Technology Integration to Gain Commercial Efficiency for the Urban Goods Delivery System, Meet Future Demand for City Passenger and Delivery Load/Unload Spaces, and Reduce Energy Consumption

YEAR ONE PROGRESS REPORT

OCTOBER 1, 2018 - DECEMBER 31, 2019

START DATE: October 1, 2018

END DATE: December 31, 2021

PROJECT FUNDING: $2,140,200

DOE SHARE: $1,500,000

NON-DOE SHARE: $640,200

PROJECT FUNDER:

U.S. Department of Energy

Office of Energy Efficiency and Renewable Energy (DOE EERE)

Prinicpal Investigator
Anne Goodchild
Founding Director, Supply Chain Transportation & Logistics Center
Box 352130
Seattle, WA 98195-2130
Annegood@uw.edu

DOE Technology Manager
Mark Smith
U.S. Department of Energy

DOE Project Officer
Erin Russell-Story
U.S. Department of Energy

SUPPLY CHAIN TRANSPORTATION & LOGISTICS CENTER
UNIVERSITY *of* WASHINGTON
Urban Freight Lab


FedEx
PROPERTY OF
UNITED PARCEL
SERVICE
Supreme Baker's Rack
G.W.: 5.5 kg
Hello
FRESH


Introduction

An innovative public-private partnership housed at the Supply Chain Transportation & Logistics Center at the University of Washington, the Urban Freight Lab (UFL) is a structured workgroup that brings together private industry with City transportation officials to design and test solutions around urban freight management.

We are living at the convergence of the rise of e-commerce, ride-hailing services, connected and autonomous vehicle technologies, and fast-growing cities. Online shoppers want the goods delivery system to bring them whatever they want, where they want it, in one to two hours. At the same time, many cities are replacing goods delivery load/unload spaces with transit and bike lanes.

Cities need new load/unload space concepts supported by technology to make the leap to autonomous cars and trucks in the street, and autonomous freight vehicles in the final 50 feet of the goods delivery system.

UFL researchers coined the term "final 50 feet" to describe the last leg of a product's journey from warehouse to customer: beginning at a load/unload space located at the curb, in an alley, or a private loading by; tracking the freight carrier as they maneuver sidewalks, intersections, and security in buildings, and ending when the customer receives their goods. This final segment of the supply chain is the most difficult and expensive (estimated at between 25-50% of total supply chain transportation costs). Our Final 50 Feet research program designs and tests solutions to improve this essential segment.

In this project, the UFL and Pacific Northwest National Laboratory (PNNL), with the support of the Seattle Department of Transportation (SDOT) and their other partners will develop, pilot test, and (using a learn/do approach) improve upon technologies supporting new operational strategies to optimize use of urban load/unload space, as well as business efficiencies in the final 50 feet of the goods delivery system.

Objectives

The objectives of this project are to develop and implement a technology solution to support research, development, and demonstration of data processing techniques, models, simulations, smart phone applications, and a visual-confirmation system to:

- Reduce parking seeking behavior by approximately 20% in the pilot test area by returning current and predicted load/unload space occupancy information to users on a web-based and/or mobile platform to inform real-time parking decisions.
- Reduce parcel truck dwell time in pilot test area locations by approximately 30%, thereby increasing productivity of load/unload spaces near common carrier locker systems.
- Increase network and commercial firms' efficiency by increasing curb occupancy rates to roughly 80%, and alley space occupancy rates from 46% to 60% during peak hours, as well as underutilized private loading bay occupancy in the afternoon peak times, in the pilot test area.

Approach

We have designed a three-year plan as follows to achieve the objectives of this project.

In Year 1 we will develop integrated technologies and finalize the pilot test parameters. This involves finalizing the plan for placing sensory devices and common locker systems on public and private property, letting the request for proposals and selecting vendors, and gaining approvals necessary to execute the plan. We will also develop techniques to preprocess the data streams from the sensor devices, and begin to design the prototype app to display real-time load/unload space availability, as well as the truck load/unload space behavior model.

In Year 2 we will execute the initial implementation, which includes overseeing installation of the sensors, and collecting and processing data. We will also manage installation, marketing and operations of common locker systems in the pilot test site; test the prototype smart phone app with initial data streams; and write a code to simulate truck parking behavior in the model.

In Year 3, we will expand and improve upon project implementation. We will continue to measure results against project goals and make improvements, develop a visual-confirmation system to alert drivers if they overstay their authorized time in the space (inducing improved compliance), and run the behavior model to evaluate demand and other scenarios.

Results

Key findings of the project over the past year (October 1, 2018 through December 31, 2019) are summarized below in terms of each project objective:

KEY FINDING #1 – We identified a list of site selection criteria to choose the pilot test area for this study. After lengthy negotiations with Seattle Department of Transportation (SDOT) and Bellevue Transportation department (BTD), and facilitation to ensure that the two involved transit agencies' (Sound Transit and King County Metro Transit) needs were also part of the final agreement, **we selected an 8-block pilot site in the Belltown area in Seattle and another one in downtown Bellevue**. The selected sites balance the project's need for high-demand delivery locations and agencies' interests. The pilot test areas were toured by all project partners in July 2019.

1 **Objective 1. Reduce parking seeking behavior by approximately 20% in the pilot test area.**

KEY FINDING #2 – More and more, city privacy and/or surveillance ordinances preclude use of advanced technologies such as computer vision to track parking seeking behavior in public right of way. As this is the case in Seattle, **we developed a new, rigorous data collection protocol to gain quantitative insights into commercial vehicle drivers' operations** – based on (a) observations taken aboard delivery vehicles (ride-alongs) and (b) highly granular private data (GPS route traces) provided by delivery firms. These methods are explained below and we will use them to evaluate the effectiveness of the parking app in reducing parking seeking by comparing the 'before' (collected in Year 1-2) with 'after' data (collected in Years 2-3).

a. *Delivery vehicle ride-alongs.* We developed and tested a data collection methodology to collect real-time data from riding with delivery vehicles' drivers to inform the design of the app and selection of key variables for the development of the parking decision model. The collected data will include vehicle route, parking location alternatives, parking location choice, dwell time, pick-up and delivery activities, and parking inefficiencies (one of queueing for load/unload spaces, re-routing, parking cruising, or unauthorized parking).

b. *GPS route traces.* We developed a methodology to analyze historical GPS traces data obtained from delivery companies to identify and quantify parking inefficiencies. For each delivery trip, we calculate the difference between the real trip time (time between start of delivery and end of the previous delivery event) with the estimated travel time from Google API. This difference could be related to time spent searching for parking (parking cruising) or other parking inefficiencies. This data will also enable us to better understand commercial vehicle drivers' parking behaviors, and understand which type of routing and parking information they use to make routing and parking decisions.

KEY FINDING #3 – We arranged for and conducted 9 ride-alongs with delivery companies. Researchers rode with delivery vehicle drivers during their shifts and collected data by observing the driver's parking behavior and delivery operations in Seattle. Based on these observations, **we created four categories of parking behavior that will be used to inform development of a driver parking choice model** in Years 2-3:

1. *Pre-parking-arrival plan.* Experienced route drivers often have a pre-determined load/unload space in mind long before they approach the delivery location. They do not 'seek a parking space', but rather they see if their preferred space at a given location is available or not.
2. *Re-routing.* When drivers cannot find a load/unload space near their delivery location, some will go across town to do another delivery before returning to that location.
3. *Unauthorized parking.* In addition to commercial vehicles load zones (CVLZs), drivers also consider other parking zones, including paid parking, no-cost passenger load zones, no-parking zones, and even travel lanes, as potential parking locations.
4. *Invisible queueing.* Some drivers are willing to wait in nearby non-CVLZ parking spaces until a desired CVLZ is available.

KEY FINDING #4 - We started cleaning and processing data collected from the ride-alongs and **created four main delivery datasets**, listed below:

- Ride-along dataset - Containing information about the ride-along, including vehicle type, company, number of stops, total travel distance, and total travel time.
- Stop dataset - Containing information on the delivery parking events (a commercial vehicle parking and performing one or more delivery/pick-up), including start and end timestamps, dwell time, latitude and longitude of the parking location, parking choice, whether any waiting or re-routing was experienced, number and type (delivery/pick-up) of activities performed, number and types of goods handled.
- Segment dataset - Containing information on each "activity segment". Activity segments are classified into two types: a) delivery segment (starts with the driver parking the vehicle and ends with the driver leaving the parking spot) and b) driving segment (a vehicle trip between two stops). For each segment the recorded data includes start/end timestamps, total time and distance, latitude and longitude of start and end location, segment type, average speed and altitude.
- GPS dataset - Containing all the GPS traces obtained for all segments. The traces show the routes taken by the drivers both while driving the vehicle and when walking to perform the deliveries/pick-ups.

KEY FINDING #5 - We used paper prototypes to facilitate post-observation interviews with delivery drivers about a potential parking occupancy information app, to **develop a better understanding of app requirements from drivers' perspective, as well as the factors an app would need to have to accommodate drivers' ease of use.** After the ride-alongs, the Pacific Northwest National Lab (PNNL) refined paper prototypes into wireframes and storyboards to describe app interactions in greater detail. PNNL started app development using the data obtained from mapping the study area and the simulated parking data. App development efforts included establishing the development environment and creating the full front end and back end server, and the general architecture and design. The design is somewhere in between prototype and production. Since parcel and big/heavy delivery firms represent a significant share of the urban delivery market, the mobile parking app will be targeted to those user groups.

KEY FINDING #6 – We obtained GPS data from two delivery companies (a parcel delivery firm and a big/heavy delivery firm). Using the developed GPS traces methodology, we estimated the parking cruising time (difference between real trip time and estimated travel time), and **analyzed (1) the empirical distribution of parking cruising time and (2) the factors that affect these differences**. We found that 70% of the trips shows a positive difference between trip time and estimated travel time, with a mean difference of 9 minutes. Furthermore, using regression modelling, we showed that the variability in trip time deviations can be explained by the characteristics of the parking infrastructure at destination. These results can help city authorities in detecting "hot spots", urban areas that experience heavy congestion, as well as understanding how to best to allocate parking infrastructure to improve the final 50 feet of the urban logistics system.

KEY FINDING #7 – The Seattle Department of Transportation (SDOT) Curbside Management team **developed criteria for selecting a parking occupancy sensor vendor, and has designed a request for proposal (RFP) based on those criteria to select a vendor.** The Bellevue Transportation Department (BTD), on the other hand, has installed a few computer vision-based parking sensors in the Bellevue pilot test area to evaluate the accuracy of the technology. BTD is currently testing some other sensor technologies and plans to install more sensors in 2020.

2 Objective 2. Reduce parcel truck dwell time in pilot test area locations by approximately 30%, via increasing productivity of load/unload spaces near common locker systems.

KEY FINDING #8 – We held a walkthrough of the Belltown pilot test area for all project partners and UFL members in July to **recommend potential locations for common lockers and notable considerations for locker system installment associated with certain locations**, including transit stations, alleys, private parking lots, curbside locations, sidewalks, or indoor locations.

We also compiled an extensive list of potential common locker vendors and their service offerings for the RFP. We designed an RFP to select a common locker system vendor, and after being reviewed by the University of Washington's procurement services, risk management and capital projects offices, the RFP was released in September. After reviewing the received proposals, **we selected Parcel Pending, a smart electronic locker systems company based in California, and signed a contract with them** for the next two years of the project.

Together with Parcel Pending, we **analyzed the potential locker locations in the pilot test area, narrowed down the list to six locations**, and started working with building managers and business owners to pick the final three locations.

3 Objective 3. Increase network and commercial firms' efficiency by increasing curb occupancy rates to roughly 80%, and alley space occupancy rates from 46% to 60% during peak hours, as well as underutilized private loading bay occupancy in the afternoon peak times, in the pilot test area.

KEY FINDING #9 – We held a walkthrough of the Belltown pilot test area for all project partners and UFL members in July to observe and describe commercial vehicles parking issues in the area and to recommend potential metered/paid parking spaces to be reclassified to CVLZs. Following the walkthrough, the Curbside Management team at SDOT decided to **move CVLZs in the Seattle pilot test area**, based on their longstanding expertise in curb management and their observations during the walkthrough. Those observations led to design principles listed in Table 1 that the research team will evaluate in the CVLZ reallocation. SDOT also decided to **increase the minimum length of CVLZs to 35 feet**.

The SDOT Curbside Management Team have completed the design of the new CVLZ locations and regulation changes and is prepared for installation in January 2020. The SDOT staff also conducted an outreach regarding these changes to residents, businesses and others, by mailing a project information sheet to all addresses in the Belltown study area (about 4,100 addresses) in December. Staff also hand-delivered and discussed the project to ground-floor businesses in the area.

Table 1 Draft Design Principles and Measurable Goals for CVLZ Reallocation

DESIGN PRINCIPLE	DECISION BASIS	MEASUREABLE GOALS
Group CVLZs at the beginning of block, instead of interspersed along the curb.	• Historically, SDOT has placed CVLZs along the block in response to requests from business/property managers. This has led to a checkerboard pattern of CVLZs alternating with passenger parking spaces and other uses, which causes many delivery drivers to back into CVLZs to serve the block. During the July walkthrough, UFL and Tech Work Group members and delivery drivers interviewed on the spot recommended that the CVLZs be consolidated at the beginning of the block to allow drivers room to pull into the space. • Grouping multiple CVLZs at the beginning of the block allows longer trucks to safely park in authorized spaces. • CVLZs should be at the beginning of the block (based on travel lane direction) so the driver can easily pull in.	1: Eliminate/reduce time-consuming maneuvers into mid-block spaces.
Don't place CVLZs between a bike lane and a travel lane.	If drivers must move goods (via hand truck) across a bike lane to get from a CVLZ to the sidewalk, they may create an obstacle for bicyclists, and walking in the bike lane may not be safe. Walking in a through lane to get to the corner is also a safety problem for the delivery drivers.	2: Move CVLZs adjacent to the bike lane on 2nd Ave to the other side of the street or to nearby cross streets.
Place some CVLZs by common locker locations.	Common lockers create delivery density, which has private and public benefits.	3: Reduce delivery time in the Final 50 Feet at these locations

Conclusions

This project will significantly improve three important aspects of urban freight systems:

1. Provide new and deep knowledge of urban good delivery system operations.

There are significant gaps in the current understanding of urban goods systems at an operational level. This project integrates and analyzes real-time data (when vehicles are occupying load/unload spaces, as well as how long each of the spaces are occupied) collected via multiple sensory technologies, with a new network-use-concept for city load/unload spaces. Data from the sensors will develop knowledge of curb, loading zone, and alley usage, and parking cruising behavior. Which vehicles use which infrastructure features? How do dwell times vary across these parking locations? How is usage of these features differentiated over the course of a typical day? Answering these questions is essential to developing improved city infrastructure planning and policy development.

In addition to benefiting city officials and professional staff responsible for planning and managing public assets, this information can benefit delivery firms' dispatchers and drivers once shared with them: drivers can better plan their routes to schedule visits when parking is more likely to be available; carriers can compare their average dwell times to the status quo, and identify drivers who spend longer/less than average at locations; municipalities can use this information inform pricing and enforcement strategies that will best achieve desired outcomes.

2. Enable active management of the comprehensive urban load/unload space network.

Real-time information about dwell times and infrastructure usage allows cities to implement active management strategies. The proposed integrated data systems will enable evaluations of alternative management approaches. In many cities curb space is allocated to specific vehicle types: transit, passenger, or freight vehicles. With comprehensive sensor systems, alternative approaches to curb management could be tested by comparing results to the status quo. These could include sections of the curb dedicated to vehicles with certain stop durations (e.g. 15 minutes or less), or to vehicles of certain size (e.g. motorcycles, cars, etc.) and dynamically allocating usage by time of day. In the future, sensor data could be incorporated into a separately considered permitting upgrade where the sensors play a role in vehicle recognition, payment and enforcement somehow. This could scale past loading to cover digital permitting for many very short-term curb users such as ride-hailing. Moreover, the sensor data could support strategies, such as time-of-day pricing, where the prices can be set based on evidence and knowledge of existing usage patterns.

3. Produce commercial benefits.

Real-time information about infrastructure usage and parking availability opens the possibility to dramatic improvements for drivers and carriers. This information could be provided on mobile devices available in vehicles, and/or at fixed locations around the city, and will reduce the amount of vehicle circulation and the amount of time required per stop. When integrated into mobile device applications, driver routing tools can direct vehicles to the route that minimizes parking-cruising time. In the future, these apps could also automatically reserve spaces so that parking will be guaranteed to be available upon arrival. Of course, parking reservations could also be made independent of the routing algorithm.

A final application of the sensing, information, and communications systems proposed are specific to driver stop times. The common carrier lockers systems can cut truck dwell times, leading to higher turnover and increased productivity of load/unload spaces.

We are on schedule for achieving the project objectives. The main achievements since the start of project are:

- Formed and staffed the project's advisory and technical work groups
- Determined study pilot areas
- Secured permission to execute the project in the pilot areas
- Designed the RFP to select a parking occupancy sensor vendor and sensor data collection plan
- Selected a common locker system vendor through a UW-led RFP process
- Developed data collection methodologies to gather data from ride-alongs and GPS route traces data to estimate commercial vehicles' parking cruising time
- Performed multiple ride-alongs, and identified several sources of parking inefficiencies that affect the performance and operations of commercial vehicles in urban areas
- Designed a prediction model for commercial vehicle parking occupancy, trained on synthetic data
- Identified criteria for locker locations and developed a list of potential locations for placing common lockers in the pilot test area
- Developed design principles and a plan for reallocating CVLZs in the pilot test area
- Translated user preferences to features and functionality, and designed wire-framing of the parking occupancy information app
- Designed and coded a prototype parking occupancy information app

Acknowledgements

We would like to thank the following organizations for their substantial work on and/or support of the project. Special thanks go to our colleagues at the Seattle Department of Transportation, who have been playing an essential role in the success of this project on various levels.

- Bellevue Transportation Department
- Boeing HorizonX
- CBRE Group, Inc.
- City College of New York
- Expeditors International of Washington
- Ford Motor Company
- King County Metro Transit
- Kroger Company
- Pepsi Co.
- Puget Sound Clean Air Agency
- Seattle Department of Transportation
- Sound Transit
- United Parcel Service (UPS)
- United States Postal Service (USPS)


OPEN
2032

SUPPLY CHAIN TRANSPORTATION & LOGISTICS CENTER
UNIVERSITY of WASHINGTON
Urban Freight Lab

SUPPLY CHAIN TRANSPORTATION & LOGISTICS CENTER
UNIVERSITY OF WASHINGTON
BOX 352130
SEATTLE, WA 98195

Phone: 206.221.6407
Email: sctl@uw.edu