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Autonomous Delivery Robots for Urban Settings

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Abstract

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Global urbanisation has been overgrowing in the past decades. In 2018, the world's urban areas were home to over half of the world's population, and by 2050 that number will rise to approximately 68%. With the fast-packed urbanisation and the rapid growth of e- commerce across the globe, cities face more pressure, particularly in terms of urban goods distribution. Traffic congestion, pollution, and last-mile deliveries are some of the most challenging issues. The World Economic Forum (WEF) projected that this trend for urban last-mile deliveries is soaring; it is set to grow by 78% globally by 2030

This thesis presents a concise background on the concepts of urban logistics and last-mile delivery. It further provides a general overview of the technology and robotics in logistics, particularly autonomous robots for last-mile deliveries, and how these innovations are being piloted and experimented in urban settings with the use of three case studies. The emperical data was collected through semi-structured interviews both face-to-face and virtually via Microsoft Teams and Zoom with the stakeholders of the pilot project: a case of the REDI-Home-on-demand delivery robot pilot run in Kalasatama, Helsinki, Finland.

The main results and the conlusions of the research indicate that autonomous robots are more beneficial in urban last-mile deliveries. Sidewalk delivery robot models are shown to be less dangerous to other pedestrians as they operate at smaller speeds, as well as suitable in most cases for hybrid-commercial and residential areas, but have limitations related to their battery life and weather conditions, particularly during winter times. The road delivery robot models, on the other hand, have shown promising benefits for urban freight distribution, but they also have legislation concerns. Nevertheless, there is a cause for optimism, mainly the implementation of autonomous delivery robots on a large scale, but again, nothing is straight forward. Because of this, more comprehensive regulatory issues regarding safety are still required to facilitate the large-scale deployment of autonomous delivery robots in urban areas.

Keywords: Last-mile , Autonomous delivery robots, Urban Logistics, Piloting

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List of Abbreviations

ADR: Autonomous Delivery Robot
6Aika : Six City strategy
WEF: World Economic Forum
FVH: Forum Virium Helsinki
LMAD: Last-Mile Autonomous delivery
RHD : REDI Home-on-demand Project
SADR : Side walk Autonomous Delivery Robots
RADR: Road Autonomous Delivery Robots

1 Introduction

Global urbanisation has been overgrowing in the past decades. In 2018, the world's urban areas were home to over half of the world population, and by 2050 that number will rise to approximately 68% per cent, (UnitedNation, 2018). With fast-packed urbanisations, cities face more pressure, particularly in terms of the movement of goods in and out of the city centres. These challenges will grow as cities require a massive quantity of goods and services, and as the demand for these human activities are more concentrated in urban areas, producing numerous externalities. (Friedrich & Bickel, 2005)

Traffic congestion, pollution, and last-mile deliveries are some of the most challenging issues that major cities will have to contend with on a daily basis in relation to city logistics. An example would be daily trips generated by public or private transport users and other vehicles that carry freight in city centres. World Economic Forum (WEF) presents evidence that this trend for last-mile deliveries is soaring; it is set to grow by 78% globally by 2030. Consequently, cities are struggling with traffic volumes, CO2 emissions, and congestions due to the increasing number of delivery vehicles in city centres. (WorldEconomicForum, 2020).

Moreover, this trend is also having severe impacts on cities' quality of life. As stated by the EPT-Alice (The European Technology Platform), urban freight is a significant component of traffic (10-15% of vehicle equivalent miles), emissions (25% of urban transport CO2, and 30 to 50% of NOx and particles), and noise in cities. (EPT-Alice, 2019).

Furthermore, at the time of conducting this thesis, the novel COVID-19 pandemic was an outbreak across the world. Like almost all industries, urban goods distribution is no exception. E-commerce has experienced soaring growth, particularly for online groceries. More people are starting to place orders for basic foodstuffs online, either for home delivery or as a pick-up service. In Finland alone, the two leading supermarket chains, both the K-Group and S-Group, reported explosive growth in online sales. In contrast, the number of customers using their online stores multiplied in 2020. (Ylenews, 2020). The ongoing COVID-19 pandemic and the rise in e-commerce have forced many businesses, retailers, and food vendors to look into various options that could tackle last-mile delivery. As a possible solution, autonomous delivery robots (ADRs) are conceived more attention since they can provide contactless delivery under the directives of social distancing.

The desire and excitement to learn about development in city logistics, especially last-mile deliveries, led me to research and write this thesis. As a result this thesis addresses the key challenges and benefits of using autonomous delivery robots (ADRs) in the urban last-mile delivery context.

1.1 Research objectives

This study addresses the key challenges in urban last-mile delivery and the benefits of using autonomous delivery robots (ADRs) as a solution for last-mile delivery. In addition, the purpose of the study is to introduce what it is like to pilot the concept of autonomous delivery robots in urban settings and the surrounding services. In the light of these objectives, the following research questions have been formulated to guide the study as it progresses.

1. What are the key challenges in urban last mile delivery ?
2. How do autonomous delivery robots (ADRs) benefit urban last-mile deliveries?
3. What are the possible barriers that could hinder the implementation of autonomous delivery robots in urban settings?

1.2 Research methodology

Methodologically, this thesis is qualitative, descriptive and non-probability research. It is based on study of three pilot projects of autonomous delivery robots. Both primary and secondary data were utilized. As the main primary source information collected from REDI Home-on-Demand -project (Case1) was used. Information about two other pilot projects that are relevant to the topic field was used as main secondary data. The other two pilot projects were the Polle food delivery robot for a senior centre in Helsinki and the LMAD autonomous robot in Otaniemi, Espoo, Finland. The literature review also included relevant sources for the study, such as journals, academic papers, eBooks, and news articles.

The primary data was collected from the stakeholders of the REDI Home-On-Demand - project via semi-structured interviews, both as face-to-face interviews and virtually via Microsoft Teams and Zoom. The interviews were conducted between October 7th and December 15th, 2020 with representatives of the pilot project stakeholders.The interviewees were chosen based on the contact information provided by the project planner of Forum Virium Helsinki ; hereafter this text will be abbreviated as FVH.

During the second week of the experimental phase of the pilot project, an email inquiring about the possibility of conducting an interview was sent to all potential interviewees provided by the project planner of Forum Virium Helsinki. Only four of them responded and accepted the request. They were representing all three different stakeholders of the project, which provided a holistic view of the pilot project, including organizing, piloting, and partner companies. All the interviewees worked in the Forum Virium Helsinki 's REDI Home-On-Demand - project and had professional backgrounds in urban development, autonomous mobility, and piloting of new services. They had a managerial position in their company.

Before the interviews were conducted, the author had a pre-interview stage when he set up the interview, familiarised himself with the background of the key partners involved in the project, and ensured that all the required equipment and materials (Zoom, Microsoft Teams, and recorder) were in working order. The interviews took about 45 minutes each, and they were recorded and transcribed. There were 10 open-ended questions, which can be seen in appendix 2.

The approach used by the researcher during the interview was conversational, reflective questioning, and unbiased, which enabled the respondents to answer all questions flexibly. The first of these interviews was conducted in autumn, 2020, during the second wave of the global pandemic, when most of the offices of the companies were temporarily closed due to the restrictions of the COVID-19 pandemic. Hence, virtual interviews were used instead of visits to company premises.

For ethical considerations, the participants were asked to give their consent to participate (See appendix 1) and they were reminded of their rights to choose how they wanted to be represented in the thesis (anonymously, by their name, or company). Most of the participants chose partial anonymity. Thus, the interviewees' names are not mentioned in the thesis or in the transcripts. To ensure each participant's partial anonymity, they are named as interviewee 1, 2, 3, and 4. Table 1 shows the profiles of the interviewees who participated in this study and gave their consent to participate in the research.

Table 1. Interviewees by the company, stakeholder group and position

#	Name	Company	Stakeholders group	Position
1	Interviewee1	Forum Virium Helsinki	Orginising company	Project Manager
2	Interviewee 2	Forum Virium Helsinki	Orginising company	Develop. Manager
3	Interviewee 3	Dimalog Oy	Piloting company	CTO
4	Interviewee 4	REDI K-Super Market	Partner company	Project Manager

1.3 Limitations of the study

This study has several limitations to pay attention to. The first limitation is the geographical location being just three pilot project in Helsinki, Finland. Another limitation was the small number of the interviewees, only four. Although these four interviews were made to the members of the stakeholders of the project, the final findings cannot be considered to represent all stakeholders involved in the project. Considering the nature of the research, the researcher would have needed more interviewees in order to have a fairer representation of the pilot stakeholders' views.This was hindered by the COVID-19 pandemic, and as result the pilot project stakeholders who were required for the interview were not accessible.

1.4 Thesis outline

This research paper is delivered through 6 chapters seen in Figure 1. The topic, background of the study, research objectives and methodology will be presented in chapter 1. Chapter 2 presents the literature review and all information required to understand the topic. Moreover, this chapter mentions main definitions such as city logistics and urban last-mile delivery and explains the current state of the robotics technology and autonomous delivery robots.

Chapter 3 emphasizes the stages of an agile piloting model with the help of the case studies. Chapters 4 presents research findindgs and results based on the interviews. Finally, chapter 5 summarizes the conclusions of this thesis and presents an outlook for future research.

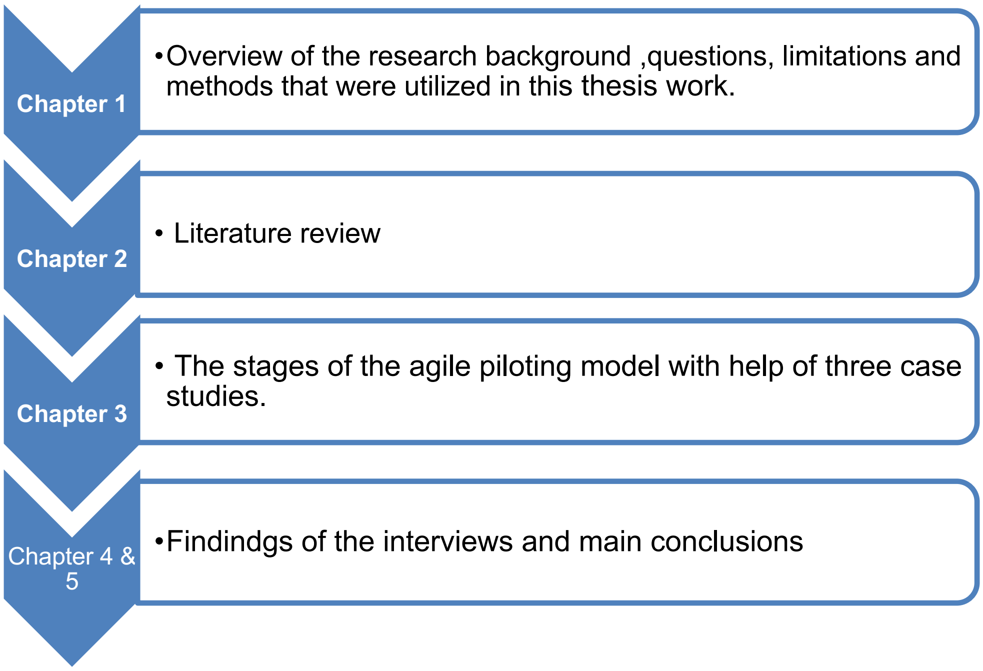

Figure 1. Outline of the thesis

2 Theoretical Background

This chapter provides an overview of the theoretical background for the research, discussing relevant literature on concepts of urban logistics, last-mile delivery challenges, and autonomous delivery robots (ADRs). The material used in the literature review has been collected from academic papers, eBooks, journal articles, company websites, and other related news articles. In addition to this, the literature search also starts with key terms like "urban logistics," "urban goods distribution," "city logistics," "last-mile delivery," "autonomous delivery robots (ADRs)," and other terms that were thought to be important for the study.

2.1 Concepts of Urban logistics and Last-mile delivery.

The domain of urban logistics and last-mile delivery is becoming increasingly complex, and it will be far more challenging in the future, with a growing demand for urban goods distribution and a negative impact on the quality of life in urban areas. Urban logistics have changed over time, and they have been a subject of interest for scholars and policymakers for several decades.

Most of the authors who have written about urban logistics have mainly used terms like "city logistics", "urban goods distribution", "urban freight transport", and "last-mile delivery" in one way or another when describing how goods flow through urban areas, which makes it possible for people to get confused about their differences . Therefore, this section briefly outlines the development of urban logistics and intends to help the reader's understanding of the topic and where it fits into the overall field of supply chain management and logistics.

In order to better understand what urban logistics is and where it fits into the broad field of supply chain management and logistics, it is important to identify keywords that have been used together in the literature about urban logistics challenges.

The term "urban logistics", or sometimes called "city logistics", is a phrase formed by the combination of two terms: urban and logistics. Consequently, there are various definitions of the term "logistics." A description adopted by the Council of Supply Chain Management Professionals (CSCMP) may represent a better definition of the term:

> " Logistics management is that part of Supply chain management that plans, implements,and controls the efficient, effective,forward and reverse flow and storage of goods, services and related informations between the point of origin an the point of consumption in order to meet customers requirements" (CSCMP, 2016).

In addition, the Chartered Institute of Logistics and Transport (CILT) in the UK defines logistics in the following way :" Getting the right product to the right place in the right quality at the right time , in the best condition at an accepble cost. (John;Lalwani;& Butcher , 2008).

Moreover, the term supply chain management (SCM) was introduced initially by businesses at the beginning of the 1980s and, since onward, has received considerable attention. Supply chain management is a much broader concept than logistics. Martin Christopher defined that "the SCM is the network of organisations that are involved, through the management of upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer." (John, et al., 2008)

Furthermore, the terms "urban logistics," "city logistics," and "urban freight transport" are used interchangeably to describe the same concept of the movement of goods, equipment, and passengers. A wide variety of definitions of city logistics are available in the literature. The Institute for City Logistics (ICL), established in Kyoto, Japan in late 1999, has adopted a definition of the term "City Logistics" that describes it as "the process for totally optimising the logistics and transport activities by private companies in urban areas while considering the environment, the traffic environment, traffic congestion, and energy consumption (and emissions) within the framework of a market economy." (Taniguchi, 2014).

As described above, city logistics has traditionally dealt with procedures and techniques to be deployed when goods are distributed in urban areas and is considered to optimise urban freight transportation. However, in developed countries, city logistics is is mostly used for projects that deal with specific problems. These problems include the negative effects of urban freight distribution, new logistics equipment, and ways of improving the delivery of goods to customers.

For a thorough understanding of supply chain management and logistics and city logistics, it is also important to define their differences. A number of academics have studied it. The Volvo Research and Education (VREF) initiative on urban freight, for example, said that while logistics is concerned about the organisation of supply chains to achieve goals, city logistics, in many respects, involves regulating freight distribution activities to minimise potential disruptions in urban areas. (Jean-Paul & Dablanc, 2018).

Besides that, we can see that supply chain management and city logistics are linked to different types of methods. Then, city logistics is part of the bigger idea of logistics. One example of how they are different is shown in figure 2 of the Volvo Research and Education (VREF) project on urban freight transport and logistics which summed up the difference beween SCM and City logistics.

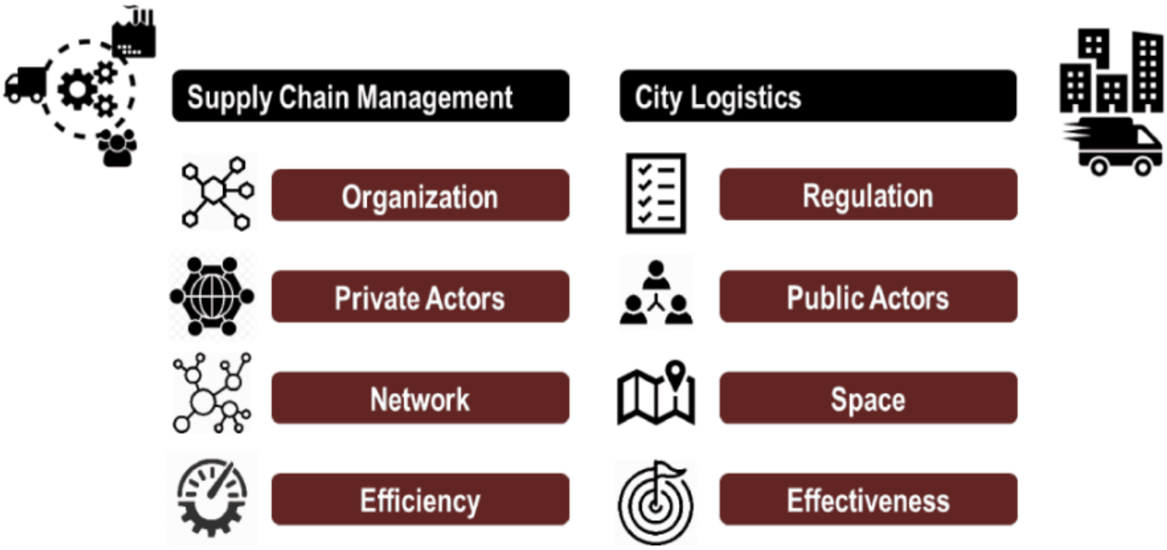

Figure 2. Difference b/w SCM and City logistics by VREF (globalcitylogistics, 2019)

Cities are complex environments where many structures are not used as they were initially intended. The complexity of cities also gives rise to a debate about how these problems and their possible solutions may be considered context-specific. Nevertheless, as already mentioned above, the trends of growing urbanization, congestion, and pollution have led many authorities to initiate new solutions in city logistics to deal with the negative environmental impacts and improve the quality of life in their cities.

Most of the innovative solutions in city logistics are carried out in developed countries. Many of these initiatives seem to be at different stages of success in the way they are applied considerably from one country to another (Sopha, et al., 2021) European countries are one of the regions that have been pioneering innovative solutions for city logistics. Some examples of city logistics projects in European countries are such as the European funded projects entitled "Freight Electric Vehicles in Urban Europe (FREVUE)" (Frevue, 2017) and "Sustainable Urban Logistics Planning Enhances Regional Freight Transport (SULPITER)" (InterregCentralEurope, 2019). The projects intend to improve urban freight transport efficiency and competitiveness in Central Europe, including the Nordic countries. In Finland, for example, the country's six largest cities have done extensive work to tackle their common urban challenges by implementing almost 60 innovative solutions in city logistics under the six city strategy projects since 2014 (6aika, 2021).

These projects involved elements such as experiments with light delivery vehicles, setting up city-centre distribution stations, and technological applications that facilitate intelligent urban mobility. In this way, they focus on sharing best practises between different cities in order to develop or adopt new innovative sustainable solutions for city logistics, such as various modes of light electric vehicles, city distribution centres, and autonomous last-mile delivery vehicles (ALMDVs).

2.2 Challenges of urban Last Mile delivery

The "Last Mile" is a phrase brought to the forefront when electronic commerce became a more popular way of doing business. The term "last mile" can be traced back to the telegram period, when one had to use a delivery bike to bring mail to the customers from the receiving point to the end of the mail line. Today, from a logistics perspective, it refers to the last segment of the supply chain, the final leg in a business-to-consumer delivery service whereby the consignments are delivered to customers either at the recipient's doorstep or collections points such as parcel lockers where customers come and pick them up. (Peng He, 2021)

Although several contributions have been made in the last-mile context, some of the authors of this topic stated that "last-mile" delivery is the most expensive, least efficient, and most pressing environmental concern of the entire urban logistics segment that causes pollution and disturbances. Last mile logistics, and urban last-mile delivery in particular, has become one of the bottlenecks of e-logistics, which has recently gained increased focus and become more important due to the increasing growth of e-commerce (Lim, et al., 2018)

The delivery of last-mile goods in cities is currently fraught with difficulties. Because of the need for effective efficiency solutions in last-mile delivery methods, many innovative technologies such as drones, autonomous delivery robots (ADRs), and autonomous vehicles (Avs) have emerged as a logical answer to last-mile challenges (Standford, 2016). All of these technologies have their advantages as well as challenges for customers and service providers.

According to a recent McKinsey Global Institute analysis, by 2025, up to 85% of all last-mile deliveries could be carried out by robots. (Schröder , et al., 2016). Moreover, McKinsey analysis on global transportation, especially last-mile delivery, autonomous delivery robots (ADRs) are predicted to reduce delivery costs in cities by 10% to 40% in 2016.

2.3 Robotics and Autonomous delivery robots

When we think of robots, most people will probably get a clear picture of machines that look like humans-a bit similar to the most popular "RobCop"- the American science fiction movie in 1987. However, today, robots are emerging in many areas and are no longer science fiction. Instead, they affect our lives in ways we would never have thought imaginable. We read about them almost every day in the news, from healthcare robots used in elderly care facilities to self-driving robots that deliver items from grocery stores to end-users.

Different classifications of robots exist. The International Federation of Robotics (IFR) and the International Organization for Standardization (ISO) classify robots into two categories: (1) Industrial robots and (2) Service robots. ISO defines the industrial robot as follows " an automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes,which can be either fixed in place or mobile for use in industrial automation applications". While the service robot is “a robot that performs useful tasks for humans or equipment excluding industrial automation applications” (ISO, 2012)

The definition of a service robot as defined by the international federation of robotics (IFR) states that a service robot operates semi-or fully autonomously to perform tasks in a useful way for the wellbeing of humans and can be categorised further into two groups: personal service robots for personal use (e.g. vacuum cleaners, automated wheel chairs, and personal mobility assistant robots) and professional service robots which are used for commercial tasks (e.g. autonomous unmanned vehicles) (IFO, 2021)

In addition, the authors of (Kagan, et al., 2019) have written a book on Autonomous Mobile Robots and Multi-Robot Systems, which offers fundamental theories of autonomous robots. According to their seminal contributions to understanding the methods and algorithms for robots and their applications, robots can be classified into two types: "fixed-base robots" and "mobile robots." These two types of robots have different tasks and working environments. Fixed-base robots are heavy installations that work in a highly defined environment, like industrial or factory assembly lines, and They also operate in specialised locations where humans are not permitted to enter while the robot is in operation.

Mobile robots are equipped with advanced navigation technology, allowing them to perform tasks in unknown environments that are not known in advance and thus do not require external heavy infrastructure. Robots of this type can be autonomous or semi-autonomous, which rely on a mixture of sensors and artificial intelligence (AI)-enabled software. Their higher levels of navigation capabilities allow them to perform tasks automatically or without the assistance of humans, and they can be deployed in commercial environments, such as autonomous delivery robots (ADRs). These two types of robot are shown in figures 3a and 3b

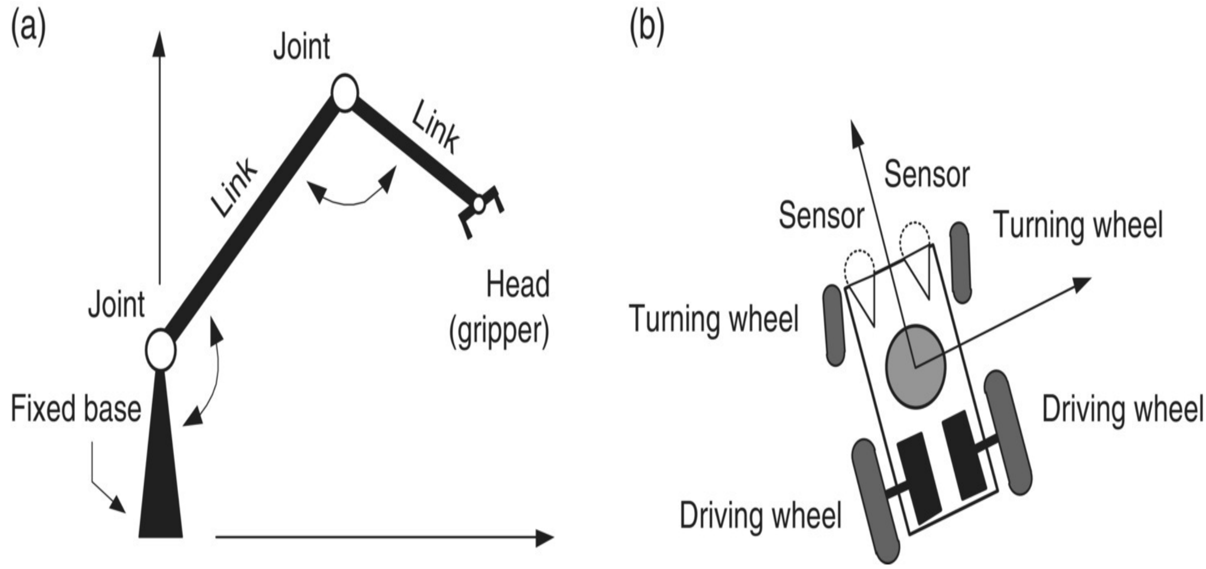

Figure 3a and 3b: Fixed-based robots and mobile robots by (Kagan, et al., 2019)

Robotics and artificial intelligence are driving forces that are making it possible for people to move away from physically hard and repetitive work and toward automated processes and software technology that helps people.Aside from that, logistics such as distribution centres and omichanel warehouses are making extensive use of autonomous mobile robot technology to improve predictability and eliminate labour hazards. Many of these mobile robots have been demonstrated to be beneficial in addressing e-commerce warehouse concerns, such as labour shortages and rising service expectations (Barbee, et al., 2021) Nevertheless, in the preceding section, we briefly discussed the introduction to technology and robotics as well as automation, particularly mobile robots, which are now used in the logistics industry. Therefore, in the following section, we will focus on autonomous robots for last-mile deliveries.

2.4 Autonomous robots in the last-mile delivery

Autonomous delivery robots (ADRs) are basically "mobile robots" that are equipped with advanced sensors and navigation technology that allow them to deliver items or packages to end-users without the intervention of traditional delivery staff. The ADR landscape in the last-mile context has evolved rapidly. Thus, according to (Figliozi & Jennings , 2020) autonomous delivery robots (ADRs) can be sub-divided into the following two types: sidewalk autonomous delivery robots (SADRs) and road autonomous delivery robots (RADRs). Both robots are ground-based delivery solutions, which are electrically powered and intended to operate at a relatively slow speed in limited residential areas.

Side walk Autonomous Delivery Robots (SADRs) are self-driving vehicles with four or six wheels that travel next to people and deliver takeout food, groceries, and other small packages. They were deployed on different continents. Some of the leading examples are Startship Technologies, Kiwi Bot, and Amazon Scout. The Startship and Amazon Scout robots have a similar design with six wheels, while the KiwiBot is smaller than the other two and has four wheels. All these robots seemed to be designed to have a package capacity of a shopping basket size to deliver items on short routes as they are meant to travel in pedestrian areas.

Some of the advantages of these SADRs are that they bear less dangerous to other side-road (pavement) users due to their lower speed. The speed limit of SADRs varies across the world. The United States, particularly Virginia, was the first state that introduced the use of sidewalk delivery robots (SADRs), with a maximum speed of 10 km/h (GeraldY, 2020). There are no specific regulations for SADRs yet in Finland. However, the speed of autonomous mobility cars and lightweight electric vehicles is limited to 25 km/h. (Vepsäläinen, 2022)

On the other hand, road autonomous self-driving robots (RADRs) are self-driving vehicles designed to operate on roads without drivers' control. Unlike SADRs, the RADRs have ample space and a longer battery life, which enables them to make deliveries to multiple locations with more items. ((Figliozi & Jennings , 2020) have studied the potential of road-autonomous delivery robots for urban freight. These studies show that RADRs are more competitive than traditional vehicles and could introduce a new business model for job automation. This model makes nonstop operations (24-hours) possible. RADRs are also promising for e-commerce, which is increasing urban delivery demand.

In addition to the fact that ADR technology could tackle last-mile delivery challenges, one significant issue that needs to be addressed is the regulatory aspects of these machines. Unfortunately, ADR regulations are currently lagging behind technology's progress, and that is why we see many countries where operations are regulated by local policies. The strengths and weaknesses of the ADRs when tackling the urban last-mile delivery challenges are summarised in table 2. Table 2. Strengths and weaknesses of autonomous delivery robots (Figliozi & Jennings , 2020)

Strenths	**Weakness**
▪ Affordable costs of delivery for business ▪ Efficency of delivering service to customers ▪ Easy to deploy due to their small size ▪ Reduce delivery vehicles in cities and GHG emission for last-mile delivery	▪ high purchase of cost ▪ Pedestrian safety

3 Piloting autonomous delivery robots - Case studies

In this chapter, the agile piloting model is presented briefly together with three different pilot project cases run by the Forum Virium Helsinki, an innovation company owned by the city of Helsinki. Forum Virium Helsinki has a good track record in European projects and proven cases of agile pilot models in the Helsinki metropolitan area and in the six biggest cities in Finland under the Six City Strategy 6Aika-project. (Urbanite, 2020)

3.1 Agile piloting model

The concept of "agile piloting" is probably one of the most popular models for quick experimentation of new services in the world today. The agile piloting programme has been widely used for creating something new, e.g. technology developments, research studies or in the context of new innovations such as autonomous mobility, self-driving vehicles and delivery robots. (Spilling , et al., 2019)

Having appropriate piloting of new services is critical for understanding any real-life challenges. Experimenting with new services in a real-life environment reduces the risk of failure at scale and enables new solutions to be learned and validated. In addition, the pieces of information gathered during the pilot study are often used to assess if it is worth conducting further experiments on the project, and they work as guidelines for related studies to prevent potentially fatal issues on a large scale. (Spilling & Rinne, 2020)

The Forum Virium Helsinki's agile piloting model engages different stakeholders at different stages of the project. These stakeholders are, e.g., organizers, partners, piloting companies, urban residents, city policymakers, and researchers. According to the Forum Virium Helsinki 's pocketbook for agile piloting, which aims to guide Finnish urban experimentation and in any other cities having similar needs and interested in applying experimental approaoches about emerging services and technologies, the Agile piloting model has five major steps and continues for six months at maximum. This model is show in figure 4. (Spilling & Rinne, 2020)

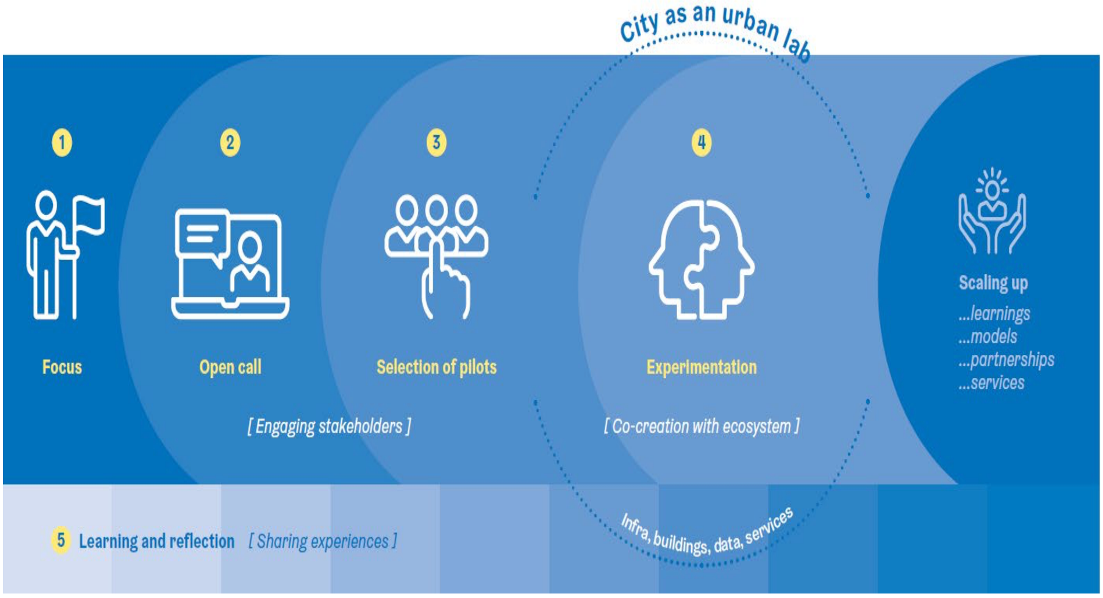

Figure 4. FVH's gile piloting process modified by (Spilling & Rinne, 2020)

1. **Focus:** Select the key stakeholders and challenges to be solved by creating a common focus and goals.
2. **Open call**: After selecting the challenges, the organizer declares the Open call for the piloting round which lasts 1.5 months
3. **Selection of the pilots**: After the piloting rounds (maximum six round), organizer is selecting the final piloting company in a transparent way.
4. **Experimentation:** The experimentation process is the core of the piloting rounds and lasts maximum of 6 months. During the experimentations, the piloting stakeholders co-develop their agile piloting with end-users.
5. **Learning and reflection:** Finally, the process ends with the evaluation stage. It aims to engage the stakeholders who followed the programme and evaluate the overall learning gained during the pilot.

3.2 Testing autonomous delivery robots in Finland

In this thesis, three pilot cases of using autonomous delivery robots were analysed. These pilot cases were conducted in the Helsinki metropolitan area, the capital region of Finland. The key characteristics of the pilot projects are presented separately. Despite the fact that these autonomous delivery robots are different in terms of size and offer different kinds of services, they are all aimed at addressing the key challenges in urban last-mile delivery. The pilot projects were organised by Forum Virium Helsinki, the innovation company of the city of Helsinki and its partners. These three pilots were chosen as case studies for this thesis in order to find out how successful autonomous delivery robot pilots experimented in urban settings

3.2.1 Case1: REDI Home-on-Demand pilot, Kalasatama

The first case study described in this thesis is the REDI Home-on-Demand pilot in fall 2020. In this pilot project, coordinated by the city of Helsinki's innovation company Forum Virium Helsinki with its partners, an Autonomous Delivery Robot (ADR) was tested in the REDI Shopping Center in Kalasatama, Helsinki, Finland for four weeks. The concept of this autonomous delivery robot test was uniquely designed to learn how autonomous couriers could address last-meter delivery challenges in everyday urban life. The robot was delivering food and other products from REDI'S K-Supermarket grocery store, which is located in the Kalasatama Shopping Center of Helsinki, to the Majakka Tower, Finland's tallest skyscraper, as can be seen in figure 5. (ForumViriumHelsinki, 2020)

Figure 5. The Home-on-Demand robot in REDI Shopping center in Kalasatama, Helsinki, Finland 2021 (ForumviriumHelsinki, 2021)

Forum Virium Helsinki is an innovation company owned by the city of Helsinki,specialising in developing new services and urban innovations. It was founded in 2006 and aims to help Helsinki's ambitious goals to be the world's most functional city and its effort to reach carbon neutrality by 2035. The Home-on-Demand robot pilot was a joint project coordinated by the Forum Virium Helsinki in collaboration with its partners SRV, KONE, Dimalog Oy, OMRON IA, Muotohiomo, and REDI's K-Supermarket under the larger project called the "Six City Strategy (6Aika): New Solutions in City Logistics" project ((ForumViriumHelsinki, 2020). Table 3 summarises the project by the time line, stakeholder groups and their roles in the project.

Table 3. Summary of REDI Home-on-Demand robot courier Pilot

REDI Home-on-Demand robot courier Pilot **September 28 – October 28: The Project experimentation period**
June : Kickoff Meetings
July : Technical and Services excursions
August 18 : Workshop for testing the robot and other preparations, online survey
September 28: Robot starts moving
Despite some delays, the robot pilot began moving in the REDI shopping centre on September 28th, 2020, where the local K-Supermarker grocery store offered customers the option of on-demand ordering of food and catering products to the residents of the Majakka Tower building, Finland's first skyscraper tower with 282 apartments and 4 communal areas. **How it works:** Customers place their orders online via the Majakka building's existing digital platform called the ASUMI app, whereupon the autonomous robot courier takes the order direct from the K-Supermarker grocery store to the customer's doorstep. **Key Pilot Partners** **PARTNERS:** SRV,KONE, and ForumVirum Helsinki (FVH) **PILOTING COMPANIES:** Dimalog Oy, OMRON IA and Design Studio Muotohiomo, an operator of the Home-on -Demand Autonomous courier robot pilot **RETAILERS:** REDI's K- Supermarket got this opportunity to test the robot and offered its customers the option of online ordering of their meals and having them delivered by doorstep. **RESIDENTS** : Majakka residents volunteered, ordering a total of 86 food packages via the ASUMI app (a adigtal platform service) owned by SRV, the building management company **ORGANIZING :** The city of Helsink's Innovation company Forum virum Helsink

The REDI Home-on-Demand robot was moving autonomously. Unlike the traditional Autonomous Guided Vehicles (AVGs), the REDI Home-on-Demand robot was designed to be easily integrated with different technology platforms. During the trial period of the pilot, the robot was connected to an existing digital platform called an "Asumi-app" used by the residents of the Majakka highrise tower in Kalasatama. The connection between the robot and the elevator worked smoothly, and the robot rode the elevator autonomously. (See figure 6)

Figure 6. ASUMI-1 robot takes the elevator to delivery items all the way to the residents of Majakka highrise tower in Kalasatama, Helsinki. (Forumvirium Helsinki, 2021)

Moreover, the ASUMI -1 delivery robot collected the neighbouring residents' on-demand food/catering orders. The loading place of the robot was REDI's K-Supermarket store and loading was done by the assigned person representing the robot courier operator (see figure 7).

Figure 7**.** The ASUMI-1 robot getting ready to deliver food to the Majakka residents. (Forumvirium Helsinki, 2021)

The robot was disinfected first and placed the packages inside the robot and finally sent on its way to deliver the food items to the residents of the Majakka Kalasatama tower.

3.2.2 Case 2: LMAD Pilot in Espoo, Finland

In August 2020, an autonomous grocery delivery robot pilot took place at the Aalto University campus in Otaniemi, Espoo, Finland. This robot delivery pilot was implemented by a technology startup company called Last-Mile Autonomous Delivery and launched by EIT Digital (a leading European digital innovation and entrepreneurial education organization) in collaboration with the City of Helsinki's innovation company, Forum Virium Helsinki, and other organisations such as BookIT TwinswHeel, Futurice, BestMile, ClickandEasy, Cap-digital, and GIM Robotics (Digital, 2020).

LMAD partnered with a grocery store, K-Market Otaniemi, which was very keen on testing autonomous delivery robots as part of their online shopping. Through this innovative partnership, LMAD's courier robot delivered groceries from the K-Market grocery store to its customers, who are mainly students at Aalto University in the campus area. The campus is one of the largest in Finland with more than 4,000 residents. (See Figure 8). (Digital, 2020).

Figure 8. Autonomous grocery delivery robot pilot in Otaniemi, Espoo, (Digital, 2020)

Based on a news article published by the smart cities world—a leading platform that publishes articles and studies about ideas to solve urban challenges—Mr. Aleksi Tapani, the owner of the K-Market Otaniemi grocery store, commented on their eagerness to test the LMAD autonomous delivery robot as follows:

> "I believe that the more options the customers have, the better," he added "With the robot, we have been giving customers one additional option to receive the goods for themselves, without as much human interaction as there might be when doing the traditional delivery."

He continued:

> "The question is how to make last-mile delivery profitable, Automatisation and robotics can be part of the solution, that's why I was keen on getting in this pilot and seeing what it would bring" (SmartCitiesWorld, 2020)

Since the pilot in Otaniemi Espoo was a success, the company launched another test pilot project coordinated by the Forum Virium Helsinki in downtown Helsinki at the Kansalaistori Square. However, this pilot was utterly different from the LMAD's previous test. The robot worked as a parcel locker in a public space nearby the city of Helsinki's central library, called Oodi. In this pilot, the library's nearby residents brought charity gifts, and the LMAD's robot delivered each gift to the nearby social service office for a charity campaign, which finally sent the gifts to the families in need. (ForumViriumHelsinki, 2020).

3.2.3 Case 3: Polle Food delivery Robot for Helsinki Senior center

In spring 2021, the "Polle" autonomous robot for food delivery services was piloted in one of the Finnish senior citizens centres (see picture 9). This pilot test was co-created by the city of Helsinki's social service and health care sector and Forum Virium Helsinki.The pilot test was conducted in the Kustaankartano senior centre, Helsinki, where the robot was transporting meals, serving dishes and other services such as mail, letters, laundry and cardboard waste from the

Kustaankartano food centre to senior citizens' centres in the wards. This pilot was part of the co-created Health and Well-being (CoHeWe) 6AIKA project funded by the European structural and investment funds-ERDF. (Forumvirium, 2021)

Figure 9. Polle food delivery robot pilot in Kustankaartano center (Forumvirium, 2021)

During the test run the automated robot navigated independently through the Kustankaartano's centre tunnel during the food distribution time. The development manager of the city of Helsinki multi-service center, Katriina Bernouli described the challenges of food distribution as follow:

> "In Kustaankartano, for example, it takes a lot time to deliver meals as the area is so large and the distance between wards are long. This technology is expected to help the situation. In order the meal deliveries to be successful, it is essential that the customers get their meals on schedule and in the event of malfunctions, an immediate notification is provided so that the deliveries can be made another manner" (Forumvirium, 2021)

4 Results and analysis of the interviews of REDI Home-on-Demand pilot

This chapter is based on the interviews with the "REDI Home-On-Demand" pilot project stakeholders. As mentioned in chapter 1, the primary data for this research was collected from the stakeholders of the "REDI Home-On-Demand" pilot project via semi-structured interviews, one as a face-to-face interview and three virtually (Microsoft Teams and Zoom) in October and November 2020. In this chapter, the insights delivered by four interviewees of the pilot project stakeholders are discussed.

The interview request was originally sent to seven potential interviewees, provided by the project planner of Forum Virium Helsinki . Despite trying to reach out to all, only four were accepted to give an interview and were allowed to use their responses as a supplement to the secondary data and analysis. The respondents represented all different stakeholders of the pilot project, like organizers, piloting and partner companies of the REDI Home-On-Demand project.

4.1 Co-creation with Agile piloting model

Questions which helped to understand how it is like to pilot the concept of autonomous delivery robots in urban settings were asked first. This information was combined with the knowledge gained from theory. The respondents view reflected their position in the project. Interviewee 1 and Interviewee 2 had a solid experience with orgazing pilot projects. Both expressed that the coordintation is a vital part of the project and stated that they had spent a lot of time exploring all kind of different aspects needed to be taken into account from the planning process of the concept to the collaboration between partners. The Interviewee 1 stated:

> “Co-creation of pilot projects is an effective way to bring different stakeholders to create a practical new innovative solutions for

> cities particularly in the development of social, healthcare and cities functionality

Interviewee 2 also described that:

> “ the piloting models allows cities, to develop their service whether it is transportation or other services ”.

Interviewee 2 continued:

> “ Pilots provide partnering companies, especially organizors, opportunites to test a new service before too many resources are spent”.

As can be seen, answers of both interviewees are quite consistent about the benefits of the Agile piloting model. In chapter 4.1 it was also mentioned that the agile piloting model provides a useful way of quick experimentation of new services.

4.2 Major challenges of autonomous delivery robots in urban settings

Autonomous delivery robots are relatively new in urban settings. Interviewees had similar answers to a question regarding major challenges that could hinder the implementation of autonomous delivery robots in urban settings. Interviewees 1 and 2 pointed out the safety issues seems one of the major barriers that could hinder deployments of robots into large scale business. Interviewee1 stated that some of the local authorities are a bit cautious about the authorization of autonomous delivery robots to be deployed in open environment like city centers and sidewalks due to safety issues.

Similarly, Interviewee 3, who was the responsible person for the actual experiment phase of the REDI Home-on-Demand robot pilot project and in charge of solving the possible technical problems during the experiment phase also stated that infrastructure and safety seems to be the major barriers at the moment. Interviewee 3, described this in the following way:

> “ the ADRs deployment phase has its own challenges. The operations need to be monitored in case unexpected situations such as pedestrians appear”.

Interviewee 4, who was the sole retailer partner of the REDI Home-on-Demand pilot project had a similar view that safety concerns are the most notable issues that could hinder investments in robots in large scale. Nevertheless, the answers from the interviewees shows that four of the participants were equally concerned about safety and regulations.

5 Conclusions

This thesis presents a concise background on the concepts of urban logistics and last-mile delivery. It further provides a general overview of the technology and robotics in logistics, especially autonomous robots for last-mile deliveries and how these innovations are being piloted and experimenting in urban settings with the use of three case studies. The three case pilots described demonstrate that autonomous delivery robots can be applied in different contexts. The experiments and testing of the three cases took place in residential areas. One of the robots was piloted in a hybrid commercial and residential indoor environment, while the other two pilots were tested in an indoor and outdoor environment. Despite their different models, they were all aimed to learn how autonomous delivery robots work in a real-life environment and could address many of our everyday urban issues. Piloting during the global pandemic of COVID-19 was also another opportunity to learn consumers' attitudes toward the willingness to use ADRs.

The REDI Home-On-Demand pilot project (Case 1), in which the author of this thesis interviewed the project stakeholders, showed that the testing period was a success and stakeholders and consumers were pleased. According to a user survey conducted by Forum Virium Helsinki at the end of the project the robot service was seen as an especially intriguing solution when working from home (remote working), when sick at home or hosting a party. (Forumvirium, 2021) Furthermore, the learnings of the case 1 pilot project experiences confirmed that the REDI Home-On-Demand robot was suitable in hybrid commercial and residential indoor environments. On the other hand, the hybrid-model delivery robot for indoor shows more safety and less investment costs than those supposed to operate both in and outdoor environments as the robots of case 2.

The other two cases of which the author had only secondary information, their experiment period was also a success, particularly in case 2 (the LMAD), which latterly led it to deploying the robot in another place, Helsinki's central library, Oodi.

When it comes to their features, the three autonomous delivery robots were designed for different services, such as groceries (Case 1), packages (Case 2), and healthcare (Case 3). The ASUMI-1 robot in case 1 was a relatively small bot with less space to carry items and was marginally bigger than the parcel package itself, while the other LMAD and Polle robots had larger space to carry items. The key distinctions between the robots are their size and battery life, but they are all designed to travel a short distance from the loading areas to nearby customers or designed places.

However, due to their small size and low speed, robots are not suitable for long distances, such as distribution to rural areas. One of the significant benefits of these robots (especially ASUMI-1 in case 1) was the possibility to use them to deliver food items, particularly perishable goods which require temperature-controlled deliveries. E-commerce, retailers, food vendors and many other industries are facing unprecedented challenges in logistics, which go beyond the current global COVID-19 pandemic. In response to these challenges the autonomous delivery robots could be a home delivery logistics solution adaptable to varied context.

To the end, based on the theory and interview data, the study's key results and conclusion indicate that autonomous robots are more beneficial for urban last-mile delivery. Models of sidewalk delivery robots that run at slower speeds are less hazardous to other pedestrians and are ideal in most cases for hybrid-commercial and residential locations, but they have limitations relating to their battery life and weather conditions, especially in the winter. On the other hand, the models of road-based delivery robots have shown promise for urban freight distribution, but they also raise regulatory issues. Nonetheless, there are reasons for hope, most notably the large-scale use of autonomous delivery robots, but nothing is straightforward. More safety laws and regulations are needed to make it easier for large-scale deployments of ADRs in urban settings.

References

CSCMP, 2016. Cscmp. [Online] Available at: https://cscmp.org/imis0/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921 [Accessed 22 February 2021].

Digital, E., 2020. Eit Digital news. [Online] Available at: https://www.eitdigital.eu/newsroom/news/article/lmad-operates-last-mile-autonomous-delivery-robot-at-aalto-campus-in-finland/[Accessed 23 February 2021].

EPT-Alice, 2019. Rethinking Urban Transportation through advanced tools and supply chain collaboration". [Online] Available at: http://www.etp-logistics.eu/?p=1710 [Accessed 6 Jenuary 2021].

Figliozi, M. A. & Jennings , D., 2020. Core.ac.uk. [Online] Available at: https://core.ac.uk/reader/326032970 [Accessed 18 March 2022].

Friedrich, R. & Bickel, P., 2005. Externe.info. [Online] Available at: http://www.externe.info/externe_2006/externpr.pdf [Accessed 22 March 2021].

Frevue, 2017. Frevues. [Online] Available at: https://frevue.eu/about-us/why-frevue/ [Accessed 22 May 2021].

ForumviriumHelsinki, 2021. ForumviriumHelsinki. [Online] Available at: https://forumvirium.fi/en/experimenting-an-autonomous-robot-courier-with-smart-kalasatama-residents/ [Accessed 13 February 2021].

ForumViriumHelsinki, 2020. ForumViriumHelsinki. [Online] Available at: https://forumvirium.fi/en/take-a-gift-to-a-robot-and-do-good-a-test-robot-is-helping-with-holiday-gift-collection-in-helsinki/ [Accessed 25 February 2021].

ForumViriumHelsinki, 2020. forumvirium. [Online] Available at: https://forumvirium.fi/en/open-call-home-on-demand/ [Accessed 22 December 2020].

ForumViriumHelsinki, 2020. Forum Virium Helsinki. [Online] Available at:

https://forumvirium.fi/en/the-new-solutions-in-city-logistics-smart-last-mile-delivery-in-urban-areas/ [Accessed 10 December 2020].

Forumvirium, 2021. Forumvirium. [Online] Available at: https://forumvirium.fi/en/polle-robot-courier-tested-in-the-food-delivery-services-of-kustaankartano-senior-centre-mail-and-laundry-delivery-also-possible/[Accessed 10 May 2021].

GeraldY, 2020. Insights. [Online] Available at: https://insights.rlist.io/2020/12/states-that-legalized pdds.html#:~:text=The%20legislative%20milestone%20for%20PDDs,%2C%20Missouri%2C%20Colorado%20and%20Tennessee.[Accessed 20 March 2022].

globalcitylogistics, 2019. [Online] Available at: https://globalcitylogistics.org [Accessed 28 March 2021].

ISO, 2012. ISO. [Online] Available at: https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en [Accessed 14 March 2022].

IFO, 2021. International Federationof Robotics. [Online] Available at: https://ifr.org/industrial-robots [Accessed 14 March 2022].

Jean-Paul, D. R. & Dablanc, . D. L., 2018. Global city logistics.org. [Online] Available at: https://globalcitylogistics.org/home/a-freight-and-the-city/what-is-city-logistics/ [Accessed 26 February 2021].

John, M., Lalwani, C. & Butcher, T., 2008. Global logistics and Supply chain management. 2nd ed. Chippenham, Wiltshire: Antony Rowe Ltd.
InterregCentralEurope, 2019. Interreg Central Europe. [Online] Available at: https://www.interreg-central.eu/Content.Node/SULPiTER.html [Accessed 22 May 2021].

John, M., Lalwani, C. & Butcher , T., 2008. What is Logistics . In: L. John Wiley & Sons, ed. Global logistics and Supply Chain Management . Chippenham, Wiltshire: Antony Rowe Ltd, , p. 8.

Kagan, E., Shvalb, N. & Ben-Gal, I., 2019. Early History of Robots. In: Autonomous Mobile Robots and Multi-Robot Systems. s.l.:John Wiley & Sons, Inc., pp. 1-30.

Nilsen Anand, Duin, R. v., Quak, H. & Tavasszy, L., 2015. Relevance of City Logistics Modelling Efforts: A Review. [Online] Available at :

https://www-tandfonline
com.ezproxy.metropolia.fi/doi/pdf/10.1080/01441647.2015.1052112?needAccess=true[Accessed 16 Febuary 2021].

Peng He, J. L., 2021. Weforum. [Online] Available at: https://www.weforum.org/agenda/2021/12/last-mile-delivery-autonomous-vehicles/ [Accessed 13 Febuary 2022].

REDI, 2020. redi. [Online] Available at: https://www.redi.fi/?lang=en [Accessed 14 October 2020].

Sopha, B. M., Sri Asih, A. M. & Imron, M. A., 2021. City logistics challenges and innovative solutions in developed and developing economies: A systematic literature review. [Online]
Available at: https://journals.sagepub.com/doi/full/10.1177/18479790211039723 [Accessed 15 March 2022].

Schröder , J. et al., 2016. [Online] Available at: https://www.mckinsey.com/~/media/mckinsey/industries/travel%20logistics%20and%20infrastructure/our%20insights/technology%20delivered%20implications%20for%20cost%20customers%20and%20competition%20in%20the%20last%20mile%20ecosystem/fast-forwarding-last-mile. [Accessed 12 March 2022]

Spilling , K., Rinne , J. & Hämäläinen , M. M., 2019. Researchgate. [Online] Available at:
https://www.researchgate.net/publication/335792186_Agile_piloting_for_smarter_cities_3_cases_of_engaging_ecosystems_and_communities_in_co-creation [Accessed 20 Febuary 2022].

SmartCitiesWorld, 2020. SmartCitiesWorld. [Online] Available at: https://www.smartcitiesworld.net/news/news/last-mile-delivery-robot-deployed-on-university-campus-5711 [Accessed 23 February 2021].

Spilling, K. & Rinne, J. R., 2020. Forumvirium.fi. [Online]
Available at: https://forumvirium.fi/en/the-guidebook-for-urban-developers-sums-up-learnings-and-experiences-from-agile-piloting-in-helsinki/
[Accessed 4 October 2021].

6Aika, 2020. 6Aika. [Online] Available at: https://6aika.fi/en/project/results-new-solutions-in-city-logistics/ [Accessed 26 December 2020].

Standford, 2016. Standford. [Online]
Available at: https://www.gsb.stanford.edu/sites/default/files/publication-pdf/vcii-publication-technological-disruption-innovation-last-mile-delivery.pdf
[Accessed 22 Febuary 2022].

Taniguchi, E., 2014. City Logistics: Mapping the future. In: City logistics: mapping the future. s.l.:CRC Press, p. 2.

UnitedNation, 2018. United Nation. [Online] Available at: https://www.un.org/development/desa/en/news/population/2018-world-urbanization-prospects.html [Accessed 22 March 2021].

Vepsäläinen, J., 2022. Aalto university. [Online]
Available at:
https://acris.aalto.fi/ws/portalfiles/portal/81002640/energies_15_02198.pdf
[Accessed 20 March 2022].

World Economic Forum, 2020. World Economic Forum. [Online] Available at : https://www.weforum.org/reports/the-future-of-the-last-mile-ecosystem/[Accessed 2 Febuary 2020].

WorldEconomicForum, 2020. WorldEconomicForum. [Online] Available at: http://www3.weforum.org/docs/WEF_Future_of_the_last_mile_ecosystem.pdf
[Accessed 22 March 2021]

WorldEconomicForum, 2020. Weforum. [Online] Available at: http://www3.weforum.org/docs/WEF_Future_of_the_last_mile_ecosystem.pdf
[Accessed 6 Jenuary 2021].

Urbanite, 2020. Urbanite-projects.eu. [Online]
Available at: https://www.urbanite-project.eu/node/463
[Accessed 20 Febuary 2022].

Ylenews, 2020. Yle. [Online] Available at: https://yle.fi/uutiset/osasto/news/online_shopping_gets_a_huge_corona_boost/11675060 [Accessed 6 January 2021].

6Aika, 2018. 6Aika. [Online] Available at: https://6aika.fi/wp-content/uploads/2015/11/6Aika-strategia_päivitys_2015_EN.pdf [Accessed 21 October 2020].

6aika, 2021. 6aika. [Online]
Available at: https://6aika.fi/en/results-of-six-city/page/2/?posts3=4
[Accessed 15 March 2022].

Appendix 1. Participant Consent Form

Title of the Thesis: Autonomous Delivery Rorbots for Urban Settings

Dear All
This consent form aims to give option interview participants how they wanted to be represented in the research. Please fill the boxes below to confirm that you agree with to participate at the interview.

Consent Form to take part in research

I ________________________(Name) of ______________________________ (Org)

I confirm that I have been made aware of the objectives and purpose of the study and assured of the confidentiality of the interviews [__]

In addition, **I agree / disagree** with having the interview voice-recorded [__]

Pursuant to the above mentioned, I give **permission** for the appropriate use of the information gained from the interview will be only used for this research purpose. The data will not be used in other contexts without a permission from the research participants.

Name of participant	Date	Signature
Researcher	Date	Signature

Signature: ____________________ Date: ___/___

Signature: ____________________ Date: ___/___

Appendix 2. INTERVIEW QUESTIONS

Questionnaire: Autonomous Delivery Rorbots for Urban Settings- Benefits in the last-mile context

The following questionnaire is aimed to gain information for my BBA degree thesis at Helsinki Metropolia University of Applied Sciences. The goal of this study is to find out how autonomous delivery robots (ADRs) benefit the urban last-mile context; and what possible barriers could hinder the implementation of ADR in urban settings.The interview questions are an academic exercise, and they will not be used in any other way but solely for the purpose of thesis

1. Can you shortly describe your self/company and role in the REDI-Home-on-Demand pilot project ?
2. Have you been involved in similar projects before ?
3. Can you describe how this REDI Home-on-Demand Autonomoud delivery robot work ?
4. How much collaboration is there with your company/organization in this agile -pilot project ?
5. What is your experience in Last-Mile context ?
6. What are the key challenges in urban last mile deliveries ?
7. How did you think that Autonomous delivery robots could tackle urban las-mile delivery challenges. ?
8. What are some of the notable barriers that could hinder the implementation of ADRs in urban settings?
9. What the future of Autonomous delivery robots will look like ?
10. How would you prefer to presented in the thesis? (A). Anonomous. (B) Your name . (C) Your company.