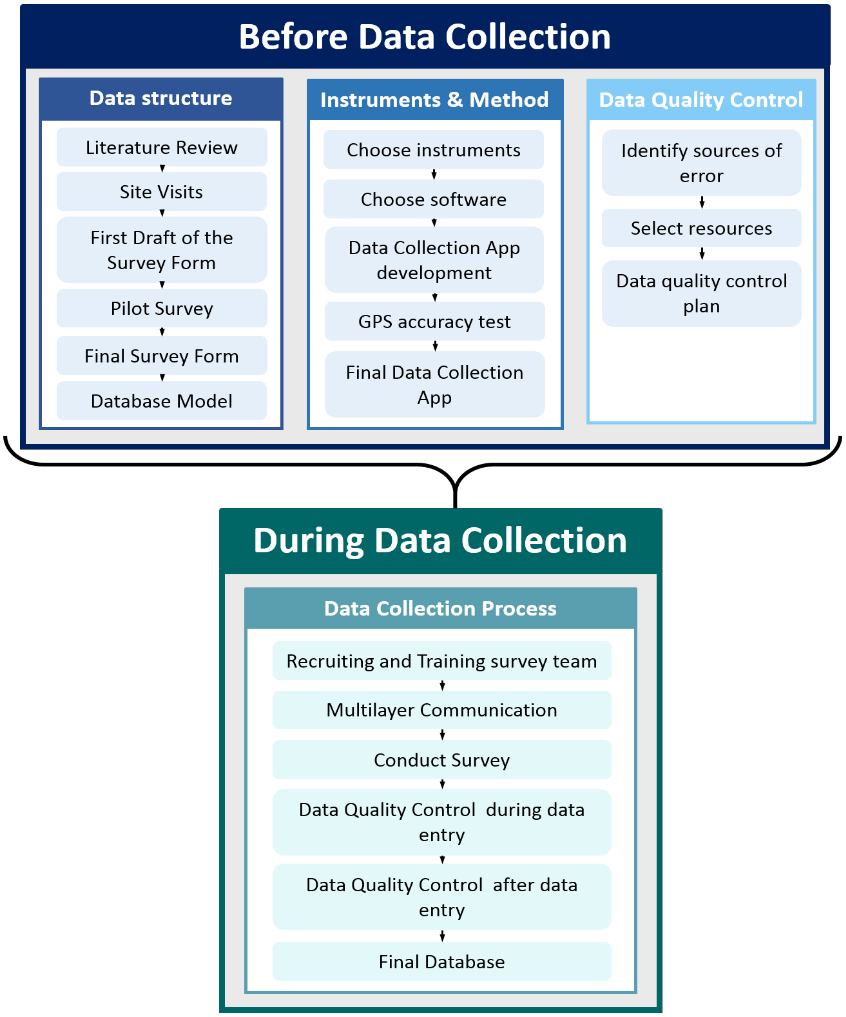
This toolkit describes the step-by-step process that city transportation professionals can follow (or adapt as desired) to carry out a private loading/unloading inventory survey.

The data-collection and analytic methods represented here are:

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

The figure below outlines the overall project data process.



STEP 1: DETERMINE STUDY PARAMETERS

The first step should define these key parameters:

- Scope/size of desired study area
- Number of city blocks in the study area: The number of city blocks could be used to assess the scope of the effort involved to complete data collection in the defined study area.
- Data-collection hours: For security reasons, it is recommended to work only during daylight hours. Because the survey includes capacity features that can only be captured when facilities are open, weekdays are recommended for data collection.

Worth noting: The research team used SDOT's publicly-available GIS layers of designated curbside parking, as well as King County's GIS layer of Seattle's alleys, to begin developing a multi-layer map of the truck load/unload locations in the city's urban centers. This UFL report adds the private infrastructure layer; an earlier UFL report updated the alley layer. Other cities also may have publicly available GIS layers that aid in any project that seeks to accurately document the load/unload network.

The research team reviewed the following Seattle GIS databases for its multi-layer map of the truck load/unload locations in the city's urban areas:

- Alleys
- Urban villages
- Arterial types
- Commercial
- Retail
- Food permit data
- Residential
- SDOT traffic lanes
- Curb space categories
- Block faces
- Year built

STEP 2: DEFINE PRIVATE LOADING/UNLOADING INFRASTRUCTURE ATTRIBUTES OF INTEREST

Section 2 in the report defines each of the three types of private infrastructure inventoried: loading bays, exterior loading docks, and exterior loading areas.

Transportation officials should also define the specific infrastructure attributes the inventory effort seeks to capture. The research team's review of design standards, city reports and research papers on recommendations regarding freight loading/unloading parking infrastructure resulted in the following extended list of infrastructure features that affect operations and that can be grouped into **location, design and capacity** features.

Important location features are the type of road at the public right of way where the access to the infrastructure is located. Poor operations of the roads connecting this infrastructure to the street network may significantly affect how private loading/unloading parking facilities are used. One example is the case of inefficient and narrow alleys, which delivery drivers tend to avoid if they have an alternative to avoid being blocked on their way out by other vehicles. The interplay between public and private freight parking infrastructure is important as well.

Design features include:

- Dimensions of access points to the infrastructure: for instance, vehicle doorway and dock doorway dimensions (width and height);
- Ground clearance: the shortest distance between vehicle tire and upper level at the infrastructure.
- The way vehicles access the infrastructure, including:
  - The access angle to the infrastructure: the angle between the vehicle access and the traffic flow
  - Access ramp's grade
  - Whether the vehicle needs to back-in
  - Maximum turning radius
  - Maximum truck size that can use the infrastructure
  - Security access measures: for instance, physical barriers, access code and any personal interaction needed to gain access.

Capacity features relate to parking spaces and mechanical devices, such as:

- Number of parking spaces;
- Apron: space for parking and maneuverability, and;
- Presence of a dock platform and dock-levelers.

Ultimately, not all features listed here were ultimately able to be captured in field, as explained in Step 3.

STEP 3: DESIGN SURVEY AND PILOT TEST

A pilot test of the initial survey gave the research team critical information about what features data collectors could capture in the field from the public right of way (e.g. sidewalks and alleys.) For this project, researchers selected a six-block area to pilot-test the draft survey. Features noted in Step 2 including turning radius, maximum truck size, and centerline distance were not possible to measure in the field due to the complexity of the geometrical features, the private infrastructure personnel's lack of knowledge or unavailability, or a lack of exterior signage. The research team used the pilot-test results to develop the final data-collection survey in Appendix A and the data structure metadata in Appendix B.

The final survey encompassed all key attributes identified in Step 2 that data collectors were able to capture from positions on sidewalks and in alleys. The specific scope of work for each project may require adaptation of the survey form used in this report. If changes are needed, the recommended process is to pilot-test the draft survey form. This pilot test enables cities to:

- Estimate the time needed to survey each infrastructure, including walking time between survey locations;
- Identify potential problems with the survey logic, and;
- Test data-collection methods and instruments.

Regarding survey logic, data collectors created a record for each loading bay entrance/exit. They recorded individual features of each loading bay.

STEP 4: SELECT DATA-COLLECTION TOOLS

It is recommended that the chosen tools of the data-collection method be:

- Able to measure metrics with sufficient accuracy
- Easy to transport
- Reasonably priced
- Available as off-the-shelf technology

Below is the list of tools used in the UFL project and their unit price:

Instrument	Unit price ($)
Laser measuring device	80
iPad mini 2 with 32 GB and Wi-Fi and cellular option*	300
Portable power bank	11
iPad Case	90
Security Vest	17.9
Clipboard	2

*This instrument may not be required if the survey instrument is paper-based.

STEP 5: CHOOSE SOFTWARE AND PROGRAM DATA-COLLECTION APP

This step requires choosing database management software that allows for:

- Controlled submission or input of data;
- Data storage in different formats, including databases with relationships;
- Geodatabases and cloud storage;
- Multiuser data editing;
- Set data rules and relationships;
- Secure data, and;
- Use of data-collection app.

These functionalities enable effective data management, data-quality control and scale-up of data collection across multiple staff members. Use of a data-collection app in field is recommended to reduce transcript time and errors. The Urban Freight Lab developed a private loading/unloading infrastructure inventory app, thought to be the first of its kind. That said, a paper-based questionnaire may be a viable alternative if a mobile data-collection app is not available or practical.

The research team conducted the data-collection process on tablets using ESRI GIS software Survey123, ArcView and ArcGIS Online. These ESRI products offer a seamless data-collection tool that allows for both visualization and editing of the collected data. Additionally, Survey123 allows selection of the most appropriate basemap to assist the geolocation input: the World Street from ArcGis.com viewer last updated in July 2017.

Additionally, the mobile data-collection app allows manual input of the infrastructure location, supported by offline basemaps. This allowed the research team to avoid the cost of having a wireless Internet plan for the tablets to support data collection. (Once collected, data could be uploaded using the Wi-Fi option.)

For precision and reliability, the research team for this inventory chose to collect GPS coordinates (geopoints) manually by dropping a pin on the map at the infrastructure location. The team then used Survey123 to average multiple GPS readings to reduce error and uncertainty in the coordinates. This process performed better in field testing than automatic geopoint collection alone.

While data quality-control checks to identify readings taken more than five-to-ten feet away from the infrastructure are effective, they are time consuming. Given the state of current technology (e.g. low accuracy of the devices), collecting the GPS coordinates of the infrastructure manually by dropping a pin at its location on the map may be the best approach. It is the approach followed in this project.

STEP 6: CREATE DATA QUALITY-CONTROL PLAN

A data quality-control plan must consider the possible sources of error in the data and the resources available to mitigate these errors at different stages of the data-collection process. This helps ensure the quality of the data before it is collected, entered or analyzed. It also helps with monitoring and maintaining the data once collected. The UFL research team identified the types and possible sources of error specific to this type of project to define the quality-control measures needed:

- **Positional error** refers to inaccuracies of GPS coordinate readings due to device issues (e.g. low satellite signal in urban canyons) and mistakes by humans manually collecting this data with tablets.
- **Attribute error** is associated with the remaining non-spatial infrastructure data collected with the survey. Some examples are incorrect data entry due to wrong measurements or mistyped data. Lack of access to the information due to obstructions or safety issues may also result in inaccurate data.
- **Conceptual error** refers to errors around identification and classification of relevant infrastructure attributes or related information. Concepts wrongly used can result in information misclassified and information not captured.

Table 1 shows the UFL project data quality-control design to address the three types of errors above. The table illustrates the measures implemented in three stages: before data collection, during data entry, and after data entry.

The Seattle project used four types of resources to carry out quality-control procedures throughout the project stages:

- **Supervisor(s):** are responsible for defining and enforcing the data collection standards and methodology; training the collectors; and monitoring and maintaining the database. The supervisor handled the data-control measures implemented before data collection and after data entry.
- **Collectors:** are responsible for data entry in field and carrying out same-day data quality-control checks after data entry.
- **Survey app:** refers to the digital and online tool that helps create entry constraints, estimates accuracy of the GPS device readings, eases the digitization of the data as it is collected and ends the need for manual information digitalization. The survey app plays an important quality-control role because it is programmed to limit inaccuracies in the data-entry stage by considering the data structure rules, attributes and relationships.
- **Carrier:** refers to the private company (UPS, a UFL member) that collaborated with the research team to review survey locations when it was unclear if the locations were used for freight operations, such as when locations had a closed door during the survey. The carrier-check happens after the collectors finish their same-day checks.

Table 1. UFL Data Quality-Control Process

	STAGE 1. BEFORE COLLECTION		STAGE 2. DURING DATA ENTRY		STAGE 3. AFTER DATA ENTRY		
	In office	In field	In field		In office		
	Supervisor(s)		Collector(s)	Survey App	Collector(s)	Carrier	Supervisor(s)
Positional	- Establish physical reference - Develop questionnaire logic to capture GPS device reading errors -Train data collectors to clean geolocation data in office following data collection	- Deliver training session to collectors about GPS location collection with survey app	- Follow instructions to always remain aware of their location - Keep track of surveyed infrastructure location with hard copies of maps	- Includes manual collection of GPS reading by dropping location pin - Includes updated base map with city blocks and building outlines	- Conduct same-day check of surveyed infrastructure location by comparing ArcGIS Online map with hard copy of map	NA = Not applicable	- Review collectors' positional check. - Identify outliers by finding geopoints out of their corresponding city block - Correctly geocode outliers based on Google Maps
Attributes *(Infrastructure features)*	- Build questionnaire's data-entry constrains in survey app - Deliver theoretical training session to data collectors - Train data collectors to clean attributes data in office following data collection.	- Deliver training on data collection with survey app and measurement devices for infrastructure features	- Take clear photos to aid data entries	- Includes visual and written aid for data fields	- Conduct same-day check of data collected in field with survey pictures using ArcGIS Online platform	NA = Not applicable	- Check numeric fields for outliers - Conduct second inspections in surveys
Conceptual *(Infrastructure concepts)*	- Establish metadata and vocabulary related to the surveyed infrastructure - Deliver theoretical training to data collectors	- Train collectors in field on how to identify infrastructure relevant to the survey	- Write open-ended comments, take additional pictures and use "Other" categories for "undefined" cases	NA = Not applicable	NA = Not applicable	- Resolve "undefined" cases due to lack of access to information	- Resolve collectors' observations and "Other" cases - Classify surveyed infrastructure - Check typology of private freight infrastructure with pictures collected

STEP 7: RECRUITING AND TRAINING OF DATA COLLECTORS

Recruiting

The workforce requirements (number of data collectors and supervisors needed) are determined by the project budget, timeline and survey length. Security concerns and survey complexity may also result in different workforce needs. For instance, data collectors may work better in teams of two to improve security conditions and enable efficient operation of the multiple data-collection instruments (e.g. laser measurement device, iPad, etc.).

In addition to data collection in field, data-collection staff may spend time commuting to and from the study area and within the study area, as well as conducting data quality-control tasks in 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 in relation to the desired project duration. For this project, data collectors were compensated for their time in transit to get to the study area.

Training

Three different training sessions are suggested for data collectors:

The first session instructs data collectors in concepts and attributes regarding the private loading/ unloading infrastructure.

This training session can be done in a classroom-type setting, with a slide presentation introducing the audience to private loading/unloading infrastructure and the various features and concepts that surround them. The research project should be explained, providing everyone with the goal, process, timeline, and information on shifts. Security in field is also addressed.

The second session focuses on practical aspects of data collection, such as how to use the questionnaire in the tablet app and the measurement tools. This training session should be done in-field to give the collectors real-world practice with the materials and process.

This training session should lead collectors through the actual process of collecting data. Attention should be paid to teaching how to take accurate measurements with the laser, how to use the hard-copy maps, and how to effectively divide collection work between the pair. One person may become very familiar with the measurement tools and always take measurements; the other may become adept at navigating and filling in the survey tool and always take responsibility for this task. Security in field is also addressed.

The third session centers on how to implement data quality-control measures.

After every shift in-field, one of the data collectors in each pair must clean the data he or she just collected. The third training session should be dedicated to this data-cleaning process: how to access the survey data results and how to properly clean the data, noting common errors to look for and needed changes to make.

STEP 8: DATA COLLECTION

The actual data-collection step depends on the size of the study area and, subsequently, the size of the workforce required. For the First Hill/Capitol Hill inventory, a total of 230 person-hours was required to survey 96 private freight loading/unloading infrastructures across 421 city blocks. It is recommended that data collectors work in two-person teams: one member normally inputs information on the tablet and the second takes measurements, updates the hard-copy inventory sheet, and maps each location surveyed. Depending on collectors' schedules, works shifts can be formed around a geographic area, with more city blocks included if the shift is longer. A check-out and check-in process can be developed for collectors to pick up and drop off the required materials needed for each shift. Supervisors must make sure territory assignments are formed and hard-copy maps are printed for each team and shift. Data collectors use hard-copy maps to know what area they are assigned, to help with quality control for positional errors, and to update progress on data collection.

Security in field

Safety of data collectors visiting the city blocks and surveying the infrastructure is paramount. It is essential to have a multilayer communications plan in place for all parties with an interest in the study area and the survey. It is also essential to have a comprehensive security protocol to avoid unsafe situations in field.

Data collectors should carry official documents from the sponsoring agency explaining the project and granting data-collection authorization. The documents should include agency official contact information should questions arise in field. Police and other relevant agencies should be informed and recruited to help communicate with all building managers in the survey area. Relevant agencies can also disseminate information on the survey and its progress to communicate with the public and relevant stakeholders. This communication can indicate where surveyors will be working and when. In Seattle, for example, the Seattle Police Department notified all building managers in the survey area in real time through the Seattle Shield program, a pre-existing information exchange for building operators and the police. SDOT also set up a new webpage at http://www.seattle.gov/transportation/thefinal50feet.htm to communicate with the public and relevant stakeholders.

STEP 9: DATA CLEANING

After data collection, data must be cleaned. Both the data collectors and the supervisors play a role in this effort, which is detailed further in Table C-1, Stage 3. The data collector must conduct a check of the surveyed infrastructure locations after having completed in-field data collection. This step makes the final cleaning of the complete dataset easier and more efficient. The supervisor(s) can conduct their data-cleaning steps during the collection process, but must perform a comprehensive clean after all the data has been collected.

The research team collaborated with experienced UPS drivers who regularly serve the study area to identify survey locations that were closed during the survey. This step allowed the team to rule out 186 of the closed-door locations across this and the earlier 2017 data collection, reducing uncertainty in the total inventory from 33% to less than 1%. This survey of UPS drivers proved integral to accurately documenting and understanding the private inventory.

As shown in the driver survey form (Figure 1), for any facility in question, drivers were given detailed location information (including photos that gave context for the door in question) and were asked whether the space was used for loading/unloading.

Figure 1. Form UPS Drivers Used for Closed-Door Locations to Determine if Used for Freight

The Final 50 Feet: Goods Delivery System Research Project

Survey of Freight Loading Bays

City Block: 19 ***Survey ID:*** 2

Survey Question

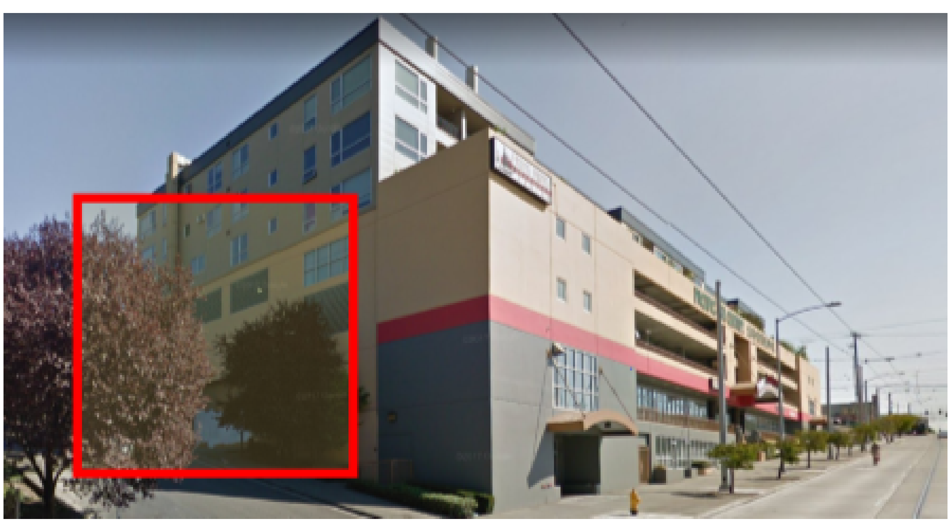
Please indicate if the space behind the door is used for loading/loading:

☐ **Yes** ☐ **No** ☐ **No response**

Please add any additional comments about the location:

Description of Facility

Building Input: Pacific Rim Center ***Address:*** 900 S Jackson St ***Located at:*** S Jackson St



STEP 10: PUT TOGETHER AND SUMMARIZE THE DATA

Varying city needs may require different final formats. The final format can be a database made of spreadsheets with relationship between them. In the Seattle project, each private loading/unloading infrastructure was considered a point feature layer on a GIS map. Most information about this infrastructure was stored in a corresponding attribute table. Pictures of private loading/unloading infrastructure features were also collected and stored as JPEG files with a naming convention that allowed them to relate to the corresponding infrastructure.

In Seattle, the final format is an up-to-date geodatabase with detailed features of private loading/unloading infrastructure represented as a point feature on the GIS map.