. We then had to pivot to another vendor capable of providing camera technology instead that could be used in a broader range of applications equivalent to the hoped for Bluetooth connection.
- **Contract extension.** A six-month extension was granted to our project to better align Stage One and Stage Two. The City of Minneapolis has been awarded a SMART Stage Two grant, and Seattle is a subrecipient. To minimize the gap between the end of Stage One, and the beginning of Minneapolis' Stage Two project, the Stage One end of performance date shifted by two quarters. With this extension the project team continued to build out relationships with local businesses and freight carriers, collected and analyzed additional sensor data for our technology assessment, conducted a detailed analysis of SDOT's curb asset data, and overall gained a better understanding of CVLZ use.

3. Prototype Evaluation and Findings

This section highlights the Stage One efforts and findings from the community outreach, data collection and analysis, and curb digitization activities. SDOT worked with small businesses and local private sector delivery companies, leveraging stakeholder engagement, data, and technology to research and conceptualize an improved digital curb system for Seattle. Additionally, SDOT translated its existing curbspace and sign regulation data into OMF's CDS standard to develop a digital twin for curb inventory, events, and metrics. These are the basis for standard data communications, evaluation, and data integration that supports long-term planning and policy.

3.1. Prototype Performance

The performance measures listed in **Table 3** indicate how SDOT assessed Stage One's prototype. One main objective of evaluating the prototype was to better understand what could be realistically achievable through citywide implementation.

TABLE 3. PERFORMANCE MEASURES, TARGETS, AND FINDINGS

Evaluation Question	Performance Measure	Performance Measure Targets	Overall Findings
Overall Project			
Can digital permits and curb monitoring technology improve curbspace efficiency and utilization?	Rigorously assess piloted technologies to understand their scaling potential	Determine which technology and policy can scale in Stage Two	V2C technologies are feasible, but more testing and analysis is required in Stage Two before pursuing full system integration. Single space parking meters with stereoscopic camera sensors have shown to be a viable option for continuously monitoring commercial curb activity though integrating a digital permit/payment ecosystem would be challenging with this technology. The data provided by this system showed promise to inform city policy and actively manage curbspace. SDOT will explore scaling this type or similar technology in Stage Two.

Evaluation Question	Performance Measure	Performance Measure Targets	Overall Findings
			AI driven camera technology for curb monitoring did not show great potential for scaling at this time due to challenges in solar powered battery performance, AI computer vision configurations, and limited of permit ecosystem integration. More analysis is required to provide a definitive answer.
Safety and Reliability			
Can digital permits and curb monitoring technology reduce the number of vehicles parking in travel lanes or other "unauthorized" locations?	Document number and type of unauthorized parking events	Create baseline dataset at 2-3 different sub-areas within study area	Approximately 80% of vehicles using CVLZs were unauthorized. 62% of permit holding CVs comply with regulations.
Resiliency			
What is the vehicle detection accuracy of V2C?	Number of vehicles correctly detected in a CVLZ parking space	98% detection	Detection rates vary widely depending on type of technology and location of load zone. Observed rates ranged from 85% average detection with IPS to 33% average detection with Umojo. Further assessment to be completed in Stage Two.
Congestion			
Are there commercial vehicle parking policy and pricing scenarios SDOT can deploy via curb monitoring and digital permits to help the city reduce transportation-created pollutants?	Review baseline data collection, in-depth interviews, and V2C assessment	Create parking policy and pricing scenarios used to improve curb access and incentivize reducing congestion	As the annual permit price increases, the proportion of respondents choosing to purchase a CLP decreases, and more respondents indicate they would choose not to pay for parking. Further assessment to be completed in Stage Two.

Evaluation Question	Performance Measure	Performance Measure Targets	Overall Findings
Access			
How do small and local businesses make deliveries and utilize the curb? Which businesses have concentrated numbers of BIPOC and low-income employees?	Understand and categorize different users of the curb (carriers) and receivers (local businesses)	Perform in-depth interviews with one small, medium, and large carriers. Analyze existing permit holder composition and conduct online survey of existing permit holders	100% of businesses interviewed see management of load zones as a key factor in curbspace value. Cruising and re-routing are less preferred options when CVLZs are not available.
Partnerships			
How do users (carriers) and receivers (local businesses) respond to digital permits and new commercial curb policies?	Document existing permit holders and other commercial vehicle operators feedback on how new system could integrate with their daily work	Collect survey responses from project participants and other stakeholders to gather feedback on pilot technology and new policy scenarios	Companies prefer permits to remain visible on the window (open to also being a digital permit) and have a strong preference for passive and frictionless technology.
Integration			
Can SDOT convert its existing digital curb regulations inventory into CDS?	Understand how CDS formatted data integrates with existing SDOT curb datasets	Develop a replicable process to translate curb regulations into CDS format	Data translation is possible, but it is complex to translate multiple non-standardized datasets into CDS. It is a time-consuming and costly process, however SDOT can make minor changes to their data for easier translation as we work on a larger overhaul of system.

3.2. Summary of Findings

The Stage One project work has yielded prescience in each of the program goals areas. SDOT is confident that we have meaningfully assessed feasibility of deploying sensor technology to test performance measures and have been able through rigorous development of the prototype, to accomplish significant project work in a short amount of time. Below is a summary of findings with more detailed analysis in Section 5.

Goal Area: Safety and Reliability

Performance Measure Target: *Create a baseline dataset at 2-3 different subareas within study area.*

SDOT used its extensive experience in data collection efforts to identify which CVLZs to study within the overall study area. IDAX's Round 1 data collection effort collected usage and turnover data at 30 blockfaces with CVLZs. This was done through temporary installation of video cameras that observed all angles of the blockfaces over two observation days. These video feeds were then manually transcribed by IDAX staff, covering 7 am - 7 pm on each observation day to record all parking events and relevant zone, vehicle type, dwell time, and behavior patterns indicating Transportation Network Company (TNC) activity or delivery activity. CLP decals and TNC decals were observed if possible. On one of the two days in each observed blockface, IDAX staff were present on the street to record whether vehicles had permit decals and other relevant information. UFL and Cambridge Systematics analyzed the baseline data to provide summary findings before the installation of V2C technology.

The main baseline data findings are as follows:

- **Use at the commercial vehicle load zones.** More than 8,000 "parking and loading" events were observed in the study area. Approximately 1/4 of these events (~2,200) occurred in CVLZs. Most parking and loading events in CVLZs were unauthorized, meaning the vehicles parking did not possess a CVLZ permit or did not meet the definition of a commercial vehicle:
  - The breakdown of CVLZ users was as follows: non-permit holder passenger vehicles (82%), non-permit holder commercial vehicles (11%), and CVLZ permit holders (7%).
  - Only commercial vehicles such as vans, box trucks or passenger vehicles with commercial vehicle permits are allowed to use CVLZs. The high incidence of unauthorized CVLZ use, calculated to be approximately 80%, is a ***strikingly*** important finding.
- **Commercial vehicles.** Commercial vehicles were responsible for 8% of parking and loading activity in the study area. 23% of these commercial vehicles displayed a valid CVLZ permit.
- **Where commercial vehicles park and load along the blockface.** Commercial vehicles, including those with CVLZ permits, do not park exclusively in commercial loading zones, but permitted vehicles are more likely to use those designated zones. 51% of all commercial vehicle parking and

loading events took place in CVLZs. 19% of commercial vehicles parked in various unauthorized locations (e.g., driveways, no parking zones, etc.), followed by paid parking zones (which is allowed if paid,17%), passenger load zones (8%), and, in the travel lane (5%). However, frequencies of parking choice were different between permit and non-permit holders. **Of permitted vehicles, 62% took place at CVLZs,** followed by paid parking (20%) and passenger load zones (14%) with only one event of a permit holder double parking and none using the "no parking" area.

FIGURE 5. SDOT CVLZ PERMITS

Example of a vehicle with multiple annual commercial vehicle load zone decal permits

From this data, SDOT concludes that **permitted commercial vehicle drivers are more likely to park at CVLZs**, and less likely to park in unauthorized parking areas, compared to non-permitted commercial vehicles.

- **Passenger vehicles.** These include vehicles making on-demand goods and food deliveries. They represented 91% of the parking events in the study area. These vehicles most frequently used paid parking spaces (35%), CVLZs (23%), and "Other" no parking areas (20%). 49 of the 1,844 observations of passenger vehicles utilizing CVLZs displayed a valid CVLZ permit.

The main findings regarding dwell times are as follows:

- **Passenger vehicle dwell time.** Passenger vehicles involved in food delivery, goods delivery, TNCs, and transit-related activities parked for less than five minutes based on median dwell time. For all vehicle types, unauthorized parking dwell times were, on average, shorter than authorized parking by 3-5 minutes, regardless of space type. Double parked vehicles exhibited the shortest median dwell time at less than 30 seconds. Notably, parking authorized by CVLZ permits for food delivery and goods delivery vehicles was longer than parking by unauthorized users by 1-6 minutes.
- **Commercial vehicle dwell time.** Permit holders parked in CVLZs for longer periods than unauthorized users, except for urban freight deliveries (e.g., construction materials and parcel delivery). Freight delivery dwell time was 12-13 minutes in CVLZs regardless of the presence of a permit. Similar to passenger vehicle behavior, double parking dwell time was the shortest of any parking behavior at 2.4 minutes. Commercial vehicles, when they used Passenger Load Zones, parked for a median time of 5-7 minutes. Commercial vehicles dwelled for longer periods (~14 minutes) in paid parking spaces.

In addition to analysis of the study area baseline observation data, the project team reviewed citywide CVLZ citation data to understand patterns of unauthorized behavior that may indicate useful information about demand and how people use CVLZs, regardless of the law. The number of citations issued per year for inappropriate use of CVLZs (Seattle Municipal Code 11.72.075) is shown in **Table 4**. Within the top eight types of violations issued in 2022 in the Stage One study area, commercial load zone violations (i.e., non-permitted vehicles parking in CVLZs) accounted for 21.2% of citations, while commercial load zone usage (i.e., permitted vehicles using CVLZs incorrectly) accounted for 1.7% of citations.

TABLE 4. NUMBER OF CVLZ-RELATED CITATIONS PER YEAR (CITYWIDE)

Year	No. Citations
2017	6,800
2018	10,647
2019	10,926
2020	9,712
2021	8,557
2022	8,071
2023	8,811
2024	11,257

Goal Area: Resiliency

Performance Measure Target: *V2C technology has a 98% daily detection rate for parking events in each CVLZ under varied conditions.*

SDOT has conducted detailed testing of two V2C technologies (IPS and Umojo) against physically observed parking events using a local data consultant (IDAX) at three CVLZs across two days. The results indicate that the project's 98% target was only met at only one location on one day by IPS – however, IPS double counted some vehicles and counted more parking events than were observed.

Table 5,Table 6, and Table 7 provide a comparison of the parking counts and dwell times for the two V2C technologies (IPS and Umojo) across three locations. The full analysis can be found in Section 5.3.

TABLE 5. V2C TECHNOLOGY ASSESSMENT AT 4TH AND WALL

Location 1: 4th Avenue at Wall Street						
	IDAX		IPS		Umojo	
Daily	7/1/25	7/2/25	7/1/25	7/2/25	7/1/25	7/2/25
Total	45	22	24	18	9	7
% Difference (to IDAX)			*53%*	***82%***	*20%*	*32%*
Avg Dwell (min)	*8:09*	*18:49*	*11:22*	*14:56*	*22:00*	*35:26*

TABLE 6. V2C TECHNOLOGY ASSESSMENT AT MINOR AND HOWELL

Location 2: Minor Avenue at Howell Street						
	IDAX		IPS		Umojo	
Daily	7/1/25	7/2/25	7/1/25	7/2/25	7/1/25	7/2/25
Total	36	32	35	36	9	14
% Difference (to IDAX)			***97%***	***113%***	*25%*	*44%*
Avg Dwell (min)	*12:14*	*12:36*	*5:53*	*9:21*	*22:18*	*22:05*

TABLE 7. V2C TECHNOLOGY ASSESSMENT AT 2ND AND BATTERY

Location 3: 2nd Avenue at Battery Street						
	IDAX		IPS		Umojo	
Daily	7/1/25	7/2/25	7/1/25	7/2/25	7/1/25	7/2/25
Total	64	64	47	58	22	25
% Difference (to IDAX)			*73%*	***91%***	*34%*	*39%*
Avg Dwell (min)	*15:31*	*10:51*	*18:01*	*12:02*	*36:11*	*23:12*

Goal Area: Access

Performance Measure Target: *Perform in-depth interviews with one small, medium, and large carrier. Analyze existing permit holder composition and conduct an online survey of existing permit holders.*

SDOT and the project team built strong relationships in Stage One through interconnected public and stakeholder engagement. These relationships have provided valuable insights into the access needs of the local businesses and freight delivery operators the CVLZs are designed to serve.

In-Depth CVLZ Permit Holder Engagement: UFL conducted six one-on-one interviews with current CVLZ permit holders, spanning different business sectors and company sizes (refer to **Table 8**). The goal of the interviews was to understand their specific delivery and loading behaviors. In particular, the interviewers focused on understanding the motivations behind the choice of purchasing CVLZ permits, the related parking and routing behaviors of their delivery drivers, and the challenges they face in performing deliveries in the study area.

TABLE 8. SUMMARY OF CVLZ PERMIT HOLDER INTERVIEWS

ID	Business Sector	Business Description
1	Parcel carrier	Large parcel delivery company
2	Wholesaler - produce	Local supplier of fresh produce
3	Wholesaler - food ingredients	Local supplier of food ingredients serving local restaurants, food businesses, and chains in Western Washington
4	Wholesaler - beverages	Multi-state beverage distributor, mostly supplying stores, bars, restaurants
5	Restaurant	Local restaurant using personal vehicles to pick up from distributors and restock the restaurant pantry
6	Brewery	Small local brewery company operating two breweries open to customers and performing deliveries to wholesalers and restaurants/bars

Key lessons learned from the CVLZ permit holder interviews are:

- CVLZs are perceived as necessary to efficiently perform operations in Seattle's downtown area, especially for those using larger vehicles and with longer dwell times. Although they are not always available or well enforced, CVLZs often represent the only viable alternative for larger commercial vehicles to park in urban, congested areas, especially without alternative parking locations such as loading docks.
- Enforcement is a key factor in how a company values permit purchase and usage, but not in the way expected. Companies report getting very few tickets. Consequently, the risk of getting a ticket is not listed as the primary reason for purchasing CVLZ permits. Instead, companies are asking for more enforcement of CVLZs, as they are frustrated when other vehicles (especially smaller food delivery/passenger vehicles like TNCs) park at CVLZs without a permit. Without additional enforcement, purchasing permits may not be seen as worth the money.
- Companies who own and operate businesses with commercial delivery outputs in the study area (the brewery and restaurant owners) have a sense of "ownership" of the CVLZ in front of their businesses. In one case, the company asked for a CVLZ to be placed in front of their downtown location.

- Urban delivery drivers undergo a complex and manual decision-making process, where drivers are the final decision makers of where to park and for how long, with almost no use of technology. For the companies interviewed, they reported not relying on routing software that auto-directs drivers, and all of those interviewed allow their drivers to re-route and change customer delivery order (within some bounds), in response to a complex, dynamic urban environment. This finding informs how SDOT should tailor building and packaging load zone occupancy/location data for carriers.
- Based on past data and current permit prices, the interviewed companies' demand for permits seems to be inelastic to increases in permit prices. While overall the City's sale of permits has dropped over the years, the interviewed companies' number of permits purchased has remained unchanged or increased despite the price increases.
- Parking at CVLZs is the preferred option, while double parking, parking in the middle lane, and re-routing to return later are the least preferred alternatives when the CVLZ is not available.

In-Depth Small Business Engagement. The project team conducted interviews with a diverse range of business owners and building managers through outreach specialists with the same cultural and language backgrounds. The results were in-depth interviews with Spanish-, Mandarin-, Korean-, Japanese- and English-speaking business owners to discuss their delivery challenges and share improvement ideas. The business owners varied, from restaurants to grocery stores, floral shops, and other retail establishments (see the full list in **Table 9** below).

TABLE 9. SUMMARY OF LOCAL BUSINESS INTERVIEWEES

No. of Interviews	Type of Business
6	Restaurant
4	Building management
3	Grocery / convenience store
1	Dentist
1	Tattoo Parlor
1	Floral Shop

Key lessons from business interviews include:

- Challenges with parking and loading for delivery vehicles are common among businesses, and most prevalent among grocery stores and restaurants as they receive frequent deliveries.
- The businesses we interviewed would like to see more parking enforcement to ensure that CVLZs are available for delivery drivers.

- Some businesses indicated a desire for more CVLZs but also want to balance that need with parking for their customers.
- Only one of the 12 businesses interviewed had a CVLZ permit. Others would consider getting one depending on the cost.

Goal Area: Congestion

Performance Measure Target: *Create load zone policy and pricing scenarios used to improve curb access and incentivize reducing congestion*

SDOT worked with UFL to create and distribute an online survey to commercial vehicle operators in Seattle. The goal of the survey was to understand the curbside loading challenges, commercial vehicle operator's experience using CVLZs, and investigate the impact of future policies and pricing scenarios for the CLP program.

The analysis of the UFL interview responses highlights significant differences between permit holders and non-permit holders, particularly in factors like fleet size, route frequency, parking preferences, and operational constraints. Permit holders operate more routes, make more stops, and park closer to their destinations, which possibly can be due to their reliance on CVLZs. In contrast, non-permit holders indicated they park farther away, have longer stop durations, and have a higher preference for informal parking solutions, which can possibly suggest greater curbspace access challenges. The long history of permit purchasing and the high permit-to-fleet ratio further confirm the importance of CVLZ access for many businesses.

The survey data showed that as the annual permit price increases, the proportion of respondents selecting to buy the annual permit decreases, and more respondents indicate they would choose not to pay for parking. The share of respondents who chose the pay-per-use option remains mostly constant despite changes to the price of the annual permit. This suggests that demand for the annual permit is price elastic, with higher prices potentially leading to a shift to alternative options.

Despite the structured permit system, businesses express their concerns and challenges, including limited CVLZ availability, competition from non-commercial vehicles, parking enforcement restrictions, and construction-related disruptions. Direct quotes from survey respondents are shown in **Table 10**. These findings emphasize the need for potential adjustments to CVLZ policies and enforcement structures to better accommodate commercial vehicle operations.

TABLE 10. DIRECT QUOTES FROM SURVEY RESPONDENTS REGARDING CHALLENGES TO OPERATING COMMERCIAL VEHICLES IN SEATTLE

Direct Quotes from Survey Respondents
"People without a commercial load zone permit parked in our spots. Both unattended cars and people sitting in their cars. I find it harder and harder to find a parking spot."
"The biggest challenge is that the load zones are frequently occupied by a parked vehicle that doesn't have a load zone permit to begin with. It gets frustrating when we receive a parking ticket when forced to park on the street adjacent to a load zone and the vehicle parked in the zone without a permit doesn't receive a ticket for occupying the space. It also doesn't help that over the years the load spaces have been decreasing with the changing of vehicle accessibility to areas."
"Uber eats, postmates, etc parking in commercial load zones without a permit. Not enough commercial load zones for the density of businesses in certain areas."

As the project team shifts into Stage Two, continued research on future load zone curbspace policies and pricing scenarios will play a critical role in developing and defining the proposed changes. Building on the work in Stage One, the team will continue to engage the following groups through a combination of interviews and surveys:

- Freight carriers with and without CVLZ permits
- Local businesses
- Meal, grocery gig delivery, and rideshare gig drivers
- Building services such as Heating, Ventilation, and Air Conditioning (HVAC), electrical, plumbers, elevator mechanics, etc.

Goal Area: Partnerships

Performance Measure Target: *Collect survey responses from project participants and other stakeholders to gather feedback on pilot technology and new policy scenarios*

In speaking with small businesses in the project area, all interviewees recognized the challenge of limited parking. Additionally, nearly all liked the idea of digital permits and sensors for curb management and parking enforcement, particularly restaurants and grocery stores, and several were open to helping test out the technology.

When engaging with commercial vehicle companies, some reported using routing software, but even those leave their drivers free to reroute and make changes, responding to a dynamic and complex urban environment. Several companies reported using a "pencil and paper" method to plan routes, partially because their routes are static and do not change drastically over time and partially because route optimization software does not consider the complexities of their order cutoffs and Seattle downtown topography. Generally, companies prefer the permit to remain visible on the windshield as a decal, versus a digital-only permit. Companies also report a strong preference for passive technology: if the digital permit system requires tapping or other actions by the drivers, that would increase the cost of managing drivers with training and monitoring, as well as the time to perform deliveries. Some expressed concern about how enforcement would work if there was no physical decal. Many fleet owners have done some level of exploration into electric or zero/low emission vehicles with varying levels of detail.

Continuing conversations with our stakeholders is the project team's central approach to guiding the future design of the CLP program. Building on the interviews and surveys conducted in Stage One, the team will continue to engage with those where connections were built as well as seek out new citywide connections in Stage Two with a focus on the five priority business districts.

Goal Area: Integration

Performance Measure Target: *Develop a replicable process to translate curb regulations into CDS format.*

SDOT worked closely with the curb data solutions vendor CurbIQ to develop a process to translate SDOT's existing curb regulations data into the CDS format and then integrate the CDS inventory into their data platform. The CurbIQ data platform was used throughout Stage One to assist with project analysis and evaluation and is further detailed in Section 5.4.

To help SDOT deliver on the SMART goal of Integration, CurbIQ used the following 5-step process to create a curb inventory (refer to **Figure 6**) out of SDOT's existing curb data.

1. Retrieve Curb Spaces and Street Sign records from Seattle's open data portal.

   Seattle has over a dozen curb parking data sets on the City of Seattle open data platform to provide vendors such as CurbIQ necessary digital access to SDOT data. While still in a custom legacy format, the data sets are excellent quality, updated nightly, and directly connected to the City's asset management work order system.

2. Matching Methodologies.

   Match Curb Spaces to Street Signs—to translate SDOT's curb data into CDS, the first step is to match the Curb Spaces polyline geometry to an associated Street Sign point geometry. Curb Spaces contain the length of a curb zone, and the street sign data contains the parking regulation and time-limit of the adjacent curbspace. To have a complete picture of the location of a parking zone and its regulation, these two data sets must be spatially matched (refer to **Figure 6**). An algorithm was developed to automatically match Street Signs to Curb Spaces.

FIGURE 6. EXAMPLE OF CURBSPACE AND STREET SIGNS MATCHED

Blue areas indicate bus layover zones, while red dots indicate bus layover signs.

3. Parse Text and Add Schedule and Time Limit Information.

   The next step requires parsing the Street Sign “TEXT” open text field which contains day, time, time limits, and regulation information, and extracting the information into new CDS oriented data fields. This extraction can be difficult to maintain accuracy due to the nature of SDOT’s open text field containing all the important information and how records have been written differently over the last 20 years. As an example, the bus layover signs below in **Table 11** have vastly different “TEXT” descriptions depending on how the data was written.

TABLE 11. SIX DIFFERENT WAYS TO REPRESENT A SIMILAR CURB REGULATION

Sign Type	Category	Category Description	Text
R7-BUSR	PBZ	Bus Zone	DGST: R404 (0330)—TXT: *CHG LN 8: 31 37
R8-BUSLAY	PBLO	Bus Layover Signs	METRO BUS ONLY 24 HOURS EVERYDAY
R8-PSBUSLX	PPP	Short term paid parking, btw 15 min—4 hours	PAY @ PS 8A-3P MON-FRI-8A-8P SAT, METRO BUS ONLY 3-6P MON-FRI
R7-BUS	PBZ	Bus Zone	[LOGO] BUS
R8-BUSLAYX	PBLO	Bus Layover Signs	COMMUNITY TRANSIT ONLY NOON-6P MON-FRI
R7-BUSI	PBZ	Bus Zone	DGST: R403 (0003)—TXT: *CHG LN 8: 10 43

4. Create Duplicates of Segments with More than One Regulation.

   Many Street Signs include more than one type of parking regulation within a single "TEXT" data field. For example, one Street Sign "TEXT" field can have regulation information for paid parking 7a-4p and passenger loading 4p-10p Monday—Friday, and unrestricted parking at all other times. This one data field contains three different regulations. To translate this into CDS, CurbIQ creates duplicate geometries that allow for each "TEXT" field regulation to match to the appropriate geometries.

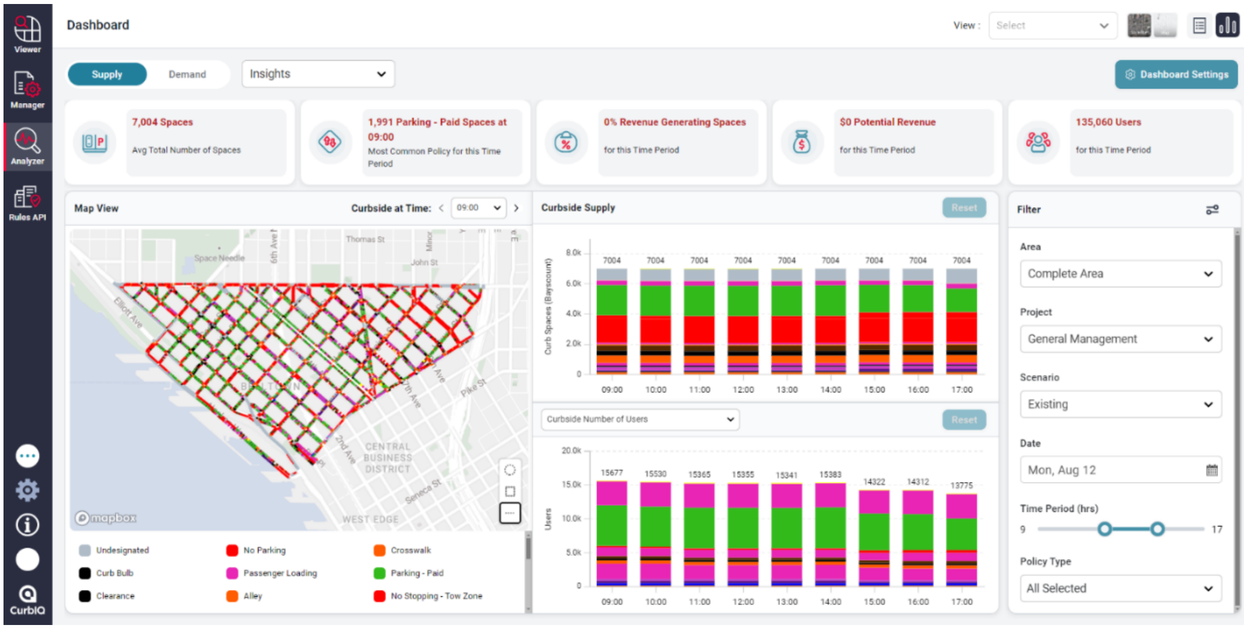
5. Create Segments of Unmatched Street Signs.

   Certain Street Signs and Curb Spaces are not able to automatically match, which requires more manual interpretation of the data. Seattle has many peak hour parking restrictions where parking is not allowed at certain times. Due to the existing asset data structure, we are unable to match our peak hour restriction Street Signs (and their relevant "TEXT" field information) to adjacent Curb Spaces. To overcome this, and ensure a complete picture of parking regulations, CurbIQ created new geometries to match the peak hour restrictions.

After CurbIQ completed the data translation, SDOT was able to successfully view, analyze, and share its curb regulations data in CDS format. (**Figure 7** dashboard interface) Although SDOT was able to accomplish CDS data translations, it's worth nothing due to the complexity of translating multiple non-standardized datasets into CDS format, it is both a time-consuming and costly process to ensure an accurate finished product. These findings have encouraged SDOT to pursue a city-managed system that uses open data standards during data creation instead of relying on third-party vendors to interpret and standardize our data before operationalizing. Furthering this, SDOT worked with asset management experts at Cambridge Systematics who provided recommendations on how SDOT can improve curb data creation, storage, and management to ease translations into CDS if implemented. More on these efforts can be found in Section 5.4. These improvements will be incorporated into an improved city-managed curb data ecosystem in Stage Two.

In Stage Two, SDOT will develop a new curb data management ecosystem developed in partnership with Minneapolis. This new data platform will be developed in a balanced way so that it streamlines some of these Seattle-specific issues, while also representing a model that can be replicated by other cities.

FIGURE 7. CURB ANALYZER—SUPPLY DASHBOARD OF ALL SPACES



3.3. Meeting the Project's Original Expectations

The Stage One project was designed as a prototype to demonstrate (1) SDOT can convert its current data into the CDS standard and (2) assess how two readily available V2C technologies could be integrated CLP program to provide data to make informed program and policy decisions. **Table 12** shows which project accomplishments were tied to our project goals.

TABLE 12. SUMMARY OF PROJECT ACCOMPLISHMENTS

Project Goals	Accomplishments
Establish baseline conditions to understand existing commercial vehicle parking and payment behaviors	• Collected usage and turnover data at 30 blockfaces with CVLZs • Surveyed delivery carriers on their parking practices and payment • Evaluated purchasing trends of permit holders
Develop freight parking policy pricing and technology scenarios using baseline data collection, stakeholder engagement, and data collected via V2C technology	• Conducted broad stakeholder engagement with local businesses and delivery companies to understand their loading needs and willingness to purchase a permit • Provided real-time availability at technology enabled CVLZs • Translated SDOT's sign and curbspace data into the CDS standard

Project Goals	Accomplishments
Assess the CLP program and V2C technology system to understand its scaling potential	• Installed V2C technology at 25 load zones to study loading activities • Analyzed V2C technology performance and revisited stakeholder conversations to hypothesized policy changes targeted to reduce unauthorized use and improve CVLZ reliability

3.4. Demonstrated Improvement in Statutory Areas

The Stage One project made considerable improvements across multiple federal statutory areas, demonstrating the transformative potential of advanced data, technology, and applications in Seattle's CLP program. Below is a summary of how the project is aligned with statutory objectives:

- **Reduce congestion and delays for commerce:** baseline data collection showed approximately 80% of parking events at CVLZs were unauthorized. Updating the CLP program for permitholders is needed to reduce congestion from delivery drivers circling for available commercial loading space.
- **(IV) Expand access and reduce transportation costs and (V) contribute to economic competitiveness:** turnover data and conversations with stakeholders highlighted the benefits and challenges of the CLP program. Updating the program and policies driven by data will increase the overall value of the program by meeting modern delivery needs and providing commercial vehicle operators with improved economic efficiencies.
- **(VII) Promote connectivity between and among connected vehicles, roadway infrastructure, and the public and (VIII) incentivize private sector partnerships:** Offering real-time availability and public accessible APIs allow commercial vehicle operators to more easily navigate to an available CVLZ.
- **(X) Increase the resiliency of the transportation system:** testing two V2C technologies with data integration into a third-party system showed us that system flexibility is achievable. This gives Seattle the ability to integrate with multiple technologies best suited to address the program's needs.

This foundational work in the statutory areas positions the project team to expand and deepen impacts in Stage Two, talked about more in Section 4.3.

4. Anticipated Costs and Benefits of At-Scale Implementation

To build a citywide foundation for effective curb access policy, planning for commercial load zones, and public-private partnerships. SDOT's Stage Two project will deliver the following:

- Develop a new data-driven policy and accompanying legislation for the City's Commercial Vehicle Load Zone permit program;
- Scale curb sensor technology to better assess and address Seattle's business districts' commercial delivery needs;
- Develop a replicable approach to building a curb digital twin as part of a comprehensive curb data management ecosystem;
- Grow internal city staffing knowledge and skillsets to capitalize on the modern digital tools needed to manage urban curbspace; and
- Implement digital tools to address and support business district commercial delivery needs.

4.1. Estimated Impacts

SDOT believes the Stage Two approach directly addresses the Stage One findings and scales the foundational Stage One efforts to an approach that can be effectively scaled citywide and could be adaptable to other cities. We anticipate the following key project outcomes will result in improved commercial curb access and improved digital management:

- Improved parking compliance driven by policy, sensor and permit technology and data driven decisions;
- Integrable digital curb tools providing the private sector the capability to inform route planning and driver workflow leading to the meaningful adoption of CDS-based curb data to improve driver safety and business efficiency;
- Packaged learnings to cities of various sizes and resources to help them transition to a digital curb. Our work can serve as a roadmap for the public and private sectors, as well as other cities to operationalize CDS as a means to implement data-driven and policy-driven curb management to support critical access and health objectives; and
- 50% reduction in unauthorized vehicle use at CVLZs.

Our Stage Two project will scale the Stage One prototype to a citywide system by building upon the lessons learned and continuing to focus on commerce, delivery logistics, and intelligent sensor-based infrastructure. The Stage Two citywide system will leverage Commercial Loading Permit (CLP) technology to facilitate data-driven curbside management policy decisions that will improve curbside access for commercial deliveries. In the citywide implementation of our CLP program, we anticipate achieving the following impacts by goal area as outlined in **Table 13**.

TABLE 13. ANTICIPATED IMPACTS OF AT-SCALE IMPLEMENTATION

SMART Program Goals	Stage Two Performance Target	Stage Two Solution	Stage Two Benefits
Safety and Reliability	50% reduction in unauthorized CVLZ use	V2C data-driven curb regulations, space allocation, and digital permit	Improved curb access for efficient commercial deliveries and other users, reduction in conflicts of competing users
Resiliency	3 new cities commit to CDS adoption based on project learnings. Staff receive at least 300 hours of digital literacy education, at least two new dedicated staff	Prove the benefits of improving digitization and internal capacity	CDS adoption scales and improves digital resources to ensure long-term benefits beyond the grant period
Access	Set data-driven policy to inform CVLZ permit rules, pricing, and space allocation	V2C data analysis, curb data management ecosystem informs policy with historical data, real-time availability	Reduced congestion, improved safety of truck related activities, better access for all, especially in disadvantaged communities
Congestion	Reduce commercial vehicle cruising by 28%	Provide real-time load zone availability via API integration, improve curb access based on data	Substantial time and cost savings for delivery drivers, businesses, improved safety and air quality outcomes
Partnerships	Increase the number of permit holders by 15%	Prove value of permit by addressing identified concerns, show value to the private sector in working with cities	Increase compliance, good driver behavior, private public partnership, improved curb access, efficiency, safety
Integration	3-4 API curb data business integrations Digital Twin is built and embedded into city processes for evaluation and decision making	Open API that communicates curb location, real-time availability, historical occupancy in CDS format	Private sector integrated digital curb tools, data sharing between public and private sector, data-based planning to create tipping point for widespread adoption, toolkits for cities detailing how to operationalize CDS

4.2. Anticipated Costs

Expanding the Stage One project to a Stage Two at-scale implementation will provide a comprehensive understanding of the current commercial delivery freight system in Seattle, a curb data management software platform to integrate into the City's enterprise asset management system and deliver a data-driven approach to improving curb access.

The Stage Two project includes the following:

- Widening technology installations to 500 CVLZs citywide. This includes funding for ongoing maintenance and support for these systems.
- Expanding the area from North Downtown Seattle with two dense business districts covering ~0.5 square miles to all paid parking areas, incorporating 30 dense business districts ~83 square miles. This includes focused baseline data collection, community outreach, and technology driven curb planning in five priority business districts.
- Developing and maintaining APIs of CDS compliant curb management data for public consumption and internal use that provide curb locations, regulations, pricing, and availability with support of the OMF.
- Expanding and improving staff capacity and resources related to digital literacy. This includes start-up costs associated with the new program and technology integration within SDOT such as data warehousing and hosting, and IT administrative requirements.
- Ongoing data collection and stakeholder outreach to support policy research needed to launch a new data driven permit policy and program.
- Utilizing our existing procurement with Sourcewell in Stage One and other established procurement flows. This ensures the unit price of the technology stays consistent as we move into at-scale implementation.

Based on these considerations, SDOT anticipates our Stage Two at-scale implementation would cost $6-7 million. These estimated costs, which are presented below in **Table 14**, are consistent with SDOT's Stage Two SMART Grant Program application.

TABLE 14. ANTICIPATED COSTS OF AT-SCALE IMPLEMENTATION

Stage Two Cost Component	Estimated Cost
City Personnel	
Salary	$1,468,303
Fringe Benefits	$264,295
Supplies	
Signage	$38,082
Contractual	
Project Management, Data Collection, Public Engagement	$1,427,140
V2C Technology	$2,492,930
Technical Assistance and Analytics	$660,000
Travel	
SMART Summit, Conferences	$125,800
Total	**$ 6,476,550**

4.3. Impacts on Statutory Requirements

While Stage One was designed at a prototype level, the project did deliver measurable contributions towards several federal statutory requirements, explained in Section 3.4. Stage Two's at-scale implementation will expand and deepen these impacts as described in **Table 15**.

TABLE 15. QUALITATIVE DESCRIPTION OF AT-SCALE IMPLEMENTATION

Statutory Goal Area	Stage Two Objectives
(I) reduce congestion and delays for commerce and the traveling public	Improve compliance driven by policy, technology, and improved signage rather than enforcement. Stage Two seeks a reduction in unauthorized vehicle use of CVLZs, as stated in the adopted *Seattle Transportation Plan*.
(II) improve the safety and integration of transportation facilities and systems for pedestrians, bicyclists, and the broader traveling public	Reduce illegal curb behavior (i.e., fewer obstructions of travel, transit, and bike lanes). One approach is addressing drivers using center turn lanes by modifying CVLZs with business engagement and machine learning analytics performed by UFL.
(III) improve access to jobs, education, and essential services, including health care	Improve curb access and availability by lowering unauthorized users and overtime stays, reducing bottlenecks at designated commercial loading spaces and allowing efficient commercial deliveries.

Statutory Goal Area	Stage Two Objectives
(IV) connect or expand access for underserved or disadvantaged populations and reduce transportation costs	Connect digital tools developed in Stage Two with smaller logistics and delivery businesses to compete on equal footing with large corporations through access to information on commercial zones and curbspace availability that facilitates efficient operations
(V) Contribute to medium- and long-term economic competitiveness	Cultivate economic benefits for local businesses through more efficient deliveries and reliable flow of goods.
(VI) improve the reliability of existing transportation facilities and systems	Improve curb access through data-driven informed curb regulations and space allocation for efficient commercial deliveries and other users, reducing the number of conflicts by competing users.
(VII) promote connectivity between and among connected vehicles, roadway infrastructure, pedestrians, bicyclists, the public, and transportation systems	Create open APIs that communicate curb location, real time availability, and historical occupancy in CDS format. These APIs can be ingested by public and private sector entities (i.e., delivery vehicles, autonomous vehicles, etc.) to improve driver performance.
(VIII) incentivize private sector investments or partnerships, including working with mobile and fixed telecommunication service providers, to the extent practicable	Generate economic benefits for private sector users such as freight carriers and incentivize partnerships by providing more dedicated curbspace, better access, and analytical information through digital tools that inform route planning.
(IX) improve energy efficiency or reduce pollution	Improve commercial load zones and curb availability, leading to less cruising and congestion.
(X) increase the resiliency of the transportation system	Build our internal digital literacy by providing training, hiring new in-house staff, and developing a workforce pipeline of transportation technology experts.
(XI) improve emergency response	Decreasing unauthorized use in CVLZs to reduce congestion and cruising times of commercial vehicles, leading to improved emergency response times.

4.4. Cost-Benefit Analysis

Anticipating the impacts of at-scale implementation is essential for setting realistic expectations. Scaling will introduce a broader range of variables and requires upfront capital and operational investment; however, the projected outcomes are quantifiable, and yield sustained, long-term value.

- **Reduced delivery delays:** Decreased unauthorized vehicle use in commercial vehicle load zones allows for more efficient and safe deliveries. The goal is to reduce unauthorized use by 50% (set in the *Seattle Transportation Plan*).
- **Increased CLP program efficiency**: Reduced unauthorized parking demonstrates that city staff are actively managing the CLP program, proving the permit's value which can lead to higher permit adoption.
- **Active curb management:** Automated curb and sign inventories with real-time analytics reduces the need for ad hoc manual studies, saving an estimated $100,000 annually. More importantly, this shifts staff time from contract administration to data analysis and active management.
- **Increased safety:** Data shows permit holders are more likely to comply with regulations, improving safety. Improved curb access for commercial deliveries and other uses can reduce conflicts between competing users
- **Business growth**: Through reliable curb access, more efficient deliveries and a reliable flow of goods are possible, creating economic competitiveness in Seattle business districts.
- **Environmental benefits:** Improving commercial load zones and curb availability can lead to less cruising, idling, and congestion.
- **Connectivity advantages:** Integrated data sharing and [CDS] standards across cities and private sector users to provide easily accessible data, proving the economic benefits of coordination to support widespread adoption.

5. Baseline Data and Analysis for Evaluation of At-Scale Implementation

The SDOT team assessed baseline conditions for the project study area, which included historic and commercial vehicle permit data, baseline curb activity data, interviews and surveys with the local community and business sector, and V2C data collection and technology assessment. These Stage One baseline findings will inform the Stage Two at-scale implementation and provide SDOT with a way to measure if Stage Two policy changes are achieving goals.

5.1. Baseline Data Analysis

Commercial Vehicle Permit Data

Figure 8 shows permit holder trends between 1994 and 2023. Seattle is one of the few cities in the US with designated commercial load zones with permit system. The total number of permits issued per year ranges from a minimum of 2,663 (in 2023) to a maximum of 6,539 (in 1999). SDOT suspects permit issuance has trended downwards over time due to increased competition, non-compliant use, lack of adequate enforcement, and other related reasons as stated throughout this report. On average, 5,260 permits were issued each year. The yearly total revenue generated by the permit purchases ranges from $0 (1994 to 1996 permits were free of charge) to a maximum of $1,008,000 (in 2017). On average, an annual revenue of $517,600 was generated. With work done by the Urban Freight Lab, **Figure 9** shows the market segmentation of permit holders by number of permits for the period 2017-2023. The business sector for each organization was obtained by identifying the respective NAICS code. The team was able to identify the North American Industry Classification System (NAICS) codes for 89% of all permits purchased during that time period. More than half of the permits issued are held by businesses working in three sectors: wholesale trade, construction, and service sectors.

FIGURE 8. TOTAL NUMBER OF VEHICLE PERMITS ISSUED AND REVENUE GENERATED PER YEAR

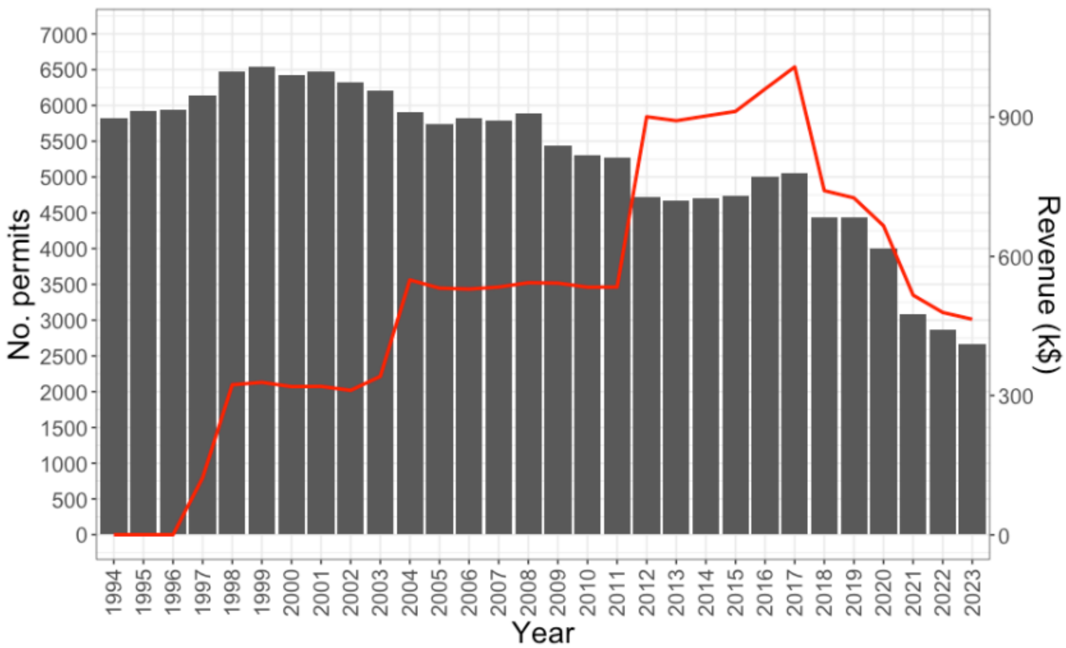
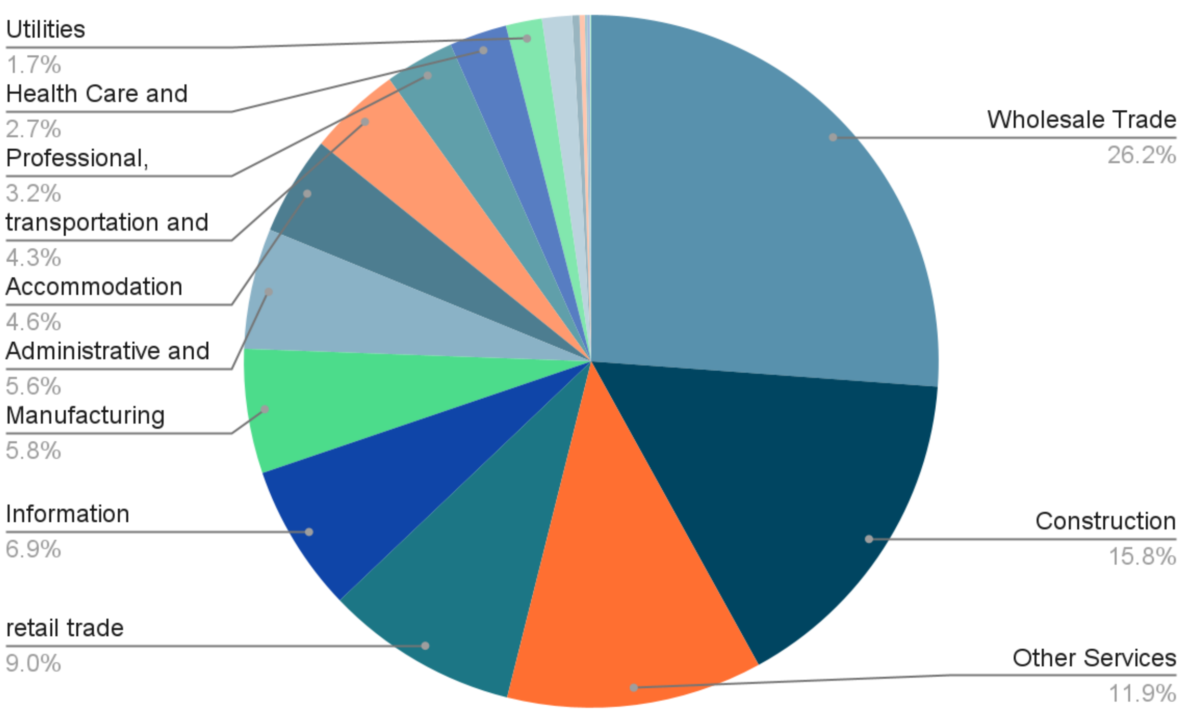


FIGURE 9. MARKET SEGMENTATION OF PERMIT HOLDERS BY NUMBER OF PERMITS



Baseline Curb Activity Data Collection

With work done by IDAX and UFL, the team conducted a large-scale curb data collection study before the installation of any V2C technology, using cameras to document all curb activities at 30 blockfaces over an eight-week period to understand commercial vehicle curb use and payment behaviors in the study area. More than 80% of the vehicles using CVLZs were passenger vehicles that are not authorized to use them. Commercial drivers who purchase a permit overwhelmingly choose to park in a CVLZ (87% of all permitted vehicle parking events). ***Business owners and delivery operators express substantial support for improving CVLZ areas and policy.*** Business owners cited that they often feel excluded from the decision-making process and see this as an opportunity to help shape a program that directly affects their bottom line. This gives Seattle the confidence to scale our Stage One work as something both business owners and delivery companies see as a positive approach for their work and livelihoods.

FIGURE 10. IDAX MANUAL DATA SURVEYOR FOR CURB EVENTS

5.2. Community and Business Engagement

SDOT and the project team built strong relationships in Stage One through interconnected public and stakeholder engagement. These relationships have provided valuable insights into the freight carriers' operational procedures and logistics, commercial vehicle operators daily lives, and access needs of the local businesses and freight delivery operators that the CVLZs are designed to provide.

There were two primary segments of communities that were interviewed to better understand the current state of commercial loading in Seattle: permit holders and local retailers and receivers (those businesses and customers receiving goods).

Small Business Engagement

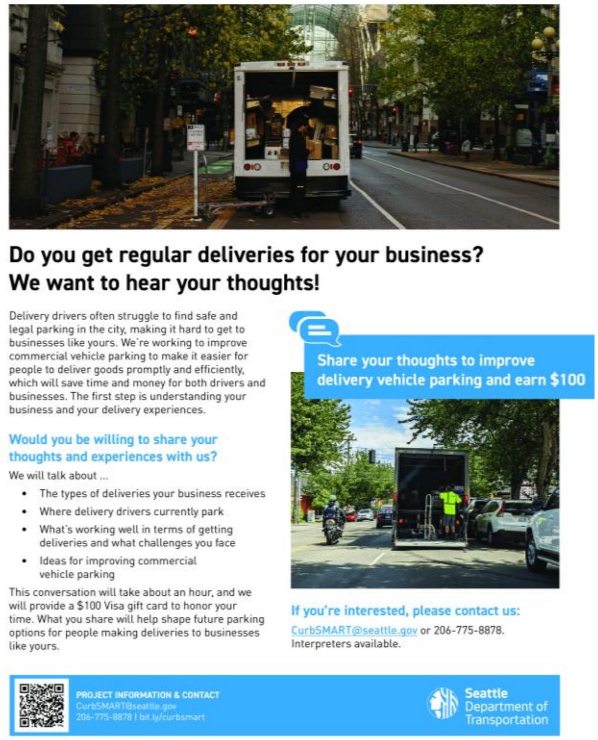
SDOT chose to conduct all initial business engagement in-person to quickly build trust and foster meaningful relationships. In-person visits allowed the team to engage directly with business owners and building managers in their environments, enabling richer conversations. Local community engagement specialists, EnviroIssues, met with local businesses and building managers to learn how they receive deliveries and use (or don't use) CVLZs. We prioritized engaging with business owners, particularly those that preferred to communicate in languages other than English because they are often overlooked and silenced in decision-making processes. This focus guaranteed underrepresented voices were heard and included in shaping policies. **Figure 11** shows the flyer (in English) which was distributed to local businesses however we translated the flyer into several different languages including Spanish, Mandarin, Korean, Japanese.

Prior to the initial engagement, EnviroIssues researched the preferred languages of the business owners and brought outreach professionals fluent in those languages. In total, 15 interviews were conducted, 12 with local businesses and 4 with building management. To honor their time and expertise, a $100 Visa gift card was provided to each interviewee. This form of compensation demonstrated our respect for their time, contributions, and encouraged active participation.

The outreach conversations focused on:

- The types of deliveries their businesses receive,
- Where delivery drivers currently park,
- What works well and the challenges they face with deliveries, and
- Suggestions for improving CVLZs.

FIGURE 11. OUTREACH FLYER FOR BUSINESSES


Do you get regular deliveries for your business? We want to hear your thoughts!

Delivery drivers often struggle to find safe and legal parking in the city, making it hard to get to businesses like yours. We're working to improve commercial vehicle parking to make it easier for people to deliver goods promptly and efficiently, which will save time and money for both drivers and businesses. The first step is understanding your business and your delivery experiences.

Would you be willing to share your thoughts and experiences with us?

We will talk about ...

- The types of deliveries your business receives
- Where delivery drivers currently park
- What's working well in terms of getting deliveries and what challenges you face
- Ideas for improving commercial vehicle parking

This conversation will take about an hour, and we will provide a $100 Visa gift card to honor your time. What you share will help shape future parking options for people making deliveries to businesses like yours.

Share your thoughts to improve delivery vehicle parking and earn $100

If you're interested, please contact us:

CurbSMART@seattle.gov or 206-775-8878. Interpreters available.

PROJECT INFORMATION & CONTACT
CurbSMART@seattle.gov
206-775-8878 | bit.ly/curbsmart

Seattle Department of Transportation

Overall, the interview responses were positive. They recognized the challenge of limited parking at the curb and expressed gratitude towards SDOT for seeking their input, as they often feel excluded from the decision-making process. Similarly, the building managers were excited to provide input and hoped it would improve the delivery experience for their building and others in the area. They all extended an open invitation for SDOT to seek their help in the future.

The degree of concern and strength of opinions among the businesses were linked to the frequency of their deliveries. Grocery stores, which receive up to three deliveries per day, were the most frustrated. Restaurants, which receive up to six deliveries per week, showed less frustration. Businesses like the tattoo parlor, dentist office, and floral shop, which have the fewest deliveries, were the least frustrated. Many businesses said drivers will try to find an available space anywhere on the block including CVLZs, alleyways, and paid parking space. Businesses spoke about the need for increased enforcement at the CVLZs as well, stating that they often observe non-commercial vehicles parked in the spaces.

Building management voiced concern about gig drivers completing food deliveries suggesting designated parking spots. Drivers are often illegally parked and leave the food in the lobby so they can get back to their vehicle quickly.

Continued stakeholder engagement is the project team's central approach to guiding the future design of the CLP program. Input from community stakeholders is critical to the success of at-scale implementation. Building on the interviews already conducted, the team will continue to engage the following groups through a combination of interviews and surveys in Stage Two:

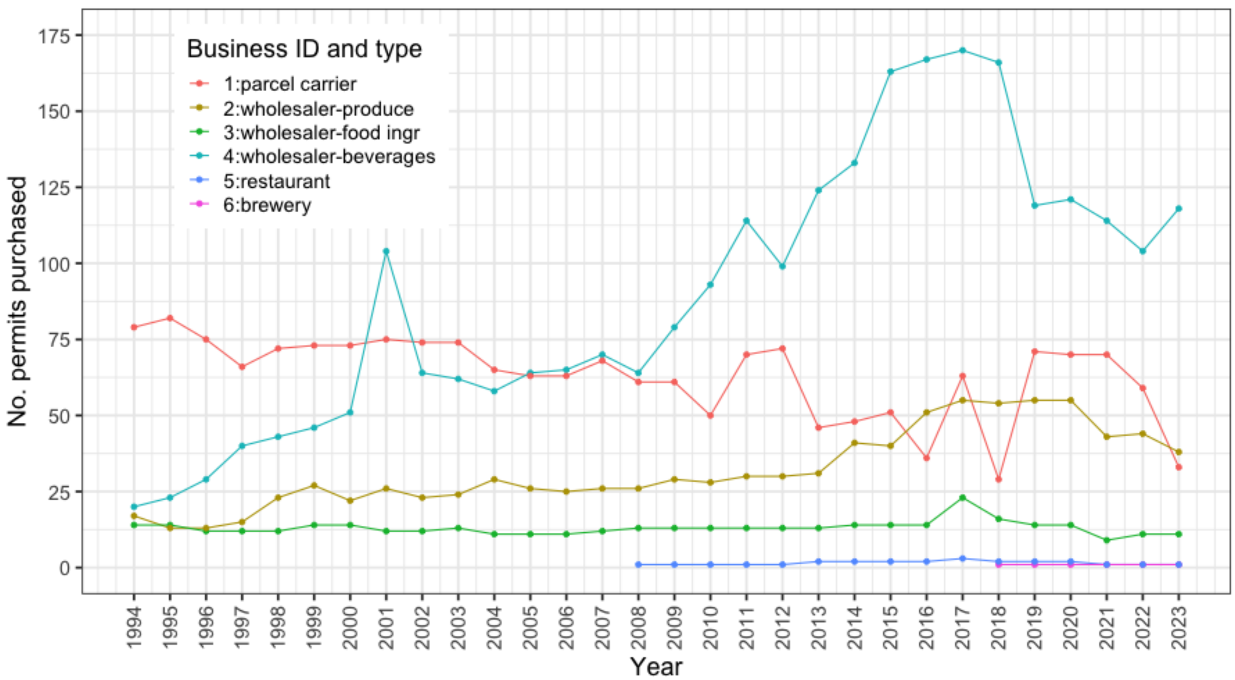
- Freight carriers with CVLZ permits
- Freight carriers without CVLZ permits
- Local businesses
- Meal, grocery gig delivery, and rideshare gig drivers
- Residential and office buildings
- Building services such as Heating, Ventilation, and Air Conditioning (HVAC), electrical, plumbers, elevator mechanics, etc.
- Business organizations such as Business Improvement Associations and Chambers of Commerce

Permit Holder Engagement

Between January and May 2024, UFL conducted six face-to-face and online interviews with organizations who were existing CVLZ permit holders. They spanned different business sectors and company sizes, from large national parcel carriers to regional wholesale distributors to local restaurants and breweries. **Figure 12** shows the number of CVLZ permits each company interviewed has purchased since 1994. Overall, companies appeared to purchase a constant number of permits from the beginning of their operations, with a general increasing trend in permits purchased. The COVID-19 pandemic seems not to have affected the number of permits purchased.

The companies showed different behaviors in choosing what portion of their fleet should be equipped with permits. Some companies are more preventive and purchase permits for most of their vehicles, while others only purchase permits only for vehicles typically entering the Seattle downtown.

FIGURE 12. NO. PERMITS PURCHASED BY INTERVIEWED COMPANIES SINCE 1994



Main reasons these companies reported purchasing permits are:

- **Being a good city partner**. Several companies reported purchasing permits to be "good" partners with the city and communities and to respect existing laws and regulations.
- **Cost of cruising for parking**. The additional cost of driver's time, able to deliver to fewer customers on a route, increased risk for perishable goods not getting delivered on time. While one company reported using CVLZs only 30% of the time, it stated CVLZs are an important asset in areas characterized by high parking occupancy, traffic congestion, and limited curb parking (mostly downtown).
- **Efficiency**. For many companies, the cost of cruising for parking is too high, and would rather purchase permits and be able to use CVLZs. Permits also allow for efficiency for drivers in that they are pre-paid, recognizable, and CVLZs are typically sized for larger vehicles.
- **Lack of alternatives**. Some companies reported only being able to use CVLZs and no other parking locations due to the need for parallel parking and the fact that the spaces are often not large enough.

The companies interviewed reported the following challenges when performing deliveries:

- **CVLZ deficiency**. Many companies noted there are not enough CVLZs, and they are not always in an optimal location. The network seems to be shrinking rather than expanding, with more CVLZs being removed than added.

- **Competition at the curb**. There is strong competition for the use of the curb, so CVLZs are not always able to use the zones when they need them.
- **CVLZs lack enforcement.** Not well enforced, with many passenger vehicles without a permit using the CVLZs (especially TNC and food delivery), as well as certain permit holders staying longer than the regulated 30 minutes.

Commercial Vehicle Operator Survey

The project team distributed an online survey to commercial vehicle operators in Seattle. The survey questionnaire was developed and tested between November 2024 and February 2025. The survey was structured into three sections: 1. Company and CVLZ information, 2. Driving and parking experience in Seattle, and 3. Future CVLZ program scenarios. The survey was implemented in Qualtrics and distributed through various channels, including direct emails to CVLZ permit holders, UFL contacts, and UFL and SDOT social media channels. A total of 126 responses were obtained. After data processing, a total of 84 responses were retained, of which 70 (83.33%) were permit holders, and 14 (16.67%) were non-permit holders.

The survey was structured into three sections as shown in **Table 16**. The first section of survey questions collected company and CVLZ-related information, including the business sector, geographic scale of operations, fleet size, vehicle types, and the number of permits held. The second section of questions was only displayed if the company operates commercial vehicles in Seattle. These questions covered routing strategies and delivery timing, followed by questions regarding CVLZ payment practices, and concluded with an open-ended question where respondents describe the challenges they face while operating commercial vehicles in Seattle.

The final selection of the survey used the Discrete Choice Experiment (DCE) methodology to collect stated preferences for future CLP program scenarios. A DCE is a survey-based method used to collect stated preferences by presenting respondents with multiple attributes and requiring them to choose their preferred option. Unlike traditional methods that assess attributes independently, DCE requires respondents to evaluate multiple attributes simultaneously. This approach more accurately reflects real-world decision-making, where consumer preferences are shaped by a combination of factors. The DCE differentiated between two distinct parking payment alternatives: permit-based parking and pay-per-use parking. The opt-out choice was also incorporated as an alternative, an option provided for respondents to choose neither permit nor pay-per-use, reflecting a scenario where they would prefer not to pay for parking at all. These alternatives vary in key characteristics, such as pricing and timing structures, attracting different users.

TABLE 16. SURVEY QUESTIONNAIRE STRUCTURE AND MAIN VARIABLES

Section	Purpose	Main variables
1. Company and CVLZ information	Gathers information about the company and its CVLZ permits	Respondents' role, company's business sector, number of commercial vehicles, type of commercial vehicles, geographic scale, number of employees, main location, history of purchasing CVLZ permit, number of purchased permits in 2024, Responsible party for CVLZ permit payment
2. Driving and parking experience in Seattle	Gathers information on the operational practices of these companies	Number of routes per day, operation weekdays and time, average number of customers served per route, number of parking event per route, maximum parking distance from customer location, stop length per delivery, preferred parking location, parking payment method, number of parking tickets in 2024, responsible party for tickets, challenges while operating
3. Future CVLZ program scenarios	Gathers respondents' preferences for various parking options, each with different durations and associated costs	Respondents' preference between the following alternatives: Pre-paid, per-pay-use, and not paying for parking

The following key insights were obtained from survey data analysis.

- **Who are the permit holders vs. non-permit holders:** The largest portion of respondents report working in the service business sector (Accommodation and Food Services, Professional, Scientific, and Technical Services, Administrative and Support and Waste Management and Remediation Services) for both permit and non-permit holders. Permit holder companies more frequently report belonging to wholesale trade, construction and manufacturing, and Other (Information, Arts, Entertainment, and Recreation, Finance and Insurance, Health Care and Social Assistance, Real Estate and Rental and Leasing) sectors. In contrast, non-permit holders are primarily represented by retail trade and transport & logistics sectors. This aligns with the market segmentation of permit holders based on the number of permits issued from 2017 to 2023, where the data shows that permit holders are primarily from the wholesale trade, construction, and services sectors, while the proportion of companies in the transportation and warehousing sector was significantly lower.
- **Permit behaviors:** On average, permit-holder businesses hold 12.33 permits. The fleet-to-permit ratio, defined as the portion of the fleet owned covered by CVLZ permits in 2024, averages

71.32%, showing that most businesses hold permits for the majority of their fleet. Moreover, permit holders have an average of 11.58 years of purchasing history, showing that current permit holders have strong retention rates when purchasing CVLZ permits.

- **Route behaviors:** On average, permit holders make more stops per route than non-permit holders. Most activities occur during the day for both permit and non-permit holders. However, 50% of non-permit holders reported operating off-peak, compared to only 24.61% of permit holders.
- **Parking behaviors:** The average survey-reported parking dwell time is 37.29 minutes (median: 30 minutes), significantly longer than the average dwell time observed in the baseline curb data collection activity. Non-permit holders reported on average, 12 minutes longer than permit holders; however, their preferred parking locations are alleys and off-street parking, while permit holders prefer parking at CVLZs. A similar trend was observed in the video data analysis, where non-permit vehicles occupied parking spaces for significantly longer. Thus, the reported behavior aligns with actual observed behavior.
- **Stated preference for future CVLZ scenarios:** The data shows that as the annual permit price increases, the proportion of respondents selecting to buy the annual permit decreases, and more respondents indicate they will choose not to pay for parking. The share of respondents choosing the pay-per-use option remains mostly constant despite changes to the price of the annual permit. This suggests that demand for the annual permit is price elastic, with higher prices potentially leading to a shift to alternative options.

5.3. Technology Assessment and Third-Party Data

Technology Assessment

One of the main goals of Stage One was to explore different curb sensors and find out which would be best suited for Seattle. The team selected two V2C technologies to evaluate: a single space parking meter with a stereoscopic sensor (provided by IPS Group Inc.) and a snapshot-based camera (provided by Umojo). Their product specifications are shown in **Table 17**.

Stereoscopic Sensor: IPS Group Inc. uses stereoscopic technology on their single space meter. The sensor identifies when an object enters the area, records the time of vehicle entry and exit, and sends the data to their cloud platform. The cloud platform is also able to provide real-time availability of the area from the sensors. No personal identifiable information such as license plates or face data is collected.

Snapshot-Based Camera: Umojo uses camera technology through a snapshot approach. The cameras capture high-resolution images of the street and upload them to their cloud platform, where advanced computer vision algorithms are applied to analyze the curb activity. No personal identifiable information such as license plates or face data is collected.

TABLE 17. V2C TECHNOLOGY SPECIFICATIONS

	IPS	Umojo
		
Model	M7™ Single-Space Smart Parking Meter	SolarCam-4G
Detection	Single space meter with stereoscopic sensor	Snapshot-based camera
Power source	Battery: IPS battery pack (rechargeable) Solay panel enabled: Yes	Battery: 10400mAh (rechargeable) Solar panel enabled: Yes
Battery life expectancy	N/A	Battery to stay consistent at 2-minute snapshot interval
Quantity installed	27	24

The technology assessment focused on a limited analysis of physically observed parking events using a local data consultant (IDAX) against two V2C technologies. The assessment needed to consider performance metrics and criteria shown in **Table 18.** Although the limited installation and time frame did not allow for a rigorous analysis of the performance metrics and criteria, the assessment does provide enough evidence that some type of sensor technology is feasible for Stage Two deployment. Additional analysis will be required in Stage Two.

TABLE 18. EXAMPLE PERFORMANCE METRICS AND CRITERIA

Goal	Type	Metric	Target
Reliability	**Uptime**	Device in operations % of day	100%
Accuracy	**Parking events**	Total parking events per day	98% of observed counts
		Parking dwell time	98% of events within 5 min of observed
		Event accuracy (ingress & egress times)	98% of events within 2 min of observed

Round 2 data collection occurred December 18-19, 2024, at three locations where CVLZs varied in length. The three CVLZ locations are listed below:

- Location 1: 4th Ave at Wall St (northeast blockface, nearest address 2404 4th Ave)
- Location 2: Minor Ave at Howell Street (southwest blockface, nearest address 1809 Minor Ave)
- Location 3: 2nd Ave at Battery Street (southwest blockface, nearest address 2327 2nd Ave)

As the project team started its Round 2 analysis, it was noticed there were sizable discrepancies to what was observed by IDAX and the two technologies. As a result, SDOT decided not to use the data and worked with each technology company to assess the layouts and adjust where necessary. Once adjustments were complete, a third round of data collection was completed.

Round 3 data collection occurred across two days (Tuesday July 1, 2025, and Wednesday July 2, 2025) at the same locations as Round 2. IPS recorded parking events instantaneously as a vehicle enters or exits a space, while Umojo recorded parking events based on two-minute snapshot intervals (to preserve battery life). The parking results for each location are summarized in tables after the description of the two technologies below. The total events metric is reported for each technology along with the percentages of the observed counts from IDAX. For the duration, only the average parking dwell time is reported for each technology and compared to the observed counts from IDAX. The percentage within two minutes of the observed counts is not calculated because of the difficulty with matching individual parking events between each technology and IDAX.

The following sections provide a summary of the Umojo, IPS, and IDAX data comparison for the four locations. These summaries compare the daily counts and average dwell times for the Umojo, IPS, and IDAX data collection efforts at the three locations. Additional analysis comparing more locations will be required in Stage Two.

Location 1: 4th Avenue at Wall Street

The 4th Avenue location has one CVLZ space on the northeast blockface closest to Wall Street. The CVLZ is 40’ long with one IPS meter at the front of the space and the Umojo camera is located across the street facing the CVLZ. **Figure 13** shows a photo of the 4th Avenue CVLZ with the IPS meter called out and viewpoint of the Umojo camera.

FIGURE 13. 4TH AVENUE CVLZ

Table 19 compares IDAX to IPS and Umojo for the two analysis days by hour. IDAX physically observed parking events and was used as the record of truth. The analysis indicates that IPS recorded a 53-82% detection rate compared to the IDAX counts, while Umojo only recorded a 20-32% detection rate. Dwell times varied by day, with IPS recording 3 minutes longer on July 1 and 3.5 minutes lower on July 2. Umojo's parking dwell times were considerably longer than IDAX and IPS on both days.

TABLE 19. 4TH AVENUE COUNT & DWELL TIME COMPARISON

	IDAX		IPS		Umojo	
Hour	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**
7:00:00	7	2	2	1	3	1
8:00:00	8	3	4	2	2	1
9:00:00	2	0	0	1	0	0
10:00:00	2	2	2	3	1	0
11:00:00	6	4	4	3	0	2
12:00:00	8	3	2	0	1	1
13:00:00	4	1	1	1	0	0
14:00:00	2	2	1	1	0	1
15:00:00	2	1	2	2	1	0
16:00:00	3	0	3	1	1	0
17:00:00	0	0	1	0	0	0

	IDAX		IPS		Umojo	
18:00:00	1	4	2	3	0	1
Total	**45**	**22**	**24**	**18**	**9**	**7**
% Difference (to IDAX)			***53%***	***82%***	***20%***	***32%***
Avg Dwell (min)	***8:09***	***18:49***	***11:22***	***14:56***	***22:00***	***35:26***

The greatest hourly discrepancy between IDAX and V2C technology occurred between 12:00 – 1:00 PM. A deeper dive into the results indicated where a vehicle parked in the CVLZ greatly impacted the number of parking events recorded by IPS and Umojo. The IDAX video was consulted to verify the entry and exit times. The video data confirmed that a vehicle parked very close to the IPS sensor can block the view of parked vehicles further back in the space. For example:

- On July 2, a vehicle parked at 11:57 AM adjacent to the meter at the front of the space and stayed until 1:26 PM. This blocked the view of the IPS meter for the entire period from 12-1 PM, which resulted in zero IPS events despite 3 vehicle parking during the hour.

Therefore, one IPS meter at the front of the CVLZ is susceptible to being blocked by vehicles, which can result in significant undercounting. The source of the Umojo undercounting could not be verified at the time of the analysis.

Location 2: Minor Avenue at Howell Street

The Minor Avenue location has one CVLZ on the southwest blockface closest to Howell Street. The CVLZ is 43' long with a dual IPS meter head located at the midpoint of the space and the Umojo camera is located across the street facing the zone as depicted in. **Figure 14** shows a photo of the Minor Ave CVLZ location with the dual IPS meter and viewpoint of the Umojo camera.

FIGURE 14. MINOR AVENUE CVLZ

Table 20 compares IDAX to IPS and Umojo for the two analysis days by hour. IDAX physically observed parking events and was used as the record of truth. The analysis indicates that IPS recorded a 97-113% detection rate, while Umojo only recorded a 25-44% detection rate. For parking dwell times, IPS recorded much shorter dwell times than the observed IDAX, with parking durations of 3 to 6 minutes shorter. Umojo again recorded much longer parking durations with dwell times almost twice the observed.

TABLE 20. MINOR AVENUE COUNT & DWELL TIME COMPARISON

	IDAX		IPS		Umojo	
Hour	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**
7:00:00	4	3	0	2	2	3
8:00:00	0	1	0	1	0	2
9:00:00	2	3	3	1	0	0
10:00:00	3	5	3	9	2	2
11:00:00	5	6	4	6	1	2
12:00:00	5	2	7	2	0	1
13:00:00	2	1	1	0	0	0
14:00:00	2	4	3	4	1	1
15:00:00	1	1	0	0	1	0
16:00:00	2	0	5	3	0	0
17:00:00	4	1	5	0	1	0
18:00:00	6	5	4	8	1	3
Total	**36**	**32**	**35**	**36**	**9**	**14**
% Difference (to IDAX)			***97%***	***113%***	***25%***	***44%***
Avg Dwell (min)	***12:14***	***12:36***	***5:53***	***9:21***	***22:18***	***22:05***

A deeper dive into the results indicated the following the dual headed meter at the midpoint of the CVLZ provides much better coverage as the IPS results were much closer to the observed IDAX counts. The 10:00 – 11:00 time period was analyzed in further detail to better understand how IPS recorded 4 more vehicles on July 2. The IDAX video was consulted to assess the discrepancy between the results. It appears that the dual sensor can double (or triple) count vehicles – especially larger trucks. For example:

- At 10:08 AM, a large white single-unit truck pulled into the space, pulling past the meter towards the front of the space. This event is recorded by the front sensor and ultimately is recorded as 14:12 minute event. However, the truck then backs up and parks – this event is recorded twice by the rear sensor – one for 6 seconds and one for 13:58 seconds. Another event is also triggered when the truck exits – this is a 6 second event.

- IDAX recorded one 13:49 second event, while IPS recorded 4 separate events. This phenomenon was the primary reason that IPS recorded more events on July 2 than IDAX.

The source of the Umojo undercounting could not be verified at the time of the analysis.

Location 3: 2nd Avenue at Battery Street

The 2nd Avenue location has one 85' CVLZ space on the southwest blockface near Battery Street. The CVLZ has two separate IPS meters evenly spaced – one at the front of the space and one at the midpoint and the Umojo camera is located across the street facing the CVLZ. **Figure 15** shows the 2nd Avenue CVLZ location with two IPS meters and the viewpoint of the Umojo camera.

FIGURE 15. 2ND AVENUE CVLZ

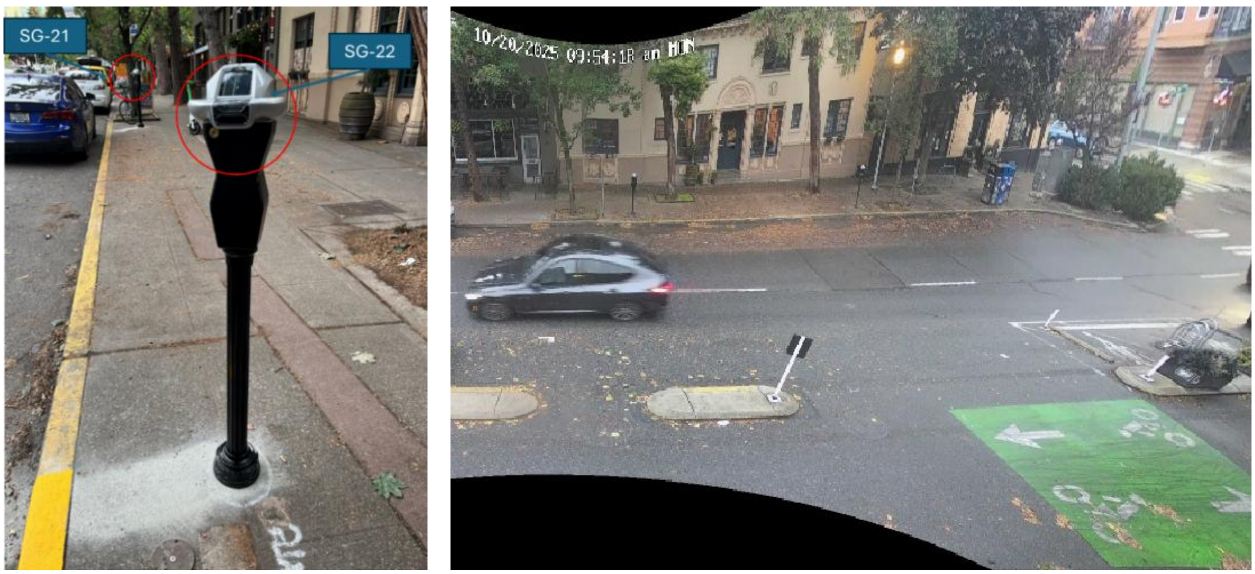


Table 21 compares IDAX to IPS and Umojo for the two analysis days by hour. IDAX physically observed parking events and was used as the record of truth. The analysis indicates that IPS recorded a 73-91% detection rate, while Umojo only recorded a 34-39% detection rate. For parking dwell times, IPS recorded longer dwell times than the observed IDAX, with parking durations 2 to 3 minutes longer than IDAX. Umojo again recorded much longer parking durations with dwell times over twice the observed.

TABLE 21. 2ND AVENUE COUNT & DWELL TIME COMPARISON

	IDAX		IPS		Umojo	
Hour	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**	**7/1/25**	**7/2/25**
7:00:00	3	1	1	2	1	1
8:00:00	0	2	1	1	0	1
9:00:00	2	0	1	0	0	0
10:00:00	4	5	2	4	1	3
11:00:00	8	6	7	6	2	4
12:00:00	10	7	3	7	4	3
13:00:00	7	11	8	11	4	5
14:00:00	5	5	1	3	2	0
15:00:00	3	7	3	5	1	1
16:00:00	6	8	6	7	2	3
17:00:00	11	5	9	3	3	2
18:00:00	5	7	5	9	2	2
Total	**64**	**64**	**47**	**58**	**22**	**25**
% Difference (to IDAX)			***73%***	***91%***	***34%***	***39%***
Avg Dwell (min)	***15:31***	***10:51***	***18:01***	***12:02***	***36:11***	***23:12***

A deeper dive into the results indicated the deployment of two single head IPS meters was critical for this longer CVLZ. The two meters were effective at generating a higher detection rate than the single meter at the front of the shorter zone on 4th Avenue.

- The 12:00 – 1:00 PM hour on July 1 was analyzed in further detail by consulting the IDAX video to understand how IPS recorded fewer parking events.
- The IDAX video shows that a large SUV parked at 11:54 AM near the front of the zone and blocked the front IPS meter. The video indicates this vehicle exited at 12:09 PM.
- However, IPS does not have this vehicle exiting until 12:54 PM and the front meter (SG-21) does not record any other vehicles towards the front of the CVLZ. It is not clear why IPS does not register that the vehicle moved at 12:09 PM.
- IDAX recorded at least 2-3 vehicles parked towards the front of the CVLZ during the hour. This explains the undercount in the data.

Overall, several challenges were identified during the analysis:

- **Systematically undercounting parking events.** Both IPS and Umojo undercounted parking events, although IPS is much closer than Umojo depending on the number and configuration of meter placement.
- **Uniform meter placement**. It is important to space IPS meters along the CVLZ to reduce the likelihood of vehicles blocking the sensors and undercounting of parking events. However, even a dual meter can be blocked by a large truck and can result in double counting of vehicles.
- **Inconsistent dwell times.** There were inconsistent dwell times across technologies, but IPS is generally close to observed. Umojo parking durations were much longer than IDAX and IPS.
- **Parking behaviors are highly variable.** The IDAX video showed a wide variety of parking behaviors – vehicles parked across multiple spaces, parking violations were frequent (e.g., not parking in marked spaces, long dwell times), and double parking was also frequent. These behaviors made it difficult to standardize and compare results with Umojo and IPS.
- **Need for reconfiguration**. After Round 2 data collection, it became apparent that the sensors at several locations needed to be adjusted, reconfigured, or add additional sensors to cover the entire CVLZ.
- **Sensor reliability depends on battery life**. Battery life expectancy was shorter than anticipated, even with solar power capabilities. This led to sensors being down for days at a time.
    - IPS: With 24/7 parking event detection, battery life of meters was between 6-8 months. When the battery was fully depleted, a technician was deployed to replace it, however, this could take a few days to complete, meaning the sensor would be offline during that period.
    - Umojo: Batteries could not be recharged by solar power daily as originally anticipated, reducing battery life expectancy significantly. SDOT had to set a 2-minute snapshot interval and restrict observation time to 6:30 AM to 6:30 PM PST. Even with these battery saving techniques, sensors would go offline and there was no local technician to replace the battery. As a result, some sensors would remain offline for several days.
- **User friendly platforms.** It was challenging to compare performance metrics between the two technology providers and IDAX. Integration with a third-party data aggregator, such as CurbIQ's platform, was beneficial to analyze the data in a standardized format. Umojo's platform was cumbersome and not user-friendly.

Third-Party Big Data Sources

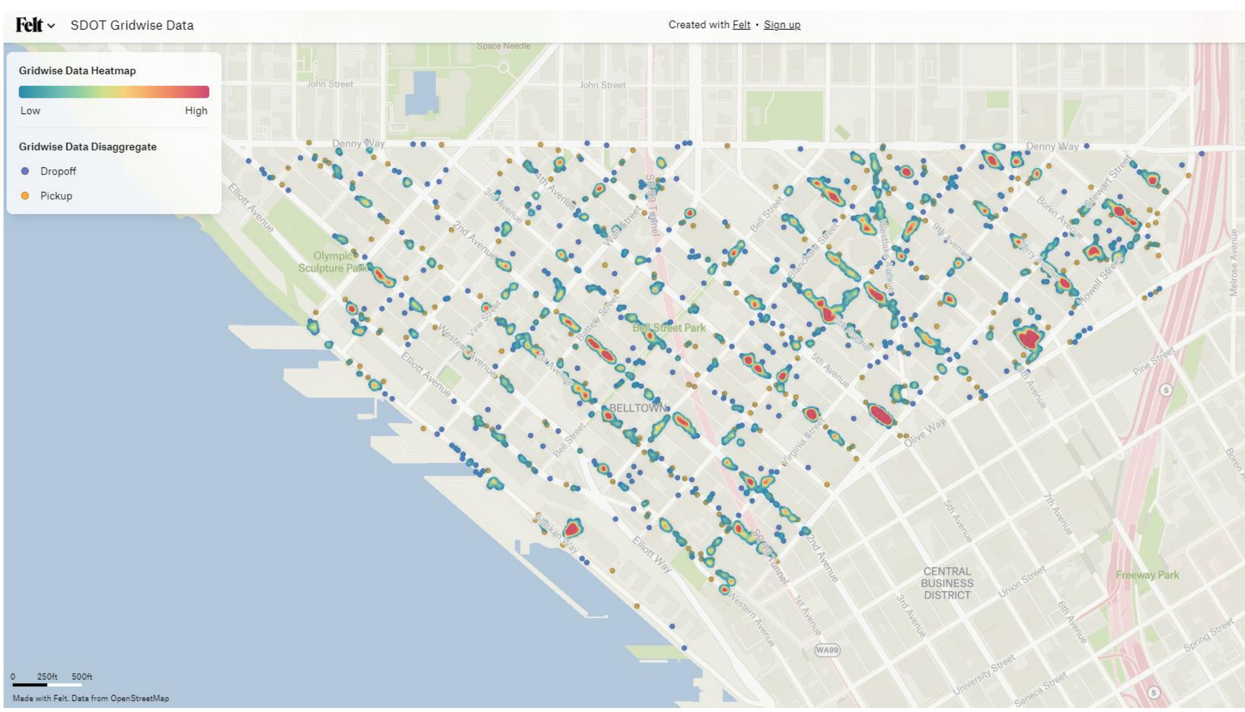
SDOT's sensor and camera data findings show that there is substantial curbside demand from commercial trucks and TNC gig drivers making pickups and drop-offs of both passengers and food delivery. SDOT sought out data from multiple third-party "big data" sources to assess the viability of using big data, i.e.

from connected vehicles, as an alternative to higher cost V2C sensors. To try and better understand TNC gig driver activity, we partnered with the technology company GridWise to access origin and destination information. The other third-party big data source we investigated was the GeoTab and LOCUS Truck dataset for commercial fleet vehicle activity. GeoTab contracts with commercial fleet operators to provide a highly accurate GPS tracking device installed in each fleet vehicle to track activity and advise route choice and delivery patterns.

Gridwise provided SDOT with granular blockface level data of origin-destination trip data. Gridwise was able to provide such granular data because the Stage One study area land use was made up of commercial, office, retail, and multi-family residential, with no single-family residences. The main privacy constraint is avoiding trip details being traced back to individual residential addresses. All of the paid parking and commercial vehicle loading zone districts that Seattle may expand this project to in Stage Two have similar land use characteristics that would be eligible for this type of data delivery from GridWise.

The project team compared the GridWise data against the baseline data collected by IDAX as a ground truth to establish the sample size and penetration rate of the GridWise data. The Felt map shown in **Figure 16** displays a heatmap of the TNC activity from the GridWise dataset overlaid on the point locations of specific pickup and drop-off events. On initial impression, this dataset appeared useful to provide a picture of the intensity of TNC activity on any given street.

FIGURE 16. HEATMAP OF GRIDWISE TNC ACTIVITY HOTSPOTS



However, upon comparing this data to the baseline data from IDAX, we realized that the Gridwise sample size was too small to correlate effectively. While the 10-week sample has hundreds of records on many streets, on a per blockface per day basis, there were no more than two records to compare against the baseline IDAX data.

The map shown in **Figure 17**, displays blockface level heatmaps of the baseline data observed by IDAX, averaging the two days of observations. The map shows a high sum of TNC activity in the study area. The project team will continue to investigate sample size issues with Gridwise. Having a big data source of TNC activity would be helpful to provide a broad-based picture of TNC activity citywide and not just on streets with technology sensors and cameras installed.

FIGURE 17. IDAX-OBSERVED TNC ACTIVITY BY BLOCKFACE

GeoTab provided information on full origin-destination trips at the block group level as well as individual trip end pickup and drop-off events at the point location. Vehicle type and industry of the fleet operator are also provided. LOCUS Truck ingests this data to provide interactive platforms to explore the activity of light duty, medium duty, and heavy-duty trucks across industry and analyzes the trip lengths and trip purposes and patterns to provide additional insight.

The project team compared GeoTab data to the baseline data from IDAX of truck and commercial fleet vehicles observed on specific blockfaces to understand how big data sets could help provide a more thorough understanding of loading activity when combined with our IDAX point in time data collection efforts. The team assessed the GeoTab point location data for pickups and drop-offs and compared it for sample size and penetration rate, similarly to how we compared the GridWise TNC activity dataset to the baseline data from IDAX for specific blockfaces and observation days.

A key challenge was matching up the categories of vehicles in each dataset, as shown in **Table 22** below of the vehicle classes. We recorded the total number of vehicles counted on any given blockface over the two observation days in both datasets, as well as passenger vehicles that were fleet operated.

TABLE 22. VEHICLE CLASS DEFINITIONS

<table>
<tr><th>GeoTab Vehicle Class</th><th>IDAX Vehicle Type</th></tr>
<tr><td>Multi-Purpose Vehicle</td><td rowspan="2">CM Pickup
Minivan
Van
Step-Van</td></tr>
<tr><td>Light Duty Truck (<=10,000 lb.)</td></tr>
<tr><td>Medium Duty Truck (>10,000 lb. and <=26,000 lb.)</td><td>Single Unit Truck</td></tr>
<tr><td>Heavy Duty Truck (>26,000 lb.)</td><td>Trailer Truck</td></tr>
</table>

Since the IDAX baseline data is a snapshot in time, there is some noise in the data while the GeoTab/LOCUS Truck data likely represents a more consistent pattern of activity when averaged over weeks and months. To build a broader understanding of curb activity by vehicle class, we compared the penetration rates of vehicle classes between IDAX and GeoTab/Locus Truck data on each blockface. The data showed some useful patterns across the vehicle types in aggregate. **Table 23** illustrates the penetration rates for each vehicle type, distributed across the blockfaces observed in the baseline data.

TABLE 23. GEOTAB/LOCUS TRUCK PENETRATION RATES BY VEHICLE TYPE

	LDT	LDT&MPV	MDT	HDT	MDT&HDT	All Comm	Pax
Mean	1.0%	5.7%	19.4%	2.0%	22.8%	8.2%	1.8%
STD	1.1%	3.8%	20.4%	1.5%	21.7%	5.3%	2.4%
Min	0.0%	1.0%	0.0%	0.0%	1.4%	1.9%	0.1%
Median	0.8%	4.0%	11.5%	2.4%	15.9%	6.5%	0.9%
Max	5.0%	14.1%	78.6%	3.6%	78.6%	21.4%	10.7%

Definitions: LDT = Light Duty Truck; MPV = Multi-Purpose Vehicle; MDT = Medium Duty Truck; HDT = Heavy Duty Truck; All Comm = All Commercial Vehicles (MPV + LDT + MDT + HDT); Pax = Passenger Vehicles.

Medium duty trucks had by far the highest penetration rate whereas heavy duty trucks and light duty trucks had the lowest penetration rate. This indicates that with additional curb monitoring data from the V2C devices proposed in Stage Two, it may be possible to build data models that can help understand curb activity by vehicle types in areas without curb monitoring technology in place.

SDOT believes there may be potential to utilize big datasets from Gridwise, GeoTab, and LOCUS Truck and the now developed baseline methodologies to support the Stage Two project approach. Curb monitoring sensors only provide information from blockfaces where they are installed, which results in large gaps in SDOT's knowledge of loading activity at a city-wide scale. The project team believes there is a place for supportive third-party data in the overall curb data management ecosystem.

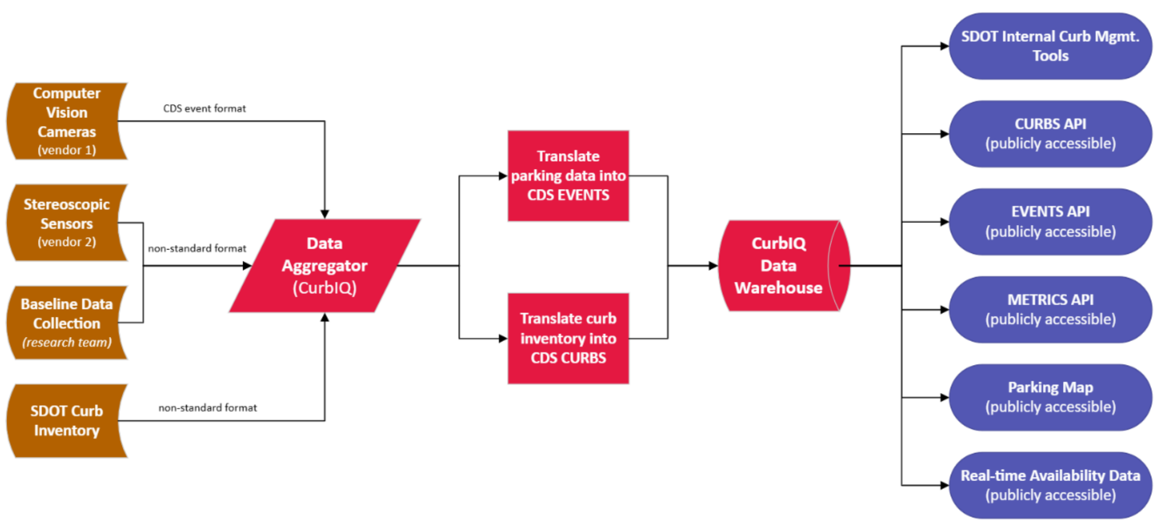
5.4. Curb Data Management

SDOT maintains many data sets such as curb signs, curb spaces, and paid parking transactions that are the backbone of the Curbside Management program. These data sets support data-driven decisions to achieve performance-based outcomes in Seattle's paid parking areas. Over time this data has become less stable and often breaks down leading to inaccurate records and additional staff time to correct. In Stage One, SDOT tested the feasibility of standardizing these data sets and integrating them into a centralized data platform. SDOT also worked with Cambridge Systematics asset management specialists to review how SDOT's curb space and curb sign data is written, stored, and managed within our asset management system.

Vendor Integration and Data Aggregation

A key goal of the project was to test digital tools built on the CDS standard. It was important for SDOT to understand how well CDS could perform as a common data language underpinning many components of the project. To test this, SDOT had CurbIQ work as the lead data aggregator for the project. As aggregator, CurbIQ ingested multiple project data sources into their data platform, translated all data into CDS format, and then output the data into multiple use-case specific deliverables. (**Figure 18**) The following steps detail how this work was accomplished and lessons learned that will inform the Stage Two project.

FIGURE 18. STAGE ONE DATA MANAGEMENT STRUCTURE



1. **Aggregate Inputs**

   There were four data inputs into the CurbIQ platform that made up the Stage One project. SDOT's curb inventory (as detailed in Section 3.2), baseline data collection (5.1), and V2C sensor companies IPS and Umojo (5.3).

   The curb inventory was the first input and served as the base layer that all other data sets were built on. Completing the curb inventory first allowed the team to understand where all the commercial loading zones were and created a common spatial understanding when discussing curbspaces with other project partners. (comparing apples to apples)

   The other inputs were all related to curbside parking activity (event) data. Baseline data collection counts from time lapse cameras were sent from the research team at UFL to CurbIQ. IPS sensor occupancy data was provided to CurbIQ in real-time via XML formatted datasets. Umojo camera event data was sent in near real-time (2-minute intervals) to CurbIQ but formatted in CDS and sent via API.

2. **Translate Data to CDS**

   As noted in Section 3.2, data translation can be difficult and time consuming depending on the source data. Thankfully the project team only had challenges with translating SDOT's curb inventory data into CDS. The other three data inputs were more manageable. IPS sent their sensor data in a simple XML formatted file which was easy for CurbIQ to translate into CDS event data. Umojo event data was sent to CurbIQ directly in CDS format. It's important to note that Umojo and CurbIQ performed one of the first ever vendor-to-vendor CDS data sharing efforts on this project. CurbIQ first provided Umojo with the CDS curb inventory. Then Umojo used the inventory data to configure their cameras and matched recorded parking events to the specific CDS curb_zone_id of the CurbIQ inventory. Once the parking events were recorded and matched, Umojo sent the parking event data back to the CurbIQ platform all in CDS format. The project team learned much from this effort, which informed several recommended improvements to CDS and the OMF Curb Collaborative. Many of these improvements can be seen in the 1.1 release of CDS on GitHub.

   It's important to note that having Umojo send their data directly to CurbIQ in CDS format was by far the most efficient and accurate way to communicate data. The SDOT team learned that it is possible to rely on a system that necessitates translating data into CDS, however going forward, SDOT will move towards a system in Stage Two that relies less on translation and more on standardized data from the start.

3. **Outputs and Access**

   The project team began to fully benefit from the standardized data after the data inputs were translated into CDS and aggregated within CurbIQ's data platform. Described below are the three key data platform outputs and how the project team accessed and integrated the information into the project.

Key Data Platform Outputs During Stage One

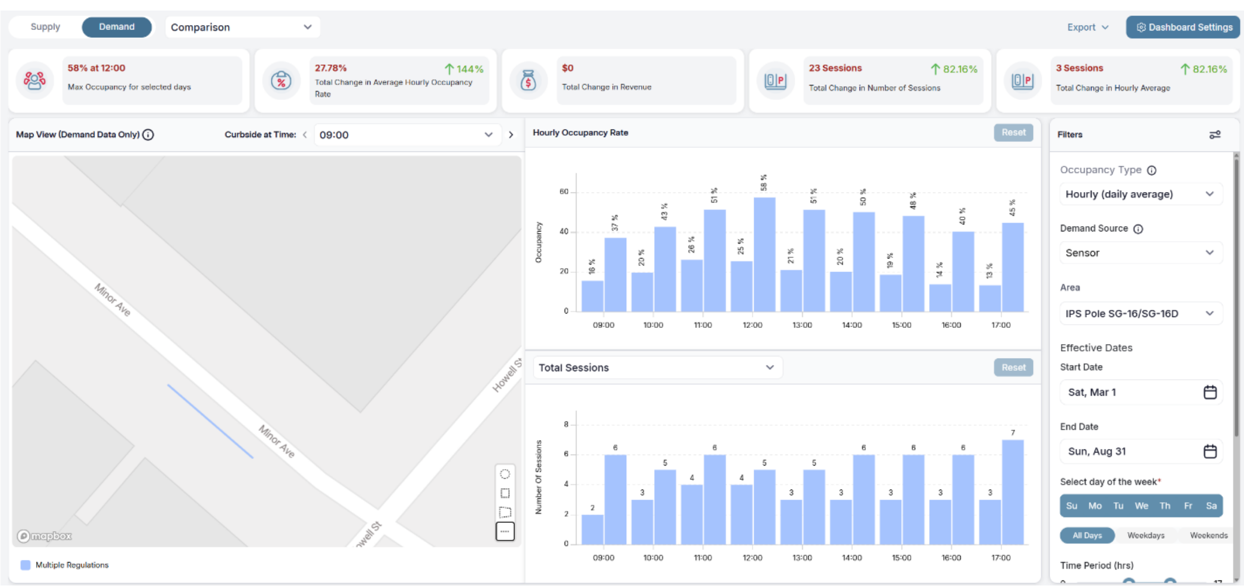
- Internal (project team) Analytics Map
- External (public) Web Map with Real-Time Availability
- CDS API Endpoints for Machine Readable Access

Internal (project team) Analytics Map

The team relied heavily on the internal analytics map to support the SMART project. Using the map, the team could quickly view and understand operational info for the entire project area. Examples include analyzing real-time and historic occupancy of CVLZs with sensors, comparing the performance of CVLZs (**Figure 19**), and identifying specific parking policies by time of day (another benefit of inventory data being in CDS format) in the project area. The team found that several load zones were seeing limited use which led to deeper analysis.

SDOT found these analytics very helpful for the SMART project but also recognized the benefits of being able to use these tools with other non-SMART data sources such as paid parking transaction data. SDOT is eager to leverage the learnings from the analytics map and begin incorporating paid parking transaction data and other parking event sources into a common data platform during Stage Two. This will provide SDOT with a comprehensive view of parking conditions that will lead to better curbside management efforts.

FIGURE 19. CURBIQ INTERNAL ANALYTICS DASHBOARD

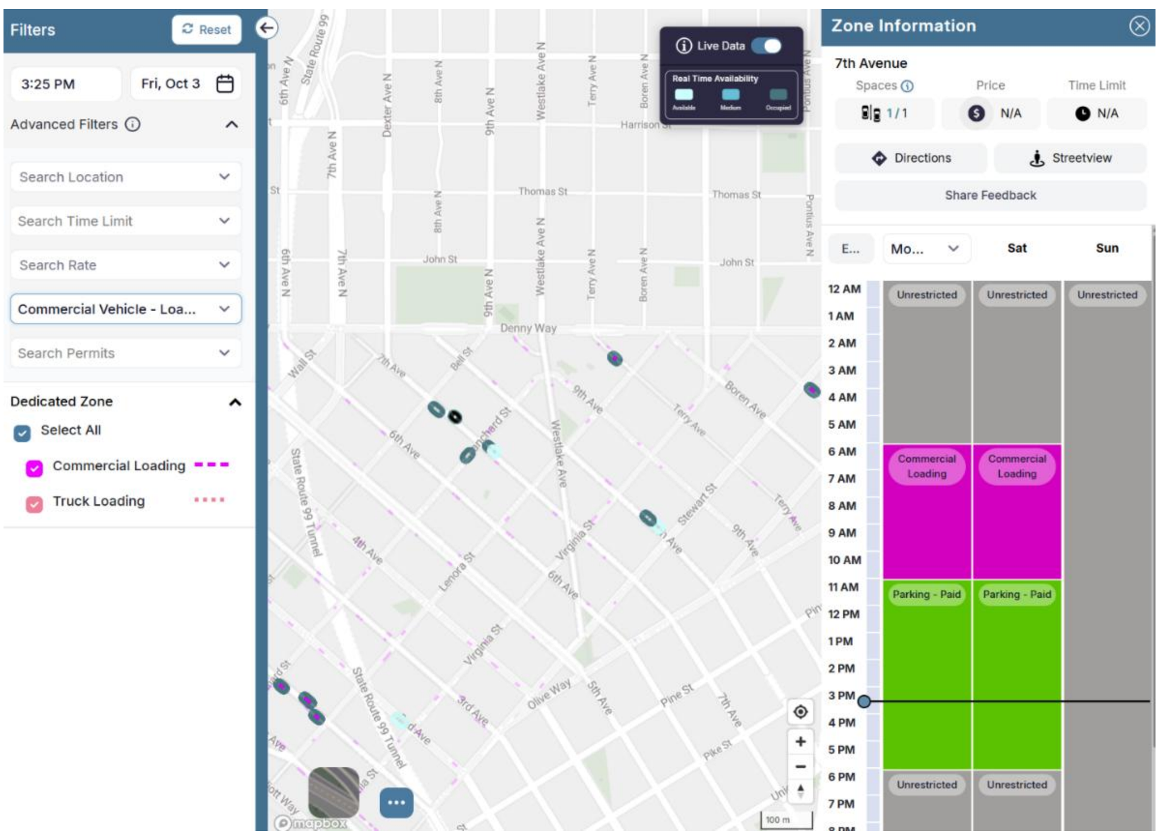


External (public) Web Map with Real-Time Availability

The external web map was a way for SDOT to test the benefits of providing the public with a more interactive way to engage and understand curbside regulations and the real-time availability of spaces. (**Figure 20**) This gets at the "Can I park here?" question that anyone who has driven a vehicle in a city before understands. The external map allowed users to select the type of vehicle they're driving, the type of curbside activity they're looking to do (commercial or passenger loading, paid parking, etc.), permit type, and the time of day/day of week they plan to travel. Another benefit of the external map was that users could also easily check the real-time availability of load zones.

Today, SDOT provides parking web maps, but they lack the functionality and interactivity that the CurbIQ public web map using CDS data provides. CurbIQ maps better align with what the public expects out of modern digital maps. Unfortunately, due to the limited time frame of Stage One, SDOT could not get the map out to as many users as initially hoped. However, during outreach, interviewees expressed great interest in having access to these types of tools. The team looks forward to providing interactive curbside access web maps to the public as part of our Stage Two priority business district outreach efforts.

FIGURE 20. CURBIQ PUBLIC FACING WEB MAP



CDS API Endpoints for Machine Readable Access

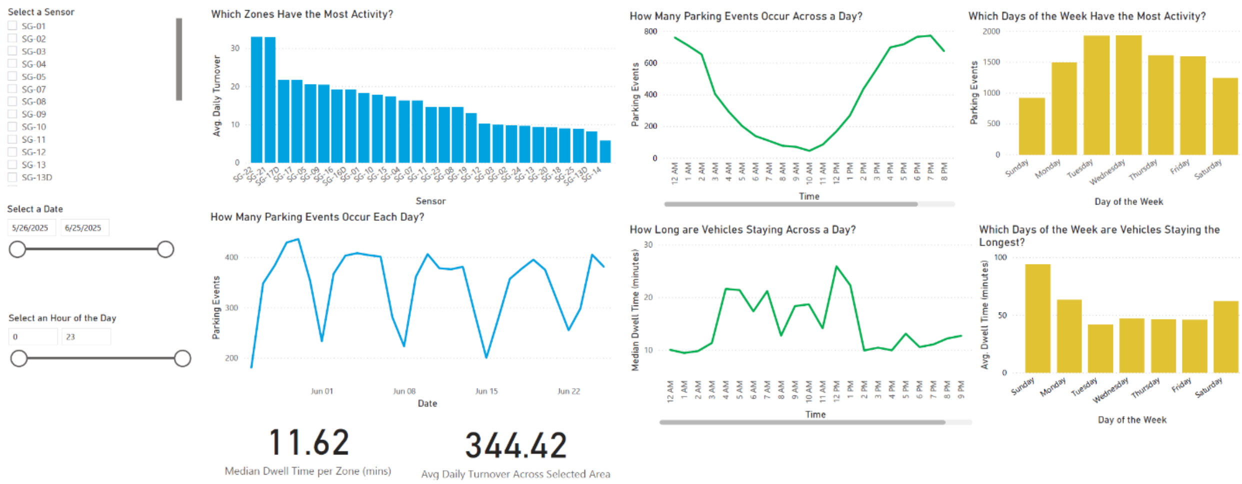
Historically, SDOT's main way of sharing curbside data has been via flat files using Seattle's open data portal[6]. (CSV, GIS shapefiles, excel tables, etc.) However, in recent years, SDOT has explored using APIs to more easily communicate data. Attempts at this have been limited in capability due to lack of resources such as appropriate technology platforms or staffing know-how. The Curbside Management team at SDOT recognizes that to manage public parking efficiently, SDOT needs to develop the ability and resources to integrate its curbside data and provide ways to communicate the data via modern APIs. This is what parking payment vendors, transportation technology vendors, and the public now expect from cities like Seattle. An important goal for the project team was to understand how to create, view, and analyze data using APIs and then educate staff on how to develop these tools using Seattle IT resources if desired.

In Stage One, CurbIQ created three CDS compliant API endpoints containing parking space geometry, regulations, and parking event data. Links to the API endpoints and helpful documentation were provided on SDOT's public SMART project website. The team promoted the APIs through social media, the OMF Curb Collaborative, and during public presentations. (CDS curb working group, IPMI conference, etc.) During the months that the APIs were available, there were 20 unique users signed up. Users ranged from individuals to academic research teams (University of Washington, University of Michigan, Berkeley, University of Arizona), non-profits, other local governments, and app developers.

SDOT used the APIs extensively to test and better understand how to interact with CDS data. As seen in **Figure 21**, SDOT created in-house analytics using already available tools like Power BI for display and analysis and python for data preparation. (separate from using CurbIQ's web map and analysis tools) SDOT also worked with other OMF Curb Collaborative cities to share knowledge of learnings and best practices using the APIs. This work directly informed Seattle's desire to work with Minneapolis on jointly developing a curb data management ecosystem. This joint effort will build a city stewarded curb data pipeline that provides cities with the flexibility to develop their own tools or connect with third-party technology vendors using standards like CDS when needed.

[6] City of Seattle Open Data portal

FIGURE 21. SDOT POWER BI DASHBOARD



Asset Management Data – Review and Recommendations

SDOT maintains thousands of digital paid area curb space and curb sign records. These records are maintained using SDOT's asset management system Hexagon (formally INFOR). As detailed in Section 3.2, SDOT worked through the challenges with CurbIQ to translate these records into CDS. The project team recognized that this translation is not a sustainable way to create an easily updateable digital twin of Seattle's curb inventory. The process required substantial QAQC to ensure accuracy but only provided a single snapshot in time of the curb regulations. Due to the complexity of translating the data, SDOT was only able to update the CDS inventory once during the project even though SDOT updates curb space asset information nightly.

To address these concerns and prepare for Stage Two, SDOT worked with our consultant Cambridge Systematics on a top to bottom review of how SDOT creates, updates, and maintains digital curb assets. The aim was to help define specific goals for managing curb signs and curb space assets, assess the current state of related datasets and processes, and develop actionable recommendations for improving data quality, consistency, and operational alignment as part of a broader enterprise asset management system. The following is a summarized version of the full report which can be found in the data repository submittal.

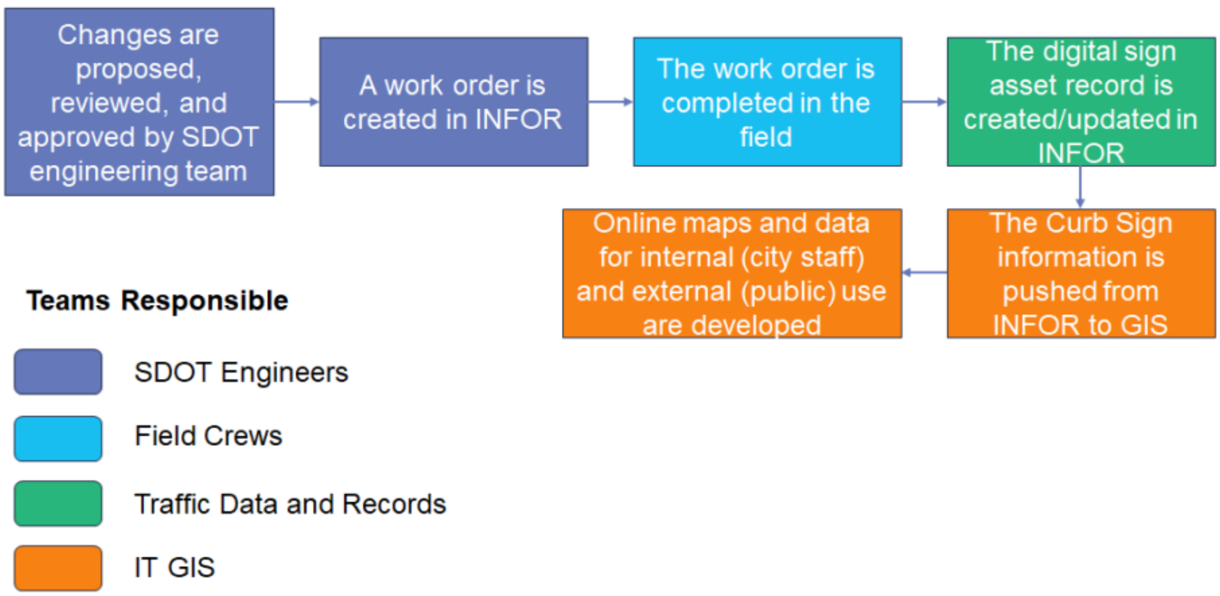
1. Vision

SDOT staff worked with the consultant on developing a vision to help guide our future curb data investments. This vision consisted of a future where SDOT has an improved curbside inventory that can easily relate to national standards (such as CDS), provides publicly accessible APIs along with interactive and intuitive web maps that allow non-technical users to understand curb right of way rules based on time of day and location. This included the importance of curb data being consistently accurate and easily updated by staff. Other ideas included real-time curb availability displayed through interactive maps, and an integration with a curbspace reservation permitting system that is seamless and efficient.

2. Key Challenges

The consultant conducted extensive interviews and work sessions with SDOT staff to document existing processes (**Figure 22**), strengths, and identified key challenges SDOT faces to obtaining its vision. Understanding the many ways and the many staff involved with updating SDOT's data was an important step towards finding out where to begin making improvements.

FIGURE 22. DIGITAL CURB SIGN ASSET WORKFLOW



The challenges identified through this effort span technical limitations, manual processes, data structure constraints, and organizational gaps. For example, one key challenge is the way SDOT stores data in many unstructured fields. This has led to inconsistent formatting, truncation, and informal or inconsistent notations. (e.g., "40'-02/04T, Sup-28/30T, -03/05T) Inconsistent formatting was a significant impediment when CurbIQ translated SDOT's data into CDS format. Other examples of identified challenges can be seen in **Table 24.**

TABLE 24. CHALLENGES IDENTIFIED

Challenge	Impact (1-Minor, 5-Critical)	Impacting Curb Signs	Impacting Curb Spaces	Teams Exposed to this Challenge
GC-1: Lack of direct data connection between curb regulations and curb spaces	5.0	Signs contain regulation data but are not directly linked to the associated curb spaces	Curb spaces lack a direct connection to regulatory data (curb signs)	Curbside Engineering, GIS, Curbside Planning
GC-2: Digital curb spaces unable to display all associated regulations	4.5	Signs often contain multiple regulations in an unstructured field, making it hard to differentiate	Digital curb spaces are defined as if they have few associated regulations, limiting accuracy	Curbside Planning, Curbside Engineering, GIS
GC-3: Lack of a holistic view when building the current processes	4.0	The current processes are fragmented and rely heavily on manual interventions, resulting in inefficiencies and a lack of seamless workflow integration	The current processes are fragmented and rely heavily on manual interventions, resulting in inefficiencies and a lack of seamless workflow integration	Curbside Planning, Curbside Operations, GIS, Traffic Data and Records, Asset Management, Accela
GC-4: High effort required to edit the current structure of the information	4.0	Limited opportunities for continuous improvement of data structure	Limited opportunities for continuous improvement of data structure	Curbside Planning, Asset Management
GC-5: Resource constraints	3.5	The Traffic Data and Records team's and Crew Chiefs/Parking Shop limited resources and capacity are bottlenecks in the curb sign asset creation or updating process	The Asset Management team expressed limited staff capacity to develop their vision; the GIS team has limited bandwidth for updates	Curbside Planning, Asset Management, Traffic Data and Records, Curbside Engineering, GIS

Challenge	Impact (1-Minor, 5-Critical)	Impacting Curb Signs	Impacting Curb Spaces	Teams Exposed to this Challenge
GC-6: Difficulty to Share Curbside Data in a Systematic Way	3.0	Difficult to share sign regulations and policies in a systematic way internally and externally	Difficult to share curb space data in a systematic way internally and externally	GIS, Asset Management, External Partners, Curbside Planning
GC-7: Manual processes and workflows	3.0	Specific steps require manual inputs into INFOR, which are time-consuming and could result in errors	Creating curb space records involves multiple manual inputs, which are time-consuming and could result in errors	Curbside Engineering, Traffic Data and Records
GC-8: Limited accessibility to historical records of curb spaces and regulations	3.0	Lack of historical records for regulations limit long-term analysis and knowledge retention	Lack of historical records for curb space delimitation limit long-term analysis, knowledge retention, and vendor accountability	Curbside Planning, Curbside Engineering, Asset Management, Curbside Planning

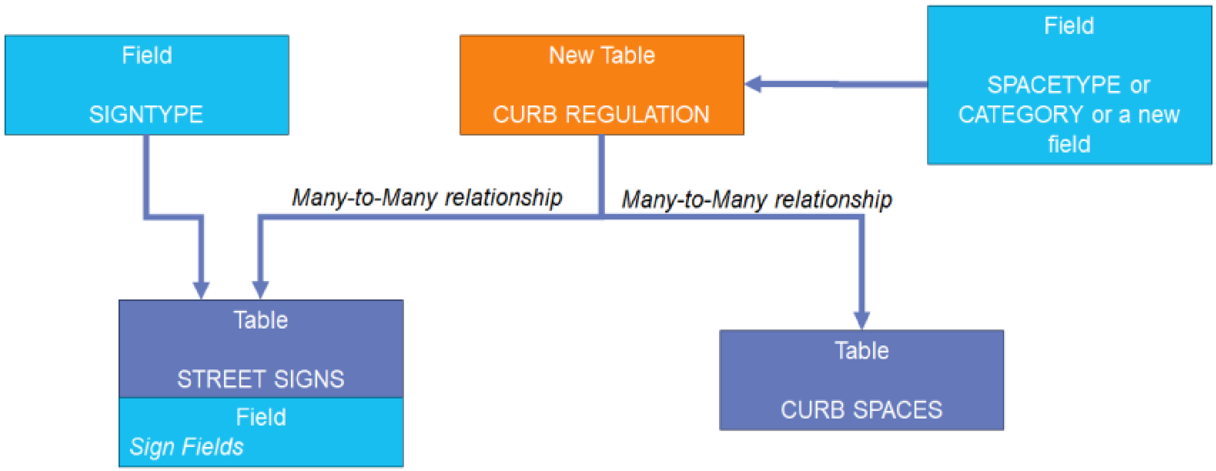
3. Recommendations

The consultant then provided detailed recommendations on how SDOT can leverage its strengths to address key data challenges. The recommendations included items such as organizational, system, and GIS specific changes. One example of a specific recommendation is:

*"Curb regulations should be defined in their own table and not be defined at the sign level. This is because the data needs for curb regulations and curb signs differ. Completely new regulations are not frequently created, however there can be many slightly different versions of a common regulation (time or days in effect) and could be listed in a small database." (***Figure 23***)*

SDOT intends to implement these recommendations and more as part of the curb data management ecosystem that will be jointly developed with Minneapolis during Stage Two.

FIGURE 23. PROPOSED DATA STRUCTURE



6. Challenges and Lessons Learned

The project did encounter challenges; however, the project team was able to learn and adapt to achieve the project goals. This section summarizes the challenges faced and the lessons learned, providing a candid look at the complexities and the resulting insights and recommendations that will guide SDOT into Stage Two.

6.1. Project Challenges

Procurement

- **Procurement pathway for OMF project partner.** SDOT encountered challenges finding a procurement pathway for partnering with the membership based non-profit OMF, a named project partner in our awarded Stage One application. SDOT and other OMF collaborative cities looked to USDOT to provide clarity on defining the collaborative with OMF as a membership service provided to SMART grant awarded cities pursuing curb management related projects, which addressed City procurement concerns on how to best move forward per the Code of Federal Regulations.
- **Extensive review of cooperative procurement process.** SDOT pursued a cooperative procurement strategy to help alleviate the administrative load to bring on the necessary vendors for the SMART grant project. As the first time using a cooperative process for federally funded services, Seattle's Purchasing Department took an extended period to review necessary documentation, internal review of the procurement was finalized in Q1 2024, which allowed SDOT to proceed to contract with the selected vendors.

Technology Suitability

- **Pilot or beta-ready passive V2C technologies are not available to test within the Stage One project timeline.** The original product requirements for V2C technology envisioned a data connection that would directly link a unique vehicle with a unique curb asset so that the team could track permit holder usage at a curb asset level. Recognizing that this study could not use license plate readers or other parking enforcement technologies for this pilot, the team explored other passive technology such as Bluetooth and RFID - whereby tags or devices might be placed on/in the vehicles that could be "read" by infrastructure-based sensors. However, after much research with tolling tech/RFID experts and promises of Bluetooth-enabled systems, SDOT realized that there are no vendors currently ready to offer pilot or beta-ready technology within Stage One.

- **Limitations on solar powered cameras.** Due to the complexity of connecting to the electric utility, our project pursued solar-powered V2C technology. SDOT chose Umojo's snapshot-based cameras because they were one of the only companies on the market to offer a solar powered option. Unfortunately, shortly after the installation, it became apparent there were technological limitations to operating solar powered cameras in Seattle. As a result, SDOT had to adapt to counteract these limitations by increasing the snapshot intervals and only operating the cameras when CVLZ regulations were active.

Third-Party Data

- **Sparse data is available from third-party sources.** While it was expected that the sample size of third-party data would be smaller than the IDAX-observed data, there was a lack of sample observations on most days using third-party data. As a result, SDOT was unable to distinguish observations from noise, and therefore unable to create expansion factors to extrapolate daily curb activity beyond the observation locations. SDOT will continue to explore how to integrate sensor data with third-party data to create a more cost-effective curb management system.

Vendor Capacity

- **Hastened expansion.** With the Sourcewell cooperative procurement, many of the SMART Curb Collaborative cities (Seattle included) chose the top-ranked vendors. Because of the grant timelines, this created capacity issues. Not being able to dedicate sufficient staff made it difficult to communicate timely, meet expectations, and adhere to deadlines.

6.2. Lessons Learned and Recommendations

Project Resources and Management

- **Weekly project meeting cadence.** With the short timeframe of Stage One project, the project team attributes progress made towards our key milestones to the weekly meeting cadence of the full project team. With full commitment to the project deadlines, the project team was able to work in lockstep and respond quickly to issues as they arose.
- **Dedicated personnel resources.** Funding from the Stage One grant award allowed SDOT to hire dedicated city project staff that enabled us to have critical resources to collaborate with USDOT, project partners, as well as our consultant teams and ultimately give this project the high-priority attention that it deserved.
- **Local academic research partnership.** As a government entity, SDOT's decade-long relationship with UFL as an academic hub for public/private engagement was exceedingly beneficial. UFL's work on the project gave meaningful insight into commercial vehicle operational practices and how commercial vehicle operators navigate through the city and interact with the curb.

- **Nationwide collaboration to support standardization and consistency of approaches.** SDOT recommends collaborating with other SMART cities working on similar projects to make sure that performance metrics are aligned across cities, at-scale implementation efforts are complimentary, and best practices can be easily shared.

Public and Stakeholder Engagement

- **Existing list of contacts.** It proved very challenging to reach delivery and logistics companies and drivers. The project team benefitted from SDOT's existing CLP program that maintains a list of businesses that purchase annual permits. This includes addresses, contact information, and number of permits. The project also benefited by partnering with UFL to lead interviews and surveys with commercial vehicle operators. This allowed the project team to engage with regional and smaller carriers and allowed us to send a survey to over 1,000 emails on the topic of permit modernization and digitization. However, those commercial delivery entities outside of SDOT's systems were difficult to reach.
- **Prioritize comprehensive engagement**. When engaging with the community, our project team sought out and engaged with business owners, particularly those who prefer non-English communication. We allocated resources to outreach specialists fluent in the preferred language(s) spoken by the business owners. This helped ensure a broad range of perspectives were being documented.
- **Effective engagement methods.** When engaging with local establishments, the team recommend in-person / door-to-door outreach rather than email or phone calls. It is much easier to reach businesses or property managers if you meet them where they are. The team also recommend having at the ready the translated materials and in-language interviews for people who speak languages other than English. If possible, working with multilingual outreach specialists is best. Even if they do speak English, this investment will encourage engagement. The team researched the likely languages spoken and had materials translated beforehand to be able to distribute and had staff who spoke those languages conduct the door-to-door outreach.

Technology Readiness

- **Conversion of existing curb regulation data into CDS.** During Stage One, the team evaluated how accurately and efficiently SDOT's team and a third-party technology vendor could translate existing curb regulation data into the CDS format and how this data could be connected to support our V2C technology. SDOT discovered that it took substantial time, effort, and cost to accurately translate the data.
- **Actionable benefits of V2C technology.** The project team learned how modern technology can facilitate curb data collection, management plans, and policies that are effective in dense

commercial activity areas. The team found that the sheer number of curb users and short-term curb stays make it costly to collect data using traditional person-based collection processes. This approach can leverage technology to understand curb dynamics, educate stakeholders, and collaborate on implementable strategies.

Procurement

- **Going from pilot to full-scale.** Since day one, SDOT has been aware there is a potential risk in identifying Stage One technologies and data management vendors that can also support a Stage Two scaled deployment. The team invested significant effort in focusing on long-term success by utilizing the Sourcewell cooperative procurement platform to create an SDOT contract that can be used for Stage Two. By taking this approach, SDOT delivered its Stage One goals and greatly reduced the procurement process for Stage Two.
- **Recognizing procurement capacity.** SDOT was ambitious in its approach to Stage One by creating a project that required a robust consultant team and multiple technology vendors to achieve its goals. SDOT recognized the City would likely not have the internal resources to fully support the number of procurements needed, which is why we pursued a cooperative procurement approach. Even with the cooperative procurement approach, SDOT still needed to rely on multiple city staff to support our contract development. Using lessons learned from Stage One, SDOT now has a more streamlined and efficient approach to using cooperative procurements and is positioned to move quickly in Stage Two. SDOT recommends working early and often with a city’s procurement staff to create more efficient processes when procuring technologies that align with project goals.

7. Deployment Readiness

This section highlights the considerations and preparations SDOT has made to ensure deployment readiness in Stage Two.

7.1. Requirements for Successful Implementation

SDOT quickly mobilized the work plan in Stage One. Contracts for project management support were finalized within one month and engagement support soon after. Within six months, the SDOT project team conducted significant engagement activities, data collection, and systems integration. Within eight months, SDOT finalized the open procurement process for technology vendors and began digital curb inventory and event data collection. The team plans to continue at this pace for Stage Two using a lightweight systems engineering process to further define and document the elements of the Stage One prototype. The team's plan is to leverage existing technology and consultant contracts developed for Stage One and source vendors directly from the Sourcewell procurement process in Stage Two. The team learned in Stage One that most vendors have equipment stocked and ready for deployment, which should alleviate potential delays due to supply chain issues.

Critical partner relationships and stakeholder support were also established in Stage One, and the team is eager to build on this momentum of support for Stage Two. SDOT also has a Curbside Management team and strong relationships with neighborhood business associations all around the city. SDOT has a long history with UFL and will be continuing the partnership from Stage One to conduct further data analysis, perform a gaps analysis of load zones, and identify where zones are over or under-allocated based on use and existing/planned land use permits in Seattle.

The Stage One team will continue in its current form for Stage Two, ensuring a seamless process and commitment for the long term. This cutting-edge multidisciplinary team comprises planners, data experts, and leaders from SDOT. Brian Hamlin, Strategic Curb Management Planner, and Mary Catherine Snyder, Parking Strategist, will lead the effort in Stage Two. The collective team, supported by outside partners, is excited to scale and operationalize our strategies more broadly through our Stage Two work.

The project team has reviewed and incorporated the relevant legal, policy, and regulatory requirements into the workplan/schedule. The project team will work closely with Seattle IT staff to ensure all privacy and surveillance legal requirements are met when scaling V2C technologies. SDOT Curbside Management team is experienced and comfortable working with payment card industry (PCI) and other sophisticated parking information and does not anticipate any regulatory delays scaling this technology. (Note that the City of Seattle is PCI-DSS [Data Security Standard] Level I compliant). We do not anticipate any concerns regarding historical structures, floodplain encroachment, or work zone impacts. The team executed agreements and secured permits (when needed) for Stage One technology installations and plans to use these existing permits to scale for Stage Two. Due to the increase in infrastructure locations, SDOT anticipates a change from Stage One to Stage Two that will require National Environmental Policy Act (NEPA) compliance. This process is incorporated into the project timeline.

Seattle's cybersecurity approach is derived from industry best practices and established frameworks such as those from the Center for Internet Security and the National Institute of Standards and Technologies, which is outlined in the project's Information System and Security Policy. The City adopted Privacy Principles and established a program in 2015. These principles provide an ethical framework for developing appropriate policies, standards, and practices regarding the public's personal information. All data is designated as open-source data.

Seattle is fortunate to have robust IT and curb asset management systems, which has been a model for other cities. During Stage One, the team evaluated how accurately and efficiently a third-party technology vendor could translate existing curb regulation data into the CDS format and how this data could be connected to support our V2C technology. The team discovered that it took substantial time, effort, and cost to accurately translate the data. To address this, SDOT intends to develop its own curb data management ecosystem in Stage Two that will integrate with other databases and workflows. SDOT will again work closely with Seattle IT to develop and integrate this new system into Seattle's internal data architecture. Bringing the curb data management ecosystem inhouse will allow SDOT to save on costs long-term. SDOT anticipates this development and integration will take approximately two years to achieve.

Seattle intends to use Stage Two funding to scale the commercial vehicle zone project approach city wide and turn the project into a sustainable, long-term program. To ensure the technology and data-driven policy development can be maintained long-term and beyond the federal funding period, SDOT anticipates Commercial Vehicle Load Zone permit fees will cover future program costs including technology or other vendor service fees. There are budgetary risks with any new program, especially ones as transformative as what SDOT is proposing. SDOT is conscious of these risks but has administrative and financial support to continue delivering complex parking program projects. SDOT is also training existing staff on how to install, maintain, and use the digital services needed to run this program. The funding mechanism and training is designed to set SDOT up for long-term success.

7.2. Maintenance and Technology Update Requirements

In Stage Two, the project team plans to build a curb data management ecosystem that is translatable into CDS and increase SDOT's internal digital literacy capacity to maintain these assets for long-term dynamic changes. This work entails data cleaning and processing and then programming a real-time connection between the existing work order / asset management application and mapping services. Without this, the team will continue to lack the processes and systems to use data effectively and will not be able to make educated decisions about curb planning and management. With the Stage Two SMART Grant award with Minneapolis, the project team will have dedicated funds to hire staff / contractors to work with applicant cities to build a consistent data architecture. SDOT will also have dedicated funds to work with private sector users to develop internal tools to ingest APIs that work across cities and pay union workers in the City's sign shop to maintain various components of the ecosystem.

7.3. Impact on Availability of Union Jobs

The Stage Two workforce strategy will build and maintain our internal capacity for the long term.

- **New jobs.** Two new full-time staff members and one new intern will have a free and fair choice to join a union and allow the City to prioritize consideration for underrepresented populations. The staff responsible for commercial load zone design, work order production, sign manufacturing, and sign installation are already union-represented.
- **Partnerships for workforce development programs.** SDOT will partner with a local academic institution to develop programs to create a talent pipeline for computer programmers and engineers focused on transportation planning for good-paying jobs with fair wages and strong labor standards. To ensure that disadvantaged people have access to these educational and workforce opportunities, SDOT anticipates partnering with the University of Washington program, Data Science for Public Good or similar programs, where students would learn about municipal curb access policies and design data science projects using their skills. Seattle has partnered on several data science-oriented student research projects for students and the city. New students are part of the UFL staff supporting the project as well.
- **Digital literacy for existing Union staff.** SDOT will increase educational opportunities for existing staff around database design, API development, and other digital tools. Staff at various levels will have educational opportunities to learn about digital technology for transportation, curb, and asset management. This will increase our institutional capacity to maintain digital tools. A critical finding from Stage One is that Seattle's IT department is often unable to dedicate the resources needed to modernize and customize enterprise systems, so building the IT capacity within SDOT will ensure the permanency of these project components.

8. Wrap-up and Key Takeaways

The Stage One project has provided initial findings that give SDOT confidence that the project's approach to providing reliable modernized access for commercial delivery vehicles at the curb using a collaborative data-driven approach is appropriate. The team has completed the curb baseline data collection and analysis, stakeholder engagement with local businesses and freight carriers, and assessments on V2C technologies which provides a strong understanding of the proposed technology driven changes to the CLP program.

Our baseline data collection effort shows us:

- The majority of vehicles that are CVLZ permit holders use CVLZs appropriately, however the number of permit holders overall is dropping year-over-year.
- Approximately 80% of vehicles using CVLZs were non-permit holding passenger vehicles that are not authorized to use these zones.

Stakeholder engagement shows us:

- Enforcement and more proactive management of CVLZs are key factors in the value add of the permit to the freight carriers, meaning that more carriers would likely purchase annual permits if the zones were managed more effectively.
- Depending on delivery type, there are vastly different routing logistics, driver experiences, dwell times, and curb needs.

Data integration efforts show us:

- There are many benefits of using a standardized data format to manage curb data management ecosystem.
- Curb regulations on parking signs and the varying formats used over the years for digital data records require custom solutions to efficiently consolidate into a uniform database.

Exploration of third-party data sources to complement our baseline data and technology solutions shows us:

- Existing data products for TNC activities are still relatively small in scale and not representative of the totality of TNC activity observed by baseline data and anecdotal observations. Rideshare and food delivery activities are important demands on curbspaces and place burdens upon CVLZs, but we are still unable to evaluate the overall intensity of activity on specific blockfaces. Technology installations such as V2C may be able to fill an important gap if they can identify TNC activity through dwell time patterns.
- Commercial fleet vehicle data products are promising and do provide robust information on different vehicle types using the curb.

These findings confirm the need and the opportunity to scale the project to fully integrate digital tools and V2C technology into SDOT's policies, systems, processes, and partnerships to build a data-driven approach to improving curb access.

From what the project team has learned in Stage One, SDOT would advise other cities to embark on a similar effort as follows:

- Appropriately scale and phase your project approach so that you can continue to make progress on deployment-ready components of the project, while working through roadblocks and other such complexities in other areas.
- Ensure your proposed technology solutions address real-world problems in your jurisdiction. Do not pursue technologies that are looking for problems. Only when you have a clearly defined problem should you begin searching for the right technological solution.
- Beware of prototypes or technical specifications that are non-negotiable from the outset. If a given vendor is unable to guarantee delivery of solutions with the necessary technical specifications on the required timeline, move on to discussions with other potential vendors.
- Clear red tape hurdles as soon as possible within your agency. Determine what contracting vehicles are options and get pre-approval from the necessary agency leaders. Build buy-in on the project goals and approach from city procurement staff as early as possible.
- Contact other cities to see about their use of technology and contracting progress, to share with internal staff and to guide decision making.

Additional advice SDOT can give to communities looking to address commercial load zone management is to be willing to take risks that challenge the status quo. Load zone access is a problem that every city must deal with but in Seattle, we are able to use empirical evidence to now show: 1) the source of the problem, 2) insights into potential solutions; and 3) a baseline to measure how effective our strategies are at addressing these problems. During Stage One, SDOT made progress on establishing a data-driven curb access framework that we believe will be scaled effectively in Stage Two but also shared for the benefit of other agencies.