


Delivery Process for an Office Building in the Seattle Central Business District

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Abstract

Movement of goods within a central business district can be very constraining with high levels of congestion and insufficient curb spaces. Pick-up and delivery activities encompass a significant portion of urban goods movement, and inefficient operations can negatively impact the already highly congested areas and truck dwell times. Identifying and quantifying the delivery processes within the building is often difficult. This paper introduces a systematic approach to examine freight movement, using a process flow map with quantitative delivery times measured during the final segment of the delivery process. This paper focuses on vertical movements such as unloading/loading activities, taking freight elevators, and performing pick-up/delivery operations. This approach allows visualization of the components of the delivery process and identification of the processes that consume the most time and have greatest variability. Using this method, the delivery process for an office building in downtown Seattle was observed, grouped into three major activities (or steps): 1. Entering, 2. Delivering, 3. Exiting. This visualization tool provides researchers and planners with a better understanding of the current practices in the urban freight system, and helps identify the non-value-added activities and time that can unnecessarily increase the overall delivery time.

The demand for goods and services is rapidly increasing in cities, in part because of the rise in online shopping and more varied delivery options. Package delivery services are a large portion of the logistic sector (1). Apart from long-distance intercity freight movements, the final leg of urban freight delivery involves various activities from loading/unloading goods to pick-up and delivery operations, serving the end customers (2). This final leg can be complex and costly, accounting for up to 28% of a product's total transportation cost (3).

The objective of this paper is to understand the process associated with the final leg of the urban freight delivery system. The focus of most urban freight research has been on vehicle mobility such as freight traffic and parking management. This has led to a lack of understanding of fundamental aspects of the urban goods movement, such as pick-up and delivery activities within the building (vertical movement). The process time spent outside of the vehicle can be much longer than the driving time, as much as 87% of the entire urban freight delivery process (4, 5). However, analysis and documentation of the off-vehicular activities are limited, and there is sparsity of data to enable researchers to examine the overall system. An in-depth analysis of the driver's delivery process and performance for the final leg of the delivery process plays a vital role in understanding and improving urban freight delivery.

Understanding the vertical goods movement within the building is important because it can directly influence the roadway capacity and performance. The lack of curbside space, because of excessively long stays by delivery workers, could increase urban congestion as other delivery vehicles circle the city blocks while looking for parking spaces (6). Vertical movements can also encompass non-value-added time or time that unnecessarily increases the overall delivery time with no corresponding benefit to the customer (7). These factors can cause negative cascading impacts on road congestion, adding costs and pressures to the trucking industry, building management, and city officials.

This paper introduces the lean philosophy and value stream mapping (VSM) approach to identify areas of improvements within the delivery process flow of an office building in downtown Seattle (7). This approach provides a way to measure the delivery time for each activity within a freight delivery process. This is especially useful when the delivery process includes several

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activities and tasks that differ by carriers, types of goods, and types of delivery vehicles. With the VSM approach, dwell times and failed deliveries can be better understood as it decomposes the delivery process at the micro level.

The study begins with the creation of a process flow map of an office building in a central business district, which provides information on each delivery task and identifies areas where bottlenecks and non-value-added times could occur. This map allows one to visualize the components of the delivery process as well as those tasks that are conducted by all carriers and those that are not. Identifying the processes that consume the most non-value added time and the greatest variability will help to identify strategies to improve the overall urban freight system and be better accountable for extended truck dwell times and failed deliveries.

Literature Review

Several studies regarding the “last mile” of urban freight deliveries have been conducted. Although urban freight delivery may vary by the characteristics of each city, there are activities that are observed regardless of the delivery type (e.g., loading goods, checking in, maneuvering within buildings). It is therefore important to understand how operations across various urban freight deliveries can contribute to congestion and affect the overall quality of life for residents, retailers, freight carriers, and government agencies.

Allen et al. conducted a comprehensive review of 162 freight studies (from the 1960s to 2008) in 18 countries (8). The data were based on freight operations from the UK, U.S., the Netherlands, Germany, and Italy, indicating active efforts worldwide on improving urban freight systems. The review noted three primary purposes of these freight studies (8):

1. to gain an understanding of urban freight operations,
2. for policy and decision-making, and
3. for use in urban freight modeling.

The review also highlights a need for a systems approach to measure inefficiencies and to provide better communication between public and private entities for the development and implementation of freight plans and policies (5, 9). A more quantitative approach can be achieved with the study method presented here, which can also provide a useful tool for highlighting the impact of freight transport movements to stakeholders, either directly (receivers, shippers, and carriers) or indirectly (city authorities, and residents). Rhodes et al. also state

that quantifying and addressing both horizontal and vertical “last mile” inefficiencies are important from a planning perspective (6).

VSM is an effective tool for identifying system efficiencies and has been used in industries related to manufacturing and health care services (10–12). The urban freight delivery process consists of many activities and parties, with few standardized processes. Using a systems approach provides insight on dwell times and failed deliveries by decomposing the delivery process. Cherrett et al. emphasized the importance of understanding freight vehicle dwell times (i.e., the times the vehicle remains stationary) because shorter dwell times could reduce traffic delays and minimize environmental impacts of freight (13). A more in-depth understanding of vehicle dwell time was proposed by Allen et al., with 12 steps of activities performed by a goods vehicle driver when making a delivery (4). This paper examines the final segment of the delivery process and considers the many steps associated with the delivery tasks.

One factor that affects dwell time is the parking location. The parking options can be classified as on-street, off-street, and alternative options such as double parking or illegal parking (14). The decision of where to park may be influenced by the package size and weight, and distance to the recipient’s location (14). The existence of off-street loading facilities does not necessarily mean they are always used (13). According to the Cherrett et al.’s review of the recent UK studies, the proportion of on-street and off-street parking varied by the type of location served (13). Deliveries made in shopping centers tend to include a higher percent of off-street parking facilities, whereas deliveries made to local shops on the street use more on-street parking (13). Based on the parked location, the levels of conflicts with pedestrians, bicyclists, and other vehicles can differ, which may cause extra delivery time.

Understanding the total delivery time as well as the time for each delivery task is important when imposing time restrictions for parking and freight loading facilities (9, 15). Too little time given at the loading facilities may lead to excessive enforcements using fines for parking/loading, clamps, and towing-away. These can affect delivery workers’ operation significantly (4). Too much dwell time can be an indicator of an inefficient process with fewer on-time deliveries.

Another factor that may influence dwell time is the time associated with using elevators. Pivo et al. state that drivers would worry less about the congestion if slower traffic could be offset with faster elevator service (16). Delivery workers are required to use the freight elevators in many office buildings no matter the size of the delivery. The bottleneck may occur because the number of

freight elevators in the office buildings is limited to one or two (16). Morris points out the lack of requirements regarding the number of freight elevators in commercial buildings of many American cities, including Atlanta, Boston, Chicago, Dallas, New York, and Seattle (2). Even though each building has different freight elevators, this study can provide insights on how much time associated with elevators can take up in the total delivery time for similar office buildings in other urban areas.

Failed deliveries is another central issue in the urban freight system. Failed deliveries are very costly as the driver needs to return (sometimes multiple times) before a successful delivery. A 2016 Interactive Media in Retail Group report in the UK showed that failed deliveries can cost up to £780 million (equivalent to \$1 billion US dollars) (17). The cost burden for failed deliveries has prompted interest in solutions that can help streamline the final segment of the delivery process.

Data Collection

The selected office building in downtown Seattle has 62 floors with approximately 5,000 tenants, including gift shops, restaurants, and coffee shops. Each floor has a unique floor configuration, which allowed the research team to capture various delivery processes. Types of observed pickups and deliveries include office supplies, parcels, food items, assorted mail, recycling, and furniture.

The building is surrounded by four one-way streets (see Figure 1). There are seven 30-minute commercial loading zones and four mixed zones combined with 30-minute commercial loading zones and passenger drop-off zones. The loading bay has seven parking spaces with a 30-minute limit. The security booth at the loading bay has a full-time security guard and is open between 6 a.m. and 6 p.m. Inside the loading bay, there are two freight elevators which require a security fob to use. Delivery

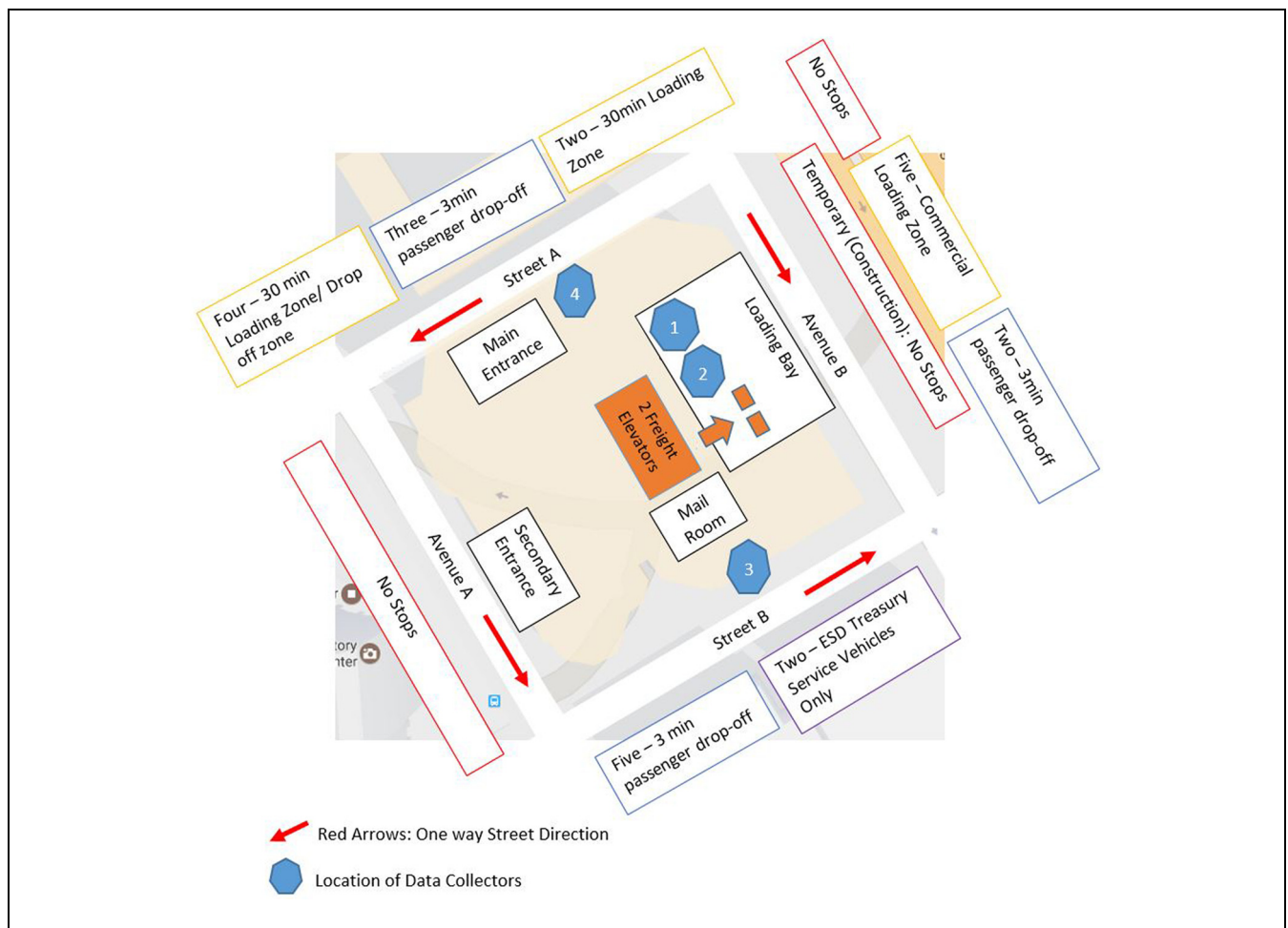


Figure 1. Configuration of the observed office building.

workers obtain a freight elevator fob from the security guard by handing in their government-issued identification card for security.

A mobile application for use in a tablet computer (Apple iPad) was developed for collecting real-time data on the delivery process. The predefined options included load/unload, waiting for/taking elevators, signing for deliveries, and much more. To identify the start of a task, the data collector taps a task button. This immediately begins recording the tasks in a web-based database and can be stopped once by tapping a sub-button once the task is finished. With this approach, each delivery task is time-stamped and the duration of each task is accurately computed even when the tasks are executed concurrently. Tasks that were not predefined could also be entered manually in the application. Other information that was recorded included whether or not a package was successfully delivered and other data-collection notes.

The data-collection process took place over five business days between January 31 and February 4, 2017, between the hours of 9:00 a.m. and 4:00 p.m. The data-collection team consisted of four people, who were trained to observe and collect data using the tablet application. The data collectors would wait until they observed a truck parking in either the loading bay or the street curbs near the building. They would then approach the delivery worker and ask permission to shadow and observe his or her delivery process. Given the observational nature of the data collection and where researchers approached the worker, these deliveries were most likely not express deliveries. Data from the tablet were then used to construct the delivery process flow map that showed the detail task durations and delivery sequences.

Process Flow Map

The process flow map is focused on the final segment of the delivery process, which is sometimes referred to as the final 50 feet (18, 19). This segment includes out-of-vehicle activities and begins with the driver parking the vehicle and ends at the point when the driver drives away from the building. There are three major steps in this segment and they are further subdivided into subtasks:

1. Entering (e.g., parking vehicles, security check-in, unloading goods, waiting for elevators to go to the destination)
2. Delivering (e.g., taking an elevator to the destination, delivery or pick-up actions, waiting for elevators to go back to truck)
3. Exiting (e.g., taking an elevator to go back to truck, loading a hand truck back to truck, security check-out)

This process flow map (see Figure 2) shows the delivery activities and subtasks that can be performed in

parallel and those that require a sequence of events for task completion. The square boxes represent the set of actions, and the diamonds represent the decisions made along the processes. Based on the collected data, the most shared common delivery subtasks at the study location was identified. Although each delivery person can generate many paths, the common delivery subtasks provide insights for areas where more effective delivery strategies can be deployed.

Table 1 summarizes the time duration of each subtask, in the same order shown in Figure 2. The ratio of standard deviation (sd) to the mean is used to identify processes that have the greatest variation. Those ratios greater than one are activities that were further examined.

Entering

Data collection began as soon as a truck parks at any of the designated on-street or off-street (loading bay) commercial loading zones. Drivers can enter the building through the loading bay or the main entrance on Street A or secondary entrance on Avenue A (see Figure 1).

In this study, 90% of the drivers (28 out of 31) parked in the loading bay to unload goods. Large volumes of office supplies could be a big contributor to this result. The mean duration for the “parking at loading bay” process (40 seconds) was slightly longer than for “parking at the street curb” (33 seconds). In tight spaces such as a loading bay, the drivers’ maneuvering ability was limited, and several forward and backward maneuvers were necessary, as expected (12). During parking activities, conflicts may also occur with pedestrians, bicyclists, and other passing-by vehicles.

Depending on the location of the parked vehicle, the driver would leave the cargo compartment open or closed. In most cases, drivers at the loading bay would leave the door open because the security guard was always present. Drivers who parked on-street tended to keep the cargo compartment closed when they left the truck for delivery. Two types of cargo compartment doors were observed: rolling and swing doors. Some heavy duty trucks had a lift that goes up and down at the back of their cargo compartment to assist the driver with entering and exiting the cargo compartment. When parking, the drivers had to allow extra space if they had swing doors or the lift. Some drivers had to lock the door after closing the cargo compartment. The wait time for the lift or locking the cargo compartment can add to the total truck dwell time.

Once a delivery worker exited the truck, he or she would walk to either the security booth to check-in or the cargo compartment of the truck to unload. Several office buildings in downtown Seattle have their own unique security check-in processes. At this office building, the

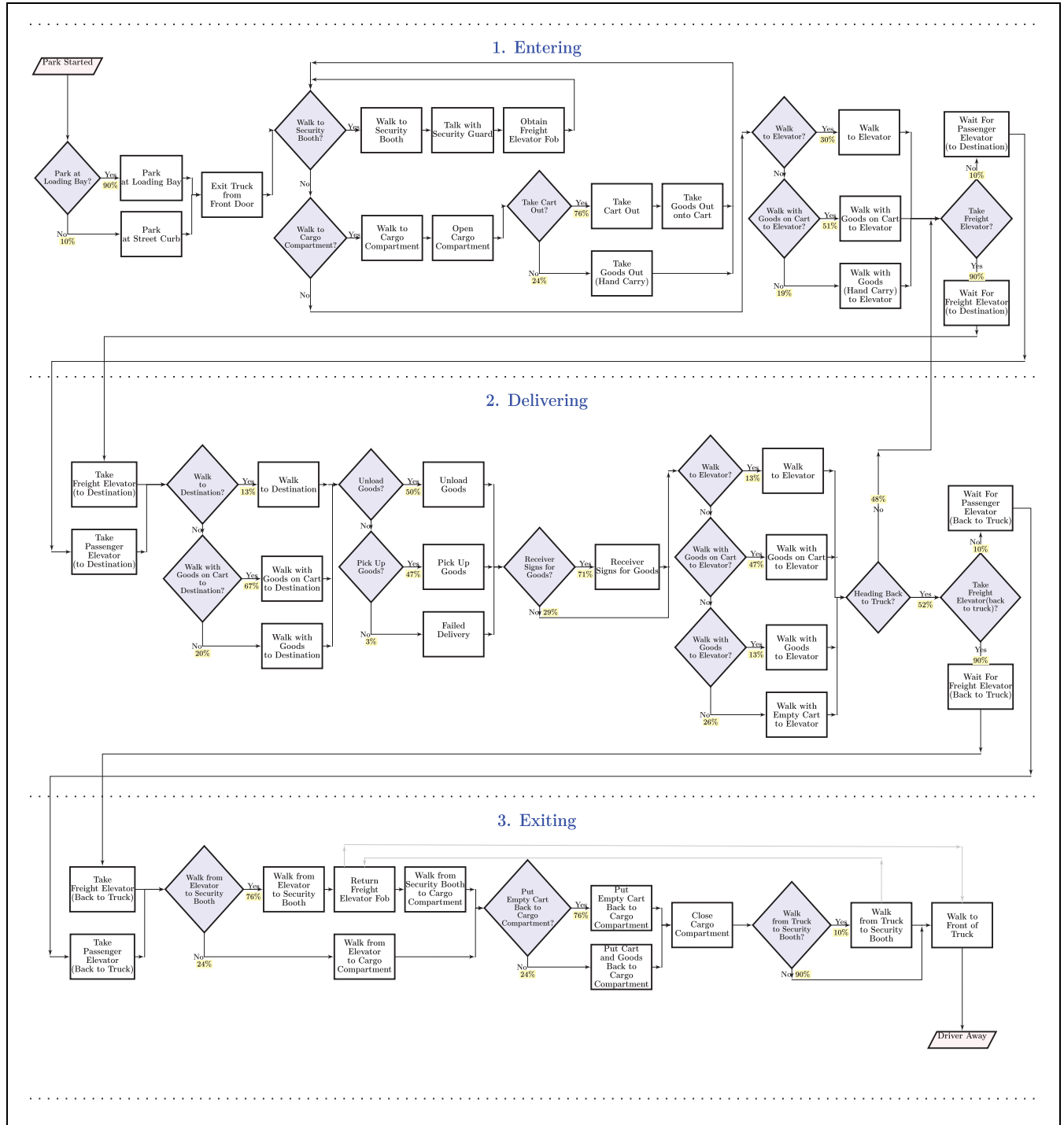


Figure 2. Delivery process flow map (n = 31).

delivery workers were required to check-in with a security guard to obtain a freight elevator fob by exchanging their government-issued identification cards. The duration of the check-in process could vary depending on the familiarity of the drivers with the security guard. If the driver made regular deliveries to the building and was familiar with the security guard, the check-in process would be fairly quick.

However, the delivery person may also take additional time to converse with the security guard. Depending on the time of day, a bottleneck could occur if multiple delivery workers arrived at the same time for check-in.

Drivers would often carry goods by hand for small and light deliveries, and by a hand truck or dolly for large and heavy deliveries. The most common method to

Table 1. Duration (in Seconds) of Tasks within the Delivery Process Flow for Common Paths ($n = 31$)

Tasks	Subtasks	mean	sd	$\frac{sd}{mean}$	min	max	mode
1. Entering	a. Parking ended at loading bay	40	40	1.01	9	165	12
	b. Parking ended at street curb	33	30	0.89	12	67	12
	c. Exit truck from front door	14	18	1.28	3	90	3
	d. Walk from truck to security booth	27	21	0.75	4	102	8
	e. Talking with security guard	83	83	1	5	242	5
	f. Obtain freight elevator fob	34	21	0.63	2	77	12
	g. Walk to cargo compartment—Entry	17	16	0.93	2	67	2
	h. Open cargo compartment	20	20	1.03	3	75	7
	i. Take cart out	27	30	1.14	1	124	1
	j. Take goods out and place on cart	54	56	1.04	3	202	12
	k. Take goods out	51	23	0.45	26	84	26
	l. Walk to elevator	54	24	0.45	26	105	44
	m. Walk with goods on cart from truck to elevator	44	28	0.64	9	129	29
	n. Walk with goods from truck to elevator	51	29	0.57	17	105	29
	o. Wait for freight elevator (to destination)	31	49	1.56	3	193	10
	p. Wait for passenger elevator (to destination)	52	22	0.42	32	76	32
2. Delivering	a. Took freight elevator (to destination)	75	93	1.23	4	486	35
	b. Took passenger elevator (to destination)	67	50	0.76	36	126	36
	c. Walk from elevator to destination	55	19	0.35	36	81	36
	d. Walk with goods from elevator to destination	87	65	0.74	26	196	26
	e. Walk with goods on cart from elevator to destination	49	50	1.03	10	200	10
	f. Unload goods	57	59	1.04	11	221	21
	g. Pick up	37	11	0.31	23	58	35
	h. Receiver signs for goods	55	77	1.41	3	404	11
	i. Walk from destination to elevator	38	16	0.43	25	64	25
	j. Walk with goods on cart from destination to elevator	40	50	1.23	3	193	10
	k. Walk with goods from destination to elevator	44	14	0.32	25	56	56
	l. Walk with empty cart from destination to elevator	39	52	1.34	2	180	2
	m. Wait for freight elevator (back to truck)	63	35	0.55	20	124	59
	n. Wait for passenger elevator (back to truck)	NA	NA	NA	NA	NA	NA
3. Exiting	a. Took freight elevator (back to truck)	148	155	1.05	2	635	36
	b. Took passenger elevator (back to truck)	78	36	0.47	54	120	54
	c. Walk from elevator to security booth	27	29	1.07	3	97	18
	d. Return freight elevator fob	44	38	0.84	5	156	6
	e. Walk from security booth to cargo compartment	34	23	0.67	9	70	9
	f. Walk from elevator to cargo compartment	30	19	0.64	9	60	9
	g. Put empty cart back into cargo compartment	42	26	0.62	5	98	33
	h. Put goods and empty cart back into cargo compartment	36	9	0.24	28	47	28
	i. Close cargo compartment—Exit	17	16	0.97	5	54	5
	j. Walk from truck to security booth—Exit	6	5	0.76	2	11	2
	k. Walk to front of truck	22	40	1.8	4	210	8
l. Enter truck from front door	28	32	1.13	1	124	7	

unload goods was by hand, but in the case of heavy deliveries, special equipment such as a forklift or pallet jack was used.

Doors of the cargo compartment can be located either at the back or side of the truck. Of the drivers observed, 76% carried goods on dollies or hand trucks and 24% hand-carried goods. In Figure 2 and Table 1, hand trucks or dollies are represented as “cart.” For pickups, the drivers skipped unloading activities and walked to the elevator directly after the security check-in.

The loading bay was located inside the building’s parking facilities where two freight elevators were accessible next to the loading dock. However, the passenger

elevators were located further away from the loading dock but very close to the lobby, next to the main entrance. Therefore, the delivery workers who entered the building through the main or secondary entrances were more likely to use passenger elevators. Although the passenger elevators were approximately 2 times faster than the freight elevators, the passenger elevators have a higher volume of frequent riders. This is reflected in the mean wait time (52 seconds) for the passenger elevators.

The mean wait time for the freight elevators to go from the loading bay to upper-level floors was 31 seconds, but the range in wait time was quite large (from 3 to 193 seconds) This is much greater than the wait time

for the freight elevator from destination back to the loading bay. This is not surprising as the delivery person at the loading bay may have to wait a long time for the elevator if it is at the top-most floors.

Delivering

Having a unique floor configuration and delivery policy for each office made it challenging for the delivery workers who visited the building for the first time. Some offices required the delivery workers to use an interphone to enter the office suites, some were open to the public, and some had a receptionist who received and signed for goods on behalf of other office workers. If the office did not have a receptionist, the delivery worker had to find an individual receiver to deliver the goods.

Once the delivery workers arrive on the floor of their destination, they performed either delivery or pick-up activities. The mean time spent for pick-up (37 seconds) was much shorter than the mean time for delivering goods (57 seconds), which often involved unloading activities. The high volume of goods could lead to a longer time when delivery workers are required to unload each item one at a time by hand. If the high volume of goods can be unloaded in bulk, a shorter unload time can be achieved.

In total, 3% of the observed deliveries failed (or were not delivered). Each company has different policies on failed deliveries: most delivery workers look for an alternate person to sign for goods. Some delivery workers can drop off goods on the receiver's desks without obtaining a signature from anyone. Some companies allowed the delivery workers to leave the site after sending a picture(s) of the dropped-off goods and locations to the clients remotely. Company policies can also vary by the types of goods. Better communication between the delivery workers and the receivers could help reduce the failed first delivery. A simple notification system could also allow both the delivery workers and the receivers to share information on estimated arrival time or the wayfinding instructions. When the receivers are notified before the delivery arrivals, the chance of failed deliveries may be reduced. When the delivery workers are well informed about the building layouts, the chances of being lost in the building could be decreased as well.

As expected, the average time for walking with goods (44 seconds) or goods on the cart (40 seconds) was longer than the average time for those walking without any goods (38 seconds) or with an empty cart (39 seconds). For multiple deliveries, the drivers would repeat delivery and pick-up activities within the building.

The mean wait time for the freight elevator to go back to the loading bay was 63 seconds. To avoid wait time for the elevator, some delivery workers would hold the

freight elevator open by blocking the elevator door until he or she comes back after completing deliveries. These delays can compound and create a continuous delay of deliveries for other drivers who are waiting for the freight elevator to other floors. Lastly, freight elevators were used by individuals that did not have any goods or freight. These individuals chose not to use the passenger elevators for their convenience, which added additional and unnecessary stops. In general, elevator bottlenecks have a significant impact on office buildings with many floors.

Exiting

The mean time in the freight elevator to go back to the loading bay was 148 seconds. Once the driver returns to the loading bay or main lobby after completing deliveries or pickups, he or she can either walk to the security booth or go back to the truck. In this study, 76% of the drivers walked from the elevator to the security booth first. At the security booth, the drivers return the elevator fob to the security guard, where they would get their identification card back.

During the peak delivery hours (10:00 a.m. to noon), the security guard experienced difficulty in accommodating all drivers and a queue began to form. In these situations, a securely automated check-in and check-out kiosk could be set up to help expedite the process. The building had a pre-screening program where some delivery workers can obtain the freight elevator fob in advance and use it without the check-in process.

The mean time for loading the empty cart or placing picked-up goods in the cargo compartment was 36 seconds with low variations ($SD = 9$). Closing cargo compartment was also fairly quick, with a mean time of 17 seconds. Once the drivers enter the vehicle, some of the drivers wait inside the truck to complete their paperwork, with or without the engine on. Some drivers can avoid paperwork by using a digital device that helps provide real-time paperless communication between the field and office workers.

Results

All delivery workers made at least one delivery to the building, with 26% (8 out of 31 delivery workers) making multiple deliveries. For those who visited more than one floor, the maximum number of deliveries observed was seven (see Figure 3).

Total Delivery Time

The tablet application allowed collection of data on dwell time for the three main delivery steps, the subtasks, as

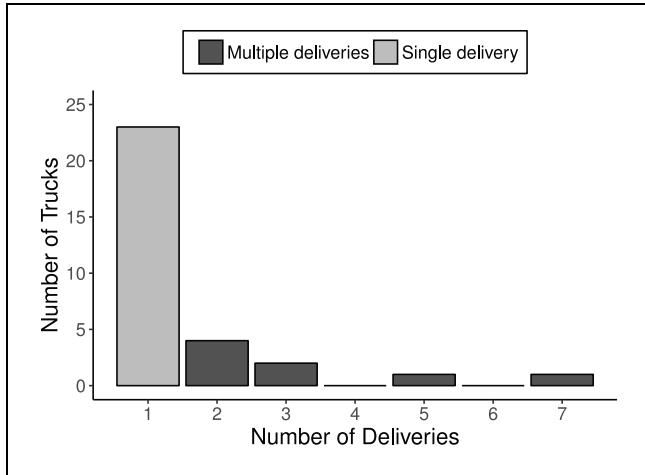


Figure 3. Number of deliveries per truck.

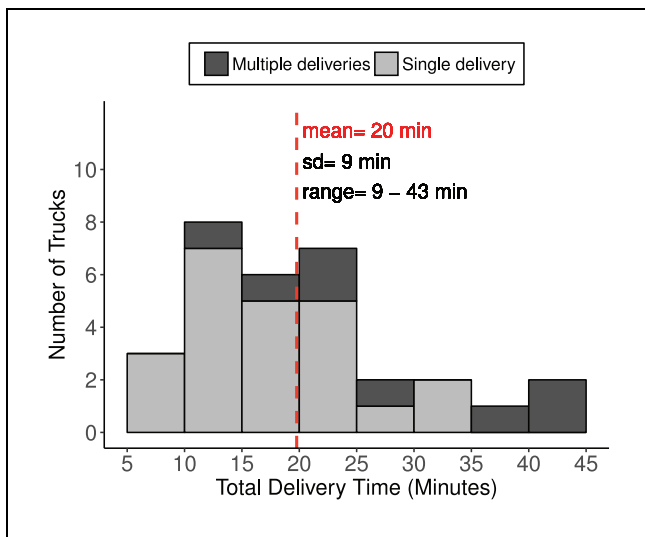


Figure 4. Distribution of total delivery time ($n = 31$).

well as total delivery time. Figure 4 summarizes the delivery time measured for each delivery truck by single and multiple deliveries. The mean total delivery time was 20 minutes. This is reasonable, as the parking time limit at the studied location was 30 minutes. The delivery times ranged from 9 minutes to 43 minutes. The range of total delivery times is comparable to that found in a previous study by Cherrett et al., which indicated 9 and 8 minutes as the shortest mean van dwell times according to 2001 and 2008 Winchester surveys (13).

As shown in Figure 5, the times for each of the three delivery steps are 7, 8, and 5 minutes for entering, delivering, and exiting, respectively. The percent of total delivery times are 35% for entering, 40% for delivering, and 25% for exiting. Unloading and organizing goods before

deliveries encompass a great deal of the time in the delivery process. The highest variation is shown in the delivering step at the final destination. Differences in delivery workers' experience and familiarity with the building, and the level of interaction with the receptionist are some of the contributors to these variations.

Variation in Delivery Time

The subtasks in Table 1 are visualized in Figure 6, which shows the distribution of delivery time based on the ratio of the standard deviation and the mean ($sd/mean$). The variation (sd) for most processes was close to the mean. The highest variations ($sd/mean > 1.5$) was observed in the activities, "walk to front of truck" and "wait for freight elevator (to destination)." The six tasks with the largest $sd/mean$ are discussed further in this section.

Task 3k ($sd/mean = 1.8$): Walk to Front of Truck. The high variation in the activity "Walk to front of truck" was caused by one specific case, which may not be as common in other delivery processes. A delivery worker failed to deliver the goods but spent 210 seconds lingering in the loading bay, walking back and forth between the front and the end of the truck. Although this is not common, it is important to examine because it is associated with a failed delivery.

Task 1o ($sd/mean = 1.56$): Waiting for Freight Elevator (to Destination). Time spent while waiting for the elevators increased the overall truck dwell time. The wait time at the bottom floor (loading bay or main lobby) may include elevator travel distance over the entire building and is affected by use during peak periods. Wait times from the office floor can be much quicker for deliveries to the middle floors of the building.

High variation in the wait time for freight elevator could also be related to the elevator age. Both freight elevators in the observed office building were installed in 1990 (27 years ago). The frequent breakdowns and slow speeds can contribute to the bottlenecks observed. Weather was also an observed factor. Strong winds from outside the building would come in through the wide opening of the loading bay entrance, and prevent the freight elevator doors from being fully closed, causing delays on the loading bay level. In these situations, a security guard would request that the delivery workers press the "close" button until the door was fully closed. However, those delivery workers that were not familiar with this defect may instead wait an excessively long time for the elevator to automatically close.

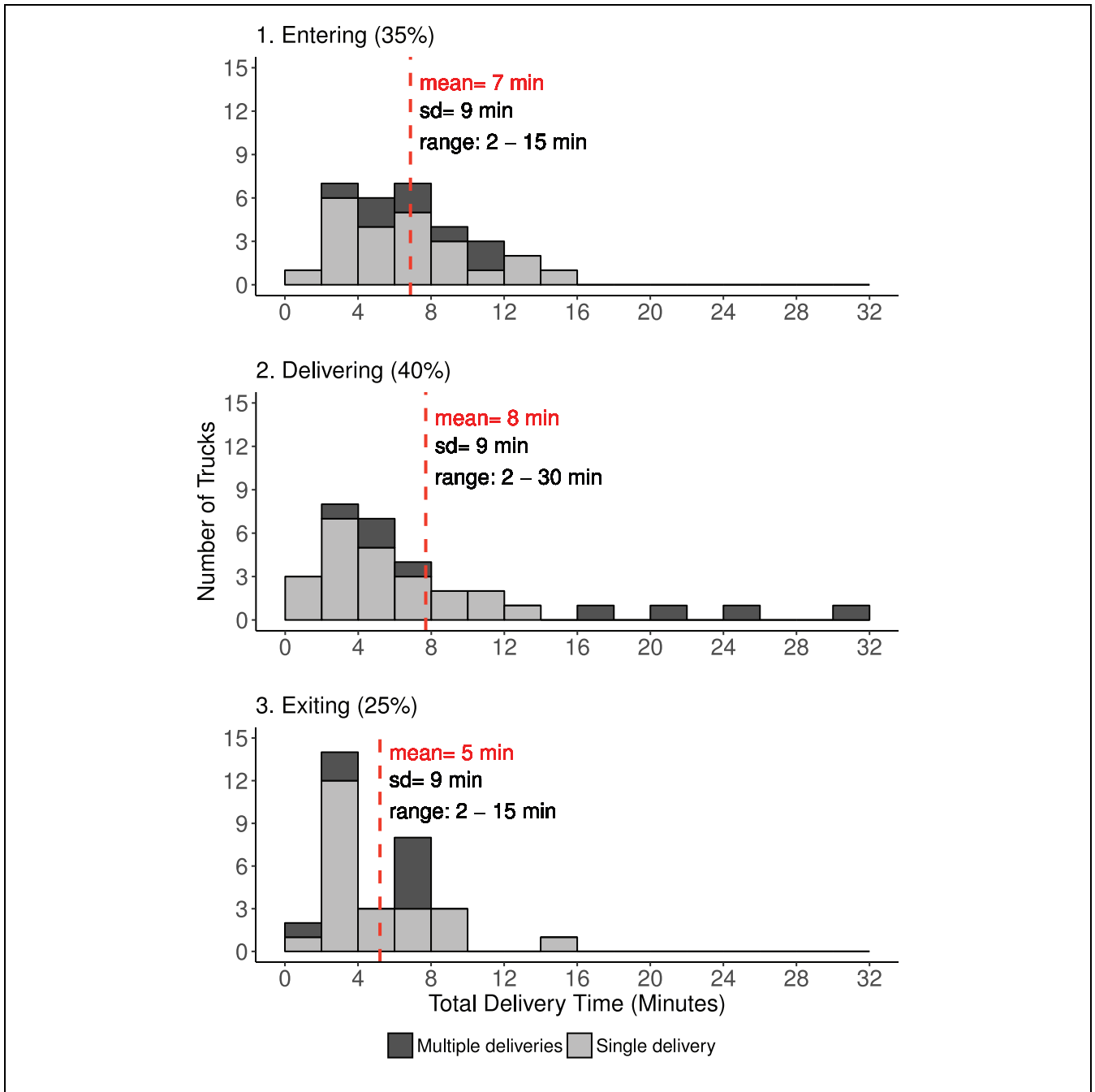


Figure 5. Delivery time by main delivery process steps (n = 31).
 Note: The letters and numbers within the horizontal bars denote the tasks and subtasks identified in Table 1. For example, 3k represented Task 3 (Exiting) and Subtask k (Walk to front of truck).

Task 2h (sd/mean = 1.41): Receiver Signs for Goods. Out of all the deliveries, 71% of the drivers were required to obtain a signature from the receiver. The time it took for the receiver to sign for the received goods varied greatly and depended on the quantity and type of received goods. For regular deliveries, the receivers anticipate certain types and amounts of goods being delivered, resulting shorter time in signing for goods. When the multiple

types of delivered goods are not organized before the delivery, the receiver took a long time to sort and count each item, increasing the total dwell times for the delivery workers at the final destination.

Task 2l (sd/mean = 1.34): Walk with Empty Cart from Destination to Elevator. The walk time within the final

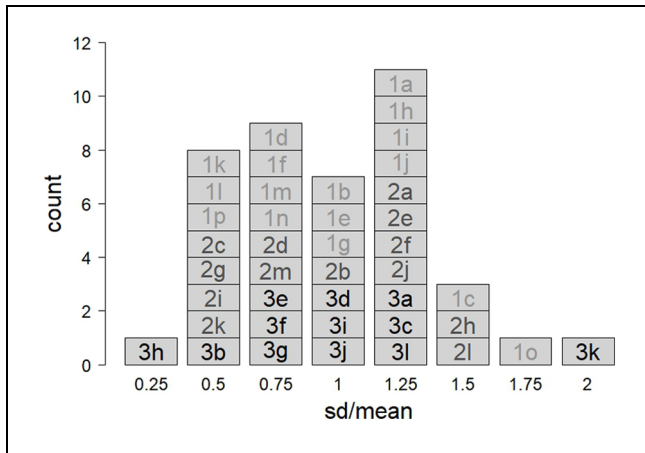


Figure 6. Ratio of standard deviation and mean (sd/mean) of delivery time.

destination also showed high variation, especially for those who walked with hand trucks or dollies, referred to as “cart” in Table 1. Depending on the size and types of cart, maneuvering the office areas with dollies and hand trucks could be time-consuming because the delivery workers required extra time to hold the office doors for hand trucks or dollies. Sharing the building infrastructure information, such as the size limits of the hallways or office doors, could help the delivery workers to plan out the deliveries ahead of time. Using standardized carts for deliveries could be another way to expedite the delivery process, avoiding any undesirable situations such as being stuck in doors or hallways.

Task 1c (sd/mean = 1.28): Exit Truck from Front Door. The high variation in “exit truck from front door” could be because of the time inside the vehicle to complete paperwork or review receiver lists while the vehicle’s door was open. In some cases, the drivers were eating or using their cell phone while exiting the truck. However, most drivers did not take long to exit the vehicle (mean duration was 14 seconds).

Discussion

Freight movement is changing rapidly and it is essential to understand the process flow of goods globally, regionally, and locally. This paper focuses on the movement of goods locally, and more specifically within an office building in the Seattle central business district. There has been increasing demand for deliveries in central business districts, but there is limited space in which to move, both structurally and operationally.

The final 50 feet of the supply chain extensively involves a vertical movement of the delivery process, as deliveries and pick-up activities occur mostly while the drivers are out of the vehicle from the loading zone to the

end customer. This paper introduces a systems approach to measure and observe detail tasks of the current final 50 feet of the supply chain by using a unique tablet application and a process flow map. An office building in downtown Seattle was observed by using this approach. The process flow map decomposes actions of the delivery workers, which helps the researchers identify bottlenecks in the current delivery process and where improvements can be made. The improvements can easy-to-implement solutions, such as an information board to notify delivery workers of imperfections in the freight elevator, to more high cost solutions such as a building redesign.

Although the study included only 31 observations, it still provides substantial insights on the variations that can occur for a one-week period within an office building, while also demonstrating that some steps are consistent regardless of carrier type. A future goal is to be able to compare the variations observed in this building with other building types and operations (e.g., shopping center, hotel, residential building). It would also be of interest to examine different operation types. Future process flow maps could also showcase temporal differences with respect to seasons, holidays, and weekend versus weekdays.

The scope of this study was also limited to the most common paths of the delivery process performed at one office building in downtown Seattle. However, this study can provide insights on the average delivery durations for other similar-sized office buildings in urban areas. Also, the focus of this paper is to understand the overview of the final leg of the delivery and pick-up activities by using the new systems approach of process flow maps with quantitative measures on dwell times. The quantitative measures of delivery time for each delivery task can enable researchers to identify those tasks with a high coefficient of variation value, being bigger than 1. This provides insights on the tasks that can be performed faster by others, which can be improved for other workers with a better understanding of the current delivery process flows. Further research on the final 50 feet of the pick-up and delivery process in different types of buildings could capture unique characteristics of different delivery procedures.

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Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: Haena Kim (HK), Linda Ng Boyle (LNB), Anne Goodchild (AG); data collection: HK; analysis and interpretation of results: HK, LNB, AG; draft manuscript

preparation: HK, LNB, AG. All authors reviewed the results and approved the final version of the manuscript.

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