Curb Occupancy Toolkit

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1 SEATTLE CURB OCCUPANCY PROJECT SYNOPSIS:

Seattle is widely thought to be the first city in the U.S. and the E.U. to comprehensively map the greater downtown area's commercial vehicle load/unload space network, including its curb space. Cities like Seattle manage curb use through several types of curb designations that regulate who can park in a space and for how long. These designations, along with factors such as building and land use, directly impact how commercial operators use curb space.

Significantly, this occupancy case study of five greater downtown areas captures the parking behavior of commercial vehicles (CVs) everywhere along the block face as well as the parking activities of all vehicles (including passenger vehicles) in commercial vehicle loading zones (CVLZs.) Specifically, the University of Washington research team documents: (1) which types of vehicles parked in CVLZs and for how long, and; (2) how long CVs parked in CVLZs, in metered parking, in passenger load zones (PLZ) and other unauthorized spaces.

This study collects and analyzes data from a three-by-three city block grid around each of five archetypal buildings, representing a hotel, a high-rise office tower, a historical building, a retail center, and a residential tower. These same buildings served as study sites for tracking how goods move vertically within a building in the final 50 feet of the urban goods delivery system.

The occupancy study documents that each building and the built environment surrounding it has unique features that impact parking operations and, ultimately, congestion. The findings highlight the need to plan a flexible loading/unloading 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 area's broader, interconnected load/unload network. A curb occupancy study helps policymakers and transportation officials understand the load/unload network's interconnected nature, how the city's curbs are being used at street level, and how parking policies and built environment impact that use.

2 STUDY GOALS:

To help cities actively manage curb space as part of the comprehensive commercial load/unload network (including private loading infrastructure and alleys) by conducting an occupancy study of representative greater downtown area curb spaces using methods that are:

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

3 METHOD OVERVIEW AND STEP-BY-STEP PROCESS TO CONDUCT A CURB OCCUPANCY STUDY

A team of seven trained data collectors worked to document curb use over three days in each of five study areas, spanning roughly six weeks in October and December 2017. Collectors worked in four-to-five-hour shifts so that each study area, a three-by-three city block grid, would be continuously observed during daytime hours. Creating a three-by-three city block grid around a designated prototype building offered sufficient diversity of curb space types for commercial vehicle parking (both authorized and unauthorized). The study documents the parking behavior of delivery, service, and other commercial and passenger vehicles along representative Greater downtown curb faces.

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

By inventorying CVLZs and PLZs for each study area and comparing Seattle Department of Transportation's curb-use GIS database to the on-the-ground reality found in field testing, the research team built a customized curb map and data-collection form for each study area. Based on each study area map, data collectors were assigned up to four strategic positions on the blocks in each area to maximize both visibility all along the curb and the diversity of curb parking types captured (CVLZ, PLZ, hydrants, tow-away zones, and lanes, where inadequate commercial vehicle parking might occur). Any commercial vehicle parked anywhere along the curb for one minute or more was recorded as was any vehicle (including passenger) parked in a CVLZ for one minute or more. Customized data-collection forms were divided by specific curb spaces and zones to be monitored at each position, with space for the data collector to record:

- The start/end time a vehicle spent parked at the specific curb space (recorded to the minute)
- The type of vehicle parked at the specific curb space

Step 1. Determine study parameters

Based on project scope and budget, determine at the outset the:

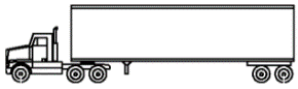
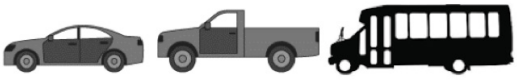
1. Scope/size of study area
2. Number and types of representative curb spaces to be observed
3. Location of each curb area to be observed
4. Data-collection/observation hours for study areas (unlike an inventory, periods of low activity should be avoided if the project seeks to document "typical" usage)
5. Use of human data collectors versus video/other technology to capture vehicle occupancy

Step 2. Use UFL's detailed vehicle typology to accurately track vehicle categories

The UFL typology covers 10 separate vehicle categories, from various types of trucks and vans to passenger vehicles to cargo bikes. **NOTE**: While passenger vehicles could be performing delivery/commercial functions, passenger vehicles were not treated as commercial vehicles in this occupancy study due to challenges in systematically identifying whether they were making deliveries or otherwise carrying a commercial permit.

UFL curb occupancy vehicle typology

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.

Step 3. Assess each study area for data needed to build maps and data-collection forms

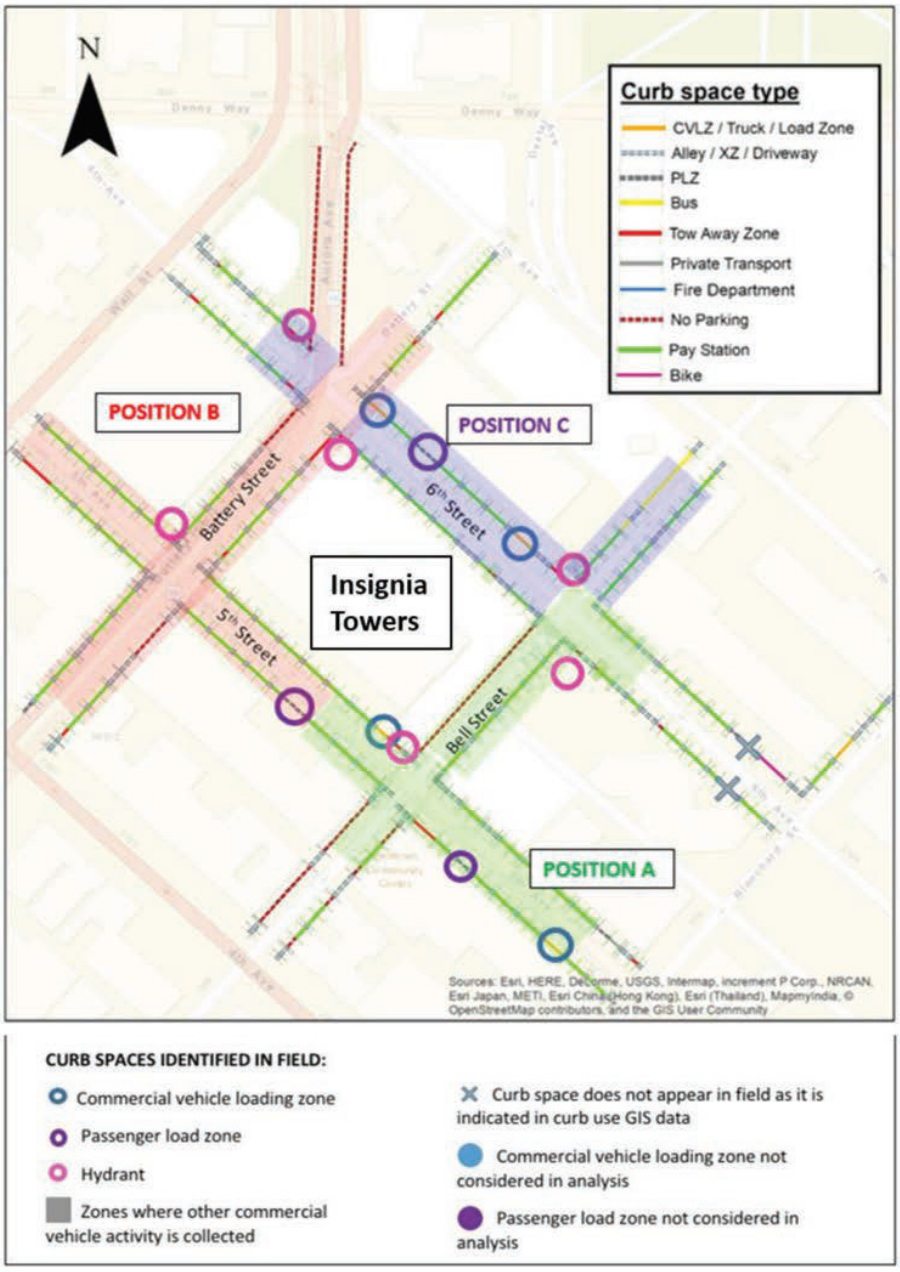
Identify the different types of curb parking and their characteristics (e.g. length, location, use restrictions).

If using a GIS curb space database, confirm accuracy in field and revise as needed.

Determine number/location of data collector positions for each study area based on visibility, number, and distribution of CVLZs and passenger load zones (PLZs) serving the building.

Ensure positions keep data collectors are out of regular traffic flow and vehicle entry/exit.

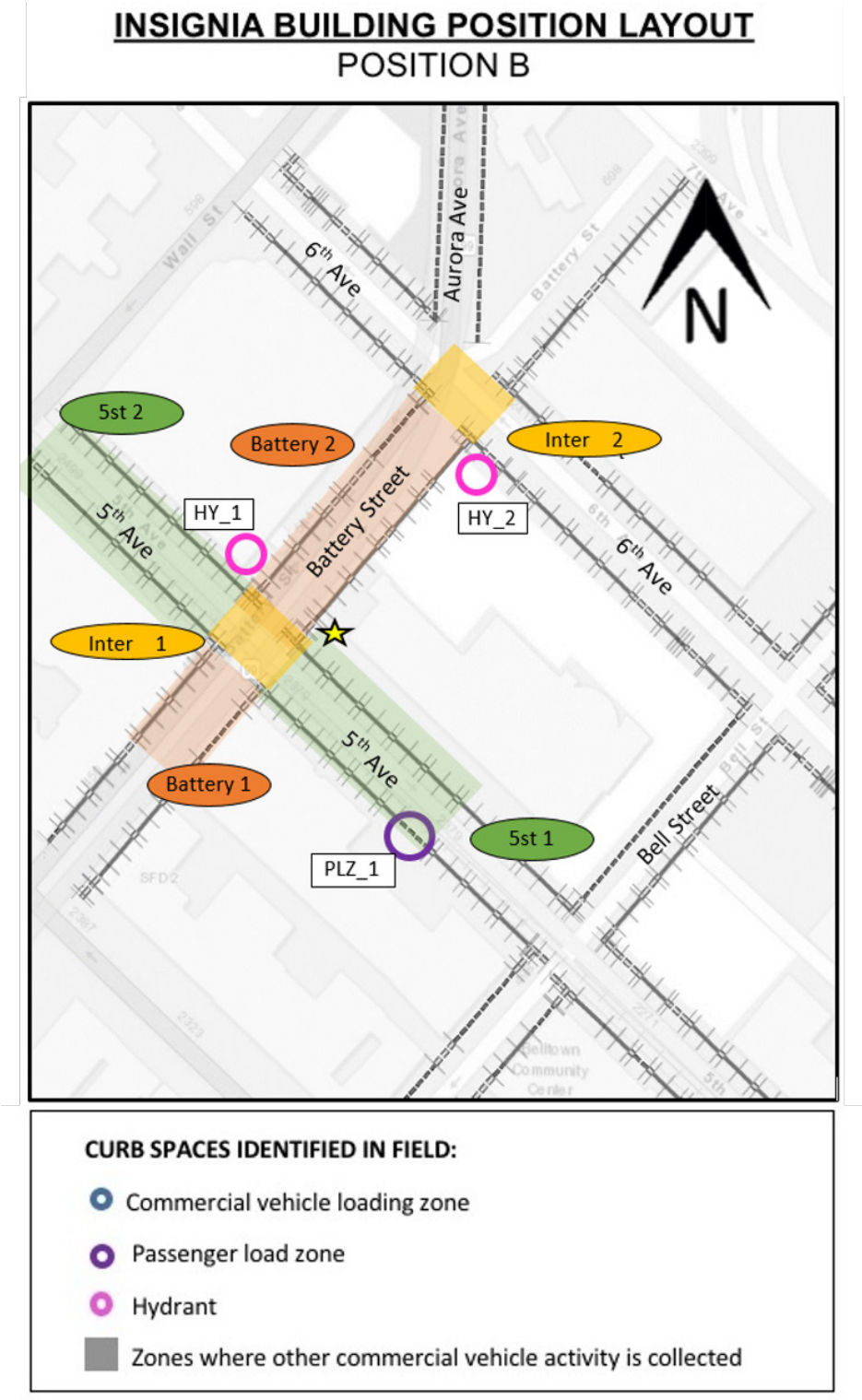
See a sample map of three positions from the UFL occupancy study below:



Step 4: Prepare customized data-collector position maps and data-collection forms

For each position in each study area, collectors need:

Position map. Include easily identifiable curb space features in field for each data-collector position (marked with star), as shown below.



Data-collection forms. Create a paper form in Microsoft Excel as shown below, ordered to allow data collectors to easily scan the curb and color-coded to allow collectors to easily find specific curb features (hydrant, PLZ, intersection etc.) on the position layout map.

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

Pilot-test maps and forms before official collection begins.

Step 5. Select data-collection tools

For each data-collection shift, collectors need:

- Position map
- Clipboard
- Security vest
- Data-collection forms
- Binoculars (as needed)
- Digital watch/timekeeping device to record start/end time of each vehicle's parking
- Official document from sponsoring agency (including agency official contact information) explaining project and granting data-collection authorization

Step 6. Recruit and train data collectors

Recruiting: Project budget; timeline; survey length/complexity; security concerns; time needed for in-field collection, including commute time to/within study area, and in-office quality-control determine number of data collectors and supervisors needed. In the UFL curb occupancy study, three to five collectors (number based on study area visibility and built environment) worked per four-to-five-hour shift, per three-by-three city block study area.

Training: Two sessions recommended, with first done in classroom-type setting and second done in field.

First session: Covers study parameters, vehicle typology, data-collection method, key curb terms, position map and data-collection forms.

Second session: Covers (and lets collectors practice in field) using position map and pilot-testing data-collection form to record CVs that park anywhere along the curb and all vehicles that park in CVLZs.

Step 7. Collect data

Develop check-out/check-in process for collectors' needed shift materials.

Ensure continuous observation of the curb in each study area. In the UFL project, data collector shifts ranged from 4-5 hours to ensure continuous observation of each three-by-three city block grid study area during daytime hours over three weekdays.

Provide regular breaks to collectors assigned to a curb position (who must not take their eyes off the curb while in position.) Such breaks can include rotating position collectors into the role of monitoring other collectors in nearby study areas.

Establish comprehensive security protocol and multilayer communications plan for all interested parties to avoid unsafe situations in field, including instructing data collectors to carry official documents from sponsoring agency (including official contact information) explaining project and granting data-collection authorization.

Recruit and inform police and other relevant agencies to help communicate with all building managers in the survey area.

- In Seattle, police notified all survey area building managers in real time where/when collectors were working via pre-existing information exchange for building operators and the police.
- Seattle Department of Transportation webpage communicated to public and stakeholders where and when data collectors were working.

Step 8. Create data transcript

Establish a method for data collectors to transcribe recorded field observations no more than 24 hours after their shift ends, allowing them to double-check entries (first step in data cleaning). In the UFL project, data collectors received a Google Excel sheet for each study area, shown below.

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

Step 9. Clean data

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

Step 10. Assemble and summarize data

Assemble data in final format that best meets city and/or researcher needs, such as a final spreadsheet listing every vehicle observed, the study area it was in, the type of curb spot it was parked in, and the amount of time it was parked there. This allows for a broad range of data analysis relevant to the study project goals.

4 KEY TAKEAWAYS FROM THE SEATTLE CURB OCCUPANCY STUDY

Cities that want to strategically manage their load/unload space network, which includes private loading bays and alleys, can use the toolkit to replicate the UFL curb occupancy study and generate much-needed data and findings to inform policy and practice.

The Seattle curb occupancy study produces several key findings that give policymakers and transportation officials new understanding of the Seattle Greater downtown area curb system and how the system can best be managed to avoid massive gridlock. Among those findings are that:

1. Commercial and passenger vehicle drivers use CVLZs and PLZs fluidly: commercial vehicles are parking in PLZs and passenger vehicles are parking in CVLZs.
2. Most commercial vehicle (CV) demand is for short-term curb parking: 15 or 30 minutes.
3. Service CVs made up more than one-third of the total CVs parked at the curb; urban parking schemes must factor in current service CV parking behavior and their future parking demand.
4. Forty-one percent of CVs parked in unauthorized curb locations. But a much higher share parked in unauthorized areas near the two retail centers as compared to the predominately office and residential areas. Curb parking behavior is associated with granular, building-level urban land use, even as other factors such as the total number, length and ratio of CVLZs versus PLZs varied widely across the five study areas.

In many cities, curb space is allocated by vehicle type: to transit, passenger, or freight vehicles. Yet the curb occupancy study shows drivers often do not follow those designations in their parking choices. And it shows

that many commercial vehicles park for short periods of time. Cities seeking to mitigate gridlock can manage curb space more flexibly, allowing different vehicle types to park in the same spaces based on the amount of time and space (due to vehicle size) they need. Curb space could be more effectively managed using emerging technologies that offer integrated data systems and real-time data to improve the productivity of finite load/unload spaces and reduce drivers circling the block in search of parking. Curb space should be managed in concert with the other elements of the load/unload network, not in isolation.

5 SUPPORTING MATERIALS

- Study area maps
- Four Seasons Hotel position layout and photos
- Step-by-Step guide to conduct a curb occupancy study
- Authorization letter for data collectors to carry in field

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

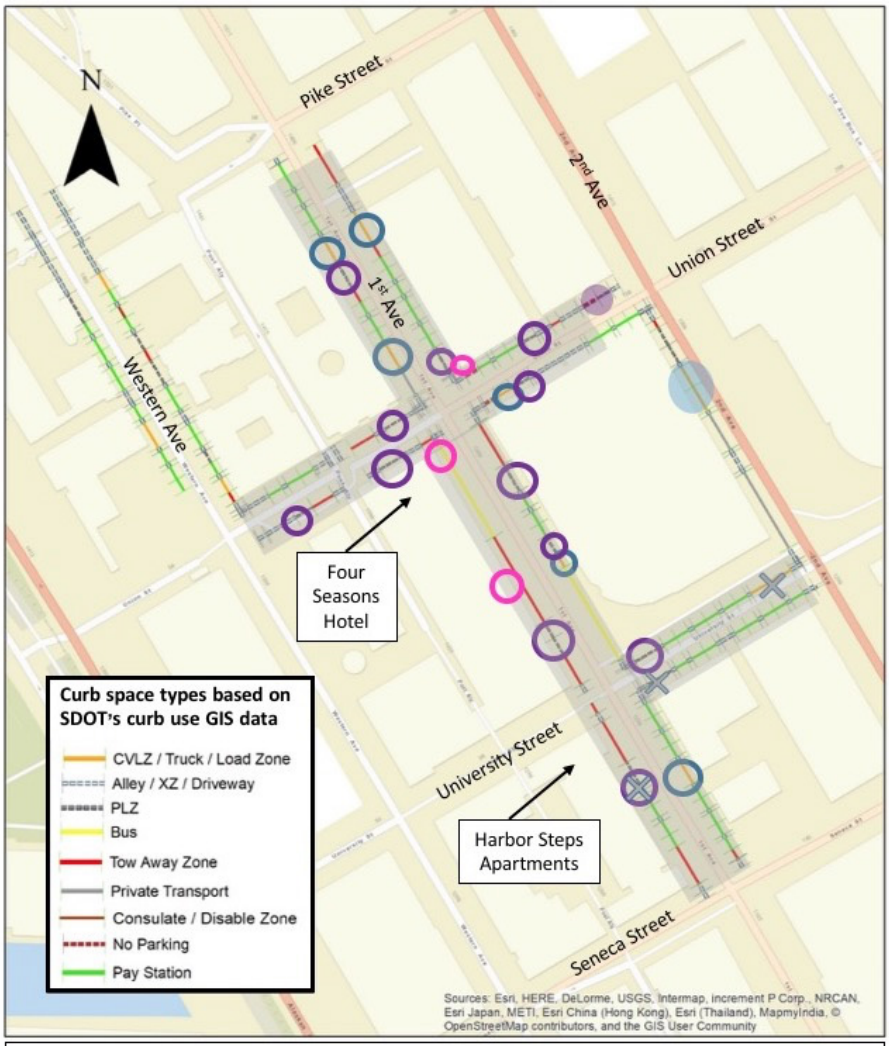


Figure 2: Map of Seattle Municipal Tower area

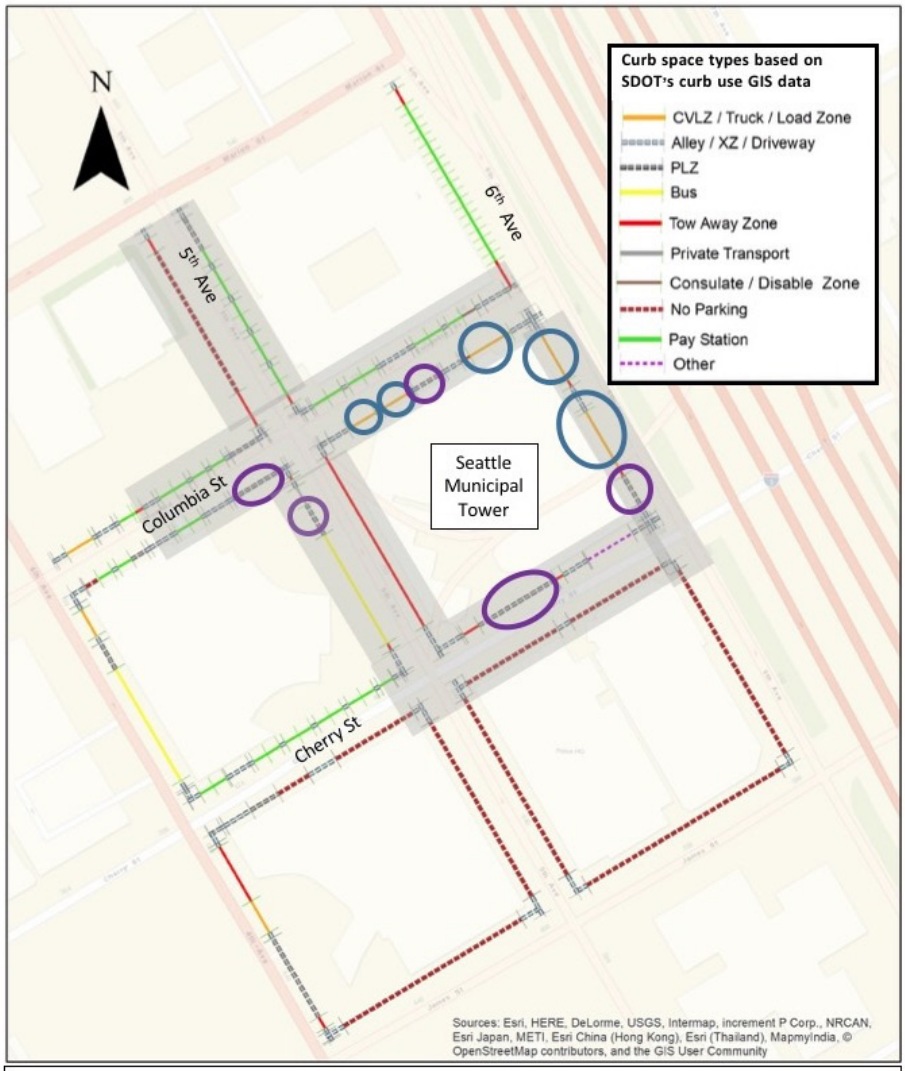


Figure 3: Map of Dexter Horton area

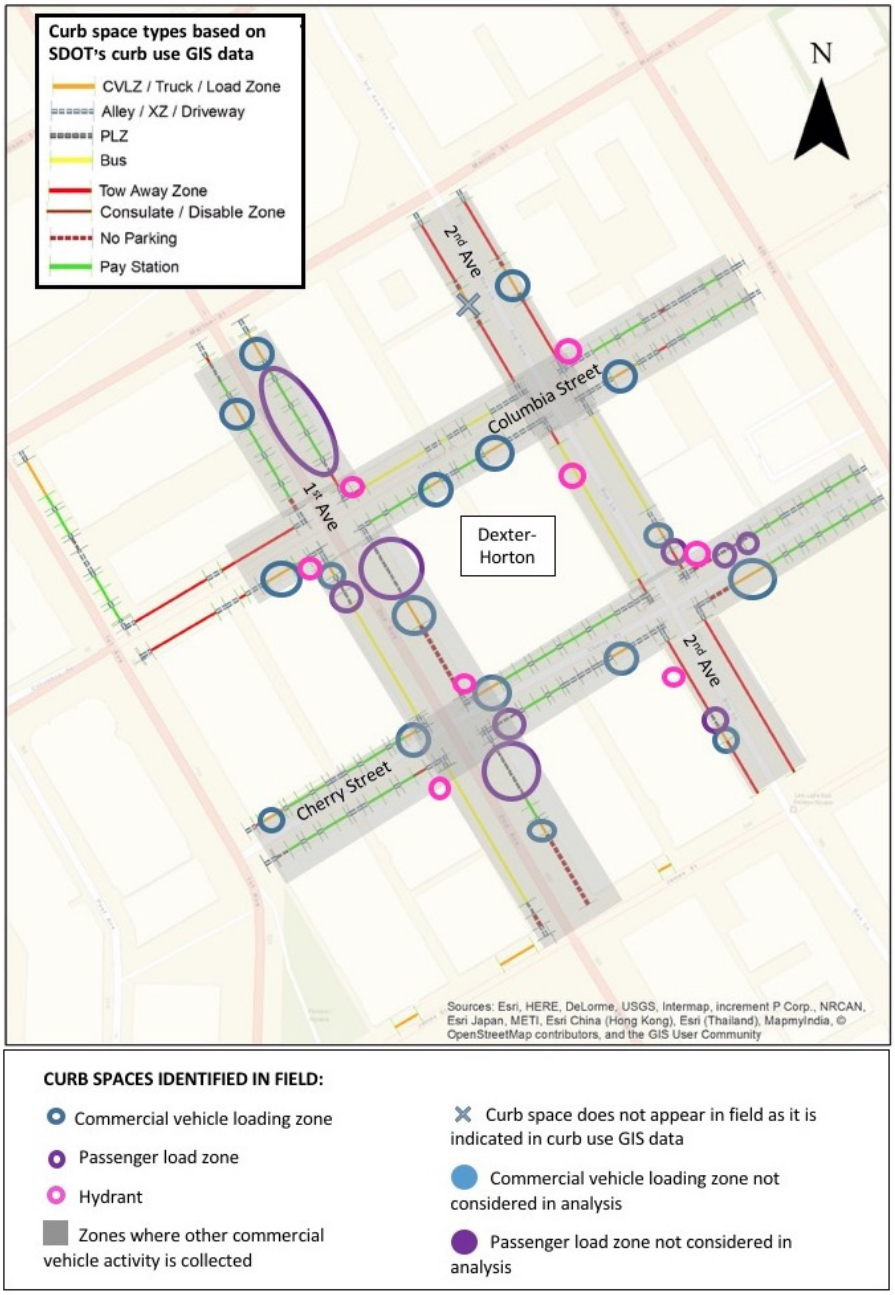


Figure 4: Map of Westlake Center area

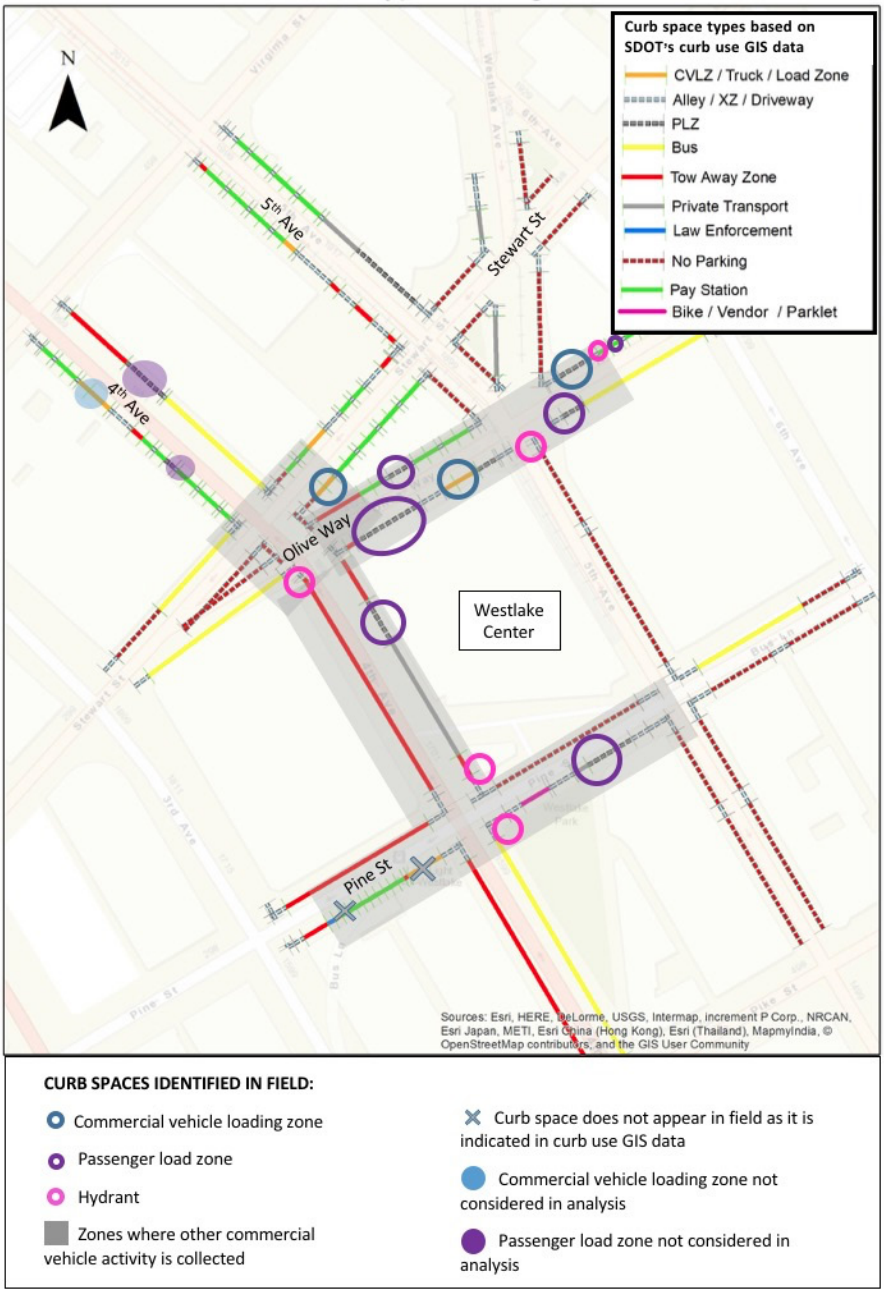
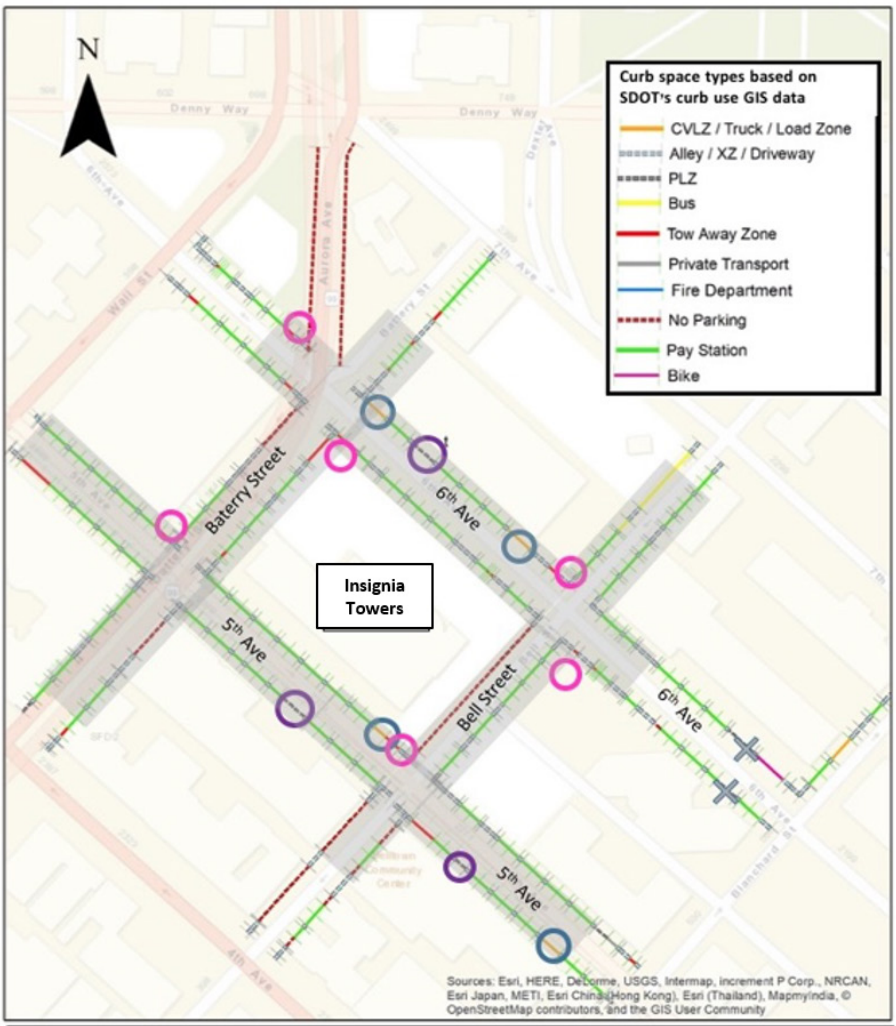


Figure 5: Map of Insignia Towers area



EXEMPLAR OF DATA COLLECTOR POSITIONS, FOUR SEASONS HOTEL

Figure 1: Four Seasons - Position A Layout

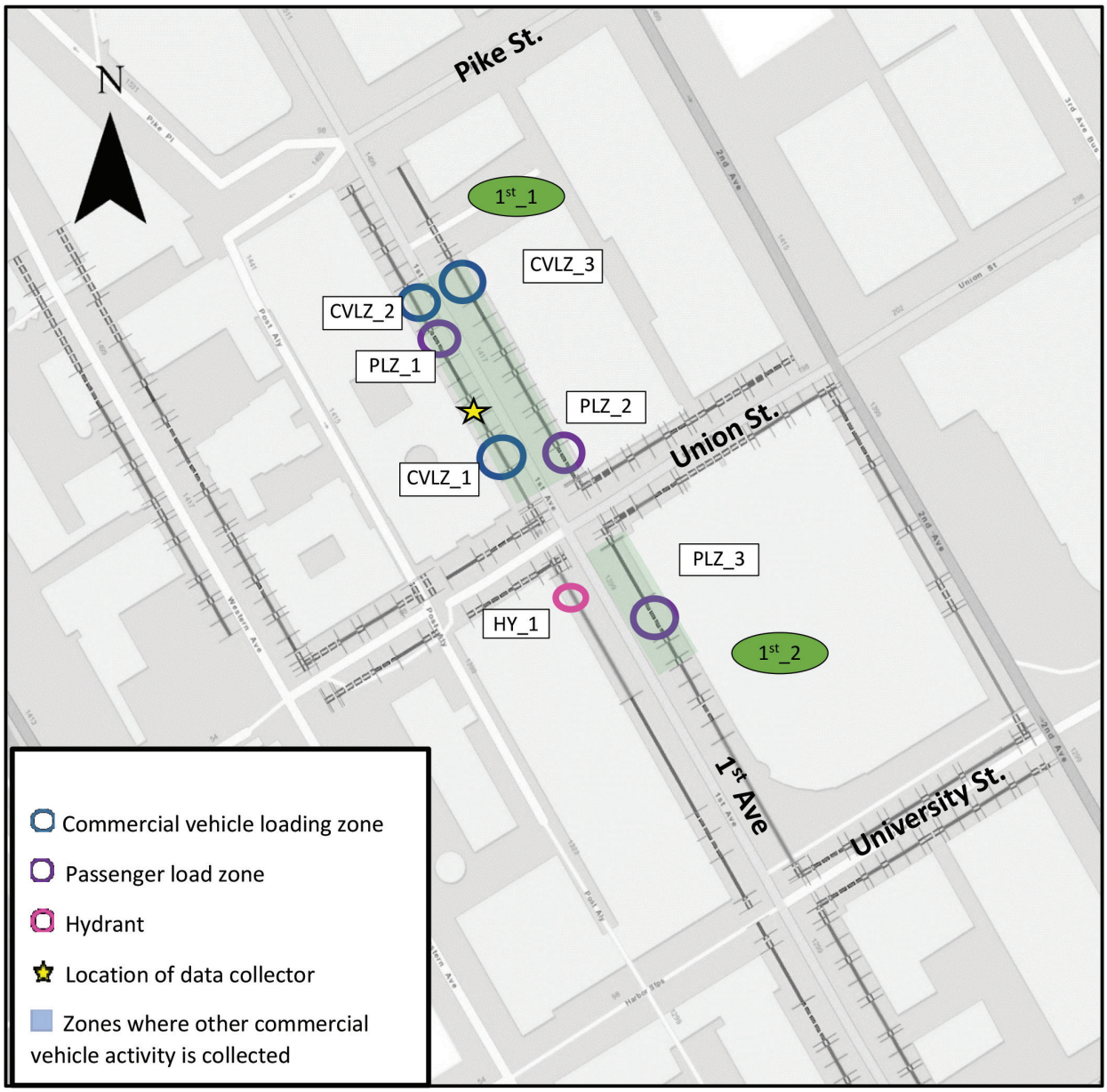


Figure 2: Four Seasons - Position A – View of 1st Ave between Pike St and Union St

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

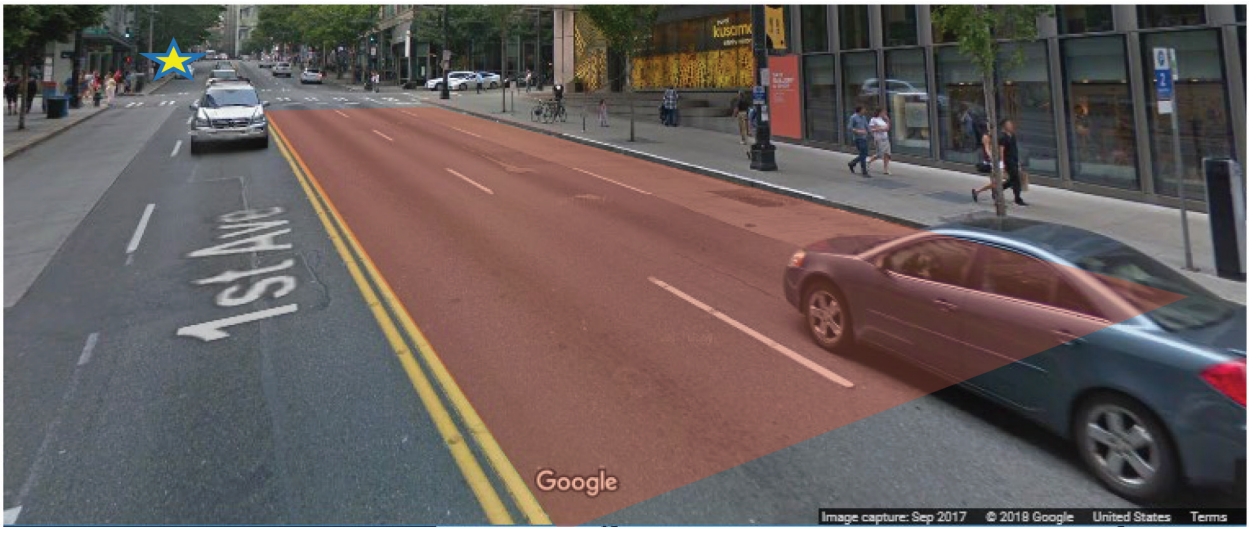


Figure 4: Four Seasons - Position A – View of 1st Ave between Pike St and Union St

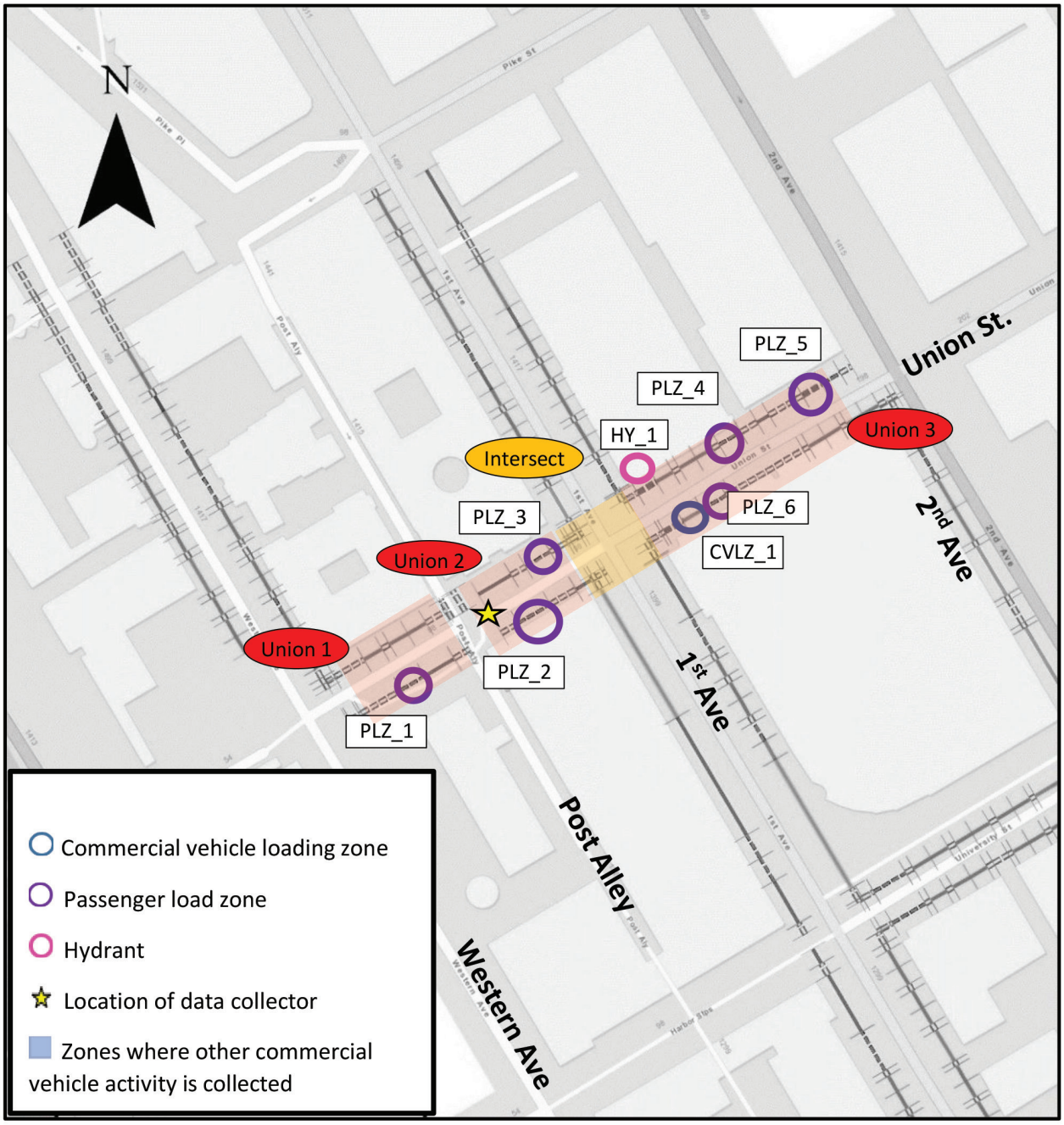


Figure 5: Four Seasons - Position B – View of Union St between Post Alley and Western Ave.

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

Figure 7: Four Seasons - Position C Layout

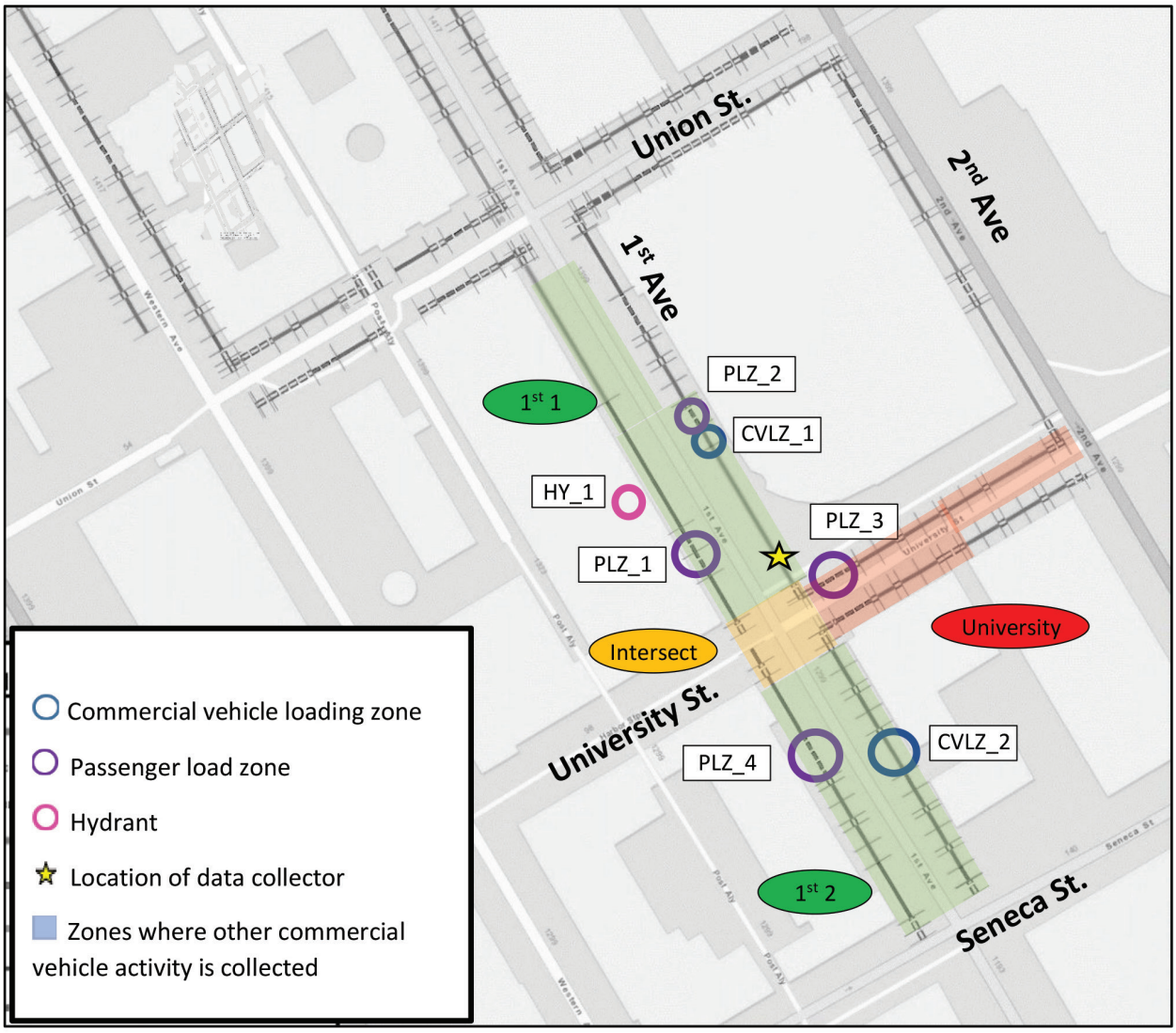


Figure 8: Four Seasons- Position C – View of 1st Ave between Union St and University St.

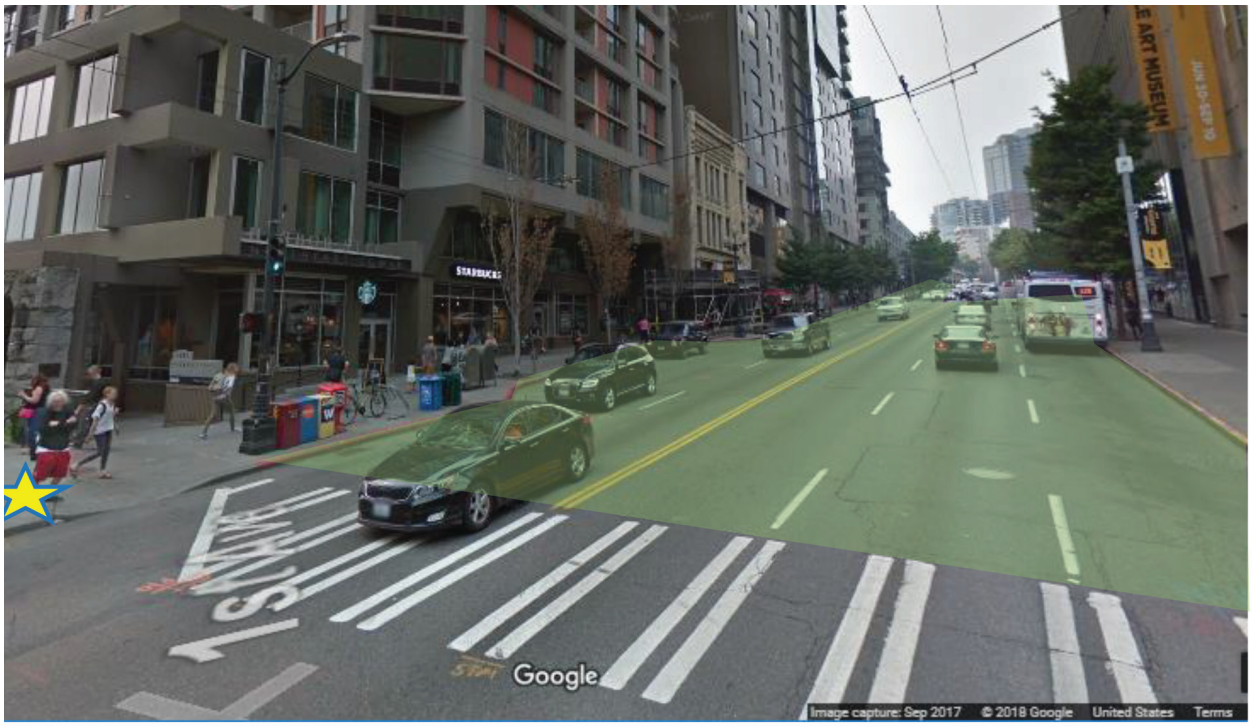


Figure 9: Four Seasons- Position C – View of 1st Ave and University St. intersection, and University St. between 1st Ave and 2nd Ave.

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

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.

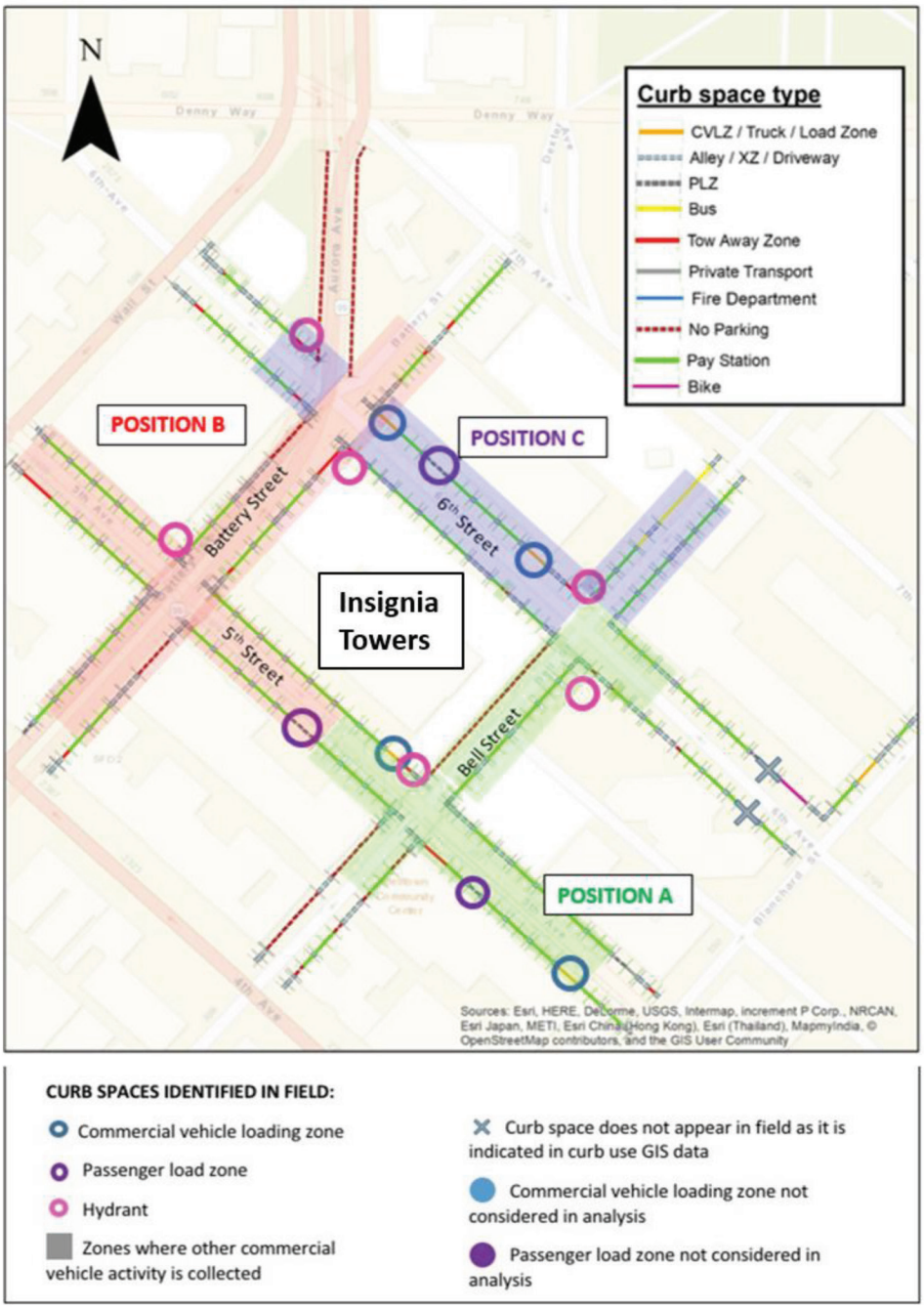
STEP 2: ASSESS EACH STUDY AREA

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



CURB SPACES IDENTIFIED IN FIELD:

- Commercial vehicle loading zone
- Passenger load zone
- Hydrant
- Zones where other commercial vehicle activity is collected
- Curb space does not appear in field as it is indicated in curb use GIS data
- Commercial vehicle loading zone not considered in analysis
- Passenger load zone not considered in analysis

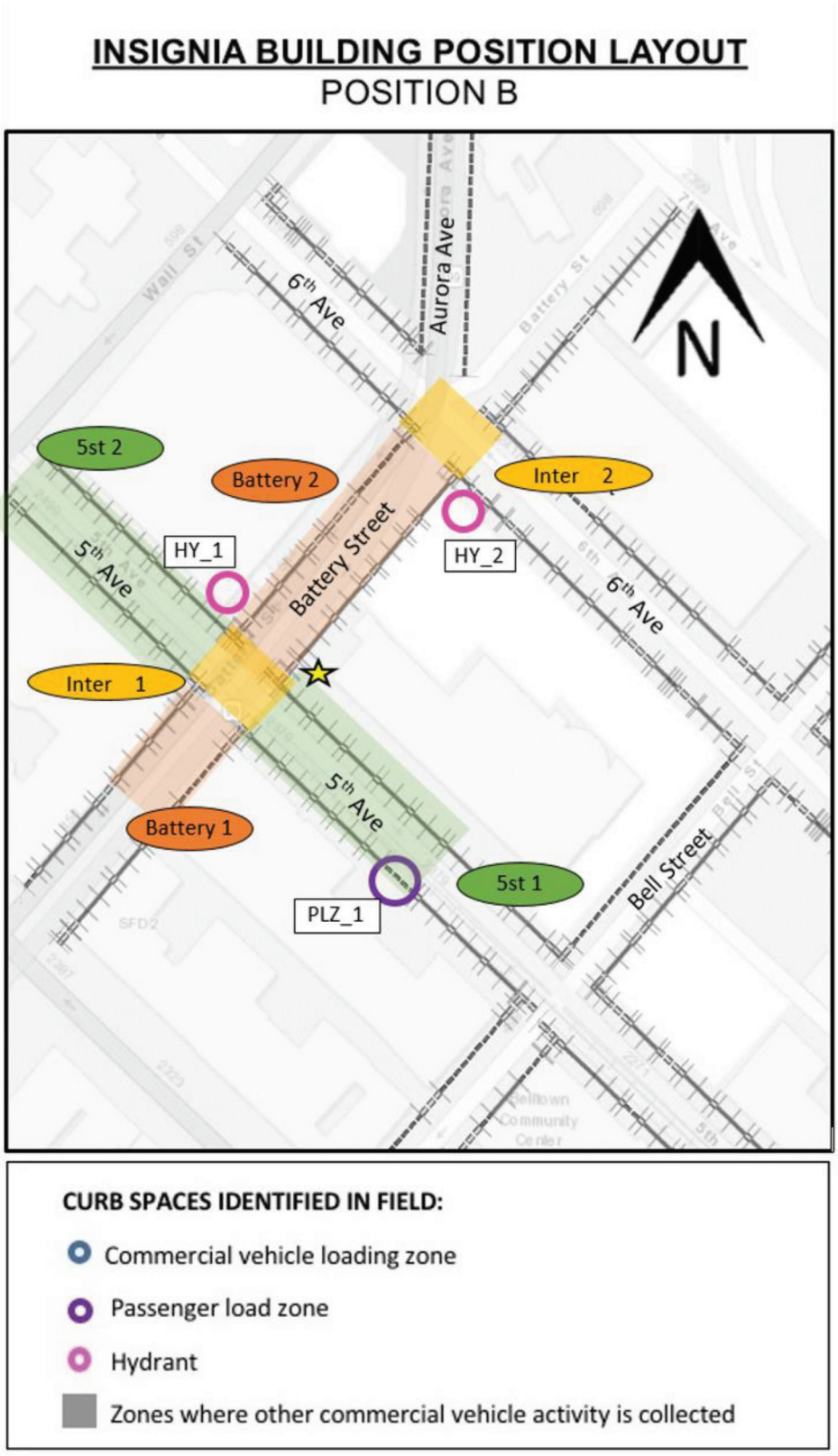
STEP 3: PREPARE MAPS AND DATA-COLLECTION FORMS

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				5th 2						Battery_2						
	a	b	Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b	Turn lane	Center	Left curb	HY_1	Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b	Inter 1	Right Curb a	Right Curb b	Center	Left Curb a	Left Curb b	HY_2	Inter 2
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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.

AUTHORIZATION LETTER FOR DATA COLLECTORS TO CARRY IN FIELD

City of Seattle
Tim Burgess, Mayor

Department of Transportation
Scott Kubly, Director

From: Seattle Department of Transportation
Transportation Operations Division
Seattle Municipal Tower 700 Fifth Avenue, Suite 3700
Seattle, WA 98104

November 8th, 2017

This letter is lists persons working with the University of Washington's Supply Chain Transportation and Logistics (SCTL) Center in cooperation with the Seattle Department of Transportation (SDOT).

The surveyors are:

- [redacted]
- [redacted]

They are performing research between October 25th, 2017 and December 15th, 2017 to better understand goods delivery in highly developed urban settings in the 'Final 50 Feet'. This complex delivery step involves parking, building access, physical delivery, inventory sign-off and even payment, and all this must be performed in tight and crowded spaces and under demanding time constraints.

With your cooperation, UW and SDOT can use the information these students are gathering to improve delivery to buildings downtown and potentially traffic flow in the Capitol Hill and First Hill Neighborhoods.

If you have questions or concerns, please feel free to contact either of us for more information.

Thank you,

Christopher Eaves P.E.
Senior Civil Engineer
[redacted]

Jude Willcher A.I.C.P.
Strategic Advisor
[redacted]

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Glossary

Commercial Vehicles (CVs) ^back
In the UFL study, commercial vehicles (CVs) includes a wide range of delivery and construction vehicles, service vehicles and garbage trucks but excludes all passenger vehicles.

Passenger Vehicles ^back
In the UFL study, passenger vehicles include cars, pick-up trucks, and shuttle buses. While passenger vehicles could be performing delivery/commercial functions, passenger vehicles were not treated as commercial vehicles in this study due to challenges in systematically identifying whether they were making deliveries or otherwise carrying a commercial permit.

Unauthorized ^back
In the UFL study, unauthorized commercial vehicle parking includes passenger loading zone (PLZ), travel lanes, bus lanes, curb segments close to hydrants, tow-away-zones, shuttle bus parking, and intersections.

Authorized and Unauthorized ^back
In the UFL study, authorized and unauthorized curb spaces include travel lanes, bus lanes, curb segments close to hydrants, tow-away-zones, shuttle bus parking, intersections, on-street meter parking and temporary construction zones.

Delivery ^back
In the UFL study, delivery commercial vehicles include box trucks, cargo vans, trucks with trailer, cargo bikes.

Service ^back
In the UFL study, service commercial vehicles include vans or pick-up trucks used to provide services (e.g., installation, maintenance) with company logos visible to data collectors.

Passenger ^back
In the UFL study, passenger vehicles include cars, pick-up trucks, and shuttle buses. While passenger vehicles could be performing delivery/commercial functions, passenger vehicles were not treated as commercial vehicles in this study due to challenges in systematically identifying whether they were making deliveries or otherwise carrying a commercial permit.