The Final 50 Feet of the Urban Goods Delivery System:

Tracking Curb Use in Seattle

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Supply Chain Transportation and Logistics Center
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EXECUTIVE SUMMARY

Vehicles of all kinds compete for parking space along the curb in Seattle's Greater Downtown area. The Seattle Department of Transportation (SDOT) manages use of the curb through several types of curb designations that regulate who can park in a space and for how long. To gain an evidence-based understanding of the current use and operational capacity of the curb for commercial vehicles (CVs), SDOT commissioned the Urban Freight Lab (UFL) at the University of Washington Supply Chain Transportation & Logistics Center to study and document curb parking in five selected Greater Downtown areas.

This study documents vehicle parking behavior in a three-by-three city block grid around each of five prototype Greater Downtown buildings: a hotel, a high-rise office building, an historical building, a retail center, and a residential tower. These buildings were part of the UFL's earlier SDOT-sponsored research tracking how goods move vertically within a building in the final 50 feet of the goods delivery system. The final 50 feet of supply chains starts when commercial vehicle drivers park in a load/unload space; includes the drivers' activities as they maneuver goods over curbs, along sidewalks and through intersections; and ends inside urban towers when they complete their deliveries or other work. *(1)*

The areas around these five prototype buildings were intentionally chosen for this curb study to deepen the city's understanding of the Greater Downtown area.

Significantly, this study captures the parking behavior of commercial vehicles everywhere along the curb as well as the parking activities of all vehicles (including passenger vehicles) in commercial vehicle loading zones (CVLZs.) The research team documented: (1) which types of vehicles parked in CVLZs and for how long, and; (2) how long commercial vehicles (CVs) parked in CVLZs, in metered parking, and in passenger load zones (PLZ) and other unauthorized spaces.

<u>Four key findings, shown below, emerged from the research team's work.</u>

1. **Commercial and passenger vehicle drivers use CVLZs and PLZs fluidly: commercial vehicles are parking in PLZs, and passenger vehicles are parking in CVLZs.** Passenger vehicles made up more than half of all vehicles observed parking in CVLZs (52%). More than one-quarter of commercial vehicle drivers parked in PLZs (26 %.) This fact supports more integrated planning for all curb space, versus developing standalone strategies for passenger vehicle and for commercial vehicle parking.

2. **Most commercial vehicle (CV) demand is for short-term parking: 15 or 30 minutes.** Across the five locations, more than half (54%) of all CVs parked for 15 minutes or less in all types of curb spaces. Nearly three-quarters of all CVs (72%) parked for 30 minutes or less. When considering just the delivery CVs, an even higher percentage, 60%, parked for 15 minutes or less. **Eighty-one percent of the delivery CVs parked for 30 minutes or less.**

3. **Thirty-six percent of the total CVs parked along the curb were service CVs, showing the importance of factoring their behavior and future demand into urban parking schemes.** In contrast to delivery CVs that predominately parked for 30 minutes or less, service CVs' parking behavior was bifurcated. While 56% of them parked for 30 minutes or less, 44% parked for more than 30 minutes. And more than one-quarter (27%) of the service CVs parked for an hour or more. Because service vehicles make up such a big share of total CVs at the curb, this may have an outsize impact on parking space turn rates at the curb.

4. **Forty-one percent of commercial vehicles parked in unauthorized locations.** But a much higher percentage parked in unauthorized areas near the two retail centers (55% - 65%) when compared to the predominately office and residential areas (27% - 30%). The research team found that curb parking behavior is associated with granular, building-level urban land use. This occurred even as other factors such as the total number, length and ratio of CVLZs versus PLZs varied widely across the five study areas.

The occupancy study documents that each building and the built environment surrounding it has unique features that impact parking operations. As cities seek to more actively manage curb space, the study's findings illuminate the need to plan a flexible network with capacity for distinct types (time and space requirements) of CV parking demand. This study also drives home that the curb does not function in isolation, but instead forms one element of the Greater Downtown's broader, interconnected load/unload network, which includes alleys, the curb, and private loading bays and docks. *(1,2,3)* SDOT commissioned this work as part of its broader effort with the UFL to map—and better understand—the entire Greater Downtown area's commercial vehicle load/unload space network. Cities and other parties interested in the details of how to conduct a commercial vehicle occupancy study can see a step-by-step guide in Appendix C.

In this study, researchers deployed six data collectors to observe each curb study area for three days over roughly six weeks in October and December 2017. To make the data produced in this project as useful as possible, the research team designed a detailed vehicle typology to track specific vehicle categories consistently and accurately. The typology covers 10 separate vehicle categories, from various types of trucks and vans to passenger vehicles to cargo bikes. Passenger vehicles in this study were not treated as commercial vehicles, due to challenges in systematically identifying whether passenger vehicles were making deliveries or otherwise carrying a commercial permit.

The five prototype Seattle buildings studied are Seattle Municipal Tower (also the site of a common carrier parcel locker pilot), Dexter Horton, Westlake Center, and Insignia Towers. *(4)* The study shows how different building and land uses interact with the broader load/unload network. By collecting curb occupancy data in the same locations as their earlier work, the research team added a new layer of information to help the city evaluate—and manage—the Greater Downtown area load/unload network more comprehensively.

This report is part of a broader suite of UFL research to date that equips Seattle with an evidence-based foundation to actively and effectively manage Greater Downtown load/unload space as a coordinated network. <u>The UFL has mapped the location and features of the legal landing spots for trucks across the Greater Downtown, enabling the city to model myriad urban freight scenarios on a block-by-block level. To the research team's knowledge, no other city in the U.S. or the E.U. has this data trove</u>. The findings in this report, together with all the UFL research conducted and GIS maps and databases produced to date, give Seattle a technical baseline to actively manage the Greater Downtown's load/unload spaces as a coordinated network to improve the goods delivery system and mitigate gridlock.

The UFL will pilot such active management on select Greater Downtown streets in Seattle and Bellevue, Washington, to help goods delivery drivers find a place to park without circling the block in crowded cities for hours, wasting time and fuel and adding to congestion. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy under the Vehicles Technologies Office is funding the project. *(5)* The project partners will integrate sensor technologies, develop data platforms to process large data streams, and publish a prototype app to let delivery firms know when a parking space is open – and when it's predicted to be open so they can plan to arrive when another truck is leaving. This is the nation's first systematic research pilot to test proof of concept of a functioning system that offers commercial vehicle drivers and dispatchers real-time occupancy data on load/unload spaces–and test what impact that data has on commercial driver behavior. This pilot can help inform other cities interested in taking steps to actively manage their load/unload network.

Actively managing the load/unload network is more imperative as the city grows denser, the e-commerce boom continues, and drivers of all vehicle types—freight, service, passenger, ride-sharing and taxis—jockey for finite (and increasingly valuable) load/unload space. Already, Seattle ranks as the sixth most-congested city in the country.

The UFL is a living laboratory made up of retailers, truck freight carriers and parcel companies, technology companies supporting transportation and logistics, multifamily residential and retail/commercial building developers and operators, and SDOT. Current members are Boeing HorizonX, Building Owners and Managers Association (BOMA) - Seattle King County, curbFlow, Expeditors International of Washington, Ford Motor Company, General Motors, Kroger, Michelin, Nordstrom, PepsiCo, Terreno, USPack, UPS, and the United States Postal Service (USPS.)

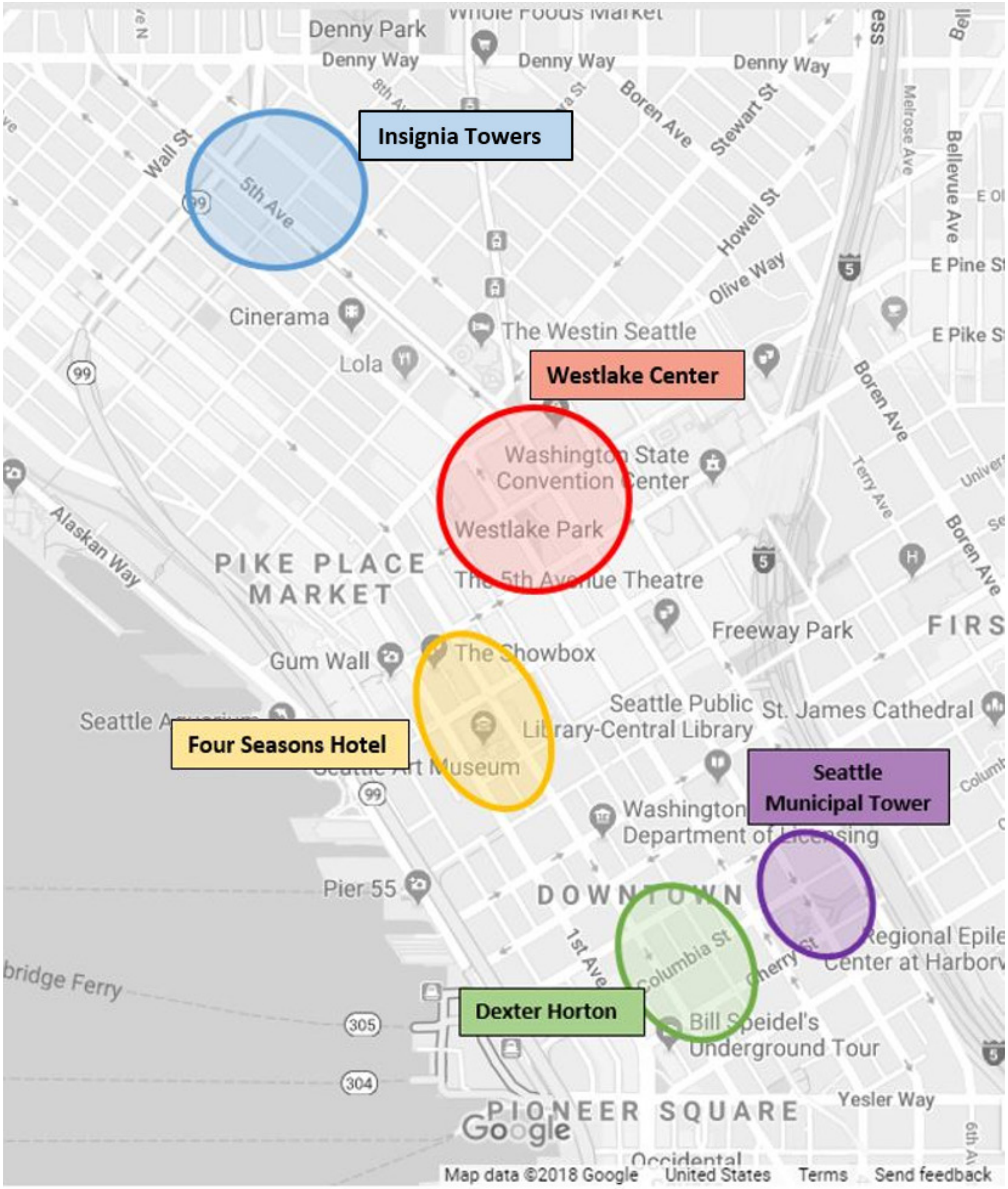
STUDY LOCATIONS

The curb occupancy study was conducted in five Greater Downtown locations. Each area covered a three-by-three city block grid around a prototype building identified in an earlier 2018 SCTL report *(1)*. These buildings were selected by SDOT and the research team in the first Final 50 Feet: Goods Delivery System research report to represent distinct building types and land-use patterns. Continuing to collect additional data, in this case curb occupancy data, in the same locations builds a much deeper understanding of how the sites function in the broad load/unload network and the role the curb plays in that network.

While it was beyond the scope of this research project to systematically link the observed curb loading/unloading activities with the prototype buildings, UPS (a UFL member) corroborated that delivery drivers typically do not park more than 100 to 200 feet away from the address to which they are delivering. That distance is approximately equivalent to one Seattle Greater Downtown area block face. Using a three-by-three city grid enabled creation of a catchment area and the inclusion of a diversity of the types of curb spaces where vehicles could park (both authorized and unauthorized). By inventorying CVLZs and PLZs for each study area and comparing SDOT's curb-use GIS database to the on-the-ground reality in the field, the research team built a detailed, accurate curb map for each study area. (Maps are in Appendix A.)

Figure 1 on the following page shows the overall map of these five study areas built around the five prototype buildings.

Figure 1. Five Greater Downtown Area Study Areas Built Around Five Prototype Buildings



The research team deployed six data collectors to observe each study area for three days over roughly six weeks in October and December 2017. Data collectors were assigned carefully considered positions on the blocks in each study area to maximize both the diversity of curb parking types captured (CVLZ, PLZ, hydrants, zones etc.) and visibility all along the curb. Data collectors recorded both the start and end parking time of vehicles in each curb space or area (to the minute) as well as the vehicle type according to the typology outlined in the next section. Location details and times of day for data collection are listed below in Table 1.

Table 1. Five Prototype Building Locations

BUILDING AREA NAME AND BUILDING TYPE	AREA LOCATION	NUMBER OF DAYS SURVEYED	TIME FRAME SURVEYED	TOTAL HOURS SURVEYED
Four Seasons Hotel and Harbor Steps Apartments (Hotel)	Between Western and 2nd Avenues and Pike and Seneca Streets	3	9:00 am to 1:00 pm	12
Seattle Municipal Tower (Office)	Between 4th and 6th Avenues and Cherry and Marion Streets	3	8:00 am to 12:00 pm	12
Dexter Horton Building (Historic Building)	Between 1st and 4th Avenues and Marion and James Streets	3	One day from 8:00 am to 12:00 pm Two days from 8:00 am to 1:00 pm	14
Westlake Center (Retail)	Between 4th and 5th Avenues and Pine and Stewart Streets.	3	8:00 am to 12:00 pm	12
Insignia Towers (Residential)	Between 4th and 7th Avenues and Blanchard and Wall Streets	3	8:30 am to 4:30 pm[1]	24

[1] The research team deliberately added afternoon hours to the Insignia Towers study area to determine whether a residential building would have peak truck delivery hours in the afternoon rather than in the morning, as is the case in the other non-residential buildings. The team hypothesized that building residents may order food or other goods later in the day versus workers in other buildings who want goods to arrive in the morning. This data on peak delivery times will be analyzed in future UFL research products.

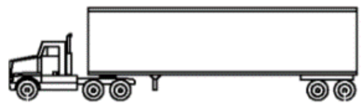
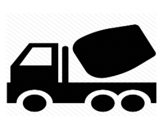
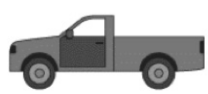
VEHICLE TYPOLOGY

The research team created detailed categories covering a wide range of vehicle types that could load/unload on the curb. Table 2 on the following page illustrates the list of defined vehicle types in this study. The vehicle typology was established based on fieldwork and knowledge of the curb operations in the Greater Downtown area.

It is important to clarify that for the curb occupancy study, taxis and passenger vehicles were not included in either the service or delivery commercial vehicle categories. The research team acknowledges that the vehicles defined as 'delivery vehicles' in the typology above are not the only vehicles delivering goods in Seattle. Passenger vehicles are also used to deliver goods, through services such as Uber Eats, Amazon Prime, Amazon Fresh and the like. But because data collectors had to remain at their assigned positions, they were not always able to discern from their vantage point whether a passenger vehicle had a commercial permit on the windshield or was otherwise delivering goods. Therefore, it was not possible in this study to systematically differentiate between a passenger vehicle with or without a commercial permit or whether a passenger vehicle was performing freight operations, dropping off passengers (e.g. a taxi or vehicle offering ride-share service, such as Lyft or Uber) or any other operation.

Additionally, as noted earlier, the only passenger vehicle parking behavior recorded was when these drivers parked in areas dedicated to commercial vehicles (CVLZs).

Table 2. Commercial and Non-Commercial Vehicles Included in Occupancy Study

COMMERCIAL VEHICLES (CV)		
Delivery Commercial Vehicles (4 subtypes shown below)		
- Truck with Trailer (T)		Truck with trailer, three or more axles.
- Box Truck (B)	 	Single-unit trucks, three axles or less.
- Cargo Van (CV)	 	A cargo van is a one-piece unit, while a box truck has a separate cab and cargo box.
- Cargo Bike (C)		
Garbage Truck (G)		
Service Commercial Vehicles (Van or Pick-Up Truck) (SV)	  	
Van (V)		A cargo or service van usually displays a business logo. If such information was not visible, the vehicle was recorded as a 'van.'
Construction Vehicles	 	
CATEGORIZED AS NON-COMMERCIAL VEHICLES IN THIS ANALYSIS		
Passenger Vehicle (P)	  	
Taxi (X)		
Motorcycle (M)		
Others (O)	Includes fire and police trucks and vans, and other buses.	

OCCUPANCY STUDY KEY FINDINGS

The glossary below is intended to aid in interpreting the study's key findings.

Glossary at a Glance

Commercial vehicle: Encompasses a wide range of delivery and construction vehicles, service vehicles and garbage trucks but excludes all passenger vehicles.

Delivery commercial vehicle: Box truck, cargo van, truck with trailer, cargo bike.

Passenger vehicle: Car, pick-up truck, shuttle bus.

Service commercial vehicle: Van or pick-up used to provide services (e.g., installation, maintenance).

Unauthorized commercial vehicle parking: passenger loading zone (PLZ), travel lanes, bus lanes, curb segments close to hydrants, tow-away-zones, shuttle bus parking, and intersections.

The following four key findings are drawn across all five study areas and represent broad parking and vehicle distribution patterns found across the sites. Site-by-site analysis of each of the five study areas can be found in Tables 7 and 9.

The curb occupancy study's four key findings are:

1. **Commercial and passenger vehicle drivers use CVLZs and PLZs fluidly: Commercial vehicles are parking in PLZs and passenger vehicles are parking in CVLZs.**

Passenger vehicles made up more than half of all vehicles observed parking in CVLZs (52%). Delivery vehicles made up just 26% of all vehicles parked in CVLZs. (See pie chart in Figure 2.)

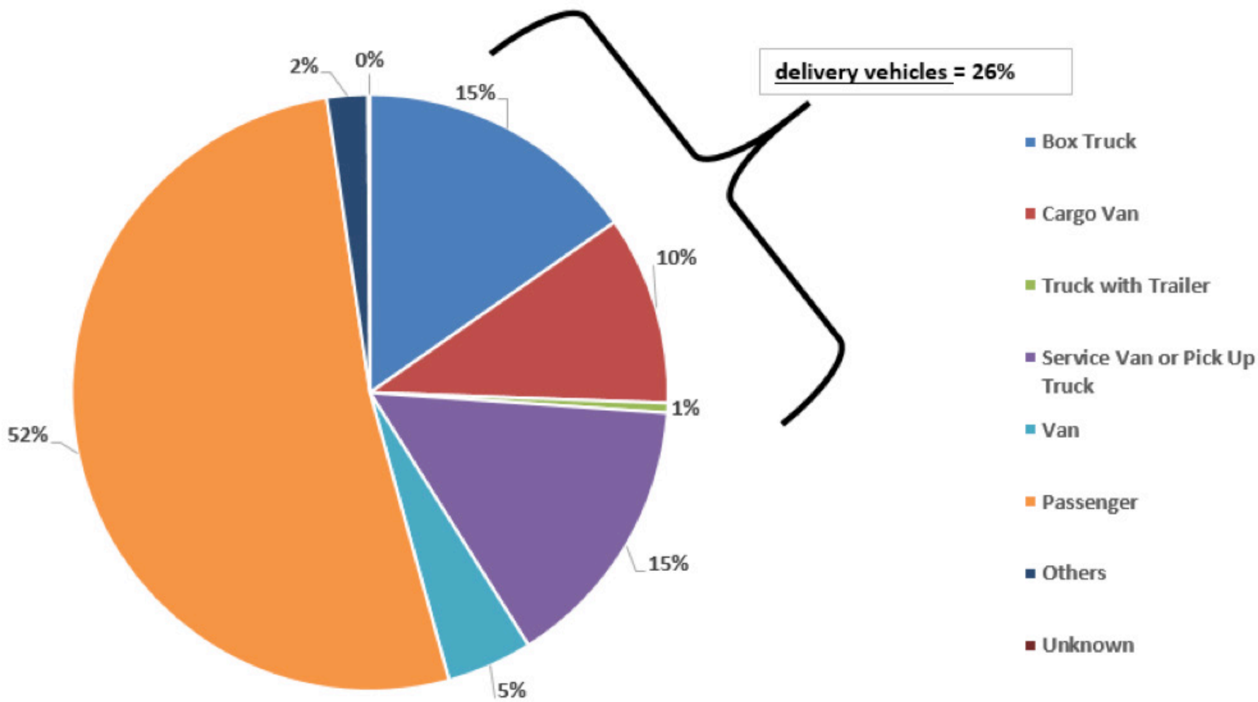
This fact supports cities taking a more integrated approach to planning for all curb space, versus developing separate, standalone strategies for passenger vehicle and for commercial vehicle parking. Clearly these uses overlap in the real world. The finding is significant and suggests stiff competition between passenger vehicles and commercial vehicles for easily accessible curb spaces.

This is even more the case in Seattle as its parking policies allow passenger vehicle drivers to buy commercial vehicle parking permits. As explained earlier, the vehicle observation method used in this study did not distinguish between passenger vehicles with a commercial permit/making a delivery and passenger vehicles without a permit/not making deliveries. It also did not distinguish between how Transportation Network Companies (TNCs) such as Uber and Lyft make use of CVLZs versus other passenger vehicles.

While commercial vehicle drivers parked predominantly in CVLZs (35%), more than one-quarter of them chose to park in PLZs (26%.) Delivery vehicles represent the biggest share of commercial vehicles parked in PLZs (18%). (See pie chart in Figure 3.)

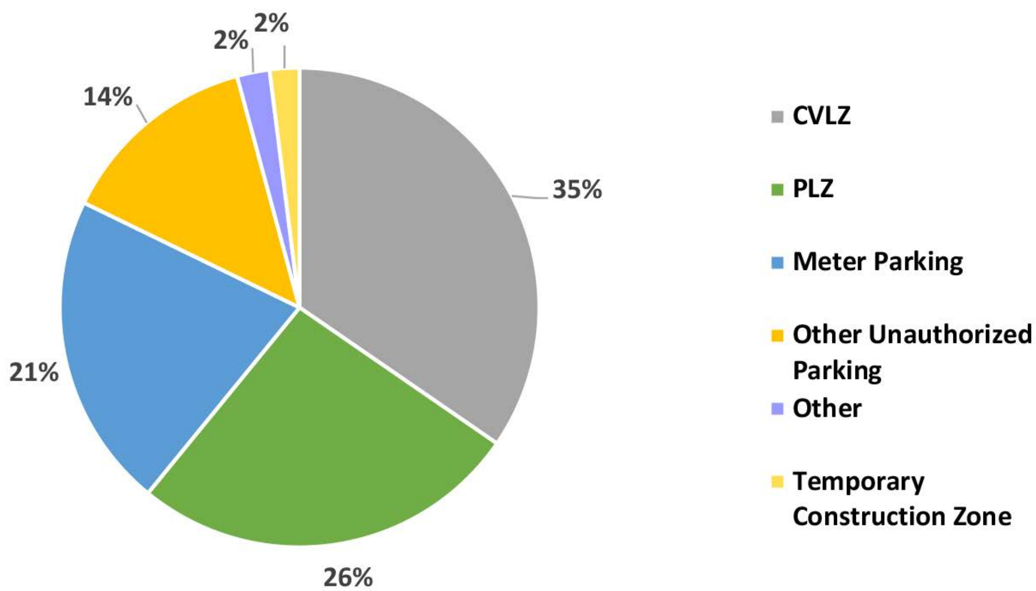
Figure 2. Passenger Vehicles Made Up 52% of All Vehicles Observed in CVLZs, Across All Study Areas

(The 'others' group includes all other types of vehicles observed, including taxis, construction, garbage and shuttle buses.)



Fifty-two percent of all vehicles in CVLZs were passenger vehicles; but half of these were only there 5 minutes.

Figure 3. More Than One-Quarter of Commercial Vehicles Parked in PLZs, Across All Locations



2. Most CV demand is for 15 minutes or 30 minutes of parking.

On average across the five locations, more than half (53.8%) of all CVs parked for 15 minutes or less in all types of curb spaces. Nearly three-quarters of all CVs (72.2%) parked for 30 minutes or less.

When considering just the delivery CVs, an even higher percentage, 60% (421 out of 693 total) parked for 15 minutes or less. **Eighty-one percent (562 out of 693 total) of the delivery CVs parked for 30 minutes or less.**

Table 3. Delivery CVs Overwhelmingly Parked For 30 Minutes or Less in All Types of Curb Spaces in Five Locations: % (#)

COMMERCIAL VEHICLE TYPE	TOTAL CVS BY VEHICLE TYPE	15 MIN OR LESS	15 - 30 MIN	30 – 60 MIN	>1 HR.
Delivery CVs	55.3% (693)	33.6% (421)	11.3% (141)	6.8% (85)	3.7% (46)
Total CVs by Time Parked	100% (1,253)	53.8% (674)	18.4% (231)	13.9% (174)	13.9% (174)

The following table provides information about all types of CVs parked along the curb across all five locations.

Table 4. How Long Did CVs Park in All Types of Curb Spaces in the Five Locations? % (#)

COMMERCIAL VEHICLE TYPE	TOTAL CVS BY VEHICLE TYPE	15 MIN OR LESS	15 -30 MIN	30 – 60 MIN	>1 HR.
Delivery CVs *There are four subcategories:*	55.3% (693)	33.6% (421)	11.3% (141)	6.8% (85)	3.7% (46)
- Box Truck	30% (376)	17.2% (215)	6.5% (82)	4.7% (59)	1.6% (20)
- Cargo Van	22.7% (285)	14.9% (187)	4.0% (50)	2.0% (25)	1.8% (23)
- Truck with Trailer	2.6% (32)	1.5% (19)	0.7% (9)	0.1% (1)	0.2% (3)
- Cargo Bike	0.1% (1)	0.1% (1)			
Service CVs: Vans and Pick Up Trucks	36.4% (456)	15.1% (189)	5.4% (68)	6.1% (76)	9.8% (123)
Van	6.5% (81)	3.9% (49)	1.6% (20)	0.8% (10)	0.2% (2)
Garbage or Construction CV	1.8% (23)	1.2% (15)	0.2% (2)	0.2% (3)	0.2% (3)
Total CVs by Time Parked	100% (1,253)	53.8% (674)	18.4% (231)	13.9% (174)	13.9% (174)

In addition to documenting how CVs park along the curb, the researchers also examined the parking behavior of all the types of vehicles that parked in CVLZs. As shown below, 78.4% of all vehicles parked for 30 minutes or less in CVLZs.

Notably, when passenger vehicle drivers parked in CVLZs, they made very short-term use of them. Passenger vehicles made up the biggest share of vehicles parking 15 minutes or less (38.3%) in CVLZs. Delivery vehicles made up the second-biggest share of vehicles parking 15 minutes or less (14.1%) in CVLZs.

Table 5. How Long Did All Types of Vehicles Park in CVLZs in the Five Study Locations? % (#)

ALL VEHICLE TYPES	% OF TOTAL CVS (# OBSERVED)	15 MIN OR LESS	15-30 MIN	30MIN-1HR	MORE THAN 1HR
Delivery vehicles	26.1% (247)	14.1% (134)	5.8% (55)	4.9% (46)	1.3% (12)
- ***Box Truck***	15.3% (145)	7.8% (74)	3.2% (30)	3.6% (34)	0.7% (7)
- ***Cargo Van***	10.2% (97)	6.1% (58)	2.4% (23)	1.2% (11)	0.5% (5)
- ***Truck with Trailer***	0.5% (5)	0.2% (2)	0.2% (2)	0.1% (1)	
Service Van or Pick Up Truck	15.0% (142)	6.3% (60)	1.8% (17)	3.5% (33)	3.4% (32)
Van	4.6% (44)	2.4% (23)	1.4% (13)	0.6% (6)	0.2% (2)
Passenger	52.0% (492)	38.3% (363)	6.2% (59)	4.1% (39)	3.3% (31)
Others	2.2% (21)	1.5% (14)	0.5% (5)	0.1% (1)	0.1% (1)
Unknown	0.1% (1)				0.1% (1)
Time parked by vehicle type	100% (947)	62.7% (594)	15.7% (149)	13.2% (125)	8.3% (79)

3. Thirty-six percent of all commercial vehicles that parked along the curb were service vehicles, showing the importance of factoring their behavior and future demand into urban parking schemes.

In contrast to delivery CVs that predominately parked for 30 minutes or less, service CVs' parking behavior was bifurcated. While 56% of them parked for 30 minutes or less; 44% parked for more than 30 minutes. And more than one-quarter - 27% - of the service CVs parked for an hour or more. Because service vehicles make up such a big share of total CVs at the curb, this may have an outsize impact on parking space turn rates at the curb.

Table 6. How Long Did Service CVs Park in All Types of Curb Spaces in the Five Locations? % (#)

COMMERCIAL VEHICLE TYPE	TOTAL CVS BY VEHICLE TYPE	<15 MIN	15 -30 MIN	30 – 60 MIN	>1 HR.
Service CVs: Vans and Pick Up Trucks	36.4% (456)	15.1% (189)	5.4% (68)	6.1% (76)	9.8% (123)

The demand for longer-term parking for service vehicles will grow commensurate with the growth of urban towers that require ongoing maintenance for HVAC, plumbing, electrical, IT and other systems. At the same time the high-rises are going up, the total square footage of private open-air parking space is going down as the land is too valuable to retain that use. One service technician who works in downtown Seattle reports that this is causing more and more parking circling behavior, as the open-air parking lots service vehicle drivers counted on vanish. (Many service CVs are too tall to fit into passenger garages.) The lots' spaces are not being replaced, which adds to demand for longer-term parking the curb.

4. Forty-one percent of all commercial vehicles parked in unauthorized locations.

But a much higher percentage parked in unauthorized areas near the two retail centers (55% - 65%) when compared to the predominately office and residential areas (27% - 30%) as seen in Table 7 on the following page. The research team found that curb parking behavior is associated with granular, building-level urban land use. This occurred even as other factors such as the total number, length and ratio of CVLZs versus PLZs varied widely across the five study areas.

Figure 4. Forty-one Percent of Commercial Vehicles Parked in Unauthorized Locations Across the Five Study Areas

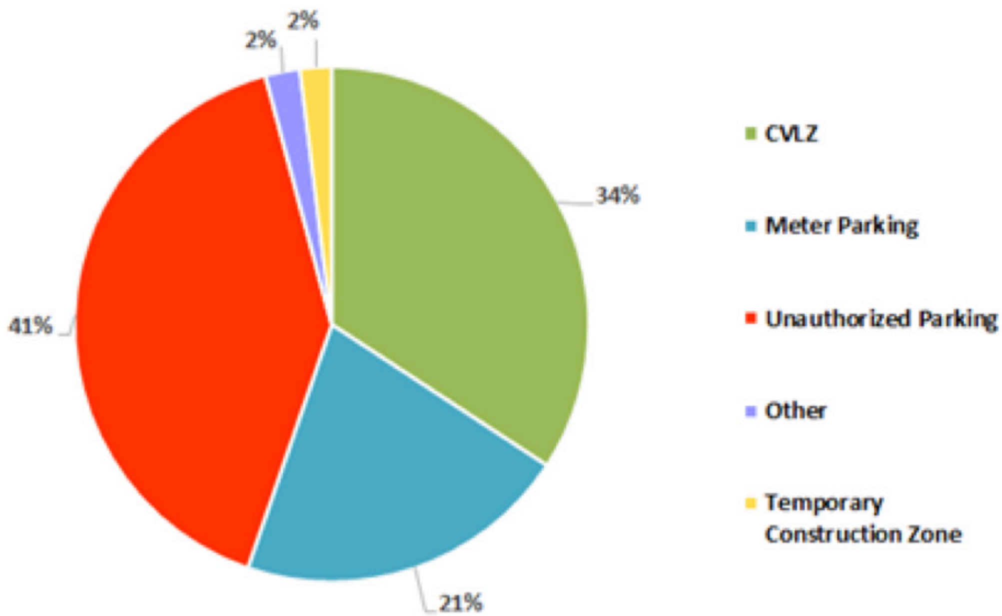


Table 7. There Was a Higher Rate of Unauthorized Parking in the Retail-Oriented Areas

CURB STUDY AREA		CVLZ SUPPLY	CV DEMAND		RATIO OF CVLZ SUPPLY TO CV DEMAND[2]	PERCENT OF CVS PARKED IN UNAUTHORIZED LOCATIONS
Building name	Primary land use	Total available parking time in CVLZs[3]	Total number of CVs parked	Total time CVs parked[4]		
Four Seasons Hotel	**Hotel, residential, retail**	**2,811**	**256**	**5,325**	**0.53**	**65%**
Westlake Center	**Retail**	**1,608**	**215**	**6,017**	**0.27**	**55%**
Seattle Municipal Tower	Office	486	152	4,368	0.11	30%
Insignia	Residential	4,207	272	13,323	0.32	28%
Dexter Horton	Historic Office	10,343	359	13,749	0.75	27%

[2] Time available to CVs in CVLZs / CV demand for curb parking (minutes)

[3] Total CVLZ observation time minus the time passenger vehicles parked in CVLZs (minutes)

[4] Minutes

Table 8 below provides more detailed information on where commercial vehicles parked along the curb across all five study areas.

Table 8. CVs Parked in Many Types of Parking Spaces at the Curb across All Study Areas

COMMERCIAL VEHICLE TYPE	% OF TOTAL CVS (# OBSERVED)	CVLZ	PLZ	METER	UNAUTHORIZED PARKING (OUTSIDE OF PLZ)	OTHER	CONSTRUCTION ZONE
Delivery Vehicles:	55.3% (693)	19.7% (247)	17.8% (223)	8.0% (100)	9.0% (113)	0.5% (6)	0.3% (4)
- *Box Truck*	30.0% (376)	11.6% (145)	9.2% (115)	3.8% (48)	5.0% (63)	0.4% (5)	
- *Cargo Van*	22.7% (285)	7.7% (97)	8.1% (101)	3.9% (49)	3.0% (37)	0.1% (1)	
- *Truck w/Trailer*	2.6% (32)	0.4% (5)	0.6% (7)	0.2% (3)	1.0% (13)		0.3% (4)
- *Cargo Bike*	0.1% (1)			0.1% (1)			
Service Van or Pick Up Truck	36.4% (456)	11.3% (142)	7.3% (92)	12.1% (151)	3.5% (44)	1.3% (16)	0.9% (11)
Van	6.5% (81)	3.5% (44)	1.2% (15)	1.0% (12)	0.6% (8)	0.2% (2)	
Garbage, Construction Vehicles	1.8% (23)	0.1% (1)		0.3% (4)	0.4% (5)	0.2% (3)	0.8% (10)
Total CVs Parked at Curb	100% (1,253)	34.6% (434)	26.3% (330)	21.3% (267)	13.6% (170)	2.2% (27)	2.0% (25)

FIVE CURB OCCUPANCY CASE STUDIES

While the previous section discusses key findings based on parking patterns found across all five study areas, this section explores each site individually. The research team found that curb parking behavior is associated with granular, building-level urban land use. This occurred even as other factors such as the total number, length and ratio of CVLZs versus PLZs varied widely.

The Final 50 Feet occupancy study continues to build and deepen the goods delivery case studies for five prototype buildings in Seattle's Greater Downtown area that were begun in 2017. The following five profiles explore how different building/land uses and surrounding combinations of designated curb load/unload space are linked to commercial vehicle parking at the curb. It is important to note that in Seattle both CVLZs and PLZs were designated based on building tenants' and/or property managers' requests to the city over many years. The tenants who originally asked for a CVLZ or PLZ outside their building may have moved, but the designation remains. Each location's mix of spaces changed over time without reference to the larger load/unload space network. Based on the high percentage of unauthorized use in every location, there does not appear to be sufficient capacity to meet current or future demand.

Table 9 below provides a site-by-site snapshot of the different types of CVs that parked along the curb in each of the five locations. Detailed maps of the areas are included in Appendix D.

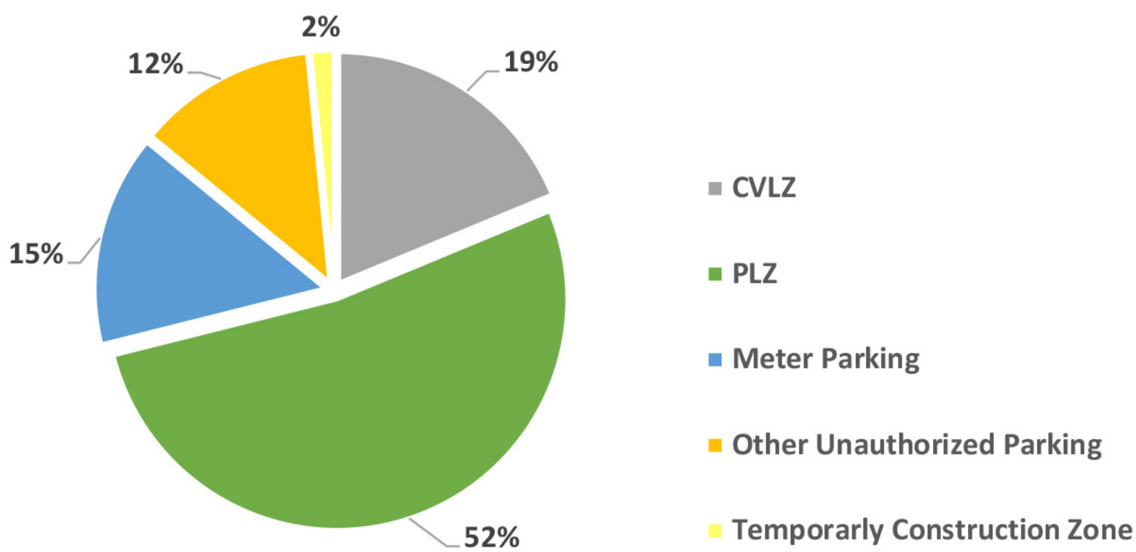
Table 9. Types of CVs That Parked along the Curb in Each of the Five Study Areas

COMMERCIAL VEHICLE TYPE	FOUR SEASONS HOTEL	SEATTLE MUNICIPAL TOWER	DEXTER HORTON BUILDING	WESTLAKE CENTER	INSIGNIA TOWERS
Delivery Vehicles	69.1% (177)	32.9% (50)	54.0% (194)	65.6% (141)	48.5% (132)
- Box Truck	39.5% (101)	23.0% (35)	32.3% (116)	30.2% (65)	21.7% (59)
- Cargo Van	25.8% (66)	9.9% (15)	20.1% (72)	28.8% (62)	25.7% (70)
- Truck With Trailer	3.9% (10)		1.7% (6)	6.0% (13)	1.1% (3)
- Cargo Bike				0.5% (1)	
Service Vehicles	27.7% (71)	52.6% (80)	34.8% (125)	26.5% (57)	45.2% (123)
Van	1.2% (3)	14.5% (22)	10.9% (39)	2.3% (5)	4.4% (12)
Construction and Garbage Vehicles	2.0% (5)		0.3% (1)	5.6% (12)	1.8% (5)
TOTAL % (#) Vehicle Type Observed at Each Location	100.0% (256)	100.0% (152)	100.0% (359)	100.0% (215)	100.0% (272)

Four Seasons Hotel

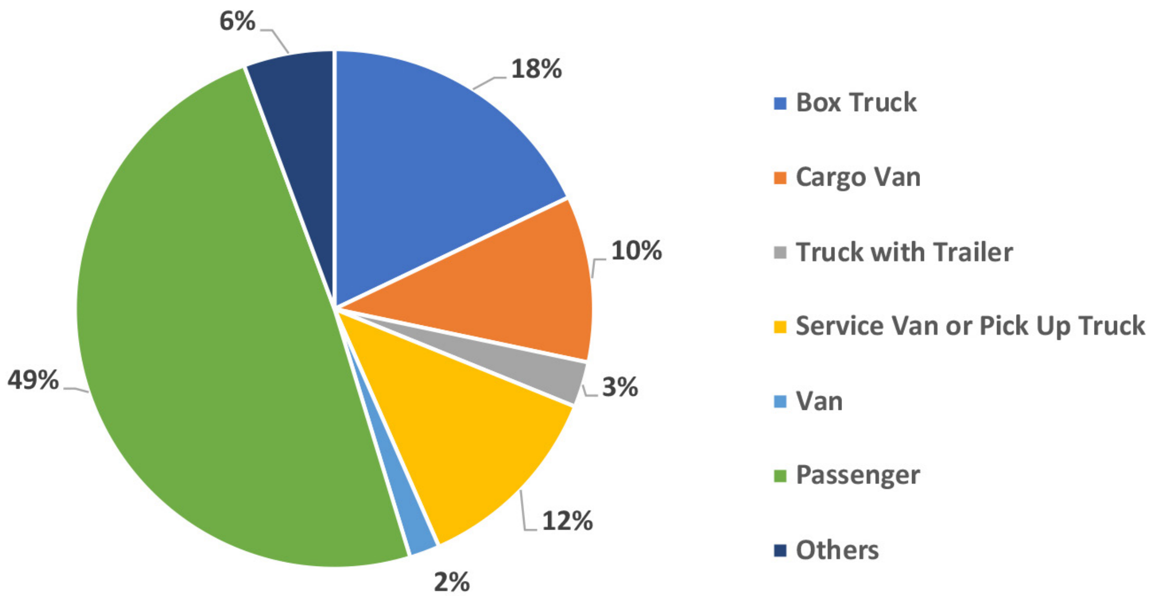
Curb parking is in high demand in the lively and walkable commercial district serving tourists and residents near the Four Seasons Hotel, with the Pike Place Market, a Target retail store, and many restaurants located in the area. This land-use mix had the highest percentage of delivery vehicles (69%) parking along the curb of all the study areas. It also had the largest percentage of commercial vehicles parking in unauthorized spaces (64%): as shown in Figure 5 below, 52% of them parked in PLZs and another 12% in other unauthorized spaces. The Four Seasons study area had the most PLZs (13) of the five areas and 6 CVLZs for a 2.2/1 ratio.

Figure 5. Where Did Commercial Vehicles Park at the Curb in the Four Seasons Hotel Study Area?



While more than half of commercial vehicles made use of the PLZs, the research team documented that 49% of the vehicles observed in CVLZs were passenger vehicles. This evidence supports Key Finding #1: Both passenger vehicle drivers and commercial vehicle drivers are using PLZ and CVLZ spaces fluidly in the Greater Downtown.

Figure 6. Distribution of All Vehicles Parked in CVLZs in the Four Seasons Hotel Study Area



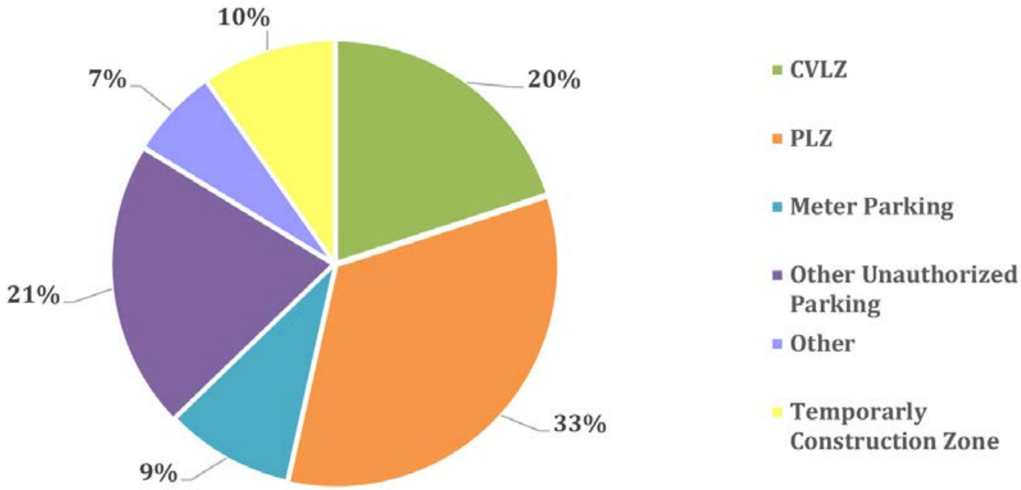
Westlake Center (Retail)

This area is in the heart of downtown Seattle's shopping district. The Westlake Center (a four-story shopping center and adjacent 25-story office tower), Mayflower Park Hotel, and freestanding major retail stores such as Macy's and Nordstrom are located within a few blocks, attracting shoppers and restaurant-goers all day and into the evening.

The curb parking activity by Westlake Center closely resembled that observed near the Four Seasons Hotel. In both cases, the proportion of commercial vehicles parking in unauthorized locations was roughly double that of the other three study areas. As shown in Figure 7, after the Four Seasons Hotel, Westlake Center had the next-highest proportion (54%) of commercial vehicles parking in unauthorized places (33% in PLZs and 21% in other unauthorized spaces).

This may be explained by the similarity of the two study sites' land use and curb parking space distribution. Although an anchor retailer such as Nordstrom Rack at Westlake schedules all their deliveries outside customer hours, many smaller retailers and restaurants require multiple deliveries throughout the day to restock. In both retail study areas, a bigger share of commercial vehicles parked in PLZs than in any other type of parking space (33% at Westlake and 52% at the Four Seasons study area). This may be because the two retail areas also had the greatest total length of PLZ space out of the five areas studied: Westlake Center area had 425 feet, Four Seasons Hotel area had 371 feet. Both buildings have loading bays, but they are surrounded by a high-energy mix of retailers that may not have off-street commercial parking.

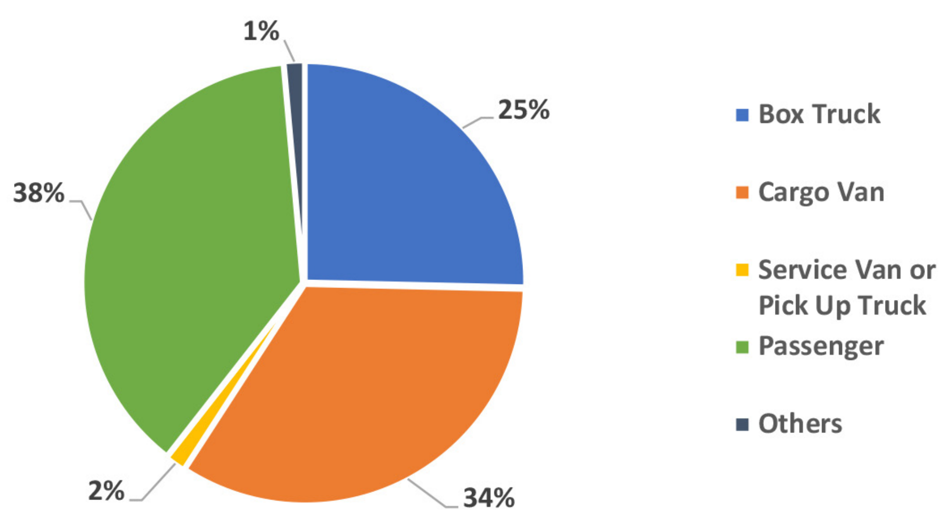
Figure 7. Distribution of Commercial Vehicles Parked at the Curb in the Westlake Center Study Area



In addition, a similar distribution of commercial vehicle types parked along the curb in the Four Seasons Hotel and Westlake Center study areas. Delivery vehicles were the most frequently observed commercial vehicle type parked along the curb in both locations; 65.6% near Westlake and 69% at the Four Seasons.

However, in contrast to all the other locations, Westlake Center had the lowest percentage of passenger vehicles parking in CVLZs: 38% versus 49%-56% in the other four areas.

Figure 8. Distribution of All Vehicles Parked in CVLZs in the Westlake Center Study Area



Seattle Municipal Tower (Office)

This study area has a dense concentration of government and other office buildings, such as City Hall, the Seattle Department of Transportation, Seattle City Light, the Seattle Police Department, the Seattle Municipal Court, the Bank of America and Columbia Tower. There are very few street-level retail stores or restaurants. As shown in Table 9, this study area had the highest proportion (52.6%) of service CVs parking along the curb of all the observed commercial vehicles in the five areas. More than two-thirds of those service vehicles were parked in CVLZs.

Not only do office towers need to be maintained, some of the service representatives may have parked near City Hall to pick up building permits and meet with city officials. This study area also had the second-highest percentage of passenger vehicles parking in CVLZs (52%).

The Seattle Municipal Tower study area had 5 PLZs and 4 CVLZs during the occupancy study for a 1.25/1 ratio. (Several CVLZs on the building's east side were removed just before this study's data-collection period.) Even with an underground freight bay for the Tower's deliveries, nearly one third (30%) of the commercial vehicles in this study area did not park in authorized spaces, as shown in Figure 9 (21% in PLZs and 9% in other unauthorized places.)

Figure 9. Distribution of Commercial Vehicles Parked at the Curb in the Seattle Municipal Tower Study Area

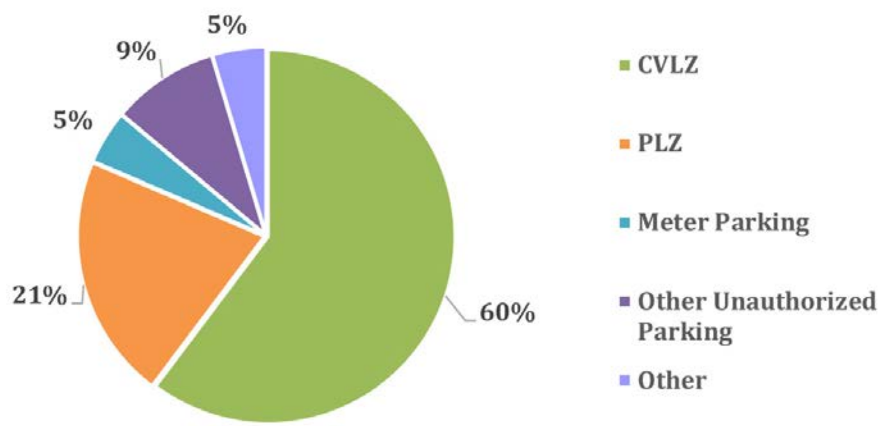
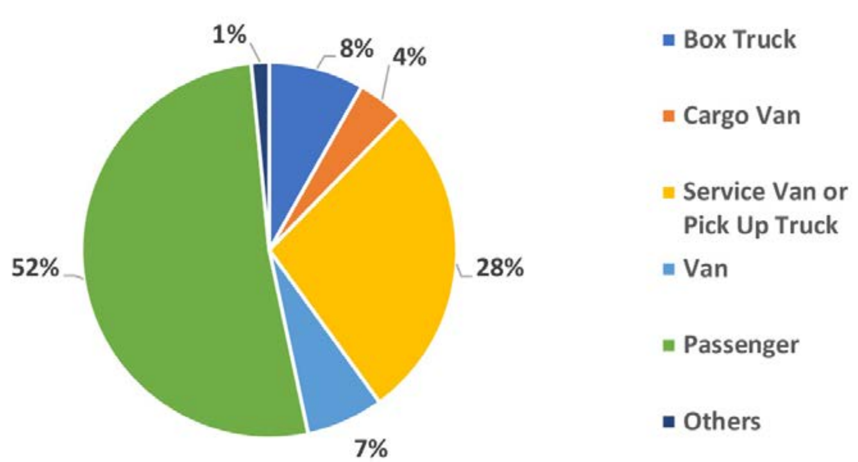


Figure 10. Distribution of All Vehicles Parked in CVLZs in the Seattle Municipal Tower Study Area

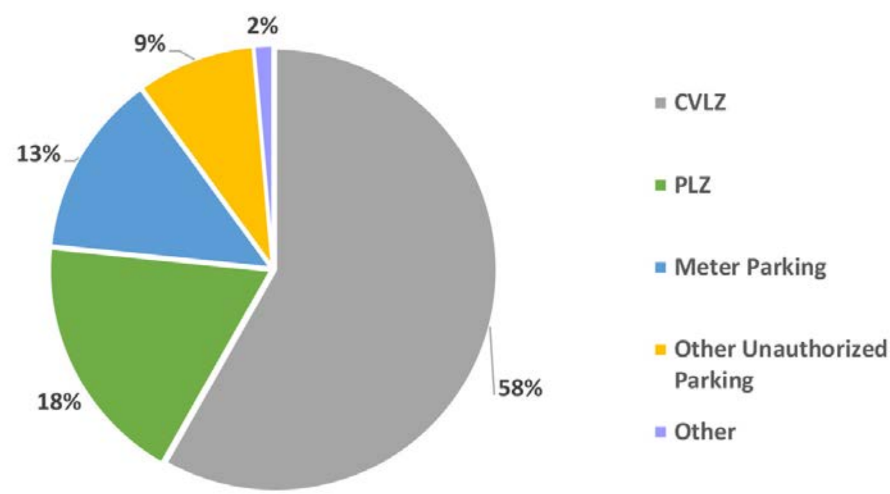


Dexter Horton (Historic Building)

The Dexter Horton historic building is in Seattle's Pioneer Square district. This location has a high concentration of office buildings with multiple uses: banks, consulting firms, chain retailers, and technology companies. As shown in Figure 11 below, the predominant parking location for commercial vehicles in this study area was in CVLZs (58%), as could be expected from the large number of nearby CVLZs. The Dexter Horton area had 9 PLZs and 17 CVLZs, a 0.5/1 ratio.

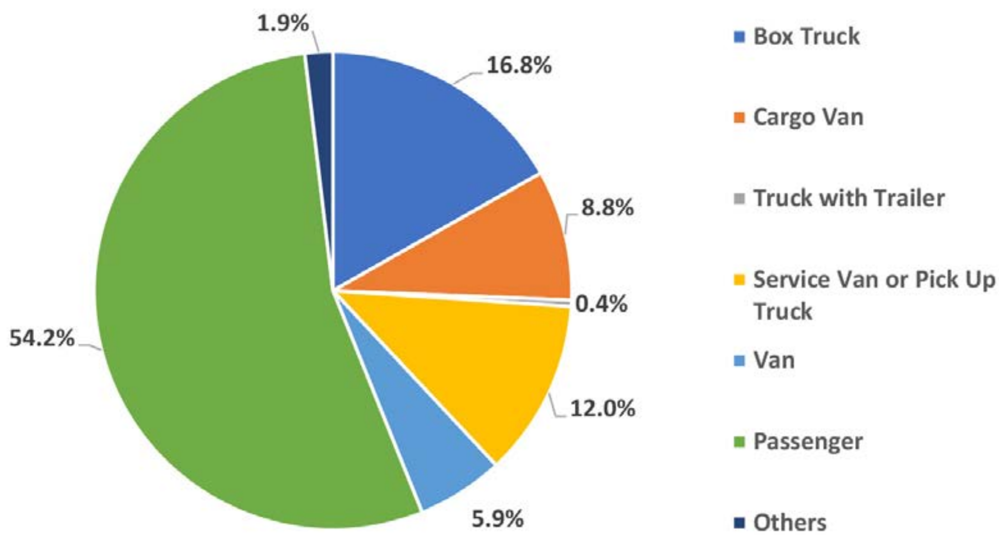
Of the five prototype buildings, Dexter Horton was chosen for the Final 50 Feet suite of research projects to represent goods delivery operations in older historic buildings. Constructed in 1924, it is the only prototype building around which the five study areas are built that does not have a private loading bay. Therefore, Dexter Horton and many neighboring buildings are 100% reliant on public curb and alley parking. Although some surrounding buildings have passenger vehicle parking garages, few have loading bays.

Figure 11. Distribution of CVs Parked along the Curb in the Dexter Horton Building Study Area



As shown in Figure 12 below, even with 9 PLZs in the immediate vicinity, passenger vehicles made up more than half (54%) of all observed vehicles parking in CVLZs in the Dexter Horton study area. Although this location had by far the most (17) CVLZs at the curb, 18% of CV drivers parked in PLZs, once again documenting how fluidly passenger and commercial vehicle drivers are using curb space in Greater Downtown.

Figure 12. Distribution of All Vehicles Parked in CVLZs in the Dexter Horton Building Study Area



Insignia Towers

The Insignia Towers residential site is made up of two 41-story towers just a 10-minute walk from Westlake Center. This study area is very close to the Amazon campus in Seattle's South Lake Union district and has a dense concentration of residential and high-tech-office land use.

Located where downtown, Belltown and South Lake Union meet, Insignia has almost 700 urban residences and more than 1,500 people residing in one city block. The condominiums have a parking garage for residents, as do several neighboring towers. There is also a loading bay that is predominately used to receive large, over-size goods by appointment; parcels and food are delivered to the 24/7 concierge through the front lobby door.

There is no curb parking at the south Tower along the full block next to the lobby entrance; it is a transit lane. Much of the other curb space in this area has metered parking. The area also has two street-level parking lots. This location has the least PLZ capacity, both in terms of number of PLZs and their total length, of any studied. In addition, the average length of CVLZs is the shortest across the study areas, at 29 feet. This relatively low capacity likely contributes to the most significant difference between Insignia and all the other study areas: Insignia had the highest percentage (57%) of commercial vehicles that parked in metered spaces, as shown in Figure 13 below.

The research team found additional patterns associated with Insignia's land use, off-street parking opportunities and curb space allocation. Compared to the other study areas, Insignia had the:

- Lowest percentage (27%) of unauthorized CV parking (9% in PLZs and 18% in other unauthorized parking locations)
- Second-highest percentage (45.2%) of service CVs parked along the curb space
- Highest proportion of passenger vehicles in CVLZs (56%)

Figure 13. Distribution of Commercial Vehicles Parked at the Curb in the Insignia Towers Study Area

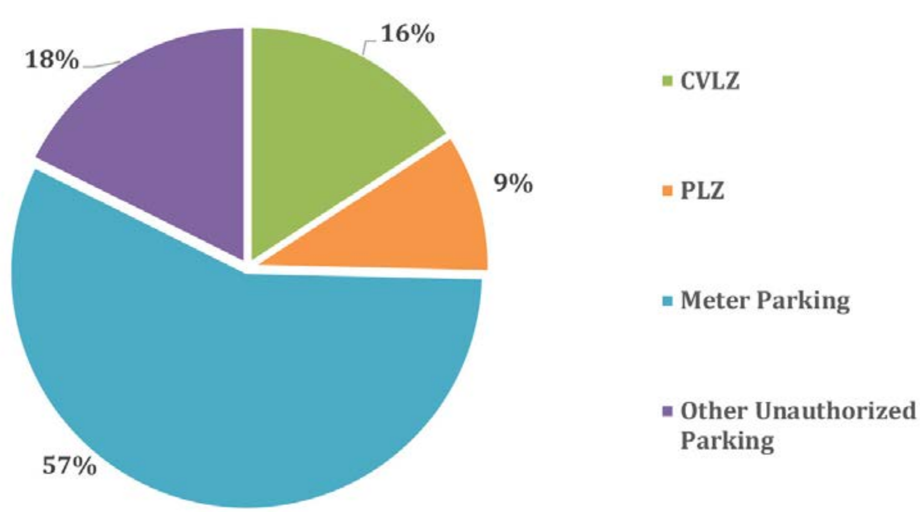
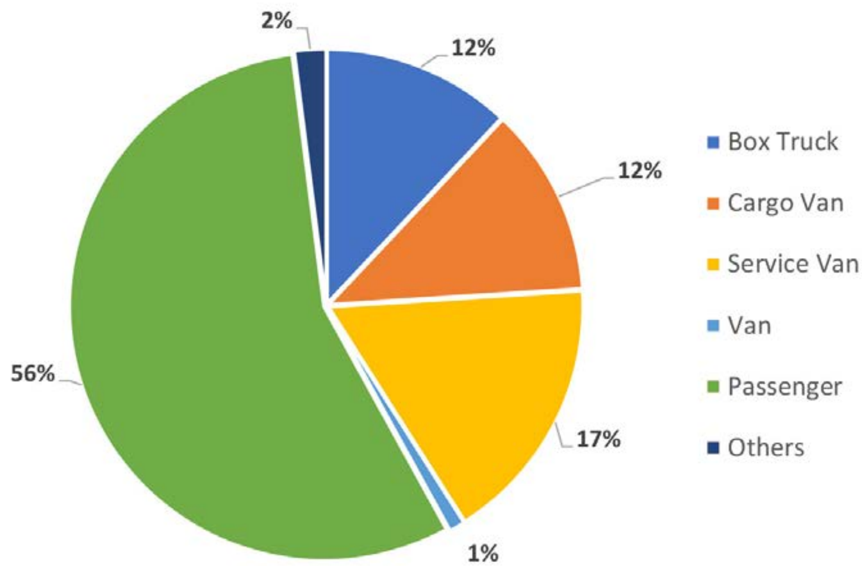


Figure 14. Distribution of All Vehicles Parked in CVLZs in the Insignia Towers Study Area



STUDY DESIGN AND PARAMETERS

Defining The Study Areas

Based on the project scope and in-field assessment of the areas surrounding the study's five prototype buildings, the research team defined the study areas as a three-by-three city block grid around each building. This was designed to provide diversity of curb parking types and to create a catchment area around the buildings. UPS, an Urban Freight Lab member, told the research team that their delivery drivers rarely park more than 200' away from a building entrance and are normally within 100 feet. The UFL researchers assume that firms delivering larger and heavier goods such as office furniture or mattresses, would be even more likely to look for nearby parking.

The research team inventoried the Commercial Vehicle Loading Zones (CVLZs) and Passenger Load Zones (PLZs) that serve each prototype building. (See Table 10.) Additionally, since commercial vehicles park outside of CVLZs and PLZs, they included other potential parking options (both authorized and unauthorized) in each site data collection map: travel lanes, bus lanes, curb segments close to hydrants, tow-away-zones, shuttle bus parking, intersections, on-street meter parking and temporary construction zones.

While they used SDOT's curb GIS database to create the preliminary data collection maps for each of the study areas, the data collection team found variances between the city's data layer and the actual, current designations during their initial field visits. To ensure accuracy, they double-checked the SDOT curb space layer in the field to look for changes that had occurred (such as the creation of temporary construction zones) and revised the data collectors' maps as needed.

Table 10. Distribution and Total Length of CVLZs and PLZs by Building Area

BUILDING AREA	OVERALL LAND USE OF 3X3 CITY BLOCK GRID STUDIED	TOTAL LENGTH OF CVLZS (FT.)	COUNT OF CVLZS	TOTAL LENGTH OF PLZS (FT.)	COUNT OF PLZS
Four Seasons Hotel	Hotel, Residential, Retail	197.3	6	424.8	13
Seattle Municipal Tower	Offices	258.9	4	267.4	5
Dexter Horton	Offices	643.4	17	525.3	9
Westlake Center	Retail	90.7	3	370.7	6
Insignia Towers	Residential	117.3	4	88.8	3

Data-Collection Method

When planning the project, the research team intended to use video cameras to collect the data. But the City of Seattle Surveillance Ordinance 125376 took effect on September 1, 2017 and made this approach unfeasible. The ordinance instituted a new permission process to video tape in public areas. Both SDOT and the research team anticipated that the time needed to obtain the required permit would not allow the team to meet project timeline requirements.

The UW researchers decided to use human observers to gather data for the occupancy study, which has advantages. While a video camera could be blocked by a large vehicle or other object in dynamic traffic conditions, human observers in the field can easily move around obstacles to ensure clear sightlines to the curb. Because vehicles were sometimes too far away for data collectors to systematically track details (such as which passenger vehicles had commercial windshield permits or were performing delivery activities), collectors were able to gather anecdotal details as shown in the figures below.

Figure 15. Human Observer Collecting Data at Dexter Horton

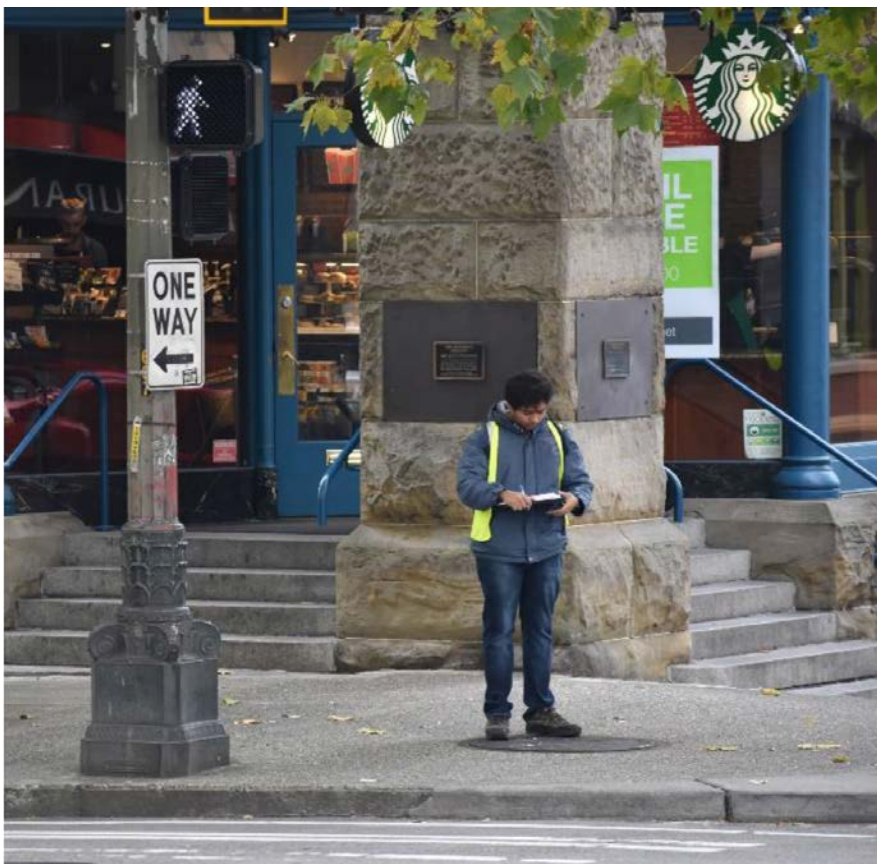


Figure 16. Customized Windshield Delivery Sign on Passenger Vehicle

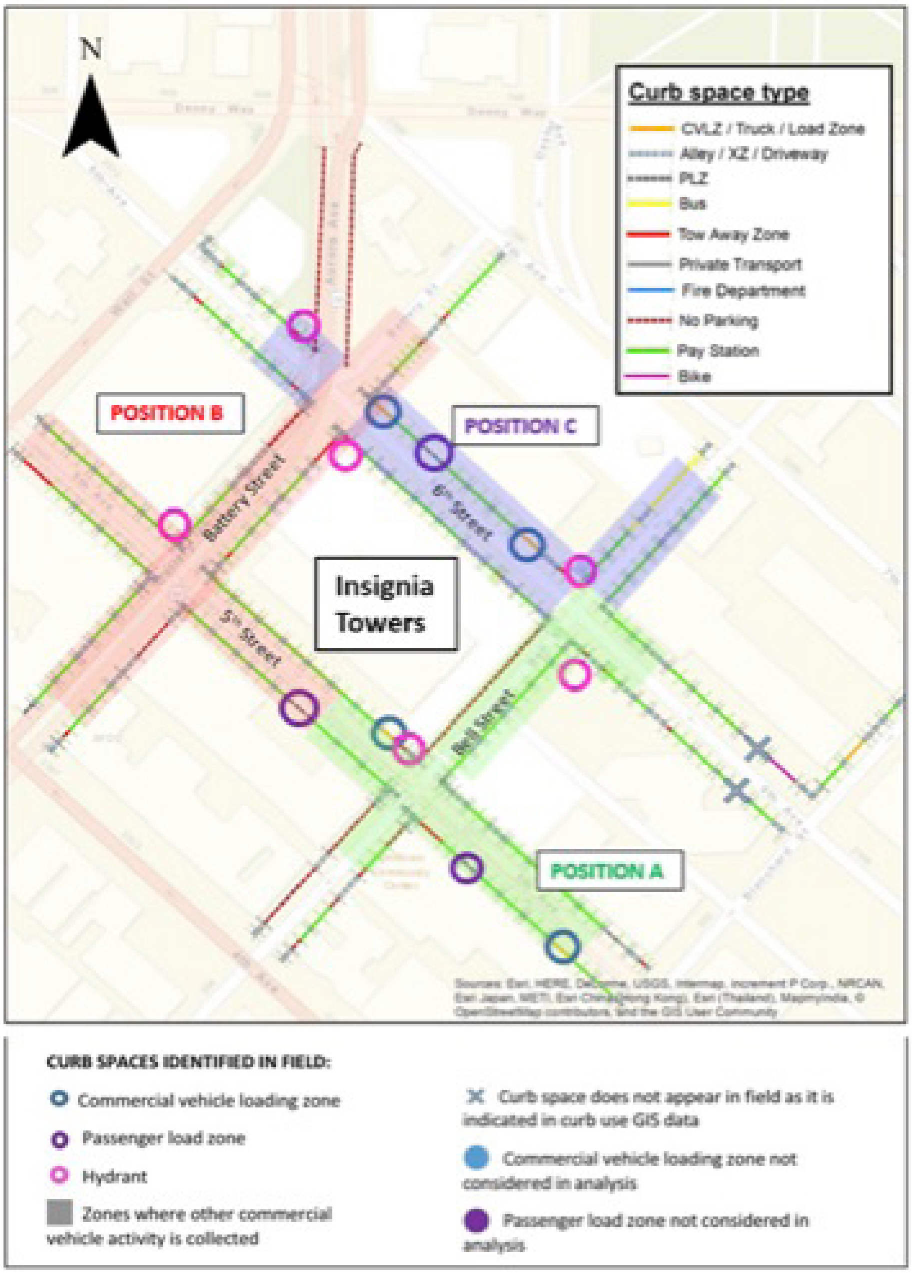
Figure 17. Passenger Vehicle Delivering Groceries with Amazon Fresh Bags Inside

Figure 18. Delivery Driver Breaking Down Pallet on Street to Access Building Stairs

Researchers designed a 'position' method for collecting data within the three-by-three city block grid in each study area. The grid was divided into subzones, or positions, with a variety of potential curb parking spaces (CVLZs, PLZs, hydrants, tow-away zones, and lanes, where inadequate commercial vehicle parking might occur.) An initial field assessment allowed the research team to generate possible position configurations for each prototype building based on the study area characteristics and sightlines to curb areas of interest.

While piloting data-collection surveys in field, the team tested the various position configurations to determine which would enable collectors to reliably collect the needed information within a one-minute interval. Based on the field pilot results, the researchers created up to four positions for each building for a total of 14 positions across the five buildings. Figure 19 below shows Insignia Towers' curb space map with three positions. (Appendix B illustrates in detail the carefully determined layout for positions using the Four Seasons Hotel as an example.)

Figure 19. Curb Space Map Showing Data-Collector Positions and Subzones in the Insignia Towers Study Area



Data collectors used a form customized to the curb features in their assigned position, as shown below. This enabled them to record the type of vehicle parking as well as the time the vehicle started and ended parking in each curb space or area. The data was collected on paper forms and then transcribed to a Google Drive Sheets document, shown in Figure 20. This hard-copy data-collection method proved faster in field testing than using a tablet, enabling data collectors to focus more on scanning the curb areas than on transcribing data.

Figure 20. Hard-Copy Data Collection Form Customized with Relevant Curb Features for Each Position in a Study Area

Curb Space Data Collection: Insignia Building - Position B | **Collector initials:** | **Date:** | **Sheet**

Vehicle type code: Truck (T) | Box truck (B) | Cargo Van (CV) | Service Van (SV) | Van (V) | Passenger & Pick-up (P) | Motorcycle (M) | Cargo-bikes (C)

Vehicle color code: USPS (US) | Blue (B) | Black (BK) | Brown (BW) | Green (G) | Gold (GO) | Red (R) | Silver (S) | White (W)

Time	PLZ_1		5th 1					Battery_1			HY_1	5th 2					Inter 1	Battery_2					HY_2	Inter 2
	a	b	Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b	Turn lane	Center	Left curb		Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b		Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b		
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Observations

CONCLUSION

The curb occupancy analysis shows that while designated curb spaces are set aside for exclusive commercial or exclusive passenger vehicle use, drivers often do not follow those designations in their parking choices. In addition to this fluid curb use, the study shows that many commercial vehicles park for relatively short periods of time (e.g. 15 minutes or less.) As cities seek to more actively manage curb space, the study's findings illuminate the need to plan a flexible network with capacity for distinct types (time and space requirements) of CV parking demand. The occupancy study documents that each building, and the built environment surrounding it, has unique features that impact parking operations.

Significantly, the UFL's cumulative Final 50 Feet research shows that 87% of Greater Downtown buildings rely solely on deliveries from curb and alley load/unload spaces, documenting the importance of public spaces.

Improving productivity in load/unload spaces of all types can reduce failed first deliveries and dwell time and meet myriad city goals, including minimizing traffic congestion, both to sustain quality of life for urban residents and to ensure the smooth flow of goods and services to support the economy.

Cities, researchers and other parties interested in replicating this curb occupancy study can refer to the Step-by-Step Toolkit included in Appendix C of this report.

The suite of Final 50 Feet work to date (of which this curb occupancy is one piece) drives home the interconnectedness of the elements of the load/unload network: private loading bays and docks, curbs, and alleys. Increasingly dense cities like Seattle can—and should—manage the network as a comprehensive whole, operating it flexibly with the help of emerging technologies that offer real-time data to meet dynamic demand and improve the productivity of finite load/unload spaces.

Actively managing an entire load/unload network is a complex undertaking. Cities should look to test-drive on the street innovative approaches to actively managing that network. The results of those on-the-street pilot tests can then inform any future large-scale adoption of these next-generation strategies.

Just such an example is the UFL pilot on select Seattle and Bellevue, Washington, streets that will give delivery drivers access to real-time information about parking availability in congested urban areas—work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy under the Vehicles Technologies Office. *(5)* This pilot can help inform other cities interested in taking steps to actively manage their load/unload network.

ACKNOWLEDGEMENTS

The Urban Freight Lab research team is grateful to SDOT for their continued support and sponsorship of advanced empirical research into supply chains, transportation and logistics topics in the UFL.

APPENDIX A:
STUDY AREAS MAPS

Figure 1: Map of Four Seasons Hotel and Harbor Steps Apartments area

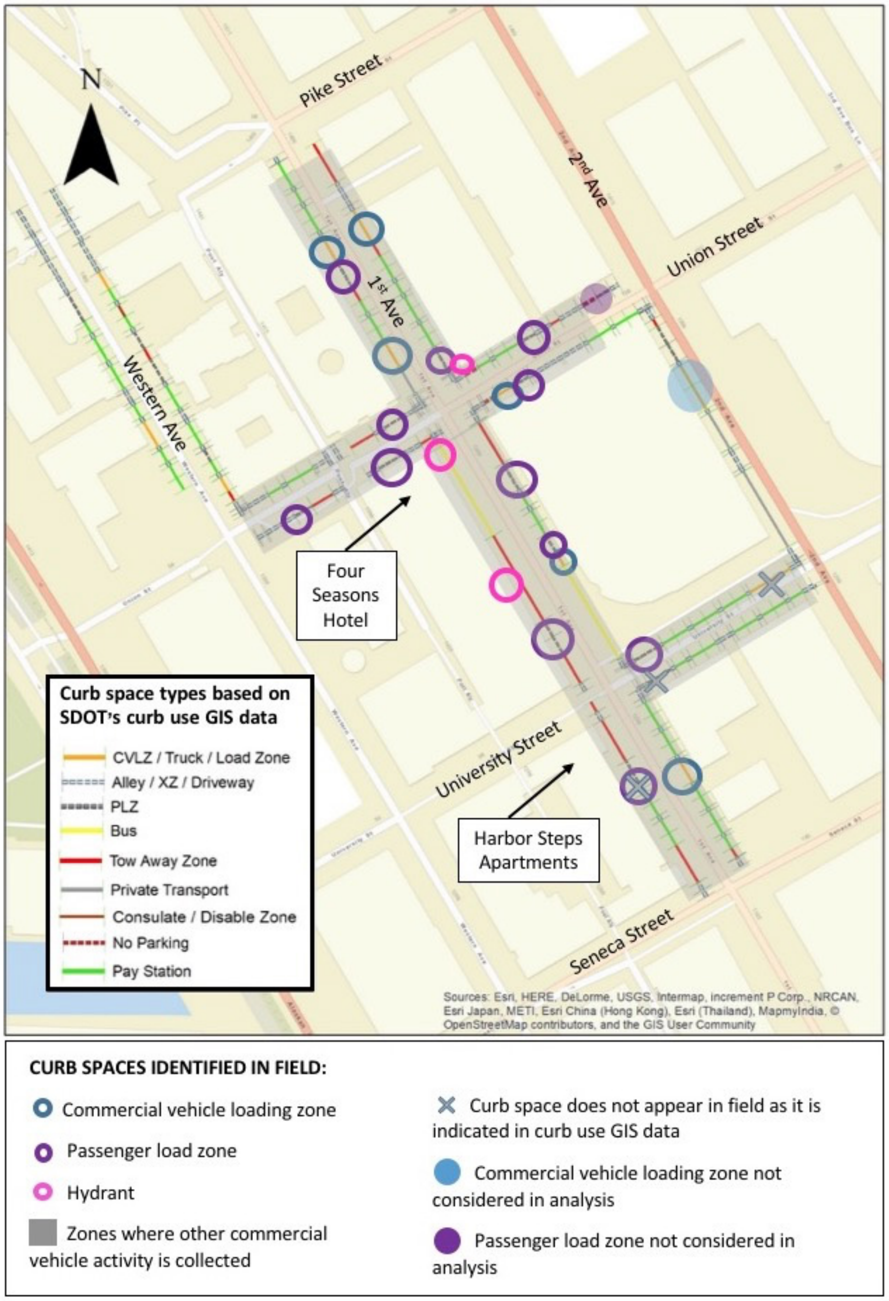


Figure 2: Map of Seattle Municipal Tower area

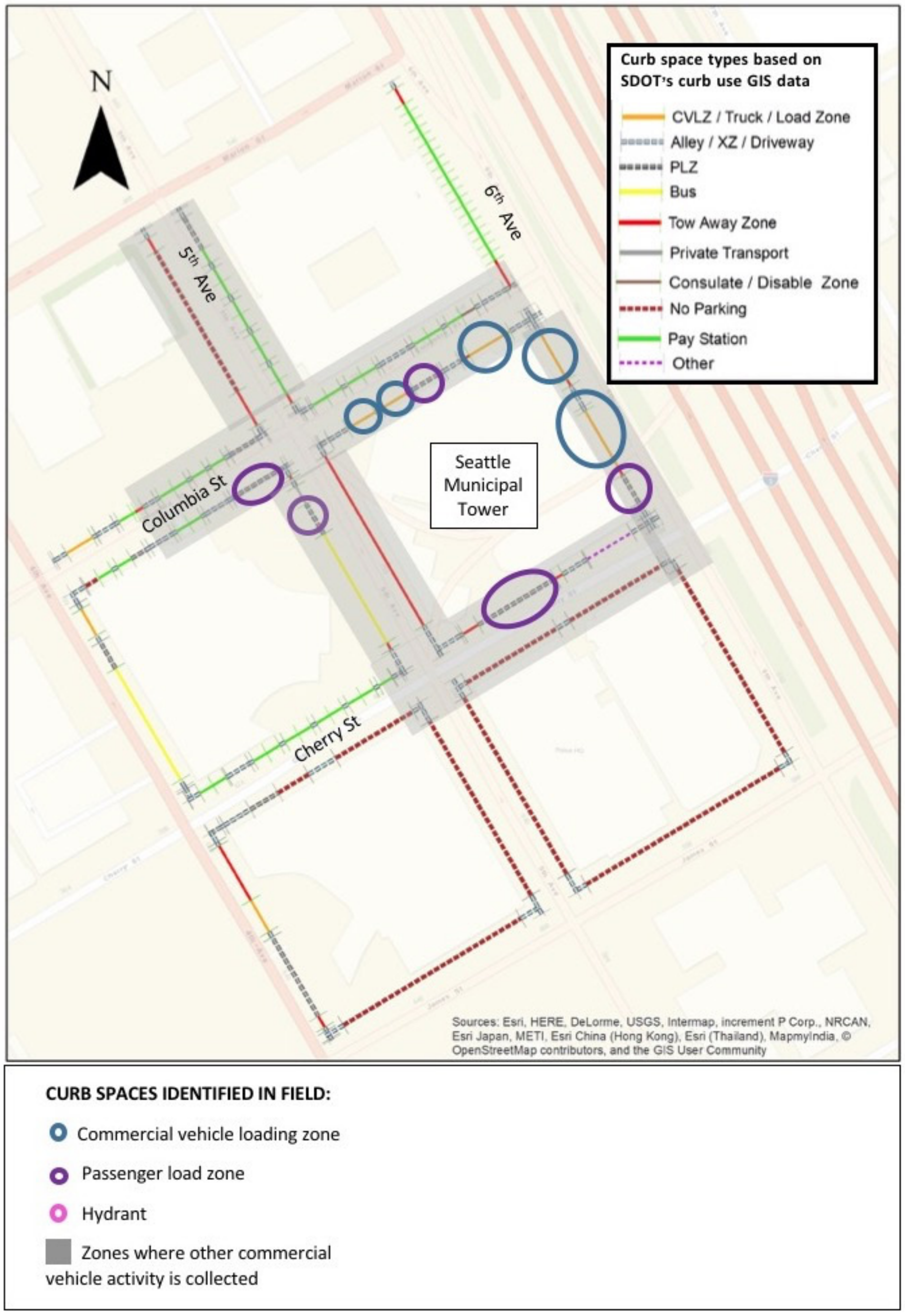


Figure 3: Map of Dexter Horton area

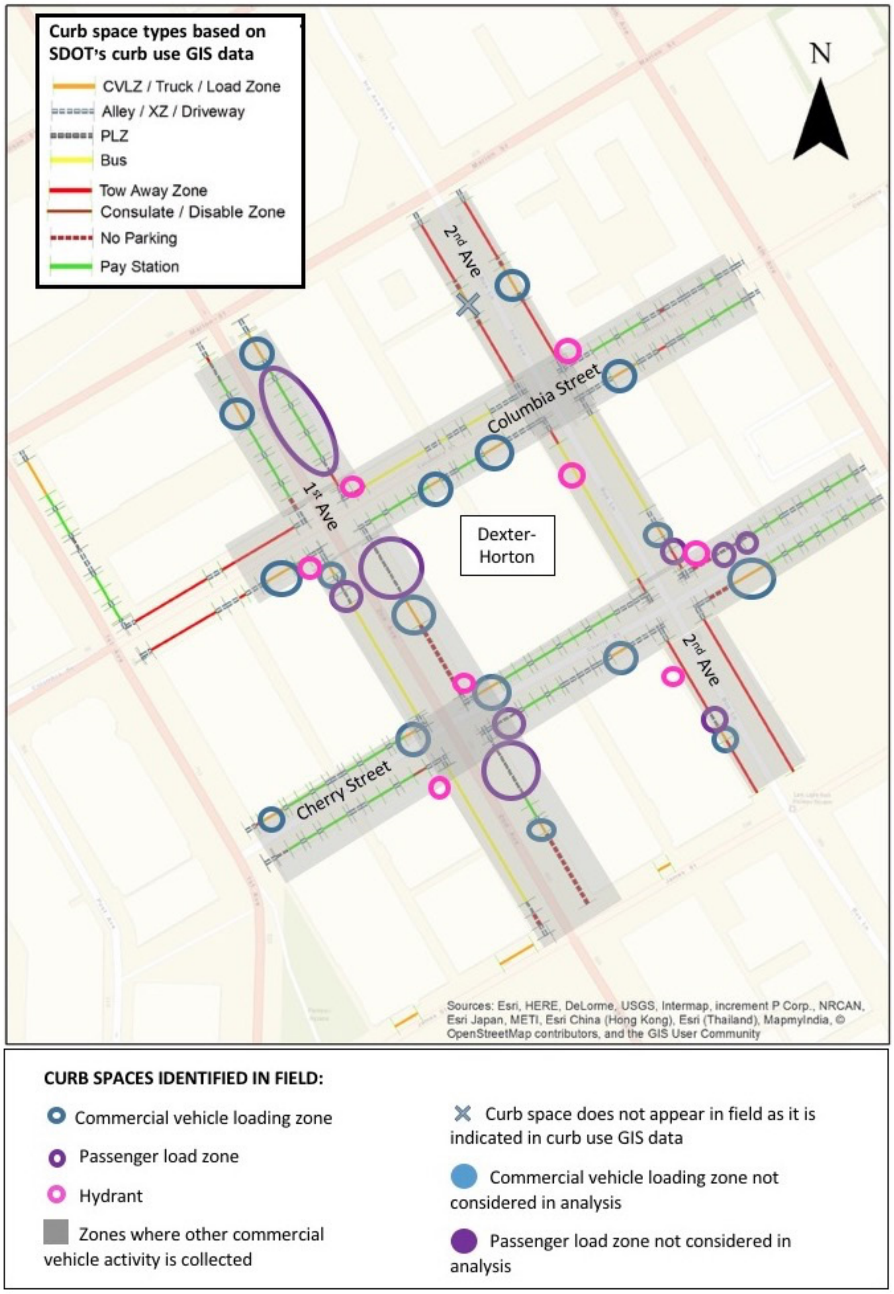


Figure 4: Map of Westlake Center area

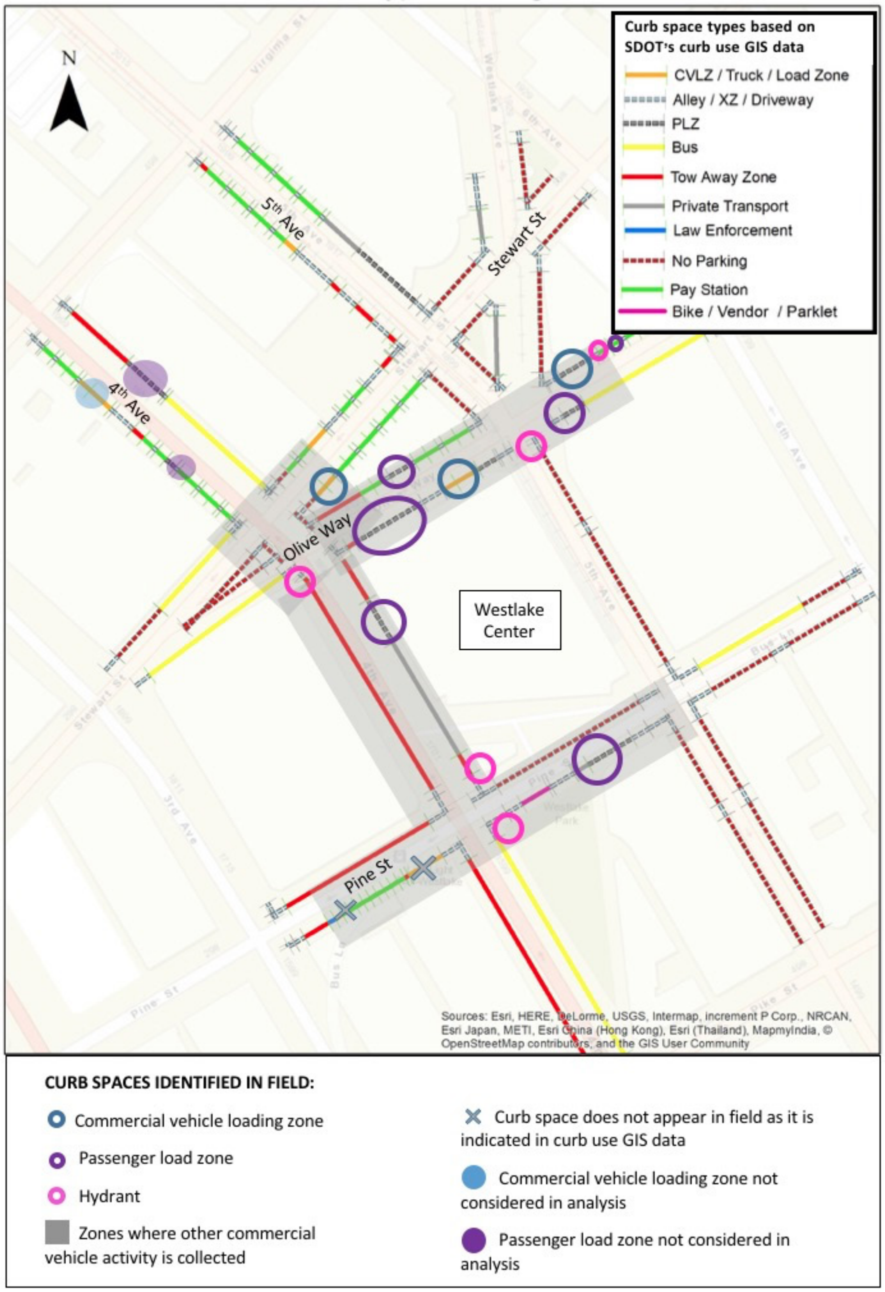
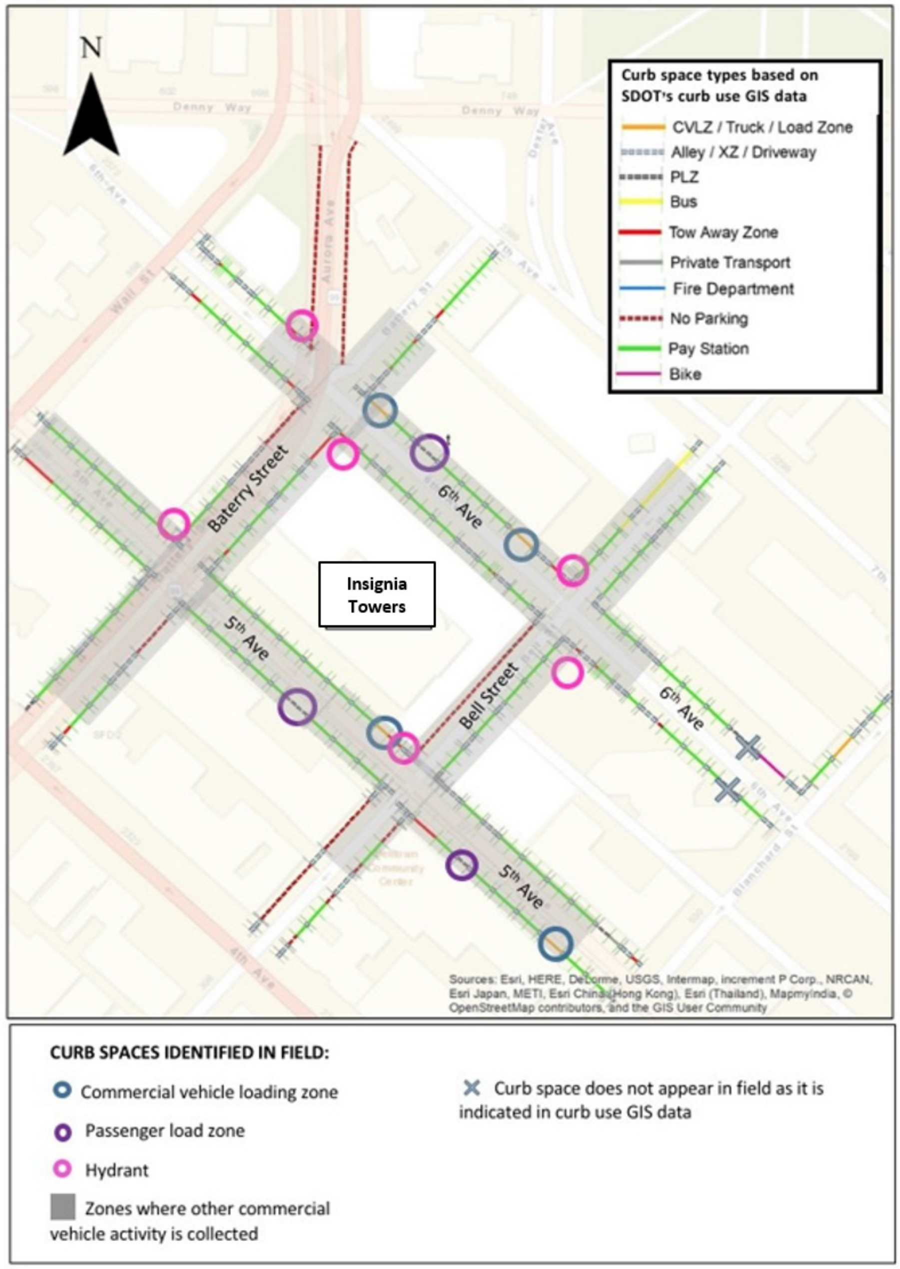


Figure 5: Map of Insignia Towers area



APPENDIX B: EXEMPLAR OF DATA COLLECTOR POSITIONS, FOUR SEASONS HOTEL

Figure 1: Four Seasons - Position A Layout

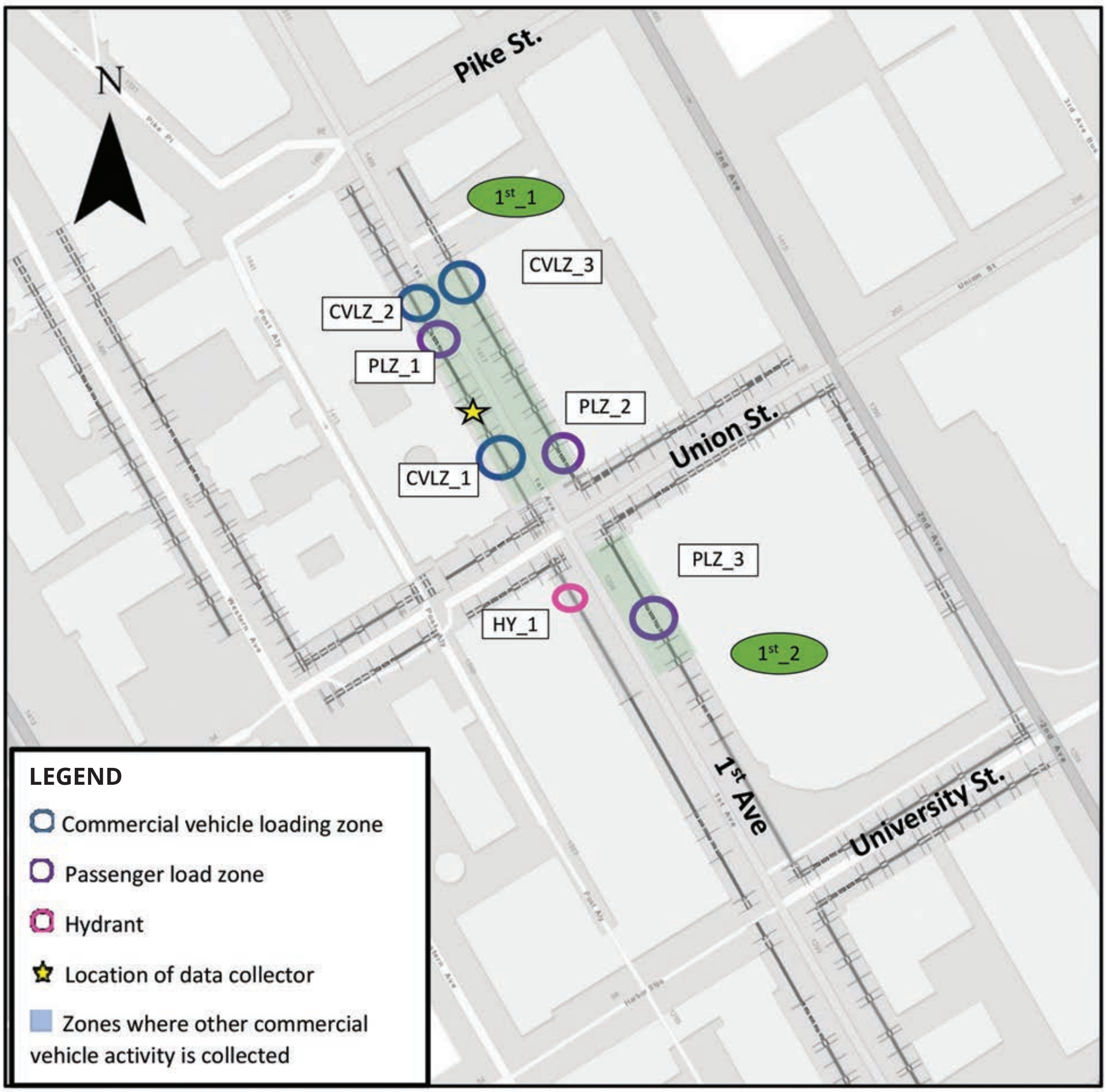


Figure 2: Four Seasons - Position A – View of 1st Ave between Pike St and Union St

Figure 3: Four Seasons - Position A – View of 1st Ave between Union St and University St

Figure 4: Four Seasons - Position A – View of 1st Ave between Pike St and Union St

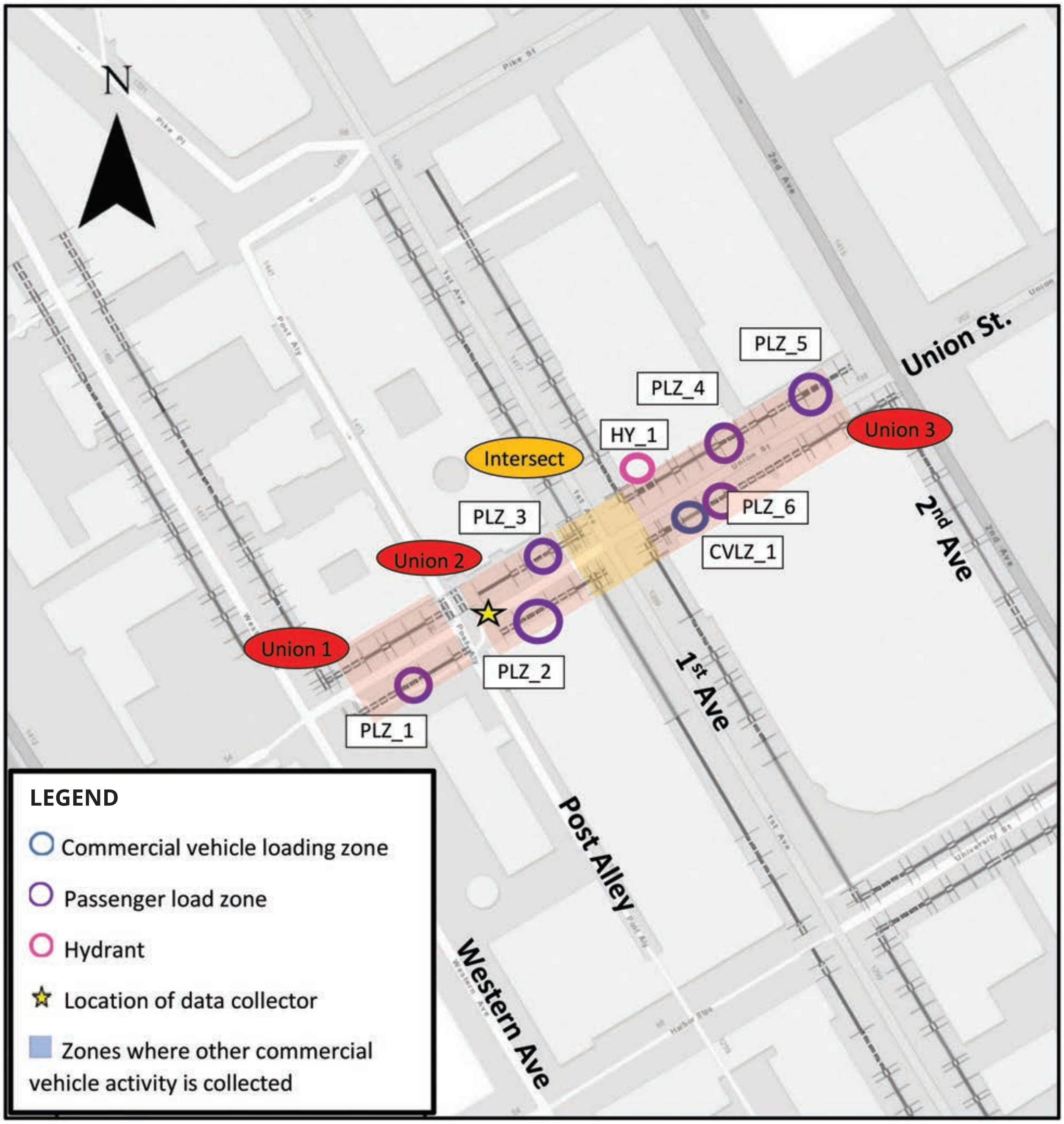


Figure 5: Four Seasons - Position B – View of Union St between Post Alley and Western Ave.

Figure 6: Four Seasons - Position A – View of Union St between Post Alley and Western Ave.

Figure 7: Four Seasons - Position C Layout

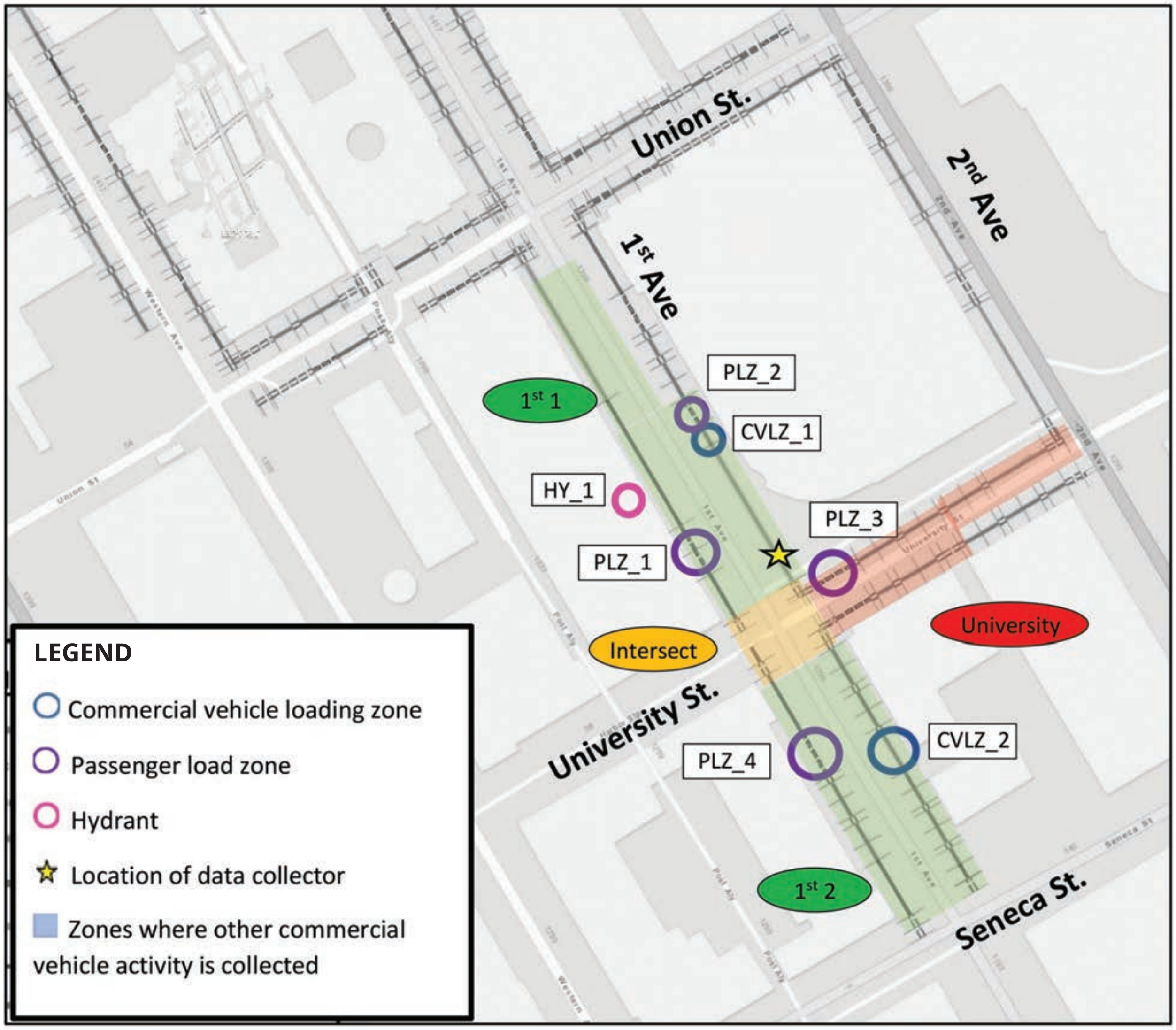


Figure 8: Four Seasons- Position C – View of 1st Ave between Union St and University St.

Figure 9: Four Seasons- Position C – View of 1st Ave and University St. intersection, and University St. between 1st Ave and 2nd Ave.

Figure 10: Four Seasons- Position C – View of 1st Ave between University St. and Seneca St.

APPENDIX C:
STEP-BY-STEP TOOLKIT FOR A CURB OCCUPANCY STUDY

The data-collection and analytic methods represented here are:

- Replicable;
- Available at a reasonable cost;
- Ground-truthed;
- Governed by quality-control measures in each step.

The following section details the step-by-step procedure to replicate the curb observation method the UFL research team developed and implemented.

STEP 1: DETERMINE STUDY PARAMETERS

The first step should define these key parameters at the study's outset based on the project scope and budget:

- Scope/size of the study area
- Number of areas to be observed
- Location of each study areas to be observed
- Data-collection/observation hours for the study areas
- Vehicle typology

The research team created specific categories covering a wide range of vehicle types that could load/unload on the curb. See Section 2 of the report for a chart of the defined vehicle types. The proposed vehicle typology was established based on fieldwork and knowledge of the curb operations in downtown Seattle. Passenger vehicle types were included to account for non-commercial vehicles occupying areas dedicated to commercial vehicles (e.g. commercial vehicle load zones, or CVLZs).

While a video camera-based data-collection could be considered, a camera can be blocked by a large vehicle or other impediment. Human observers have the advantage of being nimble in the field where traffic conditions are dynamic; observers can easily sidestep potential obstacles to ensure clear sightlines along the curb.

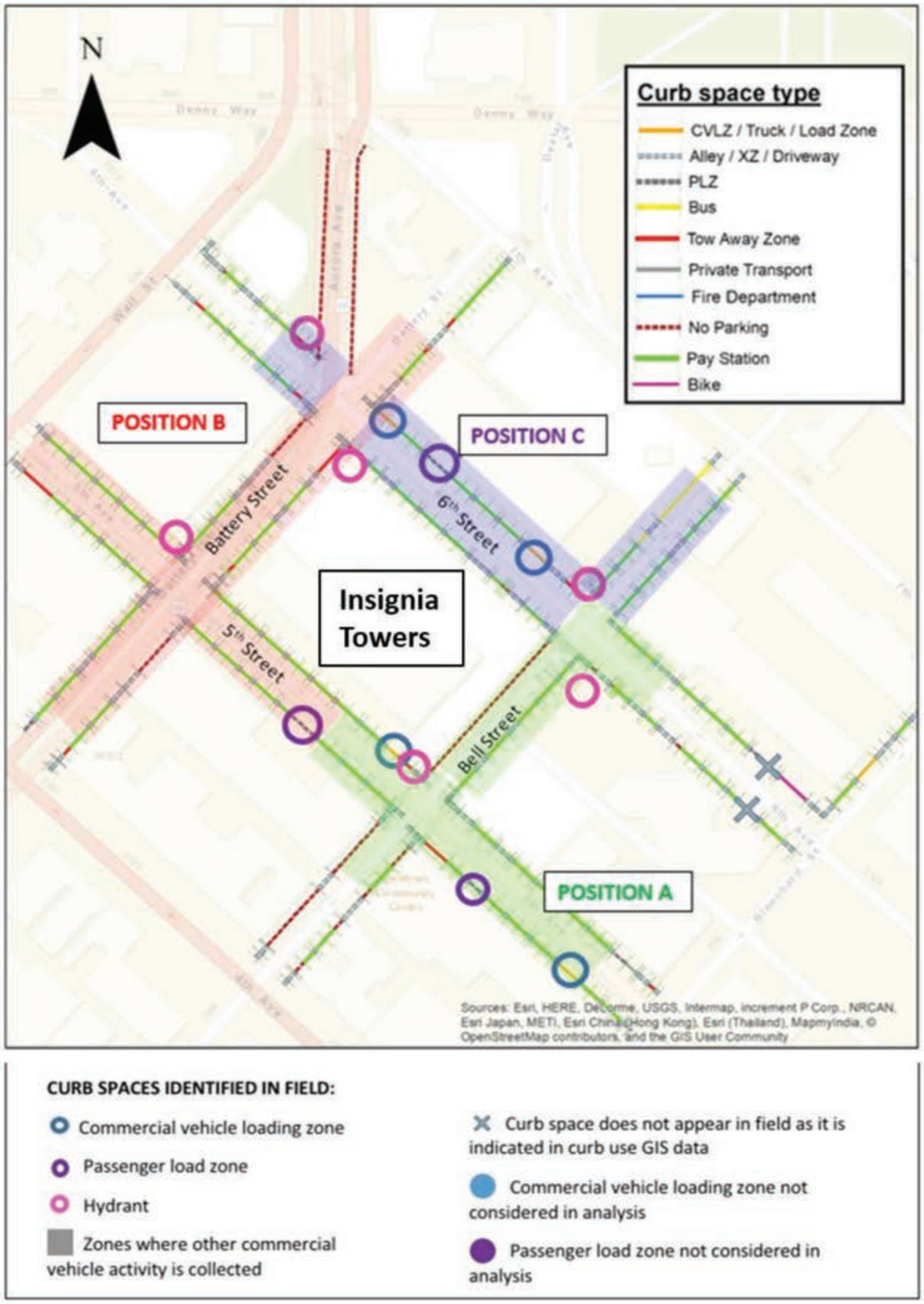
STEP 2: ASSESS EACH STUDY AREA

For each study area, it is essential to identify the different types of curb parking and their characteristics (e.g. length, location, use restrictions). Additionally, assessing the study area's curb configuration and built environment will help determine how to properly configure the positions where data collectors will stand to ensure clear sightlines.

The number and location of positions for each prototype building should be based on the study area characteristics, including the visibility, number, and distribution of the CVLZs and passenger load zones (PLZs) serving the building. If, as in the UFL occupancy study, a GIS curb space database is used, the relevant study areas should be double-checked in the field to confirm accuracy and corrected, as needed.

Position locations should assure data collectors are out of the regular traffic flow and places where vehicles are entering/exiting. The locations should also grant data collectors an unencumbered view of the vehicles parking at the curb so they can accurately record where, when and for how long the observed vehicles are parking. Below is a position map from the UFL occupancy study to indicate curb features of interest and how positions are designed to capture them.

Figure 1: Sample Map with Three Positions from UFL Occupancy Study



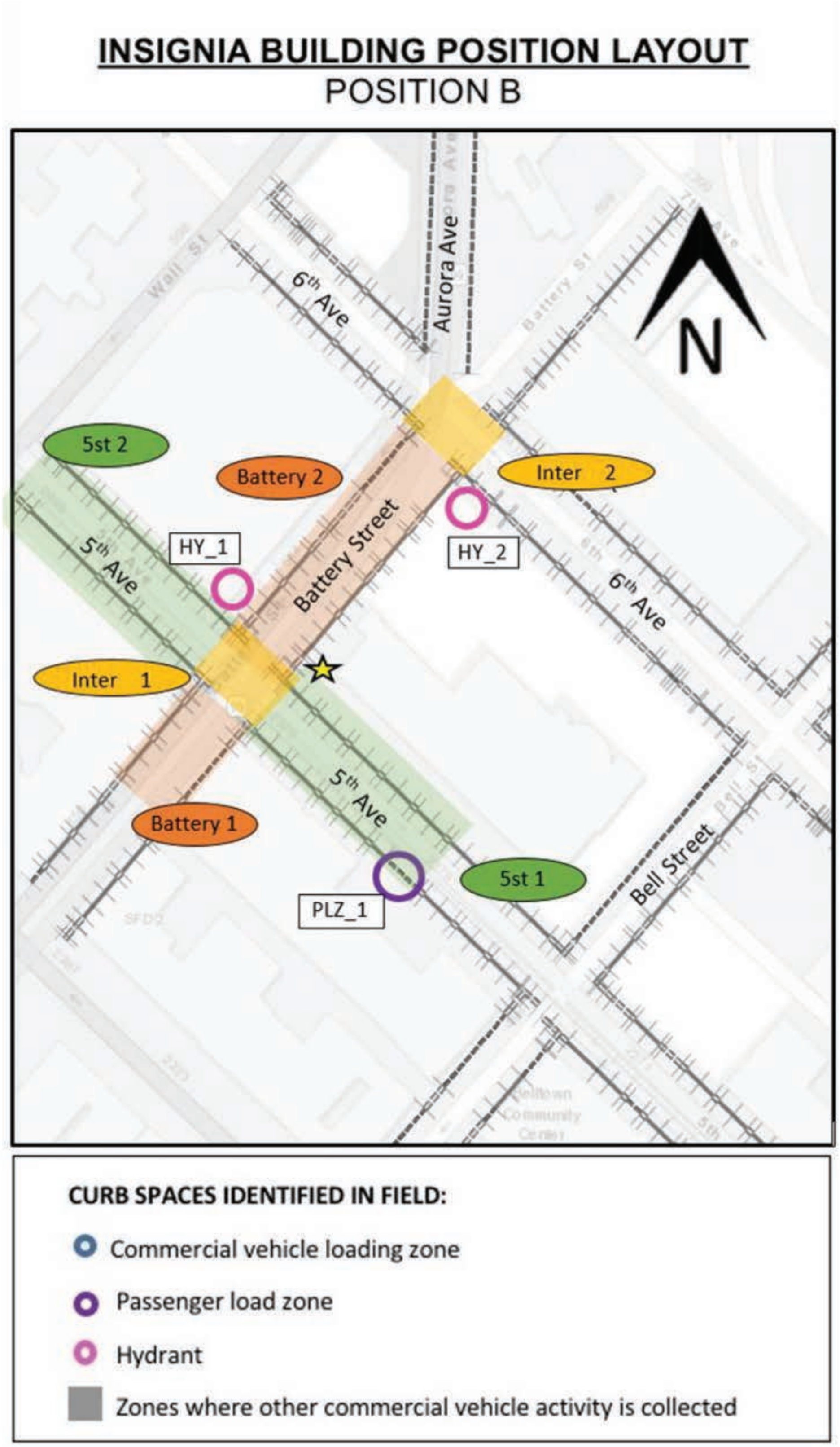
STEP 3: PREPARE MAPS AND DATA-COLLECTION FORMS

Position maps and data-collection forms should be prepared for each position within each study area.

1. **Position map:**

Each data collector is responsible for observing and collecting information for a section of the study area, called a position. Each position is divided into zones that contain CVLZs, PLZs, and curbs or areas where possible inadequate commercial vehicle parking behavior might occur (e.g., turn lanes, bus lanes, hydrant). The boundaries of each zone should be easily identifiable in field, using specific built-environment features, landmarks and/or facilities. This map (Figure 2) corresponds to the data-collection form (Figure X) and helps data collectors correctly locate vehicles in the correct column on the form depending on where the vehicles parked within a given data collector's area.

Figure 2: Map for One Position in Insignia Towers Study Area



2. Data-Collection Forms:

The data-collection forms are hard-copy spreadsheets customized with the specific curb spaces and zones to be monitored at each position. The curb spaces and zones in the spreadsheet are ordered to allow the data collector to easily scan the area; they are also color-coded to make it easier for the data collector to find their location on the position layout map.

The research team recommends piloting the data-collection form and related maps, as was done in the UFL study. After field testing, the research team decided to use hard-copy spreadsheets for data collection because it proved faster than using a tablet, enabling data collectors to focus more on scanning the curb areas than on transcribing data. The data was collected on paper forms and then transcribed to a Google Drive Sheets document.

These forms can be made in Microsoft Excel. As shown in Table 1, the form should include these components:

1. **Part I - Header**. The name of the prototype building and position.
2. **Part II - Shift information.** Space to record the data collector's name and data-collection date.
3. **Part III - Vehicle type code.** A legend listing each vehicle type and its corresponding code, along with any notes.
4. **Part IV - Vehicle color code.** A legend listing each possible vehicle color and its corresponding code, to help data collectors track each parked vehicle.
5. **Part V - Data-collection table.** A table organized by area and curb type in a clockwise direction from the data collector's position. Every row in the data collection table corresponds to one minute of data collection. Data collectors scanned the area in a clockwise direction looking for commercial vehicles in their position's area and passenger vehicles in CVLZs, if applicable. Data collectors did the scans once per minute and noted the found vehicles under the corresponding minute and column of their form.

The table should have:

a. At least one column for each zone

b. Space to record information on a vehicle that parks in the assigned position (vehicle code and color, if needed.)

Table 1: Hard-Copy Data Collection Form Customized with Relevant Curb Features for Each Position in a Study Area

Curb Space Data Collection: Insignia Building - Position B | **Collector initials:** | **Date:** | **Sheet**

Vehicle type code: Truck (T) | Box truck (B) | Cargo Van (CV) | Service Van (SV) | Van (V) | Passenger & Pick-up (P) | Motorcycle (M) | Cargo-bikes (C)

Vehicle color code: USPS (US) | Blue (B) | Black (BK) | Brown (BW) | Green (G) | Gold (GO) | Red (R) | Silver (S) | White (W)

Time	PLZ_1		5th_1					Battery_1			HY_1	5th_2					Inter 1	Battery_2					HY_2	Inter 2
	a	b	Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b	Turn lane	Center	Left curb		Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b		Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b		
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Observations

STEP 4: RECRUIT AND TRAIN DATA COLLECTORS

Recruiting

The workforce requirements (e.g. number of data collectors needed) will be determined by the project budget, timeline and survey length. Security concerns and the characteristics of the study area may also result in different workforce needs. The UFL research team used a team of 7 data collectors for five study areas, each of which was a three-by-three city block grid. For the UFL occupancy study, the research team assigned three to five data collectors for each study area; the number varied based on visibility and built environment.

Beyond the time required for data collection in-field, project organizers should also account for the time needed for data-collection staff to commute to/from the study area and conduct data quality-control tasks in the office. These tasks will take a varying amount of time depending on the nature, size, and location of the study area, and are important to consider when estimating workforce needs regarding the desired project duration.

Training

Two training sessions for data collectors are recommended before data collection starts. One can be in a classroom setting for theoretical training; the second is designed as an in-field session.

1. **Theoretical training session. A presentation should cover the following:**

- The study parameters
- The typology of vehicles
- The data-collection method
- The typology of curbs
- Review of the data collector position map and data-collection forms

2. **In-field training session. While visiting a study area, data collectors ensure they understand its representation on the map as well as the data-collection method. Data collectors field-test the recording of vehicles that park in the area.**

STEP 5: COLLECT THE DATA

For each data-collection shift, collectors require a data-collection kit comprising:

1. Position map
2. Clipboard
3. Security vest
4. Data-collection forms
5. Binoculars, if needed
6. Digital watch to record the start/end time of each vehicle's parking
7. Official letter of permission from the city or relevant entity authorizing data collectors' work and providing contact information for project leads at the city or relevant authority.

For the UFL curb occupancy project, data-collector shifts ranged from four to five hours each. Depending on the project's defined observation hours and data collectors' availability, any number of shifts can be scheduled to cover each study area. That said, collectors must not look away from the curb during their determined data-collection period. A data-collection monitor assigned to each study area granted breaks to the data collectors at assigned positions. The monitor also can collect data in case of a gap between shifts.

STEP 6: CREATE DATA TRANSCRIPT

A method must be established for data collectors to transcribe their recorded field observations after their shift ends. For the UFL project, data collectors received a Google Excel sheet for each study area. The sheet was pre-formatted with columns based on data structure defined for this method, as shown in Table2. Data collectors should enter in their observations no more than 24 hours after their shift ends. Transcribing the data allows data collectors to double-check their entries for clarity and serves as the first step in data-cleaning.

Table 2: Excel Sheet for Data Transcript to Be Completed Within 24 Hours After Data-Collector Shift Ends

Day	Study Area	Curb ID	Curb Type	Start Time	End Time	Vehicle Type

STEP 7: CLEAN THE DATA

A data-collection lead must review the data and check for data transcript errors and missing values.

STEP 8: PUT TOGETHER AND SUMMARIZE THE DATA

The data can be packaged into a final spreadsheet that concisely lists every vehicle captured, the study area it was in, and the amount of time it was parked. This allows for data analysis relevant to the study project's goals.

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