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Smart Loading Zone Applications for Urban Last Mile Delivery

Master's thesis in Quality and Operations Management

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Abstract

Last mile delivery has become increasingly difficult in urban areas; as population increases alongside the demand of the citizens, novel and smarter solutions are needed to cope with challenges of congestion and misuse of urban spaces, while at the same time sustainability goals need to be taken into consideration. The smart city concept has become the next step for the future transformation of our society. Smart cities strive towards creating better welfare for its citizens in an urban area to reach sustainable consumption of resources. This is done by leveraging technological tools such as IoT, Big Data analytics and ICT. Similarly, smart cities include smart parking which helps to facilitate the process of monitoring, controlling, and parking by the mentioned digital and technological tools. However, previous and current smart parking solutions have almost entirely been developed for passenger cars and not for commercial freight vehicles which park on so called loading zones (LZs), in order to perform loading/unloading activity for parcels and goods delivery.

The purpose of this study is to investigate the concept of smart LZs, including the definition of a smart LZ, what factors inhibit the deployment and operations of LZ use and management and lastly, how smart LZs can be implemented in Sweden. This was done by using a qualitative research approach, by analyzing semi-structured interviews and a pre-recorded focus group of relevant stakeholders: truck manufacturer, smart parking provider, urban strategists from different municipalities and logistics providers. A smart LZ should, with the help of smart technological systems, improve overall operations of last mile delivery and loading/unloading activities for the operators. The findings showed that there is no clear definition of a smart LZ; the empirical data suggest that smart LZs should be digital, having cameras or sensors, and a widely spread system for operators to interact with, like a smartphones app. Furthermore, smart LZs should provide real-time data of occupancy to facilitate operations for logistics providers. Combining the empirical data and literature review, three components were derived of what a smart LZ requires; sensing technology to gather data, predictive data analytics tools to analyze data and lastly, a user interface which could be a smartphone app to display analyzed data for the operators.

There are three holistic steps to implement optimal smart LZ solutions efficiently; the first step in developing a smart LZ is to gather data to understand the underlying problem of the LZs, this can be done via sensors placed at LZs. The next step is to involve all the relevant stakeholders including enforcement agencies, policy makers, smart parking developers, municipality/transport department and logistics providers. The last step is to do a pilot of the full system with no compromises before deploying the system on a large scale.
However, the findings showed that there are several inhibiting factors for smart LZ deployment and operations in Sweden; counterproductive policy, regulation, legislation, lack of knowledge and data of LZ utilization, not being able to book LZs, not paying for LZs or having time limits which could potentially lead to a lack of enforcement, built-in incentives for the city to decrease the number of LZs and increase the number of parking spots for passenger cars due to monetary reasons and sustainability goals overshadowing smart LZ initiatives.

Keywords: Smart city technology, smart parking technology, loading zone management, smart parking strategies, last mile delivery challenges, urban freight.

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Robin Wahid
Gothenburg, December 2020

1. Introduction

This chapter gives an introductory background to the topic of interest. The objective and research questions that the researcher will attempt to answer are presented alongside the scope and limitations for this research.

1.1 Background

Modern society is faced with a rapid change in technological advancements. Innovations and technology that have transformed and entirely reshaped different landscapes and industries have yet the potential to penetrate adjacent or less thinkable social, environmental, and economical aspects of society. With urban areas being densely populated in combination with an ever-increasing demand of citizens' needs and goods, smart city applications are becoming more important. The concept of smart city is to leverage technological tools, such as Information and Communication Technologies (ICT), Internet of Things (IoT), Machine Learning (ML) and Artificial Intelligence (AI), in order to achieve a better welfare and prosperity in urban areas for its citizens alongside economic, environmental and social sustainable consumption of resources (Al Nuaimi et al., 2015). Within smart city application, urban space management is becoming an overlooked aspect to consider; several advancements regarding smart cities have been in the energy sector or personal mobility (Al Nuaimi et al., 2015).

Freight vehicles that transport goods within urban areas load and unload on so-called loading zones (LZs). These LZs are defined as areas along the street reserved for freight doing loading and unloading activities. Moreover, city authorities have limited knowledge of the utilization of these LZs. These LZs can be used by any vehicle that loads or unloads goods without the use of a parking meter in some countries and municipalities. According to Allen et al. (2018), roughly 50-80% of a freight vehicles' operational time is spent in LZs which in turn leads to several negative societal impacts as well as violation on parking spaces. LZs in urban areas being occupied lead to operators searching for another LZ nearby, double parking or moving onto the next customer in wait for the occupied LZ to become vacant (Nourinejad et al., 2014).

According to Malik et al (2019), in an urban area in Gothenburg, 64% of the operators that were interviewed claimed that there were insufficient LZs as well as a high number of parking violations. However, data gathered from Gothenburg have shown that LZs are occupied less than 50% of the time during the 7 am and 5 pm (Malik et al., 2019). What this implies is that there could potentially be an imbalance between supply and demand. The supply is static in the sense that there are a fixed number of LZs whereas demand is highly dynamic in contrast, meaning that demand varies with time. Thus, this insinuates a need for smart space management. Demand of LZs varies with seasons, day of the week and time of the day. Supply of LZs reveals a need for more operational management; the design of LZs is mostly based on official intuition rather than hard data (Sanchez-Diaz et al., 2020). Thus, obtaining data of the demand for LZs can be crucial in the management of the LZs. The transport operators require pre-time and real-time advice through digitized solutions and data analytics tools. Due to the lack and cost of an IT infrastructure, with sensors, etc. of urban freight, there have not been any significant smart management attempts and the advancements have been delayed. However, cellphone applications could potentially have a significant role in digitalization due to its nature of providing a great quantity of data from the user (Appio et al., 2015).

1.2 Aim and Research Questions

This thesis is part of a more extensive project that was initiated before the start of this thesis This project includes multiple stakeholders and project team members. The main objective of the project as a whole is as stated by the project team *to investigate the potential of using a cellphone application-based system to enhance the design and management of loading zones in urban environments in Sweden*. The reason behind this is to have a more efficient freight operation by reducing the travel time and kilometers travelled.

The objective for this thesis is closely related to the main objective and can be divided into three parts; first, to define what a smart LZ is and implies, secondly, to understand how technologies are used for LZs currently world-wide and thirdly, to gather data that inhibits smart LZ deployment and operations as well as understanding the current challenges of urban freight and LZs. This is done by understanding the private and public sector's perspective of smart LZ - their necessity, challenges of current systems and factors that inhibit smart LZ deployment and operations. The RQs for this thesis are found below with their own methodological approach in the bullets.

RQ1: How is a smart LZ defined?

- Identify elements and derive a set of requirements from the literature review and empirical data of the definition of smart LZ

RQ2: What existing smart LZ technologies could improve urban freight operations and how would these be implemented in a city?

- Literature review on case studies and articles on LZ management
- Conduct interviews with a smart parking provider and municipalities
- Summarize several applicable LZ technologies and approaches that are suitable for Sweden

RQ3: Which factors inhibit smart LZ deployment and operations in Sweden?

- Identify the current process for LZ management
- Identify the biggest challenges for an efficient LZ operation from different stakeholder point of view based on the focus group and interviews
- Lessons learned from pilot studies explained during the interviews and focus group

1.3 Scope and Limitations

This thesis will be a contribution to a higher purpose project which includes developing algorithms to extract necessary data and evaluate a cellphone application-based system. These end products are outside the scope of the thesis, rather the focus will be on providing insights to the project team from the public and private sector. For the public sector data will be gathered from not only Sweden but other cities outside of Sweden's borders. Further, the project has already started, thus some initial stages, which lie close to this thesis, are already in progress. Those areas will be used in the thesis, including a previous focus group session. Primary data for this thesis will solely be collected from already established contacts with the project team, however, if the project team provides data from elsewhere or if the researcher finds additional data elsewhere, then this will be used as well. Further, the urban freight is a societal challenge which requires the collaboration of multiple stakeholders, more specifically these five: smart parking provider, urban freight strategist from public sector, logistics company/companies, truck manufacturer and academia. With regards to freight strategists from the public sector, there will be strategists from outside of Gothenburg in Sweden, these are Bogota in Colombia, and Stockholm in Sweden. The reason why these were chosen is due to accessibility to these municipalites.

2. Methodology

In this chapter the methodological tools and motivations behind certain methods over other will be explained. The chapter will deal with the research strategy and research design to give a holistic view of the methodology. Further, the data collection, the empirical data for the interviews, including sampling, and focus group will be explained alongside the carried-out literature review. Lastly, the data analysis in which the raw data has been analyzed will be presented.

2.1 Research Strategy

This thesis is a part of a bigger project, having this in mind is crucial for the methodology. While the project as a whole is both quantitative as well as qualitative, this thesis seeks to further add on the qualitative parts of the project. Thus, the focus for the thesis will be qualitative. However, quantitative data can be extracted as secondary data from the project team which could be combined with the qualitative data. This would then be defined as a mixed-method research and is an effective way to mitigate divergent results from the qualitative parts (Creswell, 2017). However, this will solely be a qualitative research to complement the whole project and fulfill the research objective. Furthermore, there are different orientations when investigating the research question in relation to existing literature: deductive, inductive, and abductive (Bryman, 2012). For this research, an abductive approach was used in which the researcher moved back and forth iteratively between the empirical findings and existing theory. This approach is justified due to the nature of the subject being an unexplored area. Moreover, one is required to create a methodology that adheres to the research question (Schoonenboom & Johnson, 2017). Looking at the research questions, they are of exploratory nature, which is one of three types of characteristics alongside explanatory and descriptive (Saunders, Lewis & Thornhill, 2016).

2.2 Research Design

In Figure 1, a holistic view of the research design is illustrated. In the data collection sphere, all necessary data was collected through the literature review, project team data which is a focus group and the semi-structured interviews. The methodology behind these will be explained further below. The project team data is the data that has already been gathered by the project team. In the data analysis, data was used to cluster the raw data into relevant chunks by using the software program NVivo which will add to the robustness and quality of the analysis of the research. This was then used as a basis for the final findings in which the research questions were answered. This research design is by no means the most suitable one; according to Waller, Farquharson & Dempsey (2016) there is no best approach or method to qualitative research.

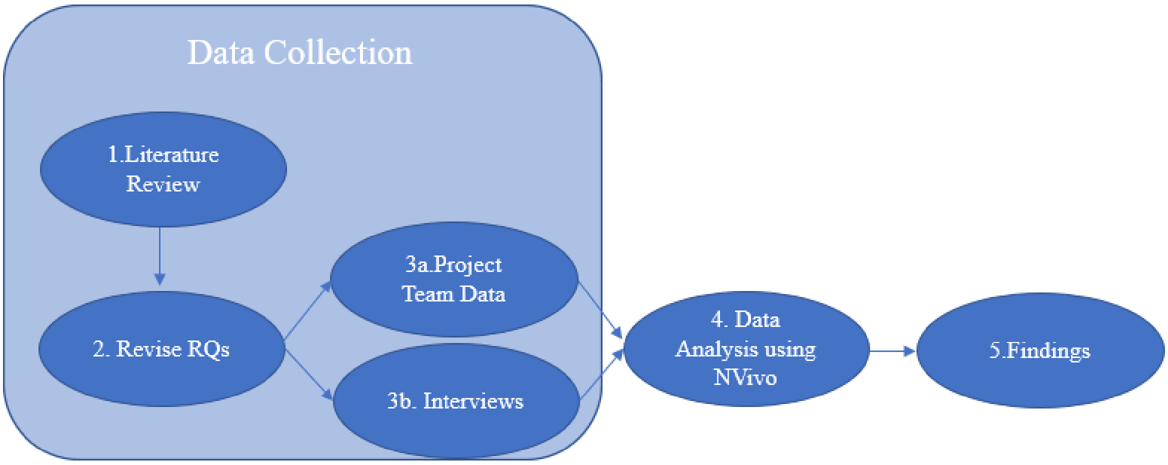

Figure 1 - Holistic view of the research design

2.3 Data Collection

In the data collection sphere, illustrated in Figure 1, the literature review, project team data and interviews were the main data gathering clusters. Initially a literature review was conducted to find potential gaps as well as to revise and refine the research questions. This was done in order to select the right types of question and data in the following stages for the interviews and the project team data. The relation between the interviews and the project team data is such that the project team data will give an overview of the topic, whereas the interviews are meant to be used to gain more in-depth insights of the topic. The quality of this research is examined with regards to three aspects which are vital to prove the trustworthiness of the findings from this research. These are validity, reliability and generalizability from Bryman and Bell (2011) and are defined as:

- "*Validity determines whether the research truly measures which it was intended to measure or how truthful the research results are*." (Joppe, 2000).

- Reliability is concerned with if the results are replicable by using the same method and whether the measures are stable and consistent (Bryman and Bell, 2011).

- Generalizability is the degree of generalizing the findings of the sample to the population (Polit-O'Hara and Hungler, 1991).

Waller et al. (2016) claim that validity can be measured from the approach the data was gathered and the way it was interpreted and analyzed. The research quality in this section will deal with what the research has done to keep a high-quality research. In section 5 the research quality and evaluation of the methodology will be discussed in terms of the analysis and findings.

2.3.1 Literature Review

To avoid reinventing the wheel, Waller et al. (2016) claim that reading previous literature on the chosen topic helps the researcher to identify gaps and articulate a more precise research question. The literature review for this thesis was of great significance for the project team but also for the abductive research approach. Thus, most of the time and resources for this thesis was invested into the literature review. According to Bryman and Bell (2011), there are two ways to conduct a literature review: narratively or systematically. The main difference is that the narrative is wider in its scope and is solely used by researchers whose objective is to gain an initial insight of the topic while the systematic review is more focused, replicable, and scientific. Thus, the methodology can be replicated when a systematic approach is applied due to the transparent nature of the process. For this thesis, a systematic literature review was used to the extent possible; Waller et al. (2016) claim that systematic literature review is not suitable for an abductive approach. Being an unexplored area, narrative review was used in the initial stage to get an understanding of the topic. But for a more reliably produced literature review the systematic approach was conducted.

Search engines Google Scholar and Chalmers library were solely used for the systematic literature review and adds to the reliability, more specifically due to other researchers being able to reproduce a similar literature review. However, case studies and articles were provided by my supervisors as well from internal sources which reduces the replicability but increases the validity as these are academics with deep knowledge of the topic. Keywords for the search engines were: urban freight challenges, smart cities, last mile delivery solutions, digitized supply chains, smart parking, IoT, Loading zone management. The outcome of the literature review helped the researcher to better grasp the topic and thus, create better methods to capture the data that was necessary to obtain. In practical terms several chapters were created from the outcome of the literature review.

- Smart City
- Supply Chains and Last Mile Delivery
- Challenges of Urban Freight and LZ
- Smart Parking

2.3.2 Empirical Data

In this section the secondary and primary data gathering methods will be described. Secondary data is data that has already been gathered for intentions that could be outside of the research scope and objective, while primary data is data that is actively collected during the research process (Waller et al., 2016). For the secondary data, an already conducted and recorded focus group was used, provided from the project team. For the primary data 7 interviewees were conducted, some of the interviewees were participants from the focus group as well.

2.3.2.1 Secondary Data - Focus Group

The empirical data was initially provided as secondary data from the project team in the form of a recorded focus group. A focus group is distinguishable from a group interview in the sense that it revolves around a discussion of a multifaceted topic that is usually societal (Waller et al., 2016). Multiple participants are involved in a discussion with a moderator that tries to steer the discussion on the right path and facilitate the discussion. Further, Waller et al. (2016) claim that the success of a focus group greatly depends on the moderator and if a focus group is held online then it will be much harder to keep the group interested into a discussion. According to Waller et al. (2016) a focus group is commonly analyzed on a group level with the rule of thumb of conducting at least two focus groups. The focus group took place during May of 2020 via Zoom and lasted for roughly 3 hours. This focus group was recorded as the researcher was not part of the project when this focus group took place.

Furthermore, there were in total 11 participants; from academia, a smart parking provider, two municipalities of different national origin, a Swedish logistics provider and a Swedish truck manufacturer. The objective of the focus group was to get insights from multiple perspectives of problems related to design, operations and usefulness of LZ and whether a smart LZ pilot study is feasible in Sweden. This recording was assessed and analyzed before gathering primary data for this thesis with the objective to see an initial trajectory of the micro and macro factors that influence the deployment and operations of LZs and smart LZs.

With regards to the quality of the focus group, it is of high validity due to being conducted by a host who is a professor within business administration and has experience with workshops/focus groups. This was conducted online which makes matters harder; however, most of the participants were engaged and there was a continuous discussion. However, Waller et al. (2016) explicitly claims that focus groups tend to be strong on validity as it incorporates multiple perspectives simultaneously. With regards to reliability, only one focus group session was conducted, thus from an initial standpoint the reliability can seem vague. However, some participants in the focus groups were interviewed which mitigates the low reliability in this case.

2.3.2.2 Primary Data - Semi Structured Interviews

According to Bryman (2012), there are three different types of interview forms, from unstructured, to semi-structured and structured interviews, with unstructured interviews having no prearranged questions to structured interviews where one asks the exact same questions to the interviewees in a standardized way. Further, Saunders et al. (2016) state that semi-structured and unstructured interviews are categorized as qualitative research methods due to their nature of having the potential to capture qualitative aspects that cannot be as easily obtained from a structured interview. Further, semi-structured interviews give a basis of questions that the interviewer can use to not deviate from the topic during the interview while following interesting sidetracks (Brikci, 2007; Bryman & Bell, 2011). Thus, semi-structured interviews were the chosen method. The interview questions were constructed based on the secondary data as well as from consultation with my supervisors in the project team. The objective with the interviews is to gain valuable and in-depth insights of the focus group participants’ perception and knowledge of urban freight and LZs. Four stakeholders were interviewed: one from the public sector and three from the private sector. A separate questionnaire targeting each stakeholder was prepared. The four sets of questionnaires can be found in the Appendix. The interviews were all conducted two-to-one with the researcher, a supervisor from the project team and the interviewee via Zoom and lasted between 45-80 minutes. The interviews were tape recorded with the participants' consent and before each interview, the interviewers gave a background to the subject and explained potential risks to the interviewees before starting the interviews. To increase the validity and reliability of the research, the researchers decided to record the interviews thus being able to fully engage and listen to the interviewees during the interviews. Things that seemed unclear during the interview when listening to the recordings were noted and emailed to the participants for clarification which adds to the validity. As there were two interviewers present, one focused on providing the question, whereas the other kept track of the time and unanswered questions which adds to the consistency of the measuring, and thus the reliability.

2.3.2.2.1 Sampling

Malterud, Siersma & Guassora (2016) claim that the sample size is dependent on the sample specificity. Thus, the more inclusion criteria that are incorporated the fewer number of participants are necessary. However, looking at the stakeholders of this project, there are four different stakeholders that reflect the different stakeholders in the focus group session; all these actors do have some role to play with regards to LZs but from different points of view. These stakeholder groups were chosen intentionally as the results can more easily be contrasted and create a consistency with regards to the data collection. In the initial stages of the sampling, participants were provided by the project team. From this point snowball sampling was used once and is defined by Bryman (2012) as a way to take advantage of the extensive network to gain relevant candidates. Snowball sampling was used for the interview with the municipality of Stockholm to get more detail of the processes of enforcement in Stockholm.

For this thesis, the plan was to conduct at least four interviews with the public sector and at least two with each of the other three stakeholders except the smart parking provider. This would give a total number of 9 interviews. To start off with the reasons behind these numbers, four participants from different municipalities with different national origins would be necessary to compare the differences and commonalities on a more global level; the underlying reason for this is also to compare the municipalities point of view to the existing literature review, as the literature review deals with multiple cities and municipalities across the world. For the smart parking provider, the project team had already created some form of collaboration with the smart parking provider Parkunload and in order to mitigate conflict of interest, it was decided to solely use a candidate which has been there from the start of Parkunload. For the logistics provider, the aim was to understand the operations and challenges the logistics provider in Sweden face, thus two logistics companies would suffice in order to understand their operations with regards to LZs as these are used more or less similarly for trucks and vans. For the e-cargo bike manufacturer, this was not initially planned, however, the participant from the e-cargo bike manufacturing company was also a logistics provider and could provide insights from this point of view as well. The researcher from the truck manufacturing company was chosen, due to being able to give a technological point of view that complements the smart parking provider because it is mostly trucks that use these LZs.

However, the interviews did not unfold as initially planned; 7 interviews were conducted, these are found in Table 1. Two planned interviews with the public sector were cancelled and none of the two logistics providers had the time to do an interview due to the current situation of covid-19 and the impact it has had on different supply chains at this moment. However, as the interviews are complemented by the focus group this had a minimal impact on the findings and research quality.

Table 1 - List of the participants for the interviews and those who participated in the focus group

Background and role of the interviewees	Participated in the focus group session
Manager – Logistics provider located in Gothenburg, Sweden	Yes
CEO - Logistics provider/Bike manufacturer located in Stockholm, Sweden	
Researcher - Truck manufacturer company in Sweden/Linköping University	Yes

Two urban strategists - Municipality of Stockholm, Sweden	Yes, one of them
Strategist - Municipality of Bogota, Colombia	
Senior consultant - Parkunload with multiple pilot projects around Europe	Yes

2.4 Data Analysis

The findings from the interview were thematically analyzed. Thematic analysis is defined by Waller et al. (2016) as a way to categorize the data into relevant clusters. The reason for a thematic analysis is due to the nature of the qualitative data and in using semi-structured interviews which could produce divergent results. This in combination with qualitative data being harder to organize compared to quantitative data. The thematic analysis thus helped the researcher to answer the research question more clearly and in an organized way. The software used to do the thematic analysis was NVivo, which facilitates the process of analysis by coding transcribed data from multiple interviews in relevant categories that can easily be compared.

The recorded focus group was analyzed without the software tool NVivo. First, an initial listening to the recorded focus group was made with some notes taken. The second time all the audio data was transcribed into text, including who said what. This text file was used to identify three parts:

- Introduction to the focus group which included the underlying motivation and goal
- The pilot study of Vic, a city in Spain, which has successfully adopted Parkunload's smart parking solution combined with insights from different stakeholders of their biggest challenges
- A wrap up of what is important to consider when planning a smart LZ pilot in Sweden

A similar approach was used for the conducted interviews; the recorded interviews were relistened to once to take general notes. A second listening was made in which the researcher transcribed the data. There were some language barriers for one of the interviewees; the interviewee decided to start speaking in their native language for some questions. Luckily, the supervisor knows the native language and translated this after the interview was conducted. The transcribed data was then uploaded to NVivo to identify several themes to include into the analysis. Each transcribed text from each of the interviewees was coded; this was done by reading through each interview question and answer, the answers were then marked and coded into a so-called node. A node in NVivo saves the marked sentence and can be given a name for example "Challenges of LZs"; further elaborating on this example, if one were to analyze another transcribed interview and find challenges then these can be referenced to the "Challenges of LZs" node as well. By doing this, one can easily get an overview of all the challenges faced by the different stakeholders with regards to LZs. The results and analysis section (Section 4) has subsections named after following topics.

- Sustainability challenges, being the greatest priority for most of the stakeholders
- Challenges of urban freight and LZs
- Suggestive solutions, ongoing projects to deal with these challenges and dream scenarios

3. Literature Review

This chapter will include four sections; the first section will explain the smart city concept and give a holistic overview of what cities strive to achieve in the future and further explain the role smart mobility plays in a smart city. Thus, this section will give the surrounding context of urban LZs and freight. The second section will investigate supply chains and last mile delivery, including the challenge of data visibility in supply chains which has to do with the data availability of the traceability of a good for the different actors in the supply chain; and the costly last mile delivery and where consumer trends are heading. The third sections will deal with several urban freight challenges and look more closely into challenges regarding LZs as well as some coping procedures to deal with these challenges. The fourth section will deal with smart parking for both commercial and noncommercial vehicles. The literature on smart parking is skewed towards passenger cars, solutions and initiatives for noncommercial vehicles will be brought up as well, alongside trying to define and classify smart parking. The section will include two tables, one for commercial (Table 5) and one for noncommercial (Table 6) vehicles, that tries to summaries initiatives, smart parking apps and procedures for smarter parking management. In Table 2, a summary of the key findings of the literature review is provided.

Table 2 – Summary of the key findings in the literature review

Section	Findings
Smart City	- The intelligence Community Open Architecture (i-COA) framework captures the essence of a smart city; it is built upon three layers, in which the first layer is the infrastructure, and the second two are innovative ecosystems and quality of life; the goal of a smart city is to increase the wellbeing for its citizens - IoT, Big Data, well developed infrastructural components alongside collaborate schemes are the backbone for a smart city transformation - IoT and Big Data; having capabilities to process big amount of heterogenous data, big data, to understand the cities needs and being flexible in regulating and fulfilling these needs. This requires IoT infrastructure which consist of hardware, connectivity, and big data storage/analytics - Smart mobility is a pivotal point to transform a city into a smart city due to its supporting functions in urban areas
Supply Chains and Last Mile Delivery	- Visibility, or traceability and availability, in supply chains is crucial; problem lies in information accuracy and providing real time data throughout the chain for relevant stakeholders; Logistics 4.0 can help cope with the visibility challenges - E-commerce is constantly growing in a rapid rate as seen in current and future forecasting consumer trends - Last mile delivery stands for the biggest chunk of the transportation cost as these vary due to route/travel time. - The future of last mile delivery; require shared software for faster technological adaptation - Half a decade left before most of the transformational technologies such IoT and digital traceability fully mature
Challenges of Urban Freight Parking	- Urban freight is a fundamental part of the economic vitality of a city

	- Urban challenges include congestion, scare space, misuse of LZs, pollution, increased demand for goods and services with an increase in population
	- Three underlying reasons for urban freight LZ challenges: Mismatch between supply and demand of LZs, LZ policies not adequate, continued scarce space with an increase of population and increased need for transportation
	- Four strategies for LZ policy; time restriction, pricing strategies, space management and parking enforcement.
	    - parking enforcement is important, especially when there are well-articulated regulations that need to be followed
	        - One can use city staff or technology such as scan-cars to increase the parking enforcement
	    - Cope with misuse of LZs by either a booking systems or physical barriers

Smart Parking	- Smart parking is defined as "*a way to help drivers find more efficiently satisfying parking spaces through information and communications technology"* - The literature of smart parking is highly diversified, with solutions being skewed towards passenger cars and noncommercial vehicles. - Smart parking is classified in three macro themes: information collection – capture data via sensor technologies; system deployment – related to software, scalability and data analytics; service dissemination – deals with social aspects such as behavior and parking competition - For a summary of smart parking initiatives and apps, visit Table 5 (noncommercial vehicles) and Table 6 (commercial vehicles).

3.1 Smart City

In this section the smart city concept will be explained. This section will provide the reader with the contextual background of what smart cities strive to achieve and what this in turn requires. The backbone for a smart city will be presented and includes Big Data and IoT infrastructure. Lastly, smart mobility in the smart city context will be explained.

According to Appio et al. (2019) smart cities are becoming increasingly pervasive in many communities worldwide. Further, Appio et al. (2019) and O'Grady & O'Hare (2012) state that there are multiple definitions of a smart city and that the term is used inconsistently in the literature. Down below are two attempts to capture the essence of what a smart city strives to achieve:

"Provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration amongst different economic actors and to encourage innovative business models in both private and public sectors" (Marsal-Llacuna et al., 2015).

"A smart city is where investments in traditional infrastructure, social development and ICT fuel sustainable growth and a high quality of life" (Caragliu, Chiara del Bo, and Peter, 2011)

This is then supplemented with Albino et al. (2015) who claim that the underlying engine to achieve this smart city is by incorporating information technology and human capital. The information technology is e.g., sensors, data analytics, interconnected devices and IoT, whereas human capital refers to public institutions, universities, and R&D-heavy companies. These two are then categorized as “hard” and “soft” smart city strategies. Moreover, Dustdar et al. (2017) emphasizes that most of the literature is heavily focused on the infrastructural aspects. One framework that captures a holistic perspective of smart city is the “intelligence Community Open Architecture” (i-COA) framework by Bill Hutchison (Appio et al., 2019; Giffinger et al., 2007). It emphasizes three dimensions: quality of life, innovative ecosystems, and infrastructure. The i-COA framework is depicted in Figure 1; the lower two levels are the “hard” aspects, and the three upper levels are the “soft” aspects. The essence of this framework is communicated by the hierarchy in which every initial building block of creating a smart city should start from the physical infrastructure. Thus, the hard aspects are the foundation for the soft aspects of creating an innovative ecosystem with an increase of the quality of life.

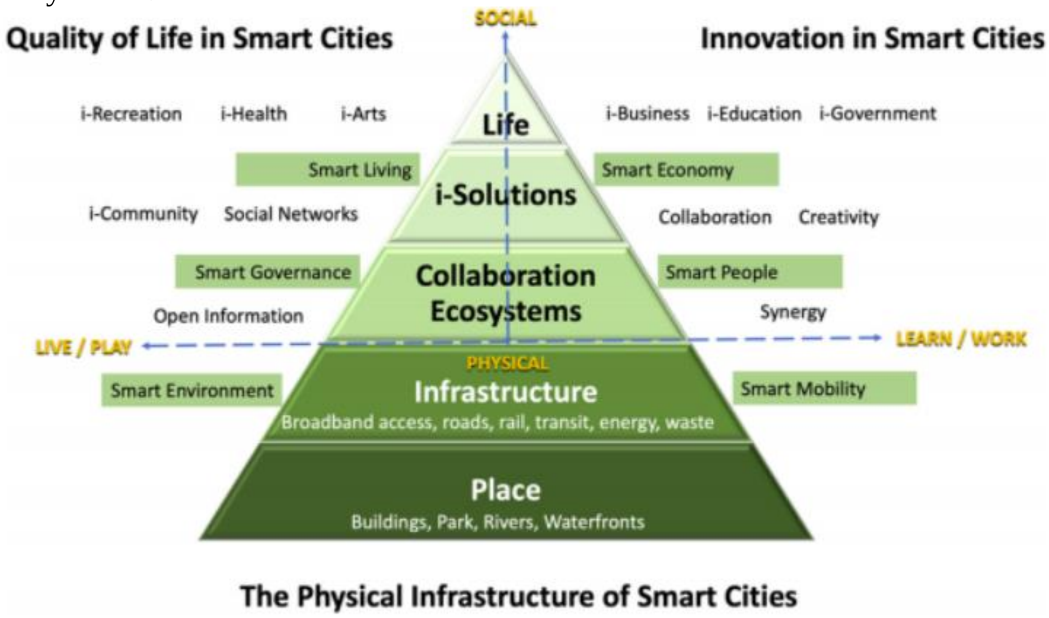

Figure 2 - An adaptation of Hutchison’s i-COA framework highlighting Giffinger’s smart city elements (Appio et al., 2019).

The physical infrastructure refers to anything physical, electrical, and digital, whereas in conventional terms physical would be associated with buildings, roads, etc. A study made by Suzuki (2017) showed that roughly 200 000 people migrate to already densely populated cities around the world every day. It is predicted that by 2050 more than 70% of the world population will live in urban areas (Mohanty, 2016). This in turn puts a tremendous toll on the infrastructural aspects, more specifically housing, energy in terms of electricity and heating and transportation systems. According to Ijaz et al. (2016) expanding in the traditional sense with regards to the infrastructure will not suffice rather smart solutions are required; by leveraging smart networks such as the Internet of Things and Big Data the environmental, social, and economic impact can be minimized.

3.1.1 The Backbone of Smart Cities - Big Data and IoT

“Big data offer the potential for cities to obtain valuable insights from a large amount of data collected through various sources, and the IoT allows the integration of sensors, radio-frequency identification, and Bluetooth in the real-world environment using highly networked services.” (Hashem et al., 2016)

3.1.1.1 Big Data

Hashem et al. (2016) claims that different smart city applications continuously produce large amounts of heterogeneous data as the smart city transformation leads to an exponential increase in data produced. There are a several different but unambiguous definitions of what Big Data is; Michalik et al. (2014) defines it as *"Data, coming from everywhere; sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction record, and cellphone GPS signal to name a few".* Further, Hashem et al. (2016) state that Big Data requires non-conventional databases and computing technologies due to the inadequacy of the processing power and storage of current database systems. Al Nuaimi et al. (2015) claim cloud computing can help challenges that come with Big Data. Elaborating on this, Mell and Grace (2011) describe Cloud computing as a variety of different computing models with multiple computers and clusters connected in real-time communication networks. Mell and Grace (2011) further explain that this type of cloud computing can deal with large and heterogeneous computing tasks, Big Data, and give an example of being able to extract and analyze social network data from different smartphone applications. Hashem et al. (2016) emphasis that tools beside computing power required to handle Big Data are collaborations between different stakeholders. Hashem et al. (2016) explains the application of Big Data in smart city context; it helps decision makers with the overall expansion and planning of resource allocation and to continuously improve and adapt to the dynamics of a city (Hashem et al., 2016).

3.1.1.2 IoT

IoT is a network of physical objects called Things that with the pervasive nature of the internet, not being solely for computers but for technological devices such as smartphones, vehicles, wearable devices, cameras and industrial systems, can be connected and exchange information to achieve more safe and efficient operations in a more interconnected world (Patel, 2016). IoT is not a single technology, rather a cluster of hardware and software that leverages information communication technology, ICT, to store and process information from big streams of real-time data, Big Data (Atitallah et al., 2020). Al-Fuqaha et al. (2015) state that a high level of technological integration and IoT is essential for the development of a smart city. Furthermore, Corradi et al. (2016) argue that actuators and in particular smartphones have a huge role for IoT as well besides sensors due to these two devices being interconnected and can exchange information via the internet. Further, Al-Fuqaha et al. (2015) explains that the IoT's roll is about having installed sensors such as Radio Frequency IDentification (RFID), Infrared (IR), Global Positioning System (GPS) and laser scanners connected to the internet and integrated into the surrounding urban infrastructure in order to track, monitor, locate and manage smartly. Prasanna and Hemalatha (2012) state that efficient transportation can be achieved by combining GPS systems with RFID technology; the RFID identifies the goods whereas the GPS keeps track of the operator; combining these can provide real-time data for different stakeholders simultaneously.

3.1.1.2.1 IoT Architecture and Applications

Atitallah et al. (2020) further divides the IoT architecture into four layers: hardware, connectivity, Big Data storage and analytics and IoT applications as seen in Figure 3. Hardware is composed of sensors and actuators. The objective of the sensors is to capture data whereas actuators are meant to transform the electrical signals into ponderable actions. The next layer is connectivity that transports the information from the hardware to the analytical level; examples of these are RFID, Wi-Fi, and Bluetooth. Within the third layer, Big Data storage and analytics, data is stored and analyzed. Within data analytics, there are three major types; descriptive, predictive and prescriptive; descriptive analytics is used in traditional businesses to historically measure previous achievements and compare these to the current performance, the objective of this kind of analytics is mainly to draw conclusions; predictive analytics is used by extracting big amount of raw data with the objective to find patterns to predict certain events of interest; lastly prescriptive analytics takes this a step further by being able to provide a quantifiable impact of a certain decision and thus suggest recommendations to make better decisions. Lastly, there are IoT applications; the features that IoT provides in a smart city is intelligence, interconnection, and instrumentation; thus, IoT creates a path of feasibility to a smart city (Ijaz et al., 2016). A few examples of applications of IoT in smart cities are listed below (Patel, 2016):

- *Safety: Digital video monitoring, fire control management, public announcement systems.*
- *Transportation: Smart Roads and Intelligent Highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.*
- *Smart Parking: Real-time monitoring of parking spaces availability in the city making residents able to identify and reserve the closest available spaces*

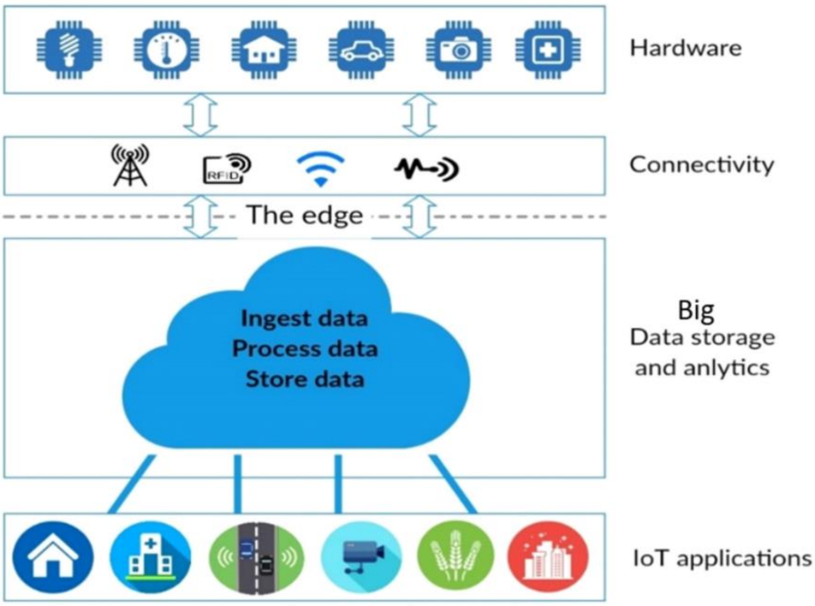

Figure 3 - IoT architecture with four layers including hardware, connectivity, Big Data storage/analytics and IoT applications (Atitallah et al., 2020)

3.1.2 Smart Mobility - Pivotal for Smart City Transformation

Referring to Figure 2, there are two dimensions: smart mobility and smart environment. Appio et al. (2015) explains from the framework how IoT can be used to rescue the environmental footprint in smart cities; from agriculture in which one can measure soil conditions amongst other things via sensors to energy distribution in which real-time data is used coupled with statistics to optimize the use of energy. Smart mobility is the second dimension and perhaps one of the biggest motivations for smart cities in the first place according to Manville et al. (2014). The difference between mobility and smart mobility is the access to real-time data that helps save time by more adaptable services and reduce carbon footprint (Manville et al., 2014). Van Audenhove et al. (2013) state that smart mobility is a pivotal point for the transformation into a smart city to occur. According to Dameri and Ricciardi (2017) congestion in urban areas is a big challenge. Solutions to this exist such as autonomous vehicles, shared car ownership and sensors being placed in every infrastructural component such as roads, bridges, and subways to provide data to make e.g., parking smoother to improve transportation. However, improving traffic is not the sole purpose of smart mobility as Aleta et al. (2017) argue; smart mobility covers both the transportation of people and goods in which the goal is to facilitate the mobility of the users; the users being pedestrians, cyclists, public or private transport vehicles and this is to reduce the time, cost, and the environmental impact. Neirotti et al. (2014) argue that smart mobility aims to create innovative and environmentally friendly transport systems for people and goods but also change in the proactive behavior of citizens. In the i-COA framework, Figure 3, Quality of Life is emphasized; Aleta et al. (2017) state that this should be the priority with regards to Smart Mobility as well, to increase the wellbeing of citizens.

3.2 Supply Chains and Last Mile Delivery

In this section the importance of supply chain visibility will be dealt with alongside consumer trends and last mile deliveries; where the current system stands and is headed. These are all components that have an indirect impact of freight operations thus, these will be crucial to explain in general.

3.2.1 Data Visibility in Supply Chains

Business models that were previously suitable for supply chains are starting to fail due to the dynamic changes in the market; change is inevitable however, the change that is occurring is accelerating according to Christopher (2011) which requires adaptable networks. Christopher (2011) and Barrat & Oke (2007) argue that one of the biggest challenges within supply chain management has to do with visibility; companies lack the visibility of real-time demand which creates difficulties when matching supply with demand. It has been shown that increasing the supply chain visibility can lead to improved responsiveness, planning, decision making and improved quality of the service and product (Mentzer et al., 2004; Kent & Mentzer, 2003). The source to this challenge lies in what Christopher (2011) calls information complexity in which different stakeholders related to a supply chain network exchange information. However, the problem of this information is not the information itself but the accuracy which can cause misinterpretation. Further, Christopher (2011) states that in order to mitigate this, transparency between different stakeholders in the network of supply chains is crucial. RFID technology is an application that has been used in different supply chains to provide visibility of moving products (Prater et al., 2005).

3.2.1.1 Logistics 4.0 – Facilitate Visibility in Supply Chains

Logistic 4.0 stems from the term Industry 4.0 which according to Barreto et al. (2017) encompasses the leveraging on technological innovations combined with Information technology into the industry. The core concept is to use cyber physical systems (CPS) which is a set of computing and communication systems that help control, monitor, and coordinate physical operations. Logistics 4.0 mimics the contributions of CPS and what it brings to the table in Industry 4.0. Logistics 4.0 can be divided into five technological applications, amongst these are Transportation Management Systems (TMS) and Intelligent Transportation systems (ITS). Barreto et al. (2017) state that a TMS is, with the help of IoT, a crucial aspect in logistic 4.0; TMS can help logistics providers and adjacent stakeholders to track and monitor freight vehicles with the use of GPS and thus it facilitates the visibility aspect in the supply chain. TMS is further a subset or an application of ITS; besides positioning systems, ITS incorporates sensors, telecommunications technology, data processing and data visualization. An ITS will be necessary for supply chains to function on a global scale. Traffic management systems and vehicle data collection are all applications of ITS. Further, Barroto et al. (2017) state that a fully operational ITS can be used for intelligent truck parking and delivery.

3.2.2 Consumer Trends

From a consumer perspective, visibility is an important factor along with speed and accuracy (Nisar, 2017). Consumers of products and goods are becoming more demanding for people in the urban areas. An increase of e-commerce businesses worldwide has led consumers to a change in their behavior; being more selective and demanding to when and where ordered goods and services should be delivered (Holgersson, 2017). Postnord has observed the e-commerce trend the past 11 years; the increase of e-commerce is thanks to the purchasing frequency online. Roughly 62% of Nordic residents in Norway, Sweden, Denmark, and Finland shop online on a monthly basis during 2019 (Postnord, 2019). 50% of the Nordic residents purchase via their phones due to the increase of fintech services such as Klarna checkout and Instagram checkout which makes it convenient to purchase online. In Table 3, different delivery methods are depicted. The most common delivery method across all Nordic countries are service points, however, it is worth mentioning that the delivery method is dependent on the nature of the product; it is not usual for furniture and bulkier goods being delivered to a service point.

Table 3 - Most common delivery methods in the Nordic countries - Sweden, Denmark, Finland, and Norway (Postnord, 2019).

	Nordic region	Denmark	Finland	Norway	Sweden
Delivery to distribution point	54%	32%	52%	61%	64%
Delivered to mailbox/ multi-occupancy mailbox	17%	11%	14%	24%	19%
Home delivery outside the door (no signed confirmation)	7%	18%	4%	4%	5%
Daytime home delivery (with signed confirmation)	5%	8%	6%	3%	3%
Collected from parcel machine	5%	14%	12%	0%	1%
Collected from a physical store	2%	2%	3%	3%	2%
Delivered to workplace	1%	3%	1%	1%	0%
Evening home delivery (with signed confirmation)	1%	0%	1%	2%	2%

3.2.3 First and Last mile Delivery

Macioszek (2018) states that when it comes to freight transportation the first and last mile delivery are the costliest due to the variation of delivery time and route from warehouses to different delivery points. According to Sanchez-Diaz et al. (2020), driving only stands for 30% of the time, 15% is spent on breaks for the operators and the remaining 55% is spent on activities such as unloading/loading, customer service and planning. Furthermore, Sanchez-Diaz et al. (2020) claim that heavier or lager trucks are more efficient with regards to volume delivered per truck compared to medium duty vehicles, which leads to capacity sub-utilization. With regards to urban logistics, rail networks and container ships are the most cost-effective according to Wang et al. (2016). However, last mile delivery from warehouses can stand up to 28% of the total shipment cost. Furthermore, the fact that most customers are not present when goods are delivered causes the operators to reattempt-delivery several times which is one of the biggest challenges in logistics and a major cost-driver (Wang et al., 2016). Furthermore, it is important to distinguish between parcels and freight delivery; while parcels come in small packages, freight items weigh more than 32kg and are typically furniture or are related to store replenishment (World Economic Forum, 2020). In a study the finding emphasizes that freight delivery, in relation to parcels, account for 85% of delivery mileage and therefore has disproportionately higher effect on CO_2 emissions and occurring congestion in urban areas.

3.2.3.1 The Future of Last Mile Delivery

Supply chains of the future and how things operate will inevitably change as technology advances. A report from the World Economic Forum (2020) shows how the underlying technology time before it fully matures. As seen in Table 4, most of the technology except autonomous vehicles and drones are 2-5 years away to fully mature. Some interventions to mitigate CO_2 emissions and congestions are applied today; dynamic rerouting, electric vehicles, parcel lockers and double-parking enforcement are such interventions. It is stated that double parking enforcement can help mitigate double parking in urban areas and thus reduce overall congestion with up to 29% (World Economic Forum, 2020). For dynamic rerouting emissions can be reduced 10% while unit cost and congestion by up to 30%. For an accelerated technological application to take place, it is stated that different players, in particular automotive OEMs, logistics providers and infrastructure providers need to get invested in shared software which can be done via increased Merger and acquisitions activity or increased partnership between different actors (World Economic Forum, 2020). To finish this section off, OECD (2018) provides a vision for the future operations of LZs and last mile delivery:

"In the future, the street (and the curb) should be self-aware and self-coordinating mixing sensing technologies and flexible, on-the-fly, adjustments enabled by design for multiple, rather than single, uses. Curb-space becomes a flex-use zone that adjusts over the course of the day based on demand and desired outcomes" (OECD, 2018).

Table 4 - Current maturity level and time to full maturity for several technologies (World Economic Forum, 2020)

Technology	Current maturity	Time to full maturity
Internet of Things	50%	2-5 years
Self-operating vehicles/drones	25%	6-10 years
Artificial intelligence	50%	2-5 years
Robots	75%	2-5 years
Digital traceability	75%	2-5 years
AR/VR	75%	2-5 years

3.3 Challenges of Urban LZs

In this section, focus will be more on commercial vehicles, more specifically trucks and vans and their relation to LZs as these should be the prime users of LZs. LZs are parking spaces usually on the curbside that should primarily be used by commercial vehicles for loading and unloading activities of freight (Munzuri et al. 2017). According to Nourinejad et al. (2014), previous literature has been heavily focusing on passenger vehicle parking management and significantly less on commercial vehicles. At the same time looking at the transportation industry, roughly 30% of all the CO_2 emission is generated from this industry in the EU region (Navarro et al., 2016). This section will include challenges of urban freight related to LZs, more specifically the mismatch between supply and demand; scarce space leading to, amongst other things, misuse of LZs; policies regarding LZs in which four policy strategies will be explained alongside diving deeper into parking enforcement and lastly, some coping strategies to deal with the misuse of LZs.

"Logistic operators often point out difficulties in accomplishing their delivery tasks: there may be insufficient space for delivery operations, available bays may be quite far from delivery points (e.g., shops) or such spaces may be occupied by non-authorized vehicles (e.g., private cars)." (Comi et al., 2018)

Comi et al. (2018) captures the essence of today's challenges with regards to LZs in urban areas. Further, urban freight has long been a fundamental part of the economic vitality of a city (Navarro et al., 2016). The parking aspect of freight vehicles is a key challenge for freight operations in urban areas; with an increasing population and increasing demand for goods and services of citizens coupled with scarce space will inevitably make the last mile delivery a demanding challenge to solve (Nourinejad et al., 2014). According to Nourinejad et al. (2014) there is a distinct reason for why commercial vehicles have a significantly greater impact on congestion, pollution and illegal parking; commercial vehicles have planned routes with multiple stops in which they have to park at each stop whereas passenger vehicles stop when the final destination has been reached. Besides this, commercial vehicle operators have different behavior as delivery time is seen as a cost, operators have greater incentives to park illegally than searching for nearby LZs (Nourinejad et al., 2014). Nourinejad et al. (2014) further explain that truck operators that do not find any appropriate parking areas either park illegally by double parking or keep driving around wasting time, generating unnecessary noise and emissions. Kawamaru et al. (2014) claim that illegal parking of freight vehicles for parcels is the third leading cause congestion in urban areas. Taking all these factors in consideration makes the last mile delivery the most expensive part of the urban freight (O'Laughin et al., 2008).

There are three underlying problems of urban freight LZs; firstly, inadequate policies that do not enforce the proper way of using LZs, this includes misusing freight space e.g. when noncommercial vehicles park or freight vehicles park illegally, double parking and parking beyond the time constraints (Alho et al., 2014). Secondly, there is a lack of actual LZs planning and design, which refers to the number, size, and location of LZs; Malik et al. (2017) elaborate on this as a mismatch between supply and demand, meaning that the logistics companies' route when to drive where is not optimized as the demand is high during certain hours, seasons, and days of the week (Malik et al., 2017). Thirdly, scarce space for parking which leads congestion, pollution, and noise and to local authorities being under pressure to, not only increase the number of passenger parking spots, but the number of LZs as well. These three factors will be further dealt with in the rest of this chapter.

3.3.1 Mismatch Between Supply and Demand of LZs

With regards to demand models, Malik et al. (2017) highlights the quantitative difference in passenger car parking demand models in comparison to freight parking demand models in the literature. Malik et al. (2017) divides parking-demand models in parking-search models and parking-choice models. The former deals with making parking decisions based on gathered information about parking alternatives and the latter is about drivers' response and preferences for a specific parking alternative. For car parking choice models the most important factors are walking distance, cost, search time, duration of parking, occupancy, and the probability to find a vacant spot. For the parking choice model of freight, the predominant factor of choice is the distance from the parking spot to the destination (Nourinejad et al., 2014). Diving deeper into the demand aspect, Malik et al. (2017) studied urban streets in Gothenburg in which their findings showed that 18 out of 22 streets were deficient in space. Further, 5 out of 10 LZ bays were occupied by waste bins. Two peak interval hours were identified: between 12 am to 1 pm and 2 to 3 pm with a total average parking duration of 13 minutes. However, Malik et al. (2017) state that there is a low occupancy of LZs and that this is due to inappropriate locations. Further, LZs that are located at the intersection of roads are preferred than LZs in the middle of a road section. Furthermore, Malik et al. (2017) state that previous studies have shown that the LZs in Gothenburg, in Sweden, are occupied less than half of the time during 8 am to 5 pm. Looking at the seasonal variation, occupancy drops during winter due to weather conditions which makes it difficult to maneuver vehicles thus cars park with greater distance from the curbside and further makes it difficult for freight vehicles to park. Drivers were interviewed and 64% of these drivers stated that LZ bays are insufficient quantitatively (Malik et al., 2017).

For the supply of LZs Dezi et al. (2010) and Pinto et al. (2016) have studied how to optimize the design and location of LZs based on the demand and business activities within a certain region. Munzuri et al. (2017) state that there are no clear methodologies to design and manage LZs which leads to city authorities taking decisions based on intuition without a hard data of the demand. Comi et al. (2018) states that for these challenges, the first step for a city should be to gather and analyze data on delivery requirements such as flows and operation duration. One of the issues when looking at a street in Gothenburg was the size of the LZ, as Malik et al. (2017) highlight, is the size of a LZs in a particular street is 15 m long and can fit two 6 m long trucks however, the number of trucks that can park depends greatly on how the first truck parks.

3.3.2 Scare Space in Urban Areas

Space scarcity is seen as one of the biggest issues with regards to urban areas and the transformation into smart city, this is in particular with regards to parking space for commercial vehicles (Al-Turjman & Malekloo, 2019). Furthermore, a continued increase in the number of vehicles coupled with a limited number of parking spaces in urban areas has led to an ever-increasing congestion which will inevitably pollute the air and lead to idle time searching for parking thus wasting time (Bibri, 2018). In big cities like New York, Los Angeles, London and Tokyo parking spaces occupy on average 31% of the urban areas, it is particularly high for Los Angeles which has a parking space occupancy percentage of 81% (Lin et al., 2017).

3.3.3 Policies for LZs

Malik et al. (2017) state that parking policies are a considerably strong measure one can take to manage travel demand patterns in urban areas. Further, the authors state that there is a wide variation and difference in urban freight policies depending on what country, city or region one observes. Comi et al. (2018) state *"the effectiveness of an implemented delivery system depends greatly on regulations that govern its management and operations control".* Additionally, Zalewski et al. (2011) state that curb space management policies have a great effect on traffic congestion and business vitality. Policy makers have in the past tried to control the parking turnover by using time limits and parking meters (Nourinejad et al., 2014). The author explains that parking meters can help relieve curb occupancy by removing passenger vehicles to off-street parking; Nourinejad et al. (2014) thus claims that the passenger vehicles policy has an indirect effect on the operations of freight vehicles. Further, it is stated by the author that any policy that creates free curbside space leads to an operationally better freight on-street parking. Sanchez-Diaz et al. (2020) state that in urban areas, regulations aim at having more livable cities which often comes as a compromise in form of restriction on transport operators.

3.3.3.1 Four Parking Policy Strategies

Nourinejad et al. (2014) further discuss four parking policy strategies for freight from case studies: time restrictions, pricing strategies, space management and parking enforcement. Time restriction is concerned with the time of the day certain vehicles can park. Time restriction strategies has been employed in New York, in which the Transportation Department of NYC had data that showed that 65% of all deliveries occurred before 12 PM, thus policy makers granted exclusive parking for freight vehicles earlier during the day and later for passenger vehicles. With regards to pricing strategies, dynamic pricing is an approach in which the parking fee increases with increasing demand for parking spaces. However, there are also Muni-meter programs with an exponential increase in price with time; in New York, this system is used in which 1h hour costs 1 USD, 2h costs 5 USD and 3h costs 9 USD. Nourinejad et al. (2014) state that this strategy has decreased dwell times with 45-160min. Looking at space management, Washington has been extending their LZs by more than 2-fold in length whereas New York has been reserving parts of the curbside for commercial vehicles solely.

3.3.3.2 Parking Enforcement

Lastly, parking enforcement initiatives are in place to make sure parking regulations are followed. According to Marucci et al. (2015), parking enforcement becomes even more important when parking regulations are articulated, this is clearly the case during peak hours when violations are more likely to occur. Furthermore, Marucci et al. (2015) state that enforcement requires monitoring which can either be by city staff or with the help of technology such as license plate recognition software or cctv cameras. In Los Angeles the transportation department has a parking enforcement program called “Tiger Teams” consisting of ten tow trucks and fifteen traffic control officials that are deployed during peak hours in the city. According to Nourinejad et al. (2014) the program has decreased the number of illegally parked vehicles. In Gothenburg, policy makers have been more focused on parking policy for cars and bicycles (Malik et al., 2017). Furthermore, Malik et al. (2017) state that freight policies are inclusive which implies that the involvement of different stakeholders is preferred when dealing with freight distribution in the city of Gothenburg.

3.3.3.4 Two Ways to Cope with LZ Misuse

Mor et al. (2020) brings forth a potential solution to deal with the misuse of LZ that causes e.g., double parking; by introducing a booking system, LZs can be regulated. This booking system should be controlled and monitored by the municipality with compulsory booking from the distributors. However, there are challenges due to timing and whether an operator will check in and out accordingly (Mor et al., 2020). Marucci et al. (2015) suggest physical barriers to enforce delivery regulations; these physical barriers could include, amongst other, roadway design, gates and bollards that are either stationary or removable.

3.4 Smart Parking

One of the components of ITS is smart parking which is defined by Lin et al. (2017) as *“a way to help drivers find more efficiently satisfying parking spaces through information and communications technology*”. However, in this definition Lin et al. (2017) focus on noncommercial vehicles when referring to “drivers”. Smart parking systems are deployed today and rely on real-time data gathered via different types of sensors. Sensors like RFID which have been placed in parking spaces and reports the presence/absence of a vehicle with different levels of success as will be explained further below (Al-Turjman & Malekloo, 2019). Lin et al. (2017) argue that literature on smart parking is very diversified with regards to solutional orientations, thus it is recommended to take a transdisciplinary approach which classifies smart parking into three macro components: information collection, system deployment and service dissemination. Each of these macro components further involves several components which will be explained below. The section will end with two tables, Table 5 and Table 6, each to summarizing initiatives, smart parking apps and procedures for smarter parking management; Table 5 is for noncommercial vehicles and Table 6 for commercial vehicles.

3.4.1 Information Collection

The first macro-component Lin et al. (2017) describe is Information Collection which is related to sensing technologies and how parking space status can be regularly updated for drivers. This is mainly by two overall stages: firstly, identification and then transmission of information that has been identified. Components of the parking information collection is information sensing, sensor connectivity, parking meter, crowdsensing and gaparking. Information sensing can either be stationary or mobile; there are two different Smart parking systems in San Francisco: SFpark and ParkNet. ParkNet has no pre-installed sensors rather the car is equipped with ultrasonic sensors coupled with a GPS. SFpark has a wireless stationary sensor at each parking spot which collects real-time data and displays this on a smartphone app for drivers (Mathur et al., 2010). Infrared sensors, cameras and acoustics can all be used as sensing measurement however, it is not whether or not the technology and its objective would be feasible rather the cost of investing in such infrastructure of thousands of stationary sensors (Lin et al., 2015). The investment cost for SFpark was around 25 million USD. Lastly, with regards to information sensing, each sensor comes with their advantages and disadvantages depending on the setting (Abdullah et al., 2013). Further, Abdullah et al. (2013) claim that RFID readers, which have previously been described, are common to install in parking spaces.

Sensor connectivity is focused on networks that transmit the information; Lin et al. (2017) explain that there is short range communication such as Bluetooth and long-range communication which could be cellular technologies. Lin et al. (2017) claim that parking meters are heavily overlooked with regards to smart parking systems. Parking meters can be used as facilitators for drivers as it links parking data to the drivers. Xerox had a smart parking initiative with parking meters in which the drivers could reserve a parking spot via an app (Isaacs & Hoover, 2013). Crowdsensing stems from the term crowdsourcing which is a way to utilize drivers via smartphone apps. Initiatives such as PhonePark, Pocketparker and Park Here! use the drivers' smartphone GPS coupled with an accelerometer to decide whether the driver is parking or unparking (Stenneh et al., 2012; Salpietro et al., 2015; Nandugudi et al., 2014). 3D compasses in smartphones can also be used similarly to GPS and accelerometer, these can also tell if there are adjacent parking spots (Villaneuva et al., 2015). These approaches are more economically beneficial. However, according to Chen et al. (2012) there are four distinct problems with smartphone crowdsensing: free riders, low participation rate, information accuracy and lastly privacy consent when extracting data from users. The idea of gaparking stems from platform technology like Spotify and Uber in which it allows peer-to-peer transactions where producers and consumers can interact directly. Gaparking helps utilize unoccupied parking spots. Private parking spot owners can put their parking space on an app for drivers that need to park nearby. Mobypark, in continental Europe, and JustPark, in the UK, are popular gaparking apps that currently exist (Lin et al., 2017).

3.4.2 System Deployment

System deployment concerns everything that is related to software and data analytics to predict unoccupied parking spots and scalability of smart parking systems. Large scale deployment has already been discussed in terms of how data and information can be collected. For large-scale deployment three different approaches exist, either mobile sensing (e.g. crowdsensing) via smartphone apps or stationary sensing via short-range or long-range communication (Lin et al., 2017). Lin et al. (2017) claim that one approach over another cannot solely be judged based on the success without the consideration of the cities' context.

SFpark and Los Angeles Express park are two smart parking systems with success. Nice, a city located in France, initiated a 15 million USD smart parking system with thousands of sensors divided between 13 areas. A smartphone app was introduced and with the help of the sensors, drivers could check the occupancy of parking spots via their smartphones. Still, most drivers were not satisfied by the smart parking system in Nice, this is due to novel implementation and the uncertain behavior of the drivers. According to Souissi et al. (2011), designing a robust user interface is detrimental. For parking vacancy prediction there are several different forecasting models for parking demand; the most common model is using historical data to predict parking occupancy. Neural network and regression trees have been used for SFpark (Zheng et al. 2015).

3.4.3 Service Dissemination

Service Dissemination focuses on the social aspects and is composed of three components: information dissemination, parking competition and driver behavior. Information dissemination has already been dealt with, thus the focus will be on parking competition and driver behavior. With regards to parking competition SFpark and LA ExpressPark have implemented a dynamic pricing policy which implies that the price is determined based on the occupancy or as Lin et al. (2017) states, intensity of the competition. Dello'Orco et al. (2005) studied different pricing policies and found the dynamic pricing model helps to artificially match supply with demand for parking spaces and also be able to tweak the pricing to keep a certain level of occupancy. There are several factors that influence the choices a driver makes with regards to parking spots. A study made by Channiotakis and Pel (2015) showed that the most important aspects of deciding where and whether to park was parking cost, parking availability and the distance from the parking to the end-destination by foot. Furthermore Rui-song et al. (2009) studied two groups of drivers, one group had insufficient information about the parking space whereas the other had complete information. Both groups were assigned to park their cars and the findings showed that the uninformed group were less sensitive to the walking distance and more on the parking cost compared to the informed group.

3.4.4 List of Smart Parking Initiatives and Apps for Passenger Cars

Table 5 – Smart parking apps and initiatives with their location, description, and comments. N/A means that either data could not be found or there is nothing else to add.

Smart parking apps and initiatives	Location	Description and type of sensors/technology used	General comment
Sfpark	Used in San Francisco mainly, US	– Sfpark has a wireless stationary sensor at each parking spot which collects real-time data and displays this on a smartphone app for drivers	- Investment cost of 25 million USD - Stationary sensors mounted to the ground - Has been a very successful smart parking deployment since

			2014
ParkNet	Deployed in multiple cities in Canada	– ParkNet has no pre-installed sensors, the car is equipped with ultrasonic sensors on the side of the car coupled with a GPS	- Mobile sensors used on the drivers cars
Xerox's PARC	Los Angeles, US	– Smart parking initiative with parking meters, stationary sensors, in which the drivers could reserve a parking spot via an app	- N/A
PhonePark	Mainly in Chicago, US	– PhonePark tracks the driver's spatial and temporal position in relation to pay boxes by utilizing GPS and accelerometer of smartphones – Mobile sensors are used	- Categorized as crowdsensing technology which does not require any external sensors
PocketParker	Mainly in New York state, US	– Uses the drivers' smartphone GPS coupled with an accelerometer to decide whether the driver is parking or unparking – Mobile sensors are used	- Categorized as crowdsensing. - Able to predict parking lot availability with 94 accuracy
Park Here!	In big cities of Germany	– Uses the drivers' smartphone GPS coupled with an accelerometer to decide whether the driver is parking or unparking – Mobile sensors are used	- Categorized as crowdsensing
LA Express Park	Los Angeles, US	– Similar to Sfpark – Stationary sensors are used	- N/A
Initiative in Nice	Nice, France	– Thousands of sensors deployed between 13 areas; drivers could check the occupancy of parking spots via the smartphone app – Stationary sensors	- 15 million USD smart parking system. Still, most drivers were not satisfied due to poorly designed interface
MobyPark	Continental Europé	– Gaparking app that helps utilize unoccupied parking spots. Private parking spot owners can put their parking space on an app for other drivers that need to park nearby.	- Categorized as gaparking - There are a limited number of gaparking apps for smart parking

			- Low market acceptance
JustPark	UK	– Similar to MobyPark	- Categorized as gaparking - Has had low market acceptance
Parking.sg	Singapore	– Drivers can see occupancy level and pay via the app – Stationary sensors are used and are mounted onto the ground	- The city has parking elevators which in cars can park vertically - Parking.sg has had a high market acceptance in Singapore
ParkingMosman	Sydney, Australia	– Provides drivers with real-time data of parking availability via the app – Stationary sensors are used	- A widely used and successful deployment in Sydney
Initiative in Chile	Chile, Santiago	– Parking app that provides real-time data and where drivers can pay via the app – Stationary sensors are used	- Resulted in a 30% decrease of congestion and drivers being enabled to find parking spots 20% faster; further, 4 out of 5 users are satisfied with the system

Sources: (Calder, 2016; Purahoo et al, 2019; Juliadotter, 2016; Aguila, 2019)

3.4.5 Urban LZs Initiatives for Freight Vehicles

In the previous section, focus has been on noncommercial vehicles, in this section the focus will be on commercial vehicles, initiatives and measures taken for LZs on a global scale as well as diving deeper into a case study by Dey et al. (2019). At the end of this section Table 6 can be found, a similar table to Table 5 but for commercial vehicles.

3.4.5.1 Location, Size, Pricing, Time Limit and Off-hour Delivery

Dey et al. (2019) is one of few published research papers that dissects what the DDOT (District Department of Transportation) of Columbia have tried in the past, what they are currently doing and future initiatives for smarter management of LZs and curb space. Challenges related to pricing, location and size of LZs have been explored in the past according to Dey et al. (2019). Recent activities have been focused on delivery windows, green LZs and reservations. According to Alho and Silva (2014) there are two holistic aspects to make urban deliveries more efficient; first, improve curbside/on-street loading and parking facilities. Second, improve parking enforcement of parking regulations for passenger vehicles. Alho and Silva (2014) discussed the location of LZs and showed that 50m between LZs and delivery location is the practical maximum distance. Cities like San Francisco and New York have specific curbside reserved commercial vehicles in central business districts during business hours (Jaller et al., 2013). Further, Dey et al. (2019) goes into pricing and time limits; it is stated that pricing and time are closely associated with one another and that the time needed for loading/unloading has a significant impact on LZ availability and congestion thereof. Examples are brought up as Chicago has no time limit for commercial vehicles whereas San Francisco has a time limit of 30min but with vague payment enforcement. With regards to delivery windows and off-hour deliveries, the New York city department of transportation has been collaborating with local retailers in order to decide the optimal delivery windows (Schaller et al. 2011). Other countries, like Brazil, have deployed truck accessibility to maximum 2 days in a week for a particular truck. Off-hour deliveries are defined as deliveries made between 7 p.m. and 6 a.m. Dey et al. (2019) state that Barcelona and London have initiated off-hour delivery practices. In the US, NYC and Los Angeles have added off-hour deliveries to established programs (Schaller et al., 2011; Zalewski et al., 2012). Furthermore, Dey et al. (2019) discusses advanced parking management systems that are systems in which one can reserve a LZ; NYC, Chicago, and San Francisco are cities that have such systems deployed. However, Dey et al. (2019) claims that these are highly inflexible as it can create a domino effect in which a freight may come late then it can create late deliveries for following freights.

3.4.5.2 Previous and Future Initiatives - Case of Columbia

In the district of Columbia, the DDOT used ArcGIS Collector application back in 2013 (Dey et al., 2019). Specific data related to side of street, length, curbside location, days, and hours of operation as well as sign pictures of 580 LZs were collected from the district. Furthermore, in 2014 the DDOT introduced a freight trip generation model called LZAM (Loading Zone Allocation Model). LZAM incorporates multiple factors including business and building data, alley access and existing LZs. Dey et al. (2019) further explains that in order to get a LZ a business must provide data on number and size of the deliveries and this data is then evaluated by the DDOT by utilizing the LZAM.

Moving to the year 2015, policies were introduced for LZ pricing in which now commercial vehicles had the option to buy either annual or one-day permit or pay via a so called PBC (pay-by-cell). This permit then gives the operator a time limit of 2h. Furthermore, Dey et al. (2019) explains that if the LZ is occupied then the two closest adjacent LZs can be used between 10 a.m. and 2 p.m. The same year all the 580 LZs' signs were updated so that each LZ now has an integrated PBC identification number. Data was extracted from the District Department of Motor Vehicles and roughly 400 000 tickets out of 9 million were related to LZs and truck violations (Dey et al., 2019); the data showed that most of the tickets were due to commercial vehicles double parking rather than misuse of LZs. However, according to the PBC data and feedback from the industry as well as time-lapse cameras this is due to unauthorized vehicles occupying LZs which leads to commercial vehicles double parking. The fine for non-commercial vehicles parked in LZs increased 100% from 50 USD to 100USD the same year as the fine for commercial vehicle double parking was unchanged.

The DDOT lay forth several steps for the future of LZ management and include: LZ enforcement, increased disincentives for violations, data driven modifications to LZ program and modification to the PBC program. With regards to disincentivizing violations, the district will evaluate whether to increase the fine for unauthorized vehicles once more. However, for their pilot test this was neglected as this could potentially lead to a bad reaction from the public. This would also require a closer collaboration with enforcement agencies (Dey et al., 2019).

3.4.4 List of Smart Parking Apps and Initiatives for Urban Freight

Table 6 - List of additional and previously mentioned initiatives and solutions for urban freight and LZ management. N/A means that either data could not be found or there is nothing else to add.

Smart parking apps and initiatives	Location	Description and technology	General comment
Parkunload	Europe - Germany, Ireland, Spain, and France	– Smart road signs are placed at the LZs and communicate via Bluetooth to a mobile device and an app. The parking conditions such as maximum time of parking is set based on several aspects: vehicle type, emissions level, location, commercial focus and time of the day.	- Has had great social acceptance and been a success in the city of Vic, in Spain
Coord	US	– First apps; first app is an Augmented Reality app called Coord Collector which then helps cities and municipalities to understand the utilization of curb spaces more easily – Second app; allows fleet drivers and logistics managers to know at any given time and location what curb space they may legally access, for how long, and at what price – Mobile sensors are used	– Been successful and improvments been seen in increase of compliance and safety in the city that have deployed Coord
N/A	Chicago, US	– Reserve LZ via an app – Specific curbside reserved for commercial vehicles in central business districts during business hours	– N/A
N/A	San Francisco, US	– Specific curbside reserved for commercial vehicles in central business districts during business hours	– N/A

		– Time limit of maximum 30min for LZs	
N/A	New York, US	– Reserve LZ: specific curbside reserved for commercial vehicles in central business districts during business hours – Off-hour delivery: collaborate with local retailers to decide optimal delivery windows	– NY has been successful and deployed multiple regulations and policies that work in synergy
N/A	Los Angeles, US	– Los Angeles have added off-hour deliveries to established programs – Tiger Team' consisting of ten tow trucks and fifteen traffic control officials that are deployed during peak hours in the city	– Similar to New York and has had a great success when combining multiple initiatives
N/A	Sao Paulo, Brazil	– Deployed truck accessibility to maximum 2 days in a week for a particular truck.	– N/A
N/A	London, UK	– Initiated off-hour delivery practices	– N/A
SyGAL	Lyon and Poitiers, France	– Interactive data set that shows the precise location, street view picture and rules of a LZ – Maximum 30min stay and the system can be used for booking spaces between 5 a.m. and 11 a.m., outside these times cars can park for maximum 10 min.	– Has only been deployed on a smaller scale but with positive results
MOSCA project	– Stuttgart, Germany – Padua, Italy – Lugano, Switzerland	– Software tools that create two-way communication with transport operators and authorities; it integrates urban goods flow with the infrastructure which allows flexibility in assessing and planning freight policy for transport operators depending on the need and demand	– A complex project that has required big investments and multiple actors
N/A	Imola, Italy	– Via the web or phone, transport and logistics	– The booking system as a

		operators can book on-street LZs for 30 min max; delivery zones have taproots; the operator needs to communicate to a control center when checking in and letting the taproots down. – Mobile sensors are used	standalone has not been of significant impact however, when incorporating a time limit of 30 minutes it has had an positive impact on the rotation of LZ use
DUM	Barcelona, Spain	– Initiated off-hour delivery practices – 9000 new LZs in area DUM after a successful pilot with regulated LZs – Specific permits allowing for short-time double parking and using private/public lots – Multipurpose bus lanes: during peak hours buses use these lanes whereas during nighttime freight vehicles.	- Area DUM has shown great results which has led to no additional advances for smart technology rather improvements to policies and regulations
STRAIGHTSOL project	Lisabon, Portugal	– Controlling and monitoring technologies, e.g., sensors, used for loading and unloading activities – Stationary sensors are used	– N/A
i-Ladezone	Vienna, Austria	– Similar system as STRAIGHTSOL project – Developed monitoring of delivery bays with management systems to have maximum availability to relieve impact on traffic	– N/A
N/A	Columbia, US	– ArcGIS Collector application combined with LZAM to understand the districts use and need of LZ; business provide data on number and size of the deliveries and this data is then evaluated by the via LZAM	– N/A

		– Annual or one-day permit or pay via a so called PBC – Increase the fine for unauthorized vehicles on LZs	

Sources: (Straightsol, 2014; Stickel and Furmans, 2005; Patier et al., 2014; Dablanc et al., 2011; Coord.com, 2020; Parkunload.com, 2020)

4. Result and Data analysis

In this section, the secondary and primary data will be presented and discussed. The underlying reason for why the results and analysis will be combined under a single chapter is to provide a better picture for the reader.

4.1 Secondary Data - Focus Group

Participants are from two different universities in Gothenburg, University of Gothenburg and Chalmers, a smart parking company called Parkunload, a researcher from a truck manufacturing company, M.Sc. students, strategists from both Vic, a city in Spain, and Stockholm and a logistics company. For ethical reasons names will not be given rather their profession as seen in Table 7 down below; in the table each of the participants' key ideas and perceptions are presented. In order to make the analysis more readable, abbreviation will be used in the text in the analysis and discussion sections.

Table 7 - List of participants of the focus group and key points

Profession	Abbreviation	Key points
Assistant professor in urban planning and design from Chalmers	PU	– The design, location, and planning is highly important. Even though policies and regulation changes are made, these will lead to a minimal impact on the time spent on the LZs if these factors are not taken into consideration.
Professor at the department of technology, economy, and management within service management from Chalmers	PSM	– 40% of the operational time is spent in the LZs and it has implications on the traffic - these implications are double parking, driving to the next customer or just driving around – Lack of knowledge with regards to space and time, how often certain LZs are used and for how long which has to do with lack of regulations amongst other things
Postdoc at the department of technology, economy, and management within service management from Chalmers	PoSM	– Data analytics can be used to find an optimal route in order for truck operators to arrive at an LZ that is not occupied
Host - Professor within business administration at university of Gothenburg	Host	– N/A
Manager – Logistics provider located in Gothenburg, Sweden	MBA	– The lack of control of LZs and unauthorized vehicles, cars, are the biggest problems alongside companies occasionally dumping their containers on LZs for weeks – The best idea is to get rid of the cars that do not belong to LZs and that reserving a LZ is not a good idea due to it being impossible to know when a van/truck

		arrives at a LZ – Thus, do not think Parkunload solution will solve their problems
M.Sc student in logitisc 1	SL1	– Electricians can use LZ for several days when working nearby – Unauthorized people are using LZs due to unsupervised LZs
M.Sc student in logistics 2	SL2	– Freight operators were not interested in a platform technology like Parkunload as this takes away their autonomy and make them stressed
Urban strategist - Municipality of Stockholm, Sweden	SSTD	– Smart signs is not necessarily the solution for Stockholm rather the problem lies in too few LZs or that some of the current LZs are obsolete – The biggest issue is that they do not know how utilized each LZ is and that this could be a problem with the current regulations. – They do not need more rules rather tools to secure compliance and securing that the rules are followed
Big mobility manager/Strategist – Municipality of Vic, in Spain	BMV	– There has been an increase of rotation and more free spaces by 30% whereas illegal parking has been reduced by 50% with Parkunload application in the city of Vic – The controls by the parking wardens is a very important factor even though the control has not increased in the area of Vic, monitoring and controlling aspect is crucial for the smart parking system to operate successfully
Researcher - Truck manufacturer company in Sweden/Linköping University	RS	– Communication systems are needed on all levels and the smart systems should be compatible if different systems are used – Challenges related to urban freight is not of a technical issue, rather a data sharing issue; how much is allowed to share
CEO of Parkunload	CEO-PU	– One has to take into consideration the different type of operators and the use, there are heavy users, and the focus should be on these first and foremost
Senior consultant - Parkunload with multiple pilot projects around Europe	SC-PU	– It is difficult for municipalities to adopt mandatory schemes, working with several operators is important and it is very difficult to include enforcement agents, but it is very important for all actors to play in the actual pilot in order to make the right decisions and see how the system will actually unfold

4.1.1 Project Overview and General Challenges of LZ Operations

The focus groups start with the host asking PSM to introduce the project and then to later move on to application of smart parking. PSM presents the different partners of the project and states that the goal is to have a common vision. Further, PSM states that the project is about using data analytics to enhance design and operations of LZs. PSM gives the motivation for the project as stated that 40% of the operational time is spent in the LZs and it has implications on the traffic - these implications are double parking, driving to the next customer or just driving around. This is emphasized in the literature by Dey et al. (2019) several times, however the underlying reason to this is due to non-commercial vehicles and misuse of LZs rather than spending excessive time on LZs. This will be further discussed down below as MBA and SSTD will highlight. The literature regarding time spent on LZs is in line with PSM's statement; Alho et al. (2014) states that some freight vehicles do park beyond the time limit. However, it is important to highlight that this is highly context dependent, some cities that the literature discusses do not have time limits at all whereas some cities do and that within the city the time constraints differ depending on the commercial activity, location and time of the day (Dey et al. 2019). Further, PSM claims that knowledge is lacking with regards to space and time, how often certain LZs are used and for how long which has to do with lack of regulations. This statement is aligned with Malik et al. (2017) as well as Munzuri et al. (2017) as it is mentioned that city authorities base their decisions on intuition rather than hard data. The two smart parking companies mentioned in the literature, Parkunload and Coord, do both in their first step in digitizing curb space and LZs create some form of inventory to understand the hotspots and how LZs are utilized in the city before implementing their respective smart solutions. Moreover, PSM stated that this could be due to lack of regulations. Taking this statement one step further, this could also be due to lack of enforcement to the regulations as will be further discussed as well. PSM lastly states that the goal is to see whether a pilot test is feasible and what this would imply.

4.1.2 Pilot study of Smart LZs in Vic

The host states that the goal is to get insights and ideas of the problem related to design, operations and usefulness from different perspectives and to decide whether a similar pilot study can be conducted in Gothenburg as in Vic. The case study in Vic is then discussed by BMV and SC-PU. BMV stated that the city council was searching for solutions to improve both parking rotation and parking priority goals for the LZs that are most demanding in the city of Vic. Four LZ problems were brought up for the city of Vic*; there is a growing demand in dense areas for delivery activities, frequent illegal parking with inefficient parking controls, lack of big data to analyze and cities demand for more efficient and sustainable urban freight.* These four challenges are all emphasized in the literature; with growing demand from e-commerce and population growth, lack of enforcement, not having tools to gather and analyze big data as well as sustainability challenges that needs to be taken into consideration and increasingly becomes more important (Nourinejad et al. 2014). The Parkunload platform technology was used in the city of Vic with great success according to SC-PU. Parkunload was described for the other participants in which one has an app that detects the LZs by Bluetooth to a smart sign. None of the smart parking applications, regardless of whether it was of commercial or noncommercial use had incorporated Bluetooth technology into their systems. This app then shows the truck operators´ parking permit and time which is variable and dynamic depending on the day and type of vehicle. The results have been a success according to BMV for the city of Vic, there has been an increase of rotation and more free spaces by 30% whereas illegal parking has been reduced by 50%. Further, Parkunload has had a good social acceptance and the productive enforcement has increased two-fold. Thus, it facilitates the wardens' task as well. A Q&A was then facilitated by the host. Three relevant questions were asked: 1. Can you reserve a spot via the app before arriving - No. 2. Can anyone easily join without being a logistics provider - Yes. 3.What if you park more than the permit allows? - The parking agency gets a notice, and the fine is bigger if the app is not used. What the first question could imply in the case of Vic is that time spent on LZs are not an issue as it has had a significant impact of the rotation leading to commercial vehicles doing their job of unloading/loading and moving on to the next delivery point which in turn leads to commercial vehicles being less inclined to park illegally. This is then combined with the wardens' role of being able to get a notice if the time has passed the given time of loading/unloading. For the second question, it seems like private cars can park as well leading to potential misuse of Parkunload's LZs. However, this was not clear of whether this was the case, due to no one mentioning private vehicles in relation to the pilot study of Vic.

4.1.3 Inhibiting Factors for Deploying Smart LZs in Sweden

After the Q&A the other participants were asked to give their opinion and perspective of the pilot study in Vic. SSTD compared the city of Vic to Stockholm and claimed that an app with smart signs is not necessarily the solution for Stockholm rather the problem lies in too few LZs or that some of the current LZs are obsolete. This indirectly implies that hard data is missing in the case of Stockholm and how the LZs are utilized in the city which makes it natural for SSTD to state that Parkunload's solution might not solve the problem Stockholm has. The first step should be to pinpoint and understand the underlying problem, based on this one should provide a context dependent solution, this is also something that is explicitly mentioned by Lin et al. (2017); the success of a particular deployment should not be solely judged on the system's success, rather the context of the city needs to be taken into consideration. Furthermore, PSM adds on to SSTD's statement and claims that for Sweden it is a problem of planning and design rather than operations. This statement is then followed up by MBA who explicitly claims that they do not want to use an app for their company. MBA justifies this by stating that a single truck from their company delivers somewhere between 70-80 parcels per day and thus the trucks must deliver quickly, a system like Parkunload would only stagnate their operations. Other problems that MBA brings up are what they should do if a driver has never driven in the city, or if one changes the trucks or if trucks are rented. But the biggest challenge that MBA finds is the misuse of the LZs. MBA thinks that the best idea is to get rid of the cars that do not belong to LZs and that reserving a spot is not a good idea, MBA states that it is impossible to know when you are going to be at a specific LZ when many deliveries are planned. In the literature, it was shown that the underlying problem of the number of fines written related to LZs were due to the misuse as the time-lapse cameras showed unauthorized vehicles using the LZs in the District of Columbia (Dey et al., 2019). However, even though MBA and SSTD are skeptical of Parkunload's system as a solution, Barreto et al. (2017) states that an ITS is a necessity in the future when the supply chains function on a more global scale, thus it will be inevitable to incorporate different telecommunication technologies and sensors regardless of whether a smart LZ app is used or not in the case of MBA or for a whole city like Stockholm. Lastly, PU has the word in which it is claimed that the design, location, and planning is highly important, even though policies and regulation changes are made, these will lead to a minimal impact on the time spent on the LZs if these factors are not taken into consideration. Regarding the misuse of LZs by passenger vehicles, Dey et al. (2019) suggest that improving the parking enforcement of parking regulations for passenger is one of two holistic aspects that can make urban deliveries more efficient. If current regulations are not followed, then implementing a system like

Parkunload would be of marginal affect, as passenger cars would park there anyway. However, if the current system and regulations are followed then novel parking systems can be deployed upon the current infrastructure.

4.1.4 Big Data Analytics – Understanding the Demand of LZs

PoSM and PSM used data from Vic for eight LZs. A forecasting model for LZs demand was made by using machine learning in which different arrival rates were calculated for each of the LZs. Arrival rate is the number of vehicles that arrive every hour. Peak hours for most of the LZs were between 8 am and 10 am. No arrivals occurred after 6 pm and vehicles arriving after noon parked longer. Looking at the literature, this coincides; as in the case of some big cities in the US, data suggested that 65% of the deliveries were made before 12 PM (Nourinejad et al., 2014). Unspecified and transportation parcels have longer parking time than any other sector from the studied data of Vic. As defined by World Economic Forum (2020) parcels are packages that are small. Elaborating on this, if a truck or van has multiple parcels then this data of Vic makes sense as multiple deliveries must take place in order to deliver smaller packages to a particular area. PoSM then dives into optimal routing for trucks and how data analytics can be used to find an optimal route in order for truck operators to arrive at an LZ that is not occupied.

4.1.5 Concluding Remarks

Two M.Sc. students interviewed several truck drivers in the Gothenburg area and found out several important factor**s;** first, unauthorized people are using LZs due to unsupervised LZs, a driver can stay as long as they want to which is aligned with not only previous statement from MBA amongst other participants, but also the from literature of Nourinejad et al. (2014). SL1 states that electricians can use LZ for several days when working close by. Further, SL2 states that the drivers were not interested in a platform technology like Parkunload. The reason for this is that it creates stress and takes away the autonomy of the driver as they can no longer plan their own routes. For the receivers it was shown that they were not interested in how things got delivered.

The host invokes another round of opinions regarding all that has been discussed. SSTD agrees with MBA on that booking of LZs should not be applied, this is mostly due to the law of public ground which does not allow reservation. Further, SSTD states that the biggest issue is that they do not know how utilized each LZ is and that this could be a problem with the current regulations. Lastly, SSTD states that they do not need more rules rather tools to secure compliance and securing that the rules are followed. MBA further thinks that the lack of control of LZs and inappropriate cars are the biggest problem; companies occasionally dump their containers on LZs, and they can stay there for weeks. Moreover, not many traffic wardens give a fine according to the experience of MBA. BMV adds on this and states that the controls by the parking wardens is a very important factor even though the control has not increased in Vic, monitoring and controlling aspect is crucial for the smart parking system to operate successfully. RS joins the discussion and explains that this is not a technical issue but has to do with data sharing and how much data is allowed to share. Moreover, RS states that communication systems are needed on all levels and the systems should be compatible if different systems are used and that the challenges related to urban freight is not of a technical issue rather data sharing and how much is allowed to share. This is something Christopher (2011) highlights for supply chains and further claims that this requires transparency between stakeholders in a network, which is clearly not the case according to RS. SSTD builds upon the statement made by RS by first saying that an app would not be a feasible way as a solution for Stockholm and that to be successful they need to build on existing systems, gather and share data. Lastly, SC-PU states that it is difficult for municipalities to adopt mandatory schemes, working with several operators is important and it is very difficult to include enforcement agents, but it is very important for all actors to play a role in the actual pilot. This is aligned with the report of the World Economic Forum (2020) in which it is stated that OEMs, logistics providers, infrastructure providers need to invest in shared software and increase partnership between different actors for an accelerated technological adaptation to take place. Additionally, as Dey et al. (2019) state, for implementation to run smoother with regards to pilot studies, it is required to collaborate more closely with enforcement agencies.

4.2 Primary Data - Interviews

The primary data, which consist of in total 7 interviews with different stakeholders, will be presented and analyzed in this following section. Data will be presented from a holistic point of view as well as stakeholder and an individual level. Down below in Table 8, the participants are introduced and their background, some of the interviewees participated during the focus-group as well. All the interviewees have some form of strategic role with regards to logistics and urban freight. In this thesis four different stakeholders were relevant: logistics providers, s smart parking provider, a truck manufacturer, and municipalities. MBA and CEB are logistics providers, CEB is also a bike manufacturer; SSTD, SSTD2 and SBTD are stakeholders from municipalities; RS is from a truck manufacturing company, and lastly SC-PU is from a smart parking company.

The following chapter will be divided into 4 sections. The first section deals with the definition of a smart LZ. The second section investigates the greatest priority – sustainability. The following section describes the challenges of, not only LZs, but urban freight and logistics, from different perspectives; a summary of the findings for the challenges can be found in Table 9. Lastly, the fourth section deals suggestive solutions and ongoing projects as well as what a dream scenario of urban freight would look like. A summary of this section can be found in Table 10.

Table 8 - List of the interviewees, their background and whether they participated in the focus group

Profession	Abbreviation	Focus group participant	Key points
Manager – Logistics provider located in Gothenburg, Sweden	MBA	Yes	– Passenger cars are the biggest problem, followed by service vehicles and containers that can occupy LZs for days
CEO - Logistics provider/Bike manufacturer located in Stockholm, Sweden	CEB		– True sustainable energy systems are not achieved by electrification of vans and trucks solely
Urban strategist - Municipality of	SSTD	Yes	– Lack of knowledge and data on LZs; some LZs are obsolete while others

Stockholm, Sweden			are occupied most of the time – Parkunload's solution of booking cannot be deployed due to Swedish regulation of not being able to reserve space
Urban strategists - Municipality of Stockholm, Sweden	SSTD2		– Scan cars would be a better solution than having hundreds of wardens in the city – Cameras and sensors need to be placed on LZs to gather data
Researcher - Truck manufacturer company in Sweden/Linköping University	RS	Yes	– Focuses on off-peak delivery; regulations do not allow night delivery which would solve most urban freight challenges
Strategist - Municipality of Bogota, Colombia *(Disclaimer: everything said is from the point of view of SBTD and not the department itself)*	SBTD		– The infrastructure of Bogota is underdeveloped – Lack knowledge and data of LZ operation and use
Senior consultant - Parkunload with multiple pilot projects around Europe	SC-PU	Yes	– Important to deploy the full system of Parkunload's smart parking solution otherwise one might end up with an unsuccessful solution – Regulations are different and could be an obstacle for Parkunload deployment

4.2.1 Definition of Smart LZ

Some of the participants were asked to define what a smart LZ is. However, not many of the participants were familiar with smart LZs and could not really give a clear definition coupled with the fact that the smart LZ definition question was not initially in the interview questions; CEB for example do not use LZ which is logical as the e-cargo bike company solely uses e-cargo bikes to provide logistics services. For RS, the awareness of LZs being an issue existed; however, the participant was never asked to give a definition of a smart LZ. The same goes for MBA and SBTD. The two participants that were asked to give a smart LZ definition and gave an answer were SSTD2 and SC-PU with the following definitions:

"First, it needs to be digital with a unique identifier to the loading zone. Second, what is required is a system for users to interact, like a smartphone app. "– SC-PU

"*It is crucial with cameras or sensors, and some widely spread system that the cargo companies can use and it's easy to use to see if a LZ is empty or not*" – SSTD2

The reason why SC-PU gave a definition even though he was the first interviewee in this research was due to the participant's background, whereas for the case of SSTD2, the participant was the last interviewee and was thus asked this question. Looking at these definitions there are two components; some form of sensor/identifier coupled with a user system. In the case of SSTD2, it is also stated with a function of being able to see whether a LZ is occupied or not. Thus, the data suggest that there should be technological tools for gathering some form of data and being able to display it for the users, the users in this case would be the logistics operators. Looking at the literature review of smart parking, not smart LZ, it is defined by Lin et al. (2017) as:

"a way to help drivers find more efficiently satisfying parking spaces through information and communications technology." (Lin et al., 2017)

There are no clear definitions of what smart LZ is and what components it should have to be called a smart LZ according to the literature, but one can derive such a definition from existing systems. All these three quotes do have something in common – leveraging some form of data gathering technological system with the hopes of facilitating the use for the operators. Lin et al. (2017) goes deeper into a smart parking definition with information collection, system deployment and service dissemination. The first step is to gather data via some form of sensors, which is commonly seen in all three quotes above; the next step is to use data analytics to process the information and the third considers social aspects which could be an easy user interface as has been emphasized by SC-PU and SSTD2. Moreover, in Table 5, in section 3.4.4, most of the smart parking solutions include some form of sensing technology and user interface, mostly smart phone apps as these are commonly used by the people with passenger cars and fulfills SSTD2's statement of being a "widely spread system", most people do carry a smartphone. In Table 6, in section 3.4.6, a list of smart parking apps and smart management for LZs are shown; some smart parking solutions incorporate some form of sensing technology coupled with data analytics tool and a user interface; however, the majority of the smart solutions has to due with smarter management and trying to change regulations, policies and operations of freight to mitigate the external effects of the challenges urban areas face. This includes special permits for LZ use, dynamic pricing, time limits, restrict accessibility with physical barriers, promoting off-hour delivery, etc. Thus, it is not required to have a smart LZ in terms of having dedicated sensors, data, analytical tools with a user interface in order to face the challenges that comes in urban areas for LZs. However, this does not mean that a smart LZ system should be neglected, in long-term the challenges of urban areas will be even more pronounced and will thus require some form of smart solution.

The empirical data and literature review imply that a smart LZ should use some form of smart technological system to improve the overall operations for the operator e.g., to provide real-time data of occupancy to facilitate operations for logistics providers. A smart LZ require three components; sensing technology of some sort to gather data coupled with a way to analyze this data with data analytics and lastly displaying this data with a system for the users, which could be a smartphone app. There are multiple sensing technologies mentioned in the literature review whereas for data analytics there are three types in which predictive would be suitable in this case as SSTD2 mentions that they want to know whether a certain LZ is occupied or not. Predictive data analytics can potentially answer questions like these, whereas descriptive data analytics cannot. Prescriptive would not be necessary as there are not any need to solve any complex problems which would also provide actionable next steps, rather understanding the utilization of LZs is the required need.

4.2.2 Sustainability - The Greatest Priority

In this section, challenges of sustainability will be presented and discussed from the point of view of each stakeholder but also at an individual level. There are multiple challenges of urban freight and for the logistics industry. Most of the interviewees at least mention sustainability as being one of the greatest and urgent challenges that should be dealt with for the transportation industry.

4.2.2.1 Municipalities

SSTD states that the biggest challenge is to meet the sustainability goals of having fossil free fuel transport but also accessibility and availability of transport. According to SSTD, focus has been on pedestrians and bicyclists for the municipality of Stockholm; *“Streets are no longer length of movement but a public place that people should want to hang out, we want a vibrant city in which people want to stay. "* - SSTD. This is aligned with Aleta et al. (2017) that states that the priority of smart mobility should be to increase the wellbeing of the citizens. Furthermore, when looking at the i-COA framework by Appio et al. (2019), Figure 2, one can clearly see that the underlying layers of smart mobility and smart environment that make up the physical environment are the foundation to the pinnacle of the hierarchy: high quality of life, which is what the municipality of Stockholm strives to achieve for its citizens, however, by focusing on the lower levels which should also be the starting point as everything else is built upon the first layers. SBTD has personally a similar view of Bogota and states that the local government is heavily interested in environmentally friendly solutions such as electrical bikes, tricycles, e-vans, etc. SBTD further states that if there were to conduct a pilot study, then the focus would be on sustainability goals, more specifically environmental sustainability rather than social sustainability as in the case of Stockholm. Thus, from a holistic municipality point of view, social and environmental sustainability aspects are of great importance and priority. This is like Al-Nuaimi et al. (2015) smart city definition of having sustainable social, economic, and environmental solutions, however, the focusing being on social and environmental aspects rather than economical. The reason behind this could be due to the organizations SSTD and SBTD are working for. Surely, they need an income source, however the business part might be more important for private companies rather than for the public sector.

4.2.2.2 Truck and Bike Manufacturer

RS and CEB are both manufacturers for two completely different types of vehicles; CEB previously manufactured e-cargo bicycles solely and at this moment has transformed from a manufacturer to being both a manufacturer and logistics provider. RS comes from a truck manufacturing company in Sweden. While their backgrounds might differ their view on an environmentally sustainable future is more similar than different; RS mentions that they introduced their first fully electrified truck last summer of 2019 and that the focus is on only producing heavy trucks as these are more efficient than having five vans with regards to transport efficiency and number of employees. This statement coincides with Sanchez-Diaz et al. (2020) as it is stated that larger trucks are more efficient with regards to volume delivery per truck compared to medium duty vehicles. Besides electrification, RS’s department has investigated geofencing with control towers for their hybrids; as soon as a truck enters a particular zone, such as an urban area, then the engine switches to electricity. CEB’s story on the reason why he started the e-cargo company was due to environmental and sustainability goals; CEB states that the key to sustainable energy systems is energy efficiency and justifies this by explaining that a e-van consumes 15 times more electricity when doing the same deliveries as an e-cargo bike which is a huge difference in energy efficiency and the same factor applies for the actual production with regards to CO2 emissions. CEB states that the industry as a whole is moving in the right direction of electrification, but CEB takes it a step further and questions the energy efficiency and brings forth the question of whether or not clean energy sources are used, because only then true sustainability will be achieved. CEB and RS discuss the social aspects of sustainability similar to SSTD and SBTD; CEB states that removing motor vehicles from the city center will add to the livability of the city. RS discusses the social aspect as well; RS claims that some of the regulations are in place in order to not have big trucks where people are moving around which has made the truck manufacturing company to focus their resources on less noisy trucks and thus silent material for urban deliveries during off-peak hours. This change in focus justifies why the truck manufacturing company is focusing solely on heavier trucks, their tires, door, and cage material and controlling speed in urban areas in order to produce less noise. Further, RS explains that they are working with other partners to find solutions for these problems. This is emphasized in the literature as well as partnership between different actors increases the technological adaptation (World Economic Forum, 2020). Focusing on off-peak hours or off-hour delivery is something that has been mentioned several times in literature of urban LZs; NYC, London, Brazil, Los Angeles, and Barcelona are just to name a few places that have imitated off-hour delivery (Dey et al., 2019; Schaller et al., 2011; Zalewski et al., 2012). However, RS further states that it is not allowed to do nighttime deliveries which off-hour delivery is defined as, doing deliveries between 7 p.m. and 6 a.m. Being able to do night deliveries would be much more efficient according to RS.

4.2.2.3 Logistics Company and Smart Parking Provider

MBA and SC-PU did not dive any deeper into sustainability aspects which could have to do with their respective backgrounds but also the nature of the semi-structured interviews diving deeper into areas that lie closer to the core of the interviewees' expertise. Overall, the literature coincides with the interviews as most of the stakeholders, in particular the municipalities and vehicle manufacturers, are on the path of a smart city transformation with a sustainability lens or more specifically smart mobility transformation which incorporates transportation of people and goods from both private and public sectors in order facilitate sustainable movement, reduce time, cost, and environmental impact (Aleta et al., 2017).

4.2.3 Challenges of Freight and LZs

In this section the challenges with regards to LZs and urban freight will be presented and discussed. The challenges are categorized and discussed from the point of view of each stakeholder, the municipality point of view, truck and bike manufacturer and lastly, smart parking provider and logistics providers. These will include several challenges related to LZ policy, enforcement and regulations, lack of knowledge, different stakeholder incentives, etc. Lastly, some pilot studies will be discussed from the interview with SC-PU. In Table 9, a summary is provided for the reader of this section.

Table 9 – Summary of the findings with regards to the challenges of urban freight and LZ

Stakeholder	Key points
SSTD and SSTD2	– Biggest challenge with regards to LZs are low levels of knowledge and data of LZs utilization; some LZs might be obsolete whereas others are occupied all the time - This is due to not historically following up after businesses apply for LZs and non-reliable inventory method where the warden

	manually gathers data of LZs – There are built in incentives for maximizing number of parking spots and minimizing number of LZs as these are not an income source; LZs are free to use, operators do not pay. Focus has been on passenger cars and pedestrians as well as environmental solutions rather than LZs – Due to regulations, legislation, and policy, in Sweden one cannot reserve space and it is difficult to use sensors and cameras; further, public actors have a harder time using these sensing technologies than private actors. – There is no time limit; operators can park as long as there is an unloading/loading activity going on; time restrictions do exist and differ depending on the location, thus some LZs can be used as short term parking – Sophisticated ICT technologies exist for the wardens, but it is not connected to the bigger picture of mobility and LZ enforcement and control.
SBTD	– The biggest challenge Bogota faces is underdeveloped infrastructure in terms of roads, signs, etc. in urban areas while at the same time e-commerce and demand of the citizens has increased – Level of knowledge and data is low and is necessary; companies in Bogota have data but do not have collaborative schemes to share this data
CEB	– Last mile delivery is run by subcontractors; logistics companies procure these subcontractors and in order for these subcontractors to adopt novel and innovative solutions such as e-cargo bikes, logistics companies need to convince the subcontractors to invest in new technology; this however, has not happened which leads to the e-cargo bike start-up becoming a logistics provider – The biggest challenge with regards to last mile delivery for CEB is no well-developed transshipment hubs
RS	– Congestion problem is due to passenger cars as 95% of all vehicles are passenger cars; passenger cars occupy LZs. – Problems with regulations: - If it would not be for regulations, then nighttime delivery would solve most of the urban freight challenges and it would be much more efficient - With the current regulations the only available solution to mitigate congestion is to have many smaller vehicles instead. However, RS claims that this solution is part of the problem, it increases congestion – Truck manufacturing company do have a lot of data; RS claims that they know that the data is valuable, but they are too scared to share it and want to find a business model for the data in order to profit from it
MBA	– Biggest problem they have as logistics providers is the passenger cars occupying the LZs in urban areas when they are needed and not other trucks nor logistics companies – Other types of vehicles or containers can take up these spaces as well such as construction and service vehicles. – GPS shows the address of the delivery points and not the actual LZs, which can be an obstacle for the operations according to MBA – MBA thinks Parkunload’s solution is a good idea but not for them; regarding booking system, it is impossible for them to know when an operator will be at a certain LZ when there is 70-80 delivery points to make in a day

SC-PU	– Lessons learned from pilot studies have shown:
	  - The user interface is very important
	  - Deploying the full system which includes the warden app is highly important for the success of Parkunload’s smart parking solution as was seen in Vic in contrast to Dublin and Belfast pilots
	– According to SC-PU regulations that differ between countries can be an issue; one needs to gather and show data that 30 minutes is a decent time limit so time limits can be set and thus increase the rotation of spaces as in the case of Vic
	– SC-PU states that there are two big drivers of the challenges for urban LZs: online e-commerce growth and pedestrianization

4.2.3.1 Municipality

From the perspective of the municipalities, the most important factor is sustainability, especially environmental and social aspects of sustainability. However, there are several challenges with regards to LZs that both Stockholm and Bogota face.

4.2.3.1.1 Stockholm

Lack of knowledge and data of LZs

In case of Stockholm, SSTD states that there are hardly any data or knowledge of how, when and by whom LZs in the municipality are used and that this is one of their biggest problems. SSTD2 similarly states that LZs are hard to plan and work with as not much knowledge is within the organization of these LZs. Logically, as the literature review implies, the first step into transforming a LZ to a smart LZ or a city to a smart city is to understand the current demand by gathering or having some data. Lin et al. (2017) states that the first step is to gather information, information collection, before the next two steps (system deployment and service dissemination) is crucial. Without truly understanding the context-dependent issue of a municipality’s LZ, there will be no optimized and probably no functioning solution, as is stated by Lin et al. (2017) “a certain approach cannot be solely judged on the success without the consideration of the city’s context”. Furthermore, In Table 6, all the smart solutions for LZs that has some form of digital/technological component that does not have to do with policies, regulations, permits, etc. do all process and gather data continuously such as Coord, MOSCA or SyGAL project, in order to be dynamic with regards to their respective smart solution.

Underlying reason for their challenges – Legislation, policy, regulations and incentives

The underlying explanation for the low knowledge level has to do with several factors; amongst other, how businesses apply for LZs in an area; SSTD states when it has been decided to create a LZ in a certain place, which depends on several factors such as how often a certain business gets deliveries, etc. then these will not be followed up. SSTD states that there could be LZs out there that have been created 10 years ago and are now obsolete and the municipality of Stockholm does not know. However, SSTD2 state that the wardens that are procured by the transport department of Stockholm do the inventory manually for LZ, but then also states that this is a vague and non-reliable method.

Further, there are also built-in incentives; for the transport department of Stockholm, parking in general is a big deal in their organization as SSTD states: the income comes from the parking fees of passenger cars but for LZs the operators and logistics provider do not pay, LZs are free. Further, SSTD states that there is some built-in interest to minimize the number of LZs and maximize passenger parking lot to increase income. Thus, the already built-in incentives for smart LZ initiatives will be low compared to smart parking for passenger cars or an environmentally friendly project. This also coincides with Malik et al. (2017) as it is mentioned that policy makers in Gothenburg, in Sweden, has traditionally focused on parking policy for cars. LZs being unprioritized by the municipality will further obstruct the challenges Stockholm has. In the literature review many of the initiatives for a smart LZ management incorporated dynamic pricing, special permits or PBCs (Dey et al., 2019); this implies that on a global scale most logistics providers do pay for their use of LZs and that this indirectly means that there is some built-in interest to focus on LZs in other countries and municipalities where you must pay due to this payment becoming someone's income, the city authorities. This is also something SSTD mentions as legislation, regulations and policy between different countries vary a lot. Furthermore, a big issue with smart LZs that SSTD highlights is that the Swedish national legislation that does not allow reservation of public spaces which has been a problem for many years. SSTD additionally claims that with regards to sensors, such as cameras, there are challenges as there are a lot of rules and GDPR issues. SSTD states that the public sector is more restricted than the private sector to deploy e.g. cameras due to legislation. Looking at Table 6, the smart initiatives and solutions such as SyGAL in France, and initiatives in Chicago, Imola and NYC enable the logistics providers with the possibility to reserve LZs and curbsides for commercial use. This coupled with the fact that the majority of these smart solutions have integrated sensors of different sort and not only cameras. Thus, one of the four parking policy strategies of Nourinejad et al. (2014), more specially pricing strategies, will be difficult to apply in the case of Stockholm due to legislation and built-in incentives. Furthermore, the Swedish legislation works like a hindrance for incorporating sensors – cameras – and reserving space for commercial use which is commonly used in the smart parking initiatives and solutions in Table 6.

LZ operations

SSTD2 explained the operations of LZs: the operator can stay as long as there is some form of loading/unloading activity when parked in the LZ. Additionally, if an operator has parked for delivery closeby, 15 minutes is the timelimit for this before a parking warden can give a fine. SSTD states that the time restriction is based on the need of the LZ. The time restriction is defined as the LZ being available for loading/unloading activity whereas during the rest of the time it can be used as a parking space short term for other vehicles; these could vary as much as 2 days a week or 24/7 or even only during daytime; this is all due to legislation according to SSTD. Thus, passenger cars and other vehicles can park on LZs during certain hours similar to Nourinejad et al. (2014) time restriction strategies. According to Marucci et al. (2015), parking enforcement becomes important when there are articulated regulations as in the case of Stockholm. This coupled with the fact that LZs are free to park in Stockholm might be the reason why there are issues such as misuse of LZs. Dey et al. (2019) further states that pricing and time limits are closely associated with one another. This could potentially imply that due to the fact that there is no pricing for LZ in Stockholm, the time limits are then also not considered.

No technical hindrances

Furthermore, SSTD2 explained that there is an app that the procured wardens use that is connected to a central data base which handles the payment and invoice if you do not pay the parking fines. The wardens can check in and out when they do surveillance and data can be gathered of their effectiveness of how many fines/per hour, number of cars searched in an hour, travel time between areas, etc. but the system cannot check on every warden as there are total number of 400 wardens spread out in Stockholm. Thus, it seems that the technological infrastructure for a smart parking of LZs do exist and that this is not a technological issue for Stockholm rather, as earlier stated, lack of knowledge, counterproductive policies and legislation and incentives to change the management of LZs.

4.2.3.1.2 Bogota

In the case of Bogota, the city has not come far in the development of smart solutions compared to Stockholm, thus the insights of smart LZs are limited.

In the case of Bogota, one common challenge as Stockholm also deals with can be found and that is the lack of knowledge and data of the current system for last mile delivery and LZs. SBTD states that data is missing, real-time information is needed to know what is happening in the LZs to support decision regarding these and to enable further development. This is aligned with Lin et al. (2017) as well as the municipality of Stockholm, as knowledge is lacking, and the first step is to gather data to understand the situation.

Furthermore, SBTD states that the underdeveloped infrastructure is big problem in the city which leads to congestion; trucks that arrive in the city lose 50% of their speed due to scare space and congestion. The problem of congestion in urban areas is a common issue according to the literature review as the population increases, the need for service and vehicles, regardless of it is freight vehicles or passenger cars, increases as well (Nourinejad et al., 2014; Navarro et al., 2016; Dameri and Ricciardi, 2017). With regards to the infrastructure, SBTD states that the roads, signs, etc. cannot deal with the dynamic economic of Bogota as businesses and the economic activity has increased the infrastructure has mostly been the same which puts a bigger stress on the infrastructural aspects. This will create inevitable hindrances for the city of Bogota to not only adopt smart parking solutions but smart city solutions as well; in the i-COA framework in Figure 2, the first layer is the physical infrastructure which includes roads as was mentioned by SBTD. It is upon the infrastructure the smart solutions can be built upon. Appio et al. (2019) states that the smart city, which includes smart mobility and smart parking, should start from the physical infrastructure.

SBTD, states that the some of the data with regards to last mile delivery is in the hands of companies, logistics providers, but that these are not willing to share this data nor have collaborative schemes, which further makes it difficult for the public sector to find optimal solutions. SBTD states that that different actors, companies, policy makers and the public sector needs to start collaborating as well, this cannot be solely solved from the public sector. This is highlighted in the literature review as well for both smart mobility and smart city transformation by Marsal-Llacuna et al. (2015) and World Economic Forum (2020).

4.2.3.2 Bike and Truck Manufacturer

CEB explains that last mile delivery is run by subcontractors and that even if there are smart and environmentally friendly solutions the logistics companies need to convince these subcontractors to invest in this kind of smart solutions. CEB further states that the reason they became logistics providers is due to this challenge of subcontractors not investing in new and smarter last mile delivery solutions. The objective with these e-cargo bikes is to replace the vans for last mile delivery according to CEB. Besides this, CEB mentions that there is a lack of hubs for transshipment of goods, that there is a challenge to find a good hub which would help the e-cargo bike operations. Not much is mentioned on a broader scale which has to do with CEB’s background of developing e-cargo bikes and not facing issues related to traffic congestion and LZs.

RS has some insights with regards to LZs and urban freight. The truck manufacturing company focuses on heavier trucks as earlier mentioned as well as off-hour delivery. RS states that if it would not be for regulations, then nighttime delivery would solve most of the urban freight challenges and it would be much more efficient. The problem lies in the regulations and that the city do not want big, smelly and noise trucks where people live according to RS. RS states that with the current regulations the only available solution to mitigate congestion is to have many smaller vehicles instead. However, RS claims that this solution is part of the problem, it increases congestion. RS blames the urban congestion problem on passenger cars and claims that 95% of all vehicles are passenger cars; if the city wants to ease congestion regulations should not solely be for freight vehicles but passenger cars as well. RS further states that these passenger cars occupy LZs. The misuse of LZs by passenger cars is mentioned several times by Mor et al. (2020) and Dey et al. (2019). RS further makes an interesting point regarding data sharing; RS refers to Amazon and Alibaba’s data use to their respective success, they have found a way to profitize on the data they have. This is something the truck manufacturing company wants to do as well, RS claims that they know the data is valuable, but they are too scared to share it and want to find a business model for the data. This could potentially be an explanation for SBTD and why companies do not share the data that the municipality could use; there are no monetary incentives for these companies to do so, perhaps for the logistics companies but not from a truck manufacturing company. The data sharing is not a technical issue rather an issue of who will own it and control it while driving it towards sustainability according to RS.

4.2.3.3 Logistics Provider

MBA has a similar challenge with regards to LZs as RS mentions; MBA states that the biggest problem they have as logistics providers is the passenger cars occupying the LZs in urban areas when they are needed and not other trucks nor logistics companies; MBA states that when a LZ is occupied their operators drive to the next delivery point and come back later or try to find another one nearby. Similarly, Nourinejad et al. (2014) states that when a LZ is being occupied operators either search for a nearby LZ, double park or move on to the next customer. MBA does not mention doing any double parking, this could be the case as when asked about getting fines MBA does not remember last time they got one and that MBA further states that there is no reason for them to park in a LZ when not performing a certain work related activity. It could also be to insufficient parking enforcement that MBA does not get any fines and that double parking actually do occur for the trucks of MBA. MBA has worked as an operator himself, and has countered passenger cars parked in LZs; the reason why certain passengers park on LZs according to MBA is due to them being closer to a certain store in order to buy something quickly, e.g. coffee before work. The walking distance is one of the most important decision factors when a driver decides where to park according to Channiotakis & Pel (2015). Furthermore, the authors state that the parking cost is another very important decision factor. This in combination of LZs being available as short-term free parking space for passenger cars during certain hours could be the explanation for the misuse of LZs by passenger cars. Besides this, MBA states that other vehicles or containers can take up these spaces as well such as construction and service vehicles. MBA manages roughly 200 trucks with 20/30 of these trucks being deployed in urban areas in the Gothenburg region. This is seen in the study by Malik et al. (2017), in which 5 out of 10 LZs in urban areas of Gothenburg were occupied by waste bins. However, previous studies have shown that the LZs in Gothenburg, in Sweden, are occupied less than half of the time during

8 am and 5 pm (Malik et al., 2017). Furthermore, MBA states that the time spent on a LZ depend on the number of parcels that is planned to be delivered in a certain area. If it's one parcel than it might take 2 minutes, if its 5 parcels this might take 20 minutes according to MBA.

Additionally, another challenge is the software that is used for the route planning. MBA states that the planning they have are pre-made schedules that are based on the normal – "we do not know who will have the parcels, but we know that there will be someone in this particular area". GPS is used however, the GPS shows the address of the delivery points and not the actual LZs, which can be an obstacle for the operations according to MBA. MBA states that he thinks that computers cannot deal with the complexity of knowing how to fit certain parcels into the truck, rather the competence inhouse of the formal drivers are required. Regarding smart LZs like Parkunload MBA thinks it is a good idea but not for them; regarding booking system, it is impossible for them to know when a driver will be at a certain LZ when there is 70-80 delivery points an operator must make. Other aspects of Parkunload's smart parking solution were not discussed, such as the easy user interface to check in and out with one button.

4.2.3.4 Smart Parking Provider – Pilot studies and Lessons Learned

Being the only interviewed smart parking provider, in this section different pilot studies will be discussed from the point of view of SC-PU.

Barcelona and Vic - Focusing on user interface and capturing data to understand demand

SC-PU firstly explains the background to Parkunload which was inspired by the area DUM city wide deployment of digitizing 9000 LZ in Barcelona. The area DUM app can be found in Table 6 as well. SC-PU explains that each of the 9000 LZ has 4 digits that make them digital and that at Parkunload they are trying to make these digital zones smarter than area DUM by putting in the digits into an app and programming the system to check in and out automatically when the operator gets into a LZ. Furthermore, Barcelona has incorporated a time limit of maximum 30 minutes during peak-hours. The focus of Parkunload according to SC-PU is to make the Parkunload app as user friendly as possible to achieve a greater market acceptance. Souissi et al. (2011) claims that designing a robust user interface is detrimental; this was shown in the case of Nice, in France, as their city-wide deployment failed due to several factors such as not understanding the driver's behavior put part of it was a poorly designed user interface (Lin et al., 2017). It seems like Parkunload has understood how important the user interface is and the importance of it being easy to use. This is then confirmed by SC-PU as multiple pilots are being conducted to, amongst other things, improve the interface for the users so they can just click on a button for the whole process of using a smart LZ.

Challenges of cameras and demand patterns

SC-PU further explains that other sensing technologies, like cameras, would be hard to implement due to data consent and angles compared to Parkunload's Bluetooth system. This is aligned with SSTD's view on cameras and the difficulty of regulations and GDPR-issues. Furthermore, with regards to data, SC-PU explains that they were working on a project for Barcelona and were given a hard disk of 2 months of hard data to analyze. The data showed the hotspots during different times, and when presenting this data, Stuttgart in Germany wanted to get onboard to analyze and deploy Parkunload's solution. This is something both SSTD and SBTD state as they need this kind of data before getting to a solution for their respective urban challenges of LZs. The data showed that in Barcelona and, later on, for Vic, the demand is higher during the morning hours. This coincides with Nourinejad et al. (2014), in NYC 65% of all deliveries occurred before 12 PM. However, there are multiple cities with different demand patterns and supply of LZs, this does not necessarily mean that all freight deliveries are made during morning hours worldwide. SC-PU states that Barcelona has tried to convince service vehicles to park on LZ during later hours of the day but has not succeeded with this. Thus, Barcelona similarly to Stockholm allows service vehicles and other commercial vehicles to be in these LZs.

Deploying the full system with the warden app is necessary

SC-PU continues and explains why the deployment in Vic, in Spain, was so successful. SC-PU states that the complete system was deployed which includes the warden app; when the warden is close to a smart sign at a LZ, the warden can visually see the time being left for the operator. This is why there was such a high rotation of the spaces and why it worked in Vic; Dey et al. (2019) states that improving parking enforcement can help improve LZ operations and mitigate any misuse. The fully deployed system with the warden app could potentially be the underlying reason for why there are no misuse similar to Stockholm and why the rotation is so high as it is easily monitored by the wardens via the app instead of manually. SC-PU finally states:

"The warden app plays a key role for the whole implementation, so spaces are freed up. Once loading zones become available and rotation is achieved it advances itself. If the warden app is not used, then you might end up with a very different result."

Two driving factors for LZ challenges

SC-PU states that there are two big drivers for the challenges for urban LZs; online e-commerce growth and pedestrianization (e.g. bicycle lanes). Pedestrianization is highlighted by SSTD, in which the focus is to make the city more vibrant and for people wanting to stay. SBTD has a similar view on e-commerce as a driving factor. With regards to the literature, e-commerce has been growing rapidly and will continue to do so (Holgersson, 2017; Postnord, 2019). This means that it will become increasingly more difficult for LZ deployment and operation as municipality goals of pedestrianization and e-commerce demand grows.

Pilot in Stuttgart – Time restriction, legislation, and regulation hindrances

Pilots are currently being conducted in Stuttgart. However, there are challenges according to SC-PU; legislation and regulations of time restriction in certain areas are obstacle for a smart LZ deployment. SC-PU explains that in Stuttgart as long as the operator is performing a loading/unloading activity then no fines can be given, however, if you stop you get a fine. According to SC-PU one needs to gather and show data that 30 minutes is a decent time limit so restriction can be made with regards to time. Stuttgart has a similar system to Stockholm with regards to LZ time-limits. Most of the smart solutions in Table 6 do have a maximum time limit of 30 min, especially during peak hours and in central business districts. Malik et al. (2017) showed that 13 minutes is the average time a freight vehicle parks on a LZ. Doubling this average time means that a maximum of 30 minutes as SC-PU suggest should be more than enough. However, there might be cases with more difficult freight which require more than 30 minutes; according to MBA, the time an operator stays at the LZ has to do with the number of parcels that are ought to be delivered close to the LZ area. MBA states that if there are 5 parcels in an urban area, then this might take roughly 20 minutes, thus requiring 20 minutes to park on a LZ at least. However, cases that may require more time might seldomly occur.

Pilots in Belfast and Dublin

SC-PU further goes into two different pilots in Dublin and Belfast. For Belfast they did a off-street pilot at a loading bay for a hospital. Regulations for the city streets are difficult according to SC-PU. According to SC-PU, hospitals have different requirement for their IT security; personal data and how this data is handled is very important for hospitals. The IT department would not integrate this pilot to the system's IT due to people data. Thus, the pilot worked as stand alone and the system could not be fully deployed. For the pilot in Dublin, LZs that the couriers did not want were chosen, the mobility department chose a place with very low use of on-street LZ, thus SC-PU states that they had a solution to a problem that did not exist, there was no problem to enforce when they were asked to use the warden app; the enforcement agencies had no reason to get involved into this.

These two pilots suggest that in order to have a successfully deployed and operational smart parking system one has to deploy the complete system and integrate this into the current system, and this pilot and system must take place where there is an actual problem to get the enforcement agencies motivated to act upon it.

4.2.4 Suggestive Solutions, Ongoing Projects and Dream Scenarios

The interviewees all have their own solutions and ongoing projects with their own vision of what a dream scenario would look like with regards to urban freight operations. This section intends to present each stakeholder's perception on this. In Table 10, a summary is provided for this section.

Table 10 – Summary of the findings of suggestive solutions, ongoing projects, and dream scenarios for each stakeholder

Stakholder	Dream scenario, ongoing initiatives and solutions

SSTD and SSTD2	– SSTD's dream scenario is to have the majority of the trucks and freight vehicle delivery during nighttime with electrical vehicles
	– SSTD2's dream scenario is to have scan cars instead of hundreds of wardens; further, to have real-time information via sensors at LZs showing occupancy to support logistics providers
	– The municipality has several ongoing projects:
	  - Working with geofencing to increase compliance to traffic rules
	  - Innovation project for 2 different LZs using different sensing technologies; objective is to share the data gathered by these sensors to interested third party developers of apps/services and increase knowledge of LZs
	  - Last mile delivery project that has been running for 4 years; combining electrical smaller vehicles with off-peak delivery has resulted in 30% reduced travel time and better environment

SBTD	– Dream scenario would be to have real-time data on LZs and the city to support decision making for logistics providers; further, to have a well-developed infrastructure that can handle the economic dynamics of Bogota – In the early stages of an environmentally friendly last mile

	delivery solution with bicycles and e-vehicles
CEB	– A dream scenario would be to have well developed and centralized hubs for transshipment of goods. - Having heavier vehicles delivering to these hubs and from these hubs e-cargo bikes are used as a last mile delivery option
RS	– Dream scenario for RS is to allow nighttime delivery as it is aligned with their truck design and overall being more efficient – Another dream scenario would be to have hubs with smaller units delivering the parcels to the delivery points – Ongoing projects for creating material and components that produce less noise to enable delivery at off-peak hours – Works with geofencing and developing control towers
MBA	– Dream scenario is to get rid of the passenger cars in the inner city; create physical barriers to make it impossible to enter the LZs or increasing the price of parking in the city for passenger cars
SC-PU	– A dream scenario for SC-PU would be to have data on a city/municipality so that the city via IoT technologies in order to pinpoint the underlying problem and challenges

4.2.4.1 Municipality

4.2.4.1.1 Stockholm

According to SSTD, there are currently some ongoing pilots; a project with geofencing of different kinds with the objective to increase the compliance to traffic rules. SSTD did not go into detail of this project as it is in its initial stage. However, it seems that compliance to existing rules is an issue in the case for Stockholm. With regards to LZs there is an innovation project going on that will deploy different sensors onto two differently located LZs that can identify different vehicles and occupancy in real-time. A part of the purpose of this innovation project is to collect data that can be shared for actors that are interested to develop a service or an app according to SSTD. This innovation project is very similar to most of the smart initiatives in Table 6 but also Table 5 in which one can see real-time occupancy of a LZ. Furthermore, this is aligned with the problem Stockholm faces of not having enough knowledge of their LZs and how these are utilized. However, there is a major issue with this project, and it is the scale of only looking at two LZs. According to SSTD, there are over 2000 LZs around Stockholm. Thus, the results of this innovation project will not be representative of how LZs are utilized in the city. As SSTD explicitly states, sustainability and environmentally friendly solutions are a priority; a project of last mile delivery solution has been running for over 4 years which combines light electrical vehicles of freight coupled with off-peak delivery. The results have been very positive, as the travel time has been reduced with 30% and this has also led to a better environment for the pedestrians with less congestion and emission. As earlier stated, the municipality of Stockholm heavily focuses on sustainable environmental and social solutions, thus it is only natural for this project to be running. SSTD lastly states that a dream scenario would be to have the majority of the freight vehicles during nighttime with electrical engines, making the trucks disappear from the lives of people. SSTD2 states that the dream scenario would be to put cameras and sensors on LZs to provide logistics companies with real-time data so they can plan their routes. Furthermore, Marucci et al. (2015) state that enforcement requires monitoring which can either be by city staff or with the help of technology such as license plate recognition software or cctv cameras; SSTD2 states that scan cars would be a better option for the wardens than having hundreds of them running around the streets.

4.2.4.1.2 Bogota

For Bogota similar environmentally friendly projects are currently undergoing planning; for last mile delivery, eco-friendly vehicles like bicycle, tricycle and e-vehicles are being evaluated. Compared to Stockholm, Bogota has not come far with their sustainable project even though sustainability is highly prioritized in both cities. This could potentially be due to the issues of Bogota having bigger challenges with underdeveloped infrastructure and that this must be dealt with before moving onto smart and environmentally friendly solutions. Similarly, to what SSTD2 and SSTD state, SBTD states that a good idea would be to have real-time information of what is happening in the LZs to support decision making for logistics providers. A dream scenario for SBTD would be to develop the infrastructure to make these new solutions applicable and possible. As was earlier mentioned, SBTD sees the underdeveloped infrastructure as one of Bogota’s biggest issues related to smart solution implementation. When the infrastructure is developed, freight can go in heavier trucks into the urban center, to hubs where smaller vehicles like bicycles can be used for last mile delivery.

4.2.4.2 Truck and Bike Manufacturer

CEB dream scenario would be to have well developed hubs for transshipment of goods as it is a challenge to find a good hub. This is aligned with the dream scenario of SBTD of having hubs and smaller units that deliver in the city center. In Stockholm, this is to a certain degree taking place with the e-cargo bikes. For RS, focus has been on geozones/geofencing and projects are ongoing related to nighttime delivery which is what SSTD is interested in and wants to see for the city of Stockholm. Being allowed to do nighttime delivery would be a dream scenario for RS like SSTD; this is due to the trucks being under development for off-peak and night-time delivery coupled with the municipality’s goal of making the city more livable by removing heavier vehicles from the inner city. RS, similarly, to CEB and SBTD, also wants to see hubs with smaller units picking parcels up but deliver these autonomously in the future.

4.2.4.3 Logistics Provider and Smart Parking Provider

The dream scenario for MBA would be to not have many cars in the city, as this is the biggest problem for MBA, thus the dream scenario of MBA is only logical. The solution he suggests is if a non-authorized vehicle enters a LZ, it should be destroyed, or it should not be able to get into the LZ. This is similar to some solutions of actual physical barriers suggested by Marucci et al. (2015); which can include gates and bollards or similar to Table 6, Imola in Italy, where operators have to communicate to a control center in order to remove taproots from the LZ. MBA states that increasing the prices of parking in the city maybe would help. However, this could potentially aggregate the problem even more, as LZs are free to use, an increase of price for passenger cars could work as an incentive to use LZs short term even more. Furthermore, if there would be a payment system for all parking spaces, including LZ in Sweden and the prices would increase collectively, then this could have a positive effect as drivers are sensitive to pricing and this is one of the most important factors when deciding where to park (Lin et al., 2017; Nourinejad et al., 2014). For SC-PU a dream scenario would be to first and foremost have data on the city to pinpoint the underlying problem with the help of IoT. According to Table 4, World Economic Forum (2020), IoT technology will mature in

2-5 years. Thus, the technology is not fully matured yet. This is also implicitly stated by SC-PU who states that this scenario is not that far away.

5. Research Quality and Evaluation of the Methodology

This chapter is intended to provide a critical view of the chosen methodology and what deviated from the planned methodology in the methodology section. The quality of the research will be evaluated from three different aspects from Bryman and Bell (2011), these are reliability, validity, and generalizability. These quality aspects can also be the holistic trustworthiness of the research approach and results (Ali and Yusof, 2011). For a definition of these quality aspects, see section 2.3 – Data Collection. Furthermore, Ali and Yusof (2011) state that there is no standardized way to evaluate the quality of a qualitative research and that many researchers have different views of what good quality research implies, especially with regards to validity and reliability in qualitative research

Not much deviated from the planned methodology except a very critical factor for the validity of the research results as will be discussed further below. This crucial factor was unsaturated data in terms of a too small sample size for some stakeholders involved. Besides this, some interviews were too long as others were too short timewise which could be a direct reflection of the extensiveness of an interviewee's answers as well as stakeholders not being allowed to share certain types of data. There were some unexpected answers to questions that were not planned to be asked but were of great interest for the research. Thus, looking across the interviews the time to conduct these varied from 30 minutes to 1.5 hours which gives an inconsistent amount of data when comparing the different views of the interviewees. The biggest limitation to this research is the small sample size for each of the stakeholders which takes a toll on the overall quality of the research.

5.1 Reliability

Reliability is concerned with if the results are replicable and whether or not the measures are stable and consistent (Bryman and Bell, 2011). Bryman and Bell (2011) further break the term reliability into two general components: internal reliability and external reliability; internal being concerned with how the researchers measure or analyze data consistently using the same scale and external referring to the consistency between the different researchers; if there are more than one researcher that analyzes the data then their ways to analyze should be similar. For this research only one researcher analyzed the qualitative data, thus external reliability is not of any concern. However, there were one interview where language was a hindrance; some questions were answered in another language. Fortunately, one of the interviewers, also being a supervisor, knows this language and had to translate what has been said. Furthermore, Nvivo was solely used for the interviews and not the literature review nor the focus group, thus there was some inconsistency in the analysis. However, the analysis has been thoroughly checked to mitigate any inconsistencies associated with these sections.

With regards to internal reliability, the researcher has tried to cluster the interviewees' answers into the perspective of the different stakeholders as well as looking on an individual level to see if there are any contradictions said within a specific stakeholder group. Both the focus group and interviews were tape-recorded which according to Waller et al. (2016) provide the researcher with more documented data and thus adds to a more reliably produced result. With regards to replicability, the research has tried to the extent possible to give a detailed approach of the methods used, however, being a qualitative research makes it difficult to produce the exact same result. The results should be more similar than different if a new but similar sample as well as the questions in the appendix were to be used. It could also be that the contradictions or coherence would be amplified if a bigger sample for each stakeholder would be used and thus determine whether or not different stakeholders see urban freight from very different perspectives or perspectives that are closer to each other. This could in turn be used to prioritize and mitigate the biggest problems more efficiently.

5.2 Validity

Bryman and Bell (2011) emphasize that one of the most important aspects of the quality is validity. Bryman and Bell (2011) similarly break down validity into four different parts: internal and external validity, measurement validity and ecological validity. External validity is also known as generalizability and will be discussed in the next paragraph. For this research only the former three validity components are relevant. Internal validity concerns causality and whether the relation between an independent and dependent variable holds water. For qualitative research this is known as credibility and is related to how believable the findings truly are. A way to do this according to Bryman and Bell (2011) is to use triangulation in which either different qualitative methods are used or respondent validation. This has been done for this research as two qualitative methods have been used: one focus group and semi-structured interviews. The results from these point towards the same direction. The reason for this however, could be due to the great extent of which the focus groups participants also participated for the interviews for this research. Thus, it would only be natural to have similar results and insight if the same sample would have been chosen.

5.3 Generalizability

Moving on to generalizability, it is defined by Polit-O'Hara and Hungler (1991) as the degree of generalizing the findings of the sample to the population. Looking at external validity, Bryman and Bell (2011) defines this as whether the results can be generalized outside the specific research context. From the researcher's perspective the results can be generalized outside the specific context, this is due to the research's context taking on global perspectives from different municipalities and participants from different stakeholder groups. However, the research is not without its flaws; if the interview would have went as planned with questions being answered properly by all the interviewees then this research would indeed be generalizable. Looking at the topic that has been studied it involves policy, regulation and legislations of different cities and countries, thus automatically the results produced cannot be generalized outside the scope of the cities studied (Gothenburg, Stockholm, Bogota and Vic).

The measurement validity implies whether the research measures what is intended to be measured. The research questions and the interview questions were created and evaluated multiple times by the project team at Chalmers thus the research believes the measurement validity is high. However, some of the interviewees answered questions that did not exists which can affect the measurability. Additionally, two interviews with the municipality of Stockholm's were conducted and gave much richer data for the case of Stockholm than Bogota and Vic. Thus, one can argue that the results of these findings in terms of generalizability, is greater for Stockholm, Sweden, than the other two cities.

6. Conclusion

RQ1: How is a smart LZ defined?

In section 4, Result and Analysis, it was shown that there is no clear definition of what a smart LZ is, however a set of requirements could be derived from the literature review coupled with the empirical data. The empirical data suggest that there needs to be some form of technological or digital tool to capture and display data in order to facilitate the operations for the users, the operators in this case. This definition overlaps with the smart parking definition from the literature review of information collection, system deployment and service dissemination. Altogether, a smart LZ requires three sets of components: some form of sensor technology to capture data, data analytics to analyze data, and some form of user interface to display data. In the literature findings, more specifically, the smart parking solutions and initiatives in Table 5 and 6, there are overwhelmingly more smart parking solutions that coincide with having these three components in Table 5, which is for passenger cars, than for Table 6, which is for commercial vehicles. The reason behind this could be due to other initiatives that would not be defined as “smart” LZ, rather incorporating policy strategies such as dynamic pricing, time restriction and parking enforcement. Thus, a conclusion to this would be that it is not required to have a smart LZ in terms of having dedicated sensors, data analytical tools with a user interface in order to face the challenges that comes in urban areas for LZs. Lastly, in the future, in order to transform a city into a smart city, LZs will inevitably have these three components, or similar technological systems as the surrounding infrastructure of a smart city will be driven by IoT and Big Data.

Figure 4 – The three components of a smart LZ

RQ2: What existing smart LZ technologies could improve urban freight operations and how would these be implemented in a city?

If we further elaborate on the smart LZ requirements from RQ1, these three components include several different types of data gathering sensors – cameras, ultrasonic, accelerometers, acoustic, infrared sensors, RFIDs, etc. Which of these should be applicable for the optimal solution depends on the city’s situation. From the interviews it was shown that cameras for example can be tricky to deal with due to data consent and GDPR issues as well as from a deploying point of view of set-up angles. For the data analytics, there are only three different types and the type that is required would be predictive. Descriptive data analytics does not have the capacity to provide real time data and prescriptive data analytics is too overkill and excessive as it can provide suggestive solutions to complex problems. However, prescriptive data analytics can be incorporated into the route planning to find the optimal route with real time data. Lastly, a user interface which is overwhelmingly being representative are smartphone apps from the literature findings as well as the empirical findings; these seems to be the most convenient way to disseminate information.

There are other smart technologies that could improve urban freight operations but are not defined as smart LZ technologies; control centers might improve urban logistics via geofencing or by giving permission to a freight vehicle to enter a LZ with physical barriers; scan cars that can help wardens' control and collect data more efficiently as a lack of control seems to be part of the problem with misuse of LZs; electrification of vehicles and e-cargo bike for urban last mile deliveries with transshipment hubs. These technologies can all indirectly help improve urban freight operations and LZ operations.

With regards to how these should be implemented, the first step would be to collect data to understand the underlying problem of the LZs in the city, which can be done by placing sensors on LZs and gather data to understand demand pattern and use of LZs. The next step is to involve all the relevant stakeholders which includes an enforcement agency, policy makers, municipality/transport department, logistics providers and smart parking developers to do pilot on the system on a smaller scale. Furthermore, as was shown from multiple pilots of Parkunload, there needs to be a deployment of the full system with all the actors being involved. This is crucial as was shown in Vic; to understand and get representative results of the full-scale deployment of the system. These three steps all require some form of collaborative scheme between the different actors and data sharing.

The first and last step requires to gather data in which data privacy needs to be taken into consideration; it is important to establish what kind of data that is not invading the privacy of the drivers and operators while at the same time can be of value for an efficient LZ operation. Moreover, can the system be integrated safely into existing systems when deploying the full system that does not disclose any other confidential information for example if the operators were to use a smartphone app and data is gathered, then this data should solely be related to the actual operations and nothing beyond this as it would invade the privacy of the driver or logistics company. For the second step data sharing and collaborative schemes are a bit different; the importance here is to share data between the different actors which can be sensitive matter for some of the actors that could potentially profitize of the data.

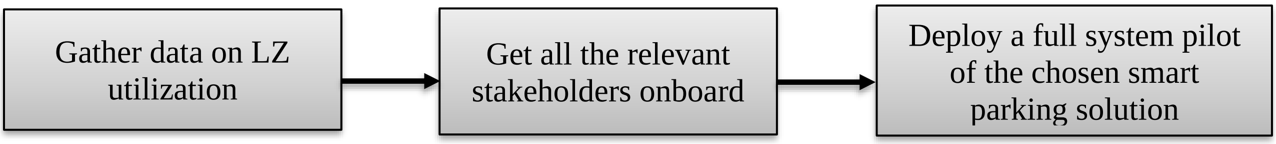

Figure 5 – Holistic view of an efficient and optimal implementation process for smart LZs

RQ3: Which factors inhibit smart LZ deployment and operations in Sweden?

In Sweden, there are several factors that hinders smart LZ deployment and operations. The overall focus in Sweden has been on environmental and social sustainability which has made initiatives and solutions more focused on pedestrianization, bike lanes, electrification of vehicles, etc. thus overshadowing LZ challenges and potential solutions. Looking at the deployment of smart LZs, the biggest problem is the lack of knowledge and data which has been shown to be the first step in a deploying any optimal system efficiently. The lack of knowledge has to do with historically not following up on LZ deployments. LZs that were applied by businesses 10 years ago could be completely obsolete. Lack of enforcement is another factor as was shown for LZ misuse, being the biggest problem for logistics providers in Sweden. From the focus group the partial explanation for this was due to unsupervised LZs; meaning a lack of enforcements for LZs by the wardens. There are multiple reasons for this which has to do with regulations and overall operations of current LZs as will be further explained down below.

From the primary and secondary data, it was also shown that the public sectors, the municipality of Stockholm, is more restricted to incorporate and deploy certain types of sensors such as cameras due to data privacy. Further elaborating on this, there are challenges to integrating smart parking software as well between different actors, meaning that data privacy is not solely an issue of deployment from an actor's perspective rather between the actors as well; the data suggested that the truck manufacturing company could potentially have data that is of value for the municipality and is also what is required in order to mitigate the challenges to lack of knowledge and data. However, the truck manufacturing company is too scared to share this data which further aggregates the potential of collaborative schemes between the different actors which is necessary for the deployment and operations of smart LZs. Looking into the smart parking system of Parkunload and challenges of data sharing this was most clearly shown in the case of a pilot in Belfast of trying to integrate their system to the system of the hospital where the bay lay; due to data privacy this was not possible thus the smart parking software had to work as a standalone. Additionally, a problem with smart LZs and the requirement of collaborative schemes between the different actors is related to the share number of actors that need to work in synergy; there are not solely two actors involved for LZs but multiple; this will create even more complexity and difficulties thereof of creating collaborative relationships between the actors.

Additionally, it was explicitly mentioned that there is some built-in interest to minimize number of LZs and maximize number of parking spots for passenger as these are a source of income. The underlying reason has to do with policy, regulation, and legislation of Sweden; in Sweden LZs are free, the operators do not need to pay and operators can stay as long as there is some unloading/loading activity going with no time limit. The time limit and pricing aspect of Swedish LZs could be a reason for the lack of enforcement of these spaces. Furthermore, another hindrance to smart LZs, is booking which is commonly found in smart LZ applications. It is not possible to reserve public space in Sweden due to Swedish national legislation. Lastly, truck manufacturers and municipalities see the solution of having night-time delivery as heavier electrified trucks can be used and would not disturb any citizens when delivering in urban areas. However, this is not allowed due to Swedish regulations.

The conclusion draw from this is that every city needs its own context-dependent solution that adheres to its regulations, policy, and legislation. For Sweden, a potential smart LZ solution would be mounted sensors with taproots with a control center, as it does not involve any booking and it solves the problem of misuse of passenger cars.

Table 11 – Summary of the factors that hinder smart LZ deployment and operations in Sweden

- Focusing on environmental and social sustainability for pedestrians and passenger cars, e-bikes, etc. overshadowing LZs challenges
- Lack of knowledge and data of LZs utilization
- Built-in incentives to minimize number of LZ and maximize parking spots for passenger cars due to monetary motives

- Collaborative schemes and data sharing between actors is nonexistent
    - Companies are scared to share their data
    - Collaborative schemes between all the actors does not exist due to, amongst other things, monetary reason
    - General difficulty when multiple actors are involved and collaborative schemes are required

- Legislation, policy, and regulation hindrances
    - Not paying nor having time limits for LZs
    - Not being able to book LZs
    - Not allowed for nighttime deliveries
    - Lack of LZ enforcement by wardens
    - Public sector having more restrictions than private sector of deploying certain sensors – cameras

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Appendix

Template/Draft for Participants

Dear XXX,

We hope this email finds you well.

Smart Loading Zones, a technology-based strategy for efficiently managing parking zones for urban deliveries, has been the research focus of a public-private project led by Chalmers University during this year. After the online workshop that counted with your participation, we want to invite you to an interview via Skype/Zoom to go into detail about your perceptions, ideas and experience regarding this topic.

As mentioned in the workshop of May, this research project looks for evaluating an app-based platform system for urban loading zones. After analyzing historical data and developing quantitative models to improve loading zones management, now we want to combine those findings and developments with qualitative research. It will help us to understand the factors that inhibit and/or enhance the design, planning and operation of smart loading zones in urban areas.

The interview will take 45-60 min via Zoom/Skype during the next week at the time of your convenience. The researchers do not anticipate any risks associated with your participation. Please inform beforehand if you need any part of your response to be kept confidential. You can withdraw from the interview at any time. Ethical procedures will be undertaken. By agreeing explicitly, you agree to be interviewed and how the information will be used. You will agree on the following:

- the interview will be recorded, and a transcript will be produced
- any statement or summary will be anonymized so that you cannot be identified
- the actual recording will be destroyed after the transcript has been completed
- any research papers/articles from the interview will be sent for approval before submitting

Please feel free of contacting us if you have any question. We look forward to meeting you and having your insights about this important topic in urban freight transport.

Regards,

Interview Questions

Private Sector

Objective: To understand the private sector's perspective of smart LZ - their necessity, challenges of current systems and factors that inhibit/enhance smart LZ deployment

Logistics Provider

Introduction

1. (introduce ourselves)
2. Can you please introduce yourself and your role?
3. Can you please explain your experience with logistics operations?

Company overview and Operations

4. How many trucks do you operate for urban distribution?
5. Could you provide us with general KPIs of your urban operations? (how many deliveries per route)
6. How are these routes set and planned for each truck? How parking influences this decision?
7. How many different types of trucks you operate? size, payload, capacity, fuel-type, emission standards? A rough estimate of % share is enough.
8. What sectors/commodities your trucks transport.
9. Are the loading and unloading activities standardized in urban areas for all goods or are fragile and/or bulky goods handled differently with different tools?
10. Do you use any mobile application for parking/LZs? Which one? Briefly explain how it works.
11. What is the average time spent on an LZ in urban areas?
    a. How have you measured this?
    b. Do different goods/sectors have different time duration when loading/unloading?

Problem, cause of problem and Fines

12. What are the biggest challenges with regards to urban freight, in particular for last mile deliveries? - finding vacant LZs? Policies?
    a. Have there been any initiatives to deal with such problems? If so, which problems are prioritized and how?
    b. Are there any challenges with loading and unloading for the truck operators? - received any complaints from truck drivers?
13. Do LZs restrict parking durations to some maximum limit? or can you park for as long as you need to? If so, how many minutes/hours? Is it sufficient? What do you think is the reasonable time limit?
14. Do you think parking fees are appropriately priced, if not free?
15. you change any aspects of the loading/unloading operations in presence/absence of a warden?
16. How often do you encounter a warden? Are the LZs sufficiently controlled and monitored?
17. How do you perceive the contribution of the warden from the perspective of your operations but also from the perspective of the city?
18. Do you get any fines and are these fines given due to the same reason? (double park, parking beyond duration time, etc.)

19. Where do you get most of the fines? Are there any commonalities between fines and type of vehicle or type of goods transported?
20. Do these fines create a big yearly cost? (ratio cost of fines and turnover)

App Based system deployment

21. Are there any current technologies that you think would help the challenges you have with regards to your urban freight?
    a. what decisions do you make based on these technologies?
22. Have you heard of smart loading zones? (Introduce Parkunload, if the interviewee hasn't heard of any SLZs)
    a. What do you think of such a system that is app-based, given that it would be mandatory for all logistics companies to use the app? pros and cons?
    b. What features would you like to see in such a system that could potentially mitigate frequently occurring problems of urban freight?
    c. Would you be able to adopt this technology if it were to become mandatory and how long would it take? What would it require from your side?

Game - Dream scenario & Policy maker

23. What would a dream scenario look like from an operational perspective regarding urban freight?
24. What would you do if you were the policy maker?

Smart Parking Provider

Introduction

1. (introduce ourselves) / the draft made above
2. Can you please introduce yourself and your role?

Business model and scalability/flexibility

3. What is ParkUnload and can you give a brief explanation of your business model?
4. In how many cities or countries have this system been applied? Is it solely for urban areas for freight vehicles?
    a. have the results been the same? has the increase of efficiency been positive? Less fines?
5. How would you define a smart loading zone compared to a "regular" loading zone?
6. What has been different when implementing this system in different areas?
7. What has been the biggest challenges in the implementation but also operations - when the system has been used? Have you received any complaints from municipalities or logistics companies?
    a. have these complaints been dealt with by some form of new feature or technology or new business model

Risk

8. Have risks been taken into consideration for such a platform system that is heavily dependent on digitalization and electronic devices?
    a. Can you mention potential risks? example: if an update is required will the app still be usable? if for some reason a smart sign is dysfunctional do you get a notice?
    b. Are there standard procedures to fix such problems quickly? Do you have regular maintenance for the smart sign?

Missing steps in this technology - have you evaluated other system solutions for smart parking

9. Have you observed other smart LZ solutions and or features that could also be implemented in your platform?

10. What differentiates you from other platform technology companies in this industry/area?

What would you do if you were a policy maker?

11. What would a dream scenario look like from an operational perspective regarding urban freight?
12. What would you do if you were a policy maker?

Truck Company

1. (introduce ourselves) / the draft made above
2. Can you please introduce yourself and your role?

Technology and design

3. How many different truck models do you manufacture?
    a. Are the different truck models suitable for different type of operations?
    b. If yes, which truck is for urban deliveries and what differentiates this truck from the other models?
4. What differentiates your trucks from other truck manufacturer? What is it that gives you a competitive advantage with regards to urban deliveries?
5. Have you looked into tools/technologies that can be used as complements for loading and unloading activities in urban areas?

Customers

6. Who are your customers for urban trucks?
7. Do you receive any complaints from customers regarding the trucks, especially for trucks that are used for urban deliveries?
8. Have requests been made from customers regarding features for urban trucks?

App Based system deployment

9. With regards to sustainable freight operations in urban areas, what do you think are the biggest challenges and hurdles?
    a. What would you suggest the solutions would be?
10. How familiar are you with the current state of loading zones for urban deliveries?
    a. Do you think digitizing loading zones so that they become “smart” would have a significant impact on the last-mile deliveries in urban areas?
    b. What would such a smart system for loading zones in urban areas require from the perspective of a truck manufacturer?
    c. What do you think of such a system that is app-based, given that it would be mandatory for all logistics companies to use the app? pros and cons?
    d. What features would you like to see in such a system that could potentially mitigate frequently occurring problems of urban freight?
    e. Would you be able to adopt this technology and/or integrate this technology and/or collaborate with smart parking companies?

What would you do if you were a policy maker?

11. What would a dream scenario look like from an operational perspective regarding urban freight?
12. What would you do if you were a policy maker?

Public Sector

Research Question: How can public policy makers implement smart parking enforcement mechanisms that provide flexibility and customized rules according to different economic sectors / supply chains?

Objective: To understand public sector's perspective with respect to Smart Loading Zones – SLZs, merits, drawbacks, challenges, and suggestions for improvements.

Questions:

1. What are the main challenges in urban freight transport at your city, especially in last-mile deliveries? How has the city prioritized and faced them?
2. How could new technologies (e.g. app-based parking system) ease monitoring and control activities of public space? How are technology adoption processes going on at your city in this regard?
3. Have you ever worked with SLZs? If so, how do SLZs work? What challenges / improvements / suggestions have you considered?
4. How is the planning process for defining freight parking zones?
5. Are parking durations in loading zones defined by public sector? If so, how did public sector come up with the defined time?
6. How many freight parking zones are in your city? Where are they located? (Not needed for Vic)
7. Does the public authority consider any particular regulation/exception policy for specific products e.g. food? If so, how did city define them?
8. What are the designed strategies for parking zones enforcement (wardens, technology, regulation…)? What are the main challenges?
9. How have you evaluated the abovementioned strategies impact on parking zones use and related KPIs (traffic, violations such as double parking, efficiency, …)?
10. How are warden allocated to the parking zones? How many zones each warden handles? How do they manage various zones in capturing violations. How far apart the zones are?
11. Have you quantified the impact of parking zones misuse on mobility? How do you penalize parking zones misuse?
12. How are pricing policies defined? How much money does the city collect from parking zones fines?
13. What are the most common violations? Time related? Vehicle type? Type of products?
14. From your experience, what are your main recommendations for public authorities and researchers around the world about succeeding in parking zones management?

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