Cargo Cycles in Urban Freight Transport

Obstacles and facilitating factors for utilising cargo cycles in urban freight transport in Stockholm, Sweden

Jan Lasovský
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Abstract

Cargo cycles can play a considerable role in mitigating the negative impacts of urban freight transport while still ensure that the material needs of the city are fulfilled. Their small size, lower operating costs, smaller carbon footprint, lack of tailpipe emissions, and manoeuvrability in congested areas are considerable advantages over traditional urban freight vehicles. However, the advantages of cargo cycles are not inherent in every urban environment and under all conditions. This problematics is in general insufficiently researched and more context specific knowledge is needed. Thus, this study investigates the obstacles and facilitating factors for utilising cargo cycles in urban freight transport in Stockholm, Sweden. To investigate these context specifications, case study approach was employed and consisted of qualitative content analysis, semi-structured interviews, and observations. This study argues that in Stockholm, contradictory forces affect the utilisation of cargo cycles in urban freight transport. On one hand, the facilitating factors are mostly associated with measures of sustainable urban freight transport and sustainable development in general: reaction to traffic situation; strategic orientation of the city; public-private partnership; and bicycle infrastructure. On the other hand, path dependence of the city connected to traditional urban freight vehicles (vans) symbolises obstacles: the absence of direct planning for cargo cycles; lack of recognition; and inconsistency of bicycle infrastructure.

Keywords
Cargo cycle; cargo bike; sustainable urban freight transport; last-mile logistics; space-efficient logistics; Stockholm; path dependence
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1. Introduction

This chapter provides the reader with the requisite background of the topic that this thesis further investigates. The concepts of (sustainable) urban freight transport and cargo cycle urban freight transport are introduced as well as the societal and academic relevance of the thesis. Consequently, the aim of the thesis is described altogether with the research questions, delimitations, and outline.

Most of today’s cities are becoming more densely populated as the urbanization trend and population growth continue globally (Cherrett et al., 2012; Taniguchi, 2014; United Nations, 2014). Moreover, trends of globalisation, spreading of mobile technology, internet, availability of goods and ever-growing e-commerce are resulting in an intensification of consumption behaviour (Cherrett et al., 2012; Kauf, 2016). These factors are contributing to even bigger dependency on well-functioning urban freight transportation (UFT), which consequently together with other forms of urban mobility intensify the pressure on the transport sector. As a result, urban areas are currently experiencing an increase in congestion rates, noise and air pollution levels which consequently decrease the liveability and quality of cities (Rudolph & Gruber, 2017; Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015; Taniguchi, Thompson, & Yamada, 2016).

Urban freight transport is only a part of a larger system of distribution of goods on a local, national and global scale, however, it is an indispensable part of everyday urban life. It deals with a vast range of activities whose aim is to satisfy all material needs within the boundaries of the urban environment (Taniguchi, 2001; United Nations, 2014). UFT is a complex system which moves around and supplies the urban areas with retail deliveries, parcels, courier service, waste transport, transport of material and equipment for the construction industry and many other types of goods movement (Russo & Comi, 2010). Thus, the UFT presents crucial part of the urban environment since it not only maintains but also increases the quality of life in urban areas and their smooth functioning (Kauf, 2016; United Nations, 2014).

However, population growth in conjunction with intensified consumption behaviour increased the need and volume of urban goods transport which consequently deepened the problems and challenges associated with this sector. Even though UFT represents less than 10% of traffic flows in cities, their environmental, economic and social impacts are disproportionally higher (Kauf, 2016; United Nations, 2014). Overall, UFT is viewed as one of the major contributors to transport-related air pollution and noise pollution. Furthermore, it significantly contributes to congestion and traffic problems in urban areas as the UFT shares the same network as a passenger and public transport (Cherrett et al., 2012; Kauf, 2016; Russo & Comi, 2010; United Nations, 2014). The problems and challenges of the sector are mostly connected with the traditional transportation modes which the urban freight sector is using (trucks and vans) and their dependency on fossil fuels.

It is argued that in order to overcome problems and challenges associated with this sector and ensure sustainable development of urban areas, sustainable UFT needs to be implemented (Allen & Brown, 2015; Kauf, 2016; Russo & Comi, 2010; Taniguchi et al., 2016; United Nations, 2014). Furthermore, the implementation of sustainability principles into UFT is viewed by many authors (e.g. Kauf, 2016; Kennedy, Miller, Shalaby, Maclean, & Coleman, 2005) as one of the most urgent issues that cities face. However, the implementation of sustainability in this sector is a challenging task. UFT is an indispensable aspect of everyday urban life and significantly affects the quality of life in urban areas. Thus, sustainable UFT must strive to ensure that the material demands of cities are met, while the negative impacts are minimalized (Kauf, 2016; United Nations, 2014). As a result, a possible solution for such problems is often associated with introducing smaller and lighter environmentally friendly urban freight vehicles (Bates et al., 2018; Oliveira, Albergaria De Mello Bandeira, Vasconcelos Goes, Schmitz Gonçalves, & D’Agosto, 2017).
It is argued (Rudolph & Gruber, 2017; Schliwa et al., 2015; Taniguchi, 2014; Taniguchi et al., 2016) that one possible solution for addressing negative impacts of UFT can be the utilisation of (electrically assisted) cargo cycles in UFT. Cargo cycle, thus, a bicycle (tricycle, four-wheeled cycle etc.) specifically designed to carry heavy goods with or without electrical assistance, is viewed as a potentially viable solution for urban freight activities in dense and congested urban areas (Saenz, Figliozzi, & Faulin, 2016; Tipagornwong & Figliozzi, 2014). The advantage of cargo cycles relates to their small size, lower operating costs, smaller carbon footprint, lack of tailpipe emissions, and advantages in manoeuvring (Rudolph & Gruber, 2017; Saenz et al., 2016; Tipagornwong & Figliozzi, 2014). It is believed that cargo cycles have potential to represent the facilitating factors and city’s characteristics which directly or indirectly contribute to creating such conditions in which cargo cycles as vehicles for urban deliveries (Lennart & Riehle, 2013; Schliwa et al., 2015; Wrighton & Reiter, 2016). Moreover, potential to contribute to reduction of congestion levels, noise levels, air pollution and other harmful outcomes associated with traditional fossil fuel-based vehicles in UFT (Conway, Cheng, Kamga, & Wan, 2017; Koning & Conway, 2015; Maes & Vanelslander, 2012; Saenz et al., 2016; Schliwa et al., 2015; Tipagornwong & Figliozzi, 2014, 2014).

However, the above-introduced abilities and advantages of cargo cycles for transporting urban freight are not inherent in every urban environment and under all conditions. The possible utilisation of cargo cycles depends on various factors. These factors affect positively or negatively cargo cycles’ performance, effectivity, safety and overall competitiveness with traditional urban freight vehicles. It is argued (Rudolph & Gruber, 2017; Schliwa et al., 2015) that some factors and preconditions are unchangeable (e.g. the geography of cities), however, others are based on planning decisions and other factors which are modifiable or directly planned for. Moreover, Rudolph & Gruber (2017) argued that the factors which facilitate or limit the utilisation of cargo cycles consist of environment-specific factors, company-specific factors, and product-specific factors. Nevertheless, the specific factors are strongly context-dependent and cannot be viewed individually, however, as a complex set of factors.

In Stockholm, Sweden, the population is predicted to grow from current 950,000 to 1.3 million by 2040 (Stockholms stad, 2018a). Moreover, in Sweden, domestic freight deliveries account for about a third of greenhouse gas emissions and significantly contribute to congestion and noise pollution mostly due to the use of traditional fossil fuelled vehicles. Sweden aims to decrease fossil fuel usage by 70% between 2010-2030 and hit net-zero by 2045. Moreover, the City of Stockholm aims to become fossil fuel-free by 2040 which draws attention to find smaller and more sustainable vehicles for urban deliveries (Stockholms stad, 2012, 2016b, 2018b). As presented above, it is argued that cargo cycles can be one such solution. Thus, this study focuses on the facilitating factors and obstacles for the utilisation of cargo cycles in UFT in Stockholm, Sweden.

1.1 Aim and research questions

The aim of the thesis is to identify and describe what are the obstacles and facilitating factors for utilising cargo cycles in urban freight transport in Stockholm, Sweden. Therefore, it is essential to investigate, firstly, what are the factors which directly or indirectly contribute to creating such condition in which cargo cycles as vehicles for UFT thrive in Stockholm (facilitating factors). Secondly, the factors and city’s characteristics which directly or indirectly contribute to creating such conditions in which cargo cycles as vehicles for UFT are not thriving in Stockholm (obstacles). In order to do that, the experience of companies which already utilise cargo cycles in UFT in Stockholm is needed to be investigated and understood. Moreover, knowledge concerning examples of how cargo cycles are used in the researched context and what is the experience with the vehicle itself (e.g. their competitiveness, cargo capacity, range and speed) is needed.
To achieve the above-presented aim, the following research questions are formulated:

- What is the experience of utilising cargo cycles in urban freight transport in Stockholm, Sweden?
- What are the facilitating factors for utilising cargo cycles in urban freight transportation in Stockholm, Sweden?
- What are the obstacles for utilising cargo cycles in urban freight transport in Stockholm, Sweden?

1.2 Delimitations of the study

The study focused on factors which facilitate or limit (obstacles) the utilisation of cargo cycles in UFT in Stockholm, Sweden. Thus, other urban environments, where findings might differ, were not examined. Moreover, previous studies argued (Conway et al., 2017; Gruber, Kihm, & Lenz, 2014; Rudolph & Gruber, 2017; Schliwa et al., 2015) that cargo cycles’ potential is predominantly in central areas of cities where congestion levels and density of population/businesses are higher. Thus, the focus of the study was mostly on central areas of Stockholm. However, the area was not explicitly bounded since the aim of the research was not to map specific obstacles and facilitating factors but to identify general types of these factors and their examples. Although other alternative urban freight vehicles and solutions may have similar abilities and potential to reduce the negative aspects associated with UFT. This thesis examined solely cargo cycles. Furthermore, there are various types of cargo cycles which differ in parameters, thus, the study had to be selective in terms of parameters of cargo cycles which were taken into consideration. The study mostly considered parameters of average sized cargo cycles which were based on previous studies and experience of companies utilising cargo cycles in researched context (see chapter 3). Moreover, even though cargo cycles without electric assistance were not explicitly excluded, due to the geography of the city and lower suitability of them for UFT, cargo cycles with electric assistance were mostly considered. Lastly, to include the experience of all companies utilising cargo cycles in UFT in Stockholm was not in the abilities of this study. Therefore, this thesis presents only the experience of selected companies.

1.3 Outline

The outline of the thesis is illustrated in figure 1. The thesis begins with an introductory chapter where the problem background, the aim, research questions and delimitations are described and introduced. Secondly, the thesis continues with a theoretical framework and a literature review where previous researches of the problematics are presented. Due to the general lack of recognition of the problematics of cargo cycles, this chapter provides the reader with necessary knowledge which helps to understand other parts of the thesis and the overall aim. Thirdly, the methodology and methods used in this study are presented together with quality assurance, limitations of chosen methods, and ethical consideration. Chapter four presents empirical findings. Consequently, in chapter five, the research questions are answered, and the empirical findings are discussed and compared with previous researches and further analysed. Lastly, the concluding remarks of the thesis are presented together with a suggestion for further research.
2. Theoretical framework and literature review

This chapter further elaborates the concepts briefly presented in the introduction. It begins by explaining the concept of sustainable development and path dependence. Thereafter, the literature review describes urban freight transport and subsequently cargo cycles and their utilisation in urban freight transport. The literature review serves as a base for comprehensive knowledge and therefore is an essential part of investigating research problematics.

2.1 Sustainable development

The principles of sustainability and sustainable (urban) development are closely related to the researched problematics and are noticeable throughout the whole thesis. As will be explained in sections below, the UFT is strongly associated with the economic development of cities. However, there is a reaction to mitigate the negative aspects connected with it by implementing sustainable UFT. Cargo cycles are considered as one solution to do it. Thus, the concept of sustainable development helps to understand the general trends in cities and in UFT which consequently contributes to a better understanding of the facilitating factors and obstacles. Hence, the concept of sustainable development must be briefly introduced and defined even though the principles are generally known in academia.

One of the most widely accepted definitions of sustainable development is: “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland & World Commission on Environment and Development, 1991, p. 37). Moreover, the concept was applied also to urban areas as sustainable urban development characterized as: “The reduction of the impact of consumption of natural systems (global, regional and local) by the city, thus keeping within natural limits, while simultaneously enabling human systems to be optimised for improving the quality of urban life” (United Nations Human Settlements Programme, 2009, p. 115). Thus, the concept is composed of three dimensions: social, economic and environmental. The core value of the concept is that all three dimensions are interdependent, furthermore, that the development should be aligned with idea to maximize each dimension while not limit the others. Moreover, the concept emphasises the need of intragenerational and intergenerational equity (Baker, 2006; Elliott, 2009). The concept will be later further developed with its application to sustainable UFT.

2.2 Path dependence

The sustainable development and the implementation of such principles in urban planning and UFT are representing new trends and new structures in urban areas. However, old (unsustainable) structures are often still present and affect the implementation of the new ones. Thus, this thesis used the concept of path dependence as its theoretical framework. It is argued by Hensley, Mateo-Babiano & Minnery (2014, p. 5) that path dependence “...is a valuable tool to analyse barriers to change in planning and policies relating to the built environment, transport and health communities.” Such notion is also valuable for understanding and analysing UFT and the use of cargo cycles within, as the sector uses the same infrastructure and similar policies apply as to the transport sector (see below). Thus, the path dependence theory was selected due to its ability to understand and discuss the capacity of the systems to undergo change. Overall, the concept was originally developed as an economic theory by Arthur and David to explain how a certain chain of events can give an advantage to certain technology over another (Hensley et al., 2014). Moreover, to explain the mechanism of how a certain product prevails in use, despite the existence of better alternative (Low & Astle, 2009). Furthermore, the concept spread beyond the field of
economy into social science and also incorporated the discussion of institutions and organisations with the notion of “…current and future states, actions, or decisions depend on the path of previous states and actions, or decisions.” (Page, 2006, p. 88).

The focus of the thesis is partly on the infrastructure which is needed for the utilisation of cargo cycles and UFT in general. To understand the process of why a certain type of infrastructure is favoured or prevalent, the thesis used the notion described by Arthur (1994). Arthur (1994) described four features of technology and its social context in relation to path dependence. Moreover, his notion addressed the characteristics and conditions of processes which determine the returns of implemented technologies and therefore willingness or unwillingness to change them (Arthur, 1994; Pierson, 2000). However, this notion was developed to understand the increased returns associated with implementing technologies and their path dependence in business areas, it is also useful for understanding planning processes associated with infrastructural investments and their capacity to undergo change.

Firstly, Arthur (1994) argued that large set-up or fixed costs create high pay-off for further investments. The initial costs for implementing a new system or technology tend to be high as it requires various forms of capital e.g. expertise, money, space etc. Furthermore, when fixed costs are high, organisations tend to protect and maintain such investments. Therefore, implementing alternative systems or technology is problematic due to an unwillingness to lose the initial investment and to invest in an alternative solution. Secondly, the learning effects contribute to path dependence and the prevalence of previously implemented system or technology. Arthur (1994) argued that gained knowledge associated with operating complex systems tend to lead to higher returns from continuous use. This is due to the fact, that over time, knowledge and experience with new systems or technology are generated, which consequently leads to more effective use of the technology or system. Thus, the implementation of alternative solutions is limited due to the lack of such experience with the new solution. Thirdly, the coordination effect is characterized by a broader spreading of the technology or system (Arthur, 1994; Pierson, 2000). When the technology is widely adopted, the benefits associated with it increase dramatically which consequently leads to further spread. Arthur (1994) argued that coordination effect is even more substantial when the technology or system requires its own infrastructure, for example, cars and their road infrastructure, fuelling stations and other facilities. Thus, due to the coordination effect, further investments and developments are made which consequently decrease the willingness to change. Lastly, the adaptive expectations describe the expectation with a new system or technology. Overall, the system and technology with greater acceptance which seems to be able to fulfil expectations are promoted and invested in (Arthur, 1994; Pierson, 2000). Such situation consequently limits the implementation of other competing solutions and technologies with less acceptance.

Moreover, Low and Astle (2009) argued that three elements of path dependence are particularly relevant to urban and transport planning: technical path dependence; institutional path dependence; and discursive path dependence. Firstly, the technical path dependence helps to understand how the physical form of the urban area can be shaped by the requirements of a particular mode of transport. To illustrate, the technological development of cars and the infrastructural changes associated with it, influenced the structure of cities and consequently shaped the way we travel (Hensley et al., 2014; Low & Astle, 2009; Troy, 1999). Secondly, the institutional path dependence helps to understand the institutions and organisations which shape the form and structure of the cities (Low & Astle, 2009; Troy, 1999). The institutional path dependence helps to understand the processes that lead to the change of physical structure of urban areas caused by technical path dependence (Hensley et al., 2014). Such processes can be illustrated by policy and planning decisions which shape for example the transport policies. Hensley (2014) argued that such processes are very difficult to modify in institutional path-dependent culture. Lastly, the discursive path dependence is characterized as “storylines” used within the organisation (Low & Astle, 2009). Such storylines or discourses are used to:”…explain and identify problems and issues that policy or plan is trying to address.” (Hensley et al., 2014,
p. 5). The discourse often assists as a tool to justify a certain path or direction (Low & Astle, 2009).

2.3 Urban Freight Transport

Most of the current cities are becoming more populated, which together with globalisation, spreading of mobile technology and internet, is consequently resulting in an intensification of consumption behaviour (Cherrett et al., 2012; Kauf, 2016; United Nations, 2014). Nowadays, urban residents can purchase goods online 24 hours a day with expected delivery within a few days as a result of wide spreading and advancements of e-commerce. This together with ever-growing availability of goods is increasing demand for the flexibility of supply and its structure (Kauf, 2016). The amount and type of the flow of goods are changing, transporting goods are becoming smaller and the deliveries are more frequent (Kauf, 2016; Verhagen & van Dolen, 2009). These factors contribute to even bigger dependency on well-functioning UFT which is a fundamental element for urban areas. Thus, in order to understand the possible utilisation of cargo cycles within this sector, the UFT itself and the processes which shape it will be now presented.

UFT, also known as urban freight distribution or city logistics, is only a part of a larger system of distribution of goods on local, national and global scale. UFT deals with a vast range of activities whose aim is to satisfy all material needs within the boundaries of the urban environment (Taniguchi, 2001; United Nations, 2014). Previous attempts to define UFT often lacked the “hidden” movement of goods such as the reverse flows of goods (e.g. wastes). However, current definitions are already accounting these factors. The OECD (2003, p. 19) defined UFT as: “The delivery of consumer goods (not only by retail, but also by other sectors such as manufacturing) in city and suburban areas, including the reverse flow of used goods in terms of clean waste”. Furthermore, Taniguchi (2014, p. 2) defined it as “the process for totally optimizing the logistics and transport activities by private companies with support of advanced information system in urban areas considering the traffic environment, the traffic congestion, the traffic safety and the energy saving within the framework of a market economy”. Dablanc (2008, p. 248) defined UFT in a broader sense as “the transport of goods carried out by or for professionals in an urban environment”, this definition excludes personal trips made by households for purposes to move goods, however, it includes all professional movement of goods within boundaries of the city.

The UFT is a complex system which is a crucial part of the urban environment, it ensures smooth functioning of cities and its absence or inefficiency is catastrophic for urban areas (United Nations, 2014). It moves around and supplies the city with retail deliveries, parcels and courier services, waste transport, transport of materials and equipment for the construction industry and variety of other types of goods transport (Russo & Comi, 2010). It is estimated that UFT is responsible for 10% to 15% of vehicle kilometres travelled in cities. Furthermore, it uses 3% to 5% or urban land and employs 2% to 5% of the urban labour force (Dablanc, 2009). In Europe, a high-income city generates about one delivery/pick up per job per week. Furthermore around 300-400 truck trips per 1000 people per day, and 30 to 50 tunes of urban freight per person per year (Dablanc, 2007). However, the conditions and actual situation significantly vary based on local characteristics and the role of cities in national and global freight distribution (United Nations, 2014).

There are many actors directly or indirectly involved in UFT. Taniguchi & Tamagawa (2005) recognized five main stakeholders: administrators, residents, shippers, freight carriers and urban expressway operators. Russo & Comi (2010) identified similar actors: the shippers; the transport companies; the receivers/shop owners; the end-consumers; and public administration (local government and national government). Furthermore, there are three main components which together shape the form of UFT (see figure 2) (United Nations, 2014). Firstly, the modes that carry the freight (trucks, vans and alternative modes). Secondly, the infrastructures which are carrying and supporting freight transport such as roads, distribution centres, terminals etc.
Thirdly, the operations which relate to the organisation and management of UFT, for example, parking, loading/unloading, scheduling and routing.

![Figure 2 Components of urban freight transport (United Nations, 2014)](image)

### 2.3.1 First and last mile of urban freight transport

The concept of UFT refers to all freight transport moved within the urban environment, however, the term is often associated or used synonymously to the term "last mile" (logistics) (Macharis & Melo, 2011; Taniguchi et al., 2016). The problem of the first and last mile is one of the most complex issues of urban transport. Although the problem has been acknowledged by many researchers, there does not exist one single, well-agreed definition. Generally, the term implies the final stage of a transport chain, e.g. the last-mile distribution of parcels between a terminal and the final customer (Bates et al., 2018). The last mile is considered as one of the most expensive, least sufficient and most polluting sections of the entire chain of logistics (Gevaers, Van De Voorde, & Vanelslander, 2011). Despite the lack of general consensus, Gevaers et al. (2011, p. 57) propose the following definition: “[the last mile]...is the final leg in a business-to-consumer delivery service whereby the consignment is delivered to the recipient, either at the recipient's home or at a collection point”. The concept itself is borrowed from the telecommunications networks industry and refers to the final stage of the transport chain, and necessarily not just to the final mile (Cardenas et al., 2017). The problem of the first and last mile is, as indicated by the name, not exclusive to the end of the transport chain. It is also applicable to the beginning, such as the activity of collecting parcels for further transport. Furthermore, it is not exclusive to freight transport, but also people and passenger transport (Tight, Rajé, & Timms, 2016). The problem of the first and last mile appears in different ways and raise different issues for different groups of road users. Regarding logistics and freight transport, the problems related to the concept refer to the increased complexities of the cities, e.g. in terms of delays and congestion (Tight et al., 2016).

The first and last mile solutions for urban logistics are often associated with implementing new technologies. This is done to create more effective and sustainable UFTation. Traditional solutions for last mile logistics have mostly used semi-light, light and medium-duty diesel trucks. In contrast to that, alternative solutions are mostly concerned with implementing smaller. Lighter and electrically powered vehicles as bicycles, tricycles (cargo bicycles) or other motorized light vehicles (Bates et al., 2018; Oliveira et al., 2017). However, there are also efforts to implement
highly innovative solutions for last mile deliveries which would consequently change the nature of it. One such solution is the implementation of drones for urban deliveries. However, this solution is still facing technological and legislative barriers (Cordon, Garcia-Milà, Ferreiro Vilarino, & Caballero, 2016). Additionally, some solutions are focusing on reducing the last mile deliveries through well-located parcel locker network, where the receivers would collect the delivery by themselves (Deutsch & Golany, 2018). The benefits of implementing alternative last mile vehicles are mostly associated with a reduction of delivery time, greenhouse emissions, air pollutants, noise emission and congestion levels. However, the drawbacks predominantly lie in the reduction of the sizes of the vehicles, thus their cargo capacity (Dell’Amico & Hadjidimitriou, 2012). Moreover, in a limited number of charging stations and power supply for electrically powered vehicles (Oliveira et al., 2017).

2.3.2 Challenges of urban freight transport

Even though UFT maintains and increases the quality of life in cities and the smooth functioning of cities without efficient urban freight is currently impossible, it also contributes to significant problems in urban areas (Kauf, 2016). Nowadays, UFT faces a variety of challenges which are mostly connected to the mode of transport the sector is using – trucks and "light goods vehicles" (vans) (Cherrett et al., 2012; United Nations, 2014). Trucks and “light good vehicles” were traditionally considered to be the most suitable vehicles for the specification of complex and dense urban areas (United Nations, 2014), however, their negative impacts for the urban environment are substantial (Kauf, 2016). UFT represents less than 10% of traffic flows in cities, nevertheless, their environmental, infrastructural and noise impacts are disproportionally higher (Kauf, 2016).

Furthermore, urban freight sector is seen as a major contributor to congestion and traffic problems (Cherrett et al., 2012) since the urban transport system is shared by UFT as well as passenger transport (Cherrett et al., 2012; Kauf, 2016; Russo & Comi, 2010; United Nations, 2014). This presents a significant problem since cities are highly constrained areas with a limited amount of space to accommodate increasing flows of both passenger transport and freight transport (United Nations, 2014).

Challenges of UFT could be divided into three categories: environmental, economic and social. Firstly, environmental challenges and problems are mostly associated with air pollution and noise pollution which is caused by trucks and vans and their high reliance on fossil fuels (United Nations, 2014). In large European cities, freight transport is responsible for half of the transport-related particular matter emissions and one-third of nitrogen oxides emissions (Dablanc, 2008; United Nations, 2014). Furthermore, UFT is in comparison with long-distance freight transport often twice as polluting (United Nations, 2014). This is mostly caused by the older age of vehicles and their smaller size. Moreover, by higher fuel consumption and higher emission levels caused by lower operating speed and idling due to congestions and traffic restrictions (United Nations, 2014). Secondly, economic challenges are associated with higher congestion levels which cause inefficiency and unreliability of UFT. Thus, affect the appropriately functioning UFT, however, also passenger transport (United Nations, 2014).

Thirdly, UFT and its externalities also negatively interact with social perspective in cities in terms of health concerns, safety and quality of life (United Nations, 2014). UFT contributes to air pollution which consequently affects the quality of life in the city as well as health-related problems. Moreover, increased traffic flow levels contribute together with passenger traffic to noise pollution which causes health-related problems and decreases quality of life (Kauf, 2016; United Nations, 2014). Additionally, UFT contributes to community disruption and lower level of social cohesion as it can decrease the property values and prolong commuting time (Hart & Parkhurst, 2011; United Nations, 2014).
2.3.3 Sustainable urban freight transport

As a reaction to the aforementioned challenges and problems, it is argued that implementation of sustainable UFT is needed to ensure sustainable development of urban areas (Allen & Brown, 2015; Kauf, 2016; Lindholm & Behrends, 2012; Russo & Comi, 2010; Taniguchi et al., 2016; United Nations, 2014). The need to address the negative impacts of UFT together with passenger transport is crucial to ensure economic growth and social equity. While at the same time decrease the negative environmental outcomes of transport (Russo & Comi, 2010). Furthermore, implementing sustainable urban transport is considered as one of the most urgent issues faced by current cities (Kauf, 2016; Kennedy et al., 2005). However, the implementation of sustainable UFT is a complex and challenging task. Urban freight companies have been historically driven by the logic of minimising the costs and maximising the efficiency, which significantly limited the possibility to implement sustainability principles (Taniguchi et al., 2016). Moreover, UFT is an indispensable aspect of everyday urban life and has a significant impact on the quality of life within cities. Hence, the underlying logic of sustainable UFT is to ensure the efficiency of goods movement on the one hand and minimize the negative environmental and social outcomes (e.g. air pollution, congestions, noise and traffic accidents) on the other hand (Kauf, 2016; United Nations, 2014). Thus, it strives to ensure the three dimensions of sustainable development: economic growth, social equity and environmental protection (Kauf, 2016; B. C. Richardson, 2005; T. Richardson & Haywood, 1996; United Nations, 2014).

2.4 Cargo cycles in urban freight transport

It is argued that cargo cycles are one of the viable solutions for ever-growing UFT and for the increasing demand for sustainable UFT (Conway et al., 2017; Gruber et al., 2014; Koning & Conway, 2015; Rudolph & Gruber, 2017; Saenz et al., 2016; Schliwa et al., 2015; Tipagornwong & Figliozzi, 2014). The following section presents the advantages and limitations of cargo cycles together with factors and planning decisions which affect their utilisation. However, firstly, the cargo cycle itself has to be presented since it is an unusual vehicle which does not necessarily have to be known by the reader. Cargo cycles have various names (e.g. cargo bikes, freight bicycles, carrier cycles), however, for purpose of consistency, in this thesis, they are referred to as cargo cycles. This term is also most frequently used in academia. Overall, cargo cycles are human powered vehicles specifically designed to carry heavy goods. Moreover, many types of cargo cycles have electrical assistance in order to increase the speed and payload of the vehicles and to reduce the demand on the rider. The specific parameters of cargo cycles are difficult to describe since many various types exist which will be addressed later in the thesis. However, cargo cycles types can be distinguished by a number of wheels which consequently partly determine the possible payload of the vehicle. Most common types are two-wheeled cargo cycles (see picture 1), cargo tricycles (see picture 2), four-wheeled cargo cycle (see picture 3) and six-wheeled cargo cycle.
Picture 1 Example of two-wheeled cargo cycle (MOVEBYBIKE, 2019)

Picture 2 Example of cargo tricycle (MOVEBYBIKE, 2019)
2.4.1 Advantages of cargo cycles in urban freight transport

Overall, the benefits of cargo cycles are mostly connected with their utilisation in dense and congested urban areas with limited parking facilities due to their small size, operating costs, smaller carbon footprint, lack of tailpipe emissions, and advantages in manoeuvring (Saenz et al., 2016; Tipagornwong & Figliozzi, 2014). The small size compared to the delivery van is a significant advantage in congested areas as cargo cycles require minimal parking space and can be in most cases parked legally on-and-off streets, on sidewalks, in bicycle facilities, or inside the business. That provides the necessary flexibility for urban logistics operators as it decreases the necessity, associated with traditional vehicles, to cruise for a free parking space/(un)loading area, double park, or park on the sidewalk (Saenz et al., 2016). Consequently, the ability to park very close to the desired destination reduces the delivery time, emissions, congestion, and costs for operators associated with fees and parking tickets caused by illegal parking (Saenz et al., 2016). This represents considerable advantage as urban logistics operators are driven by time and cost reduction. Additionally, the small size of cargo cycles and their classification as a non-motorised vehicle (in most countries) allows them to operate flexibly on motor-vehicle, bicycle, or even pedestrian infrastructure (Conway et al., 2017). In contrast, delivery vans and trucks are limited to dedicated motorised network and infrastructure with direction restrictions, therefore are susceptible to be affected by congestions. Cargo cycles have the ability to operate around congestions through bicycle lanes, parks, pedestrian zones (when the speed is adjusted to a minimum), and/or one-way streets in opposite direction (Schliwa et al., 2015). Therefore, this manoeuvrability decreases the distance, time and cost for delivering goods and freight in dense areas. However, this is not always applicable as in some cases, cities (e.g. London) adjusted the legal framework to classify cargo cycles as motorised vehicles, thus, limited their movement only for motor-vehicle infrastructure (Conway et al., 2017). Overall, Conway et al. (2017) argued that the utilisation of cargo cycles in urban logistics has significant implications for space savings. According to their study, in average, cargo cycles consume only 35% of the space required by a delivery van in the city, however, even greater space savings occur in urban areas with high traffic congestions where cargo cycles consume less than 15% of space required by a delivery van.

Another advantage associated with cargo cycles is their lack of internal combustion engine which consumes oil-based energy. The absence of internal combustion engine makes cargo cycles more environmentally friendly vehicles for local and last-mile deliveries as they lack tailpipe emissions and have smaller carbon footprint (Conway et al., 2017; Tipagornwong & Figliozzi, 2014).
Therefore, cargo cycles have the potential to reduce greenhouse emissions associated with UFT. To illustrate, a study from the Netherlands estimated that use of cargo cycles for urban deliveries would save 8,500,000 litres of diesel and 21,000 tonnes of CO₂ emissions annually (Maes & Vanslender, 2012). Rudolph & Gruber (2017) calculated the reduction of CO₂ emissions by 55% for urban logistics companies which partly implemented cargo cycles for last-mile deliveries. Moreover, assessment of cargo cycles utilisation together with micro-consolidation centres in Paris showed the same results, reduction of CO₂ emissions by 55% (Koning & Conway, 2015; Schliwa et al., 2015). This represents a significant advantage not only for cities and their residents, however also for the last-mile operators. Since with the absence of an internal combustion engine, cargo cycles operators are able to access areas with environmental restrictions, and therefore, are more flexible for deliveries (Schliwa et al., 2015). Furthermore, the absence of an internal combustion engine is also associated with noise reduction since cargo cycles are electrically assisted or human-powered. This can consequently contribute to the increase of liveability of cities and reduction of health-related problems associated with urban transportation (Gruber et al., 2014; Rudolph & Gruber, 2017; Saenz et al., 2016).

Additionally, the advantage of cargo cycles also lies in their significantly lower purchasing and operating costs in comparison with traditional diesel delivery vans. Compared to traditional diesel vans, cargo cycles are generally less expensive to purchase, maintain, insure and park (Conway et al., 2017). In terms of purchasing costs, cargo cycles costs are roughly 4.5 times lower compared to traditional vans (Tipagornwong & Figliozzi, 2014). However, the price varies and depends on the model of the cargo cycle and whether is assisted by an electric motor or not. Rudolph & Gruber (2017) calculated the costs differences between traditional diesel van and electric cargo cycle in Germany (see table 1) resulting in €6,310 (63%) purchase cost difference (€10,000 and €3,690 respectively). In terms of operating costs, the traditional diesel van costs annually more by €2,738 (78%) than electric cargo cycle (€3,500 and €763 respectively). The reduced operating costs of electric cargo cycles are mostly connected with lower energy consumption and lower cost of energy; reduced expenditure for service and maintenance; and insurance and taxes (Rudolph & Gruber, 2017; Schliwa et al., 2015). Overall, the costs per km travelled are calculated to be €0.35 for traditional delivery van and €0.08 for electric cargo cycle.

Table 1 Comparison of the total cost of ownership between van and electric cargo cycle (Rudolph & Gruber, 2017), modified by author

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Van</th>
<th>Electric cargo cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase costs</td>
<td>€10,000</td>
<td>€3,690</td>
</tr>
<tr>
<td>Kilometre travelled (per year)</td>
<td>10,000 km</td>
<td>10,000 km</td>
</tr>
<tr>
<td>Residual value after 5 years of utilisation</td>
<td>€3000</td>
<td>€554</td>
</tr>
<tr>
<td>Service and maintenance</td>
<td>€500</td>
<td>€120</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>€900</td>
<td>€15</td>
</tr>
<tr>
<td>Depreciation allowance (5 years; without residual value)</td>
<td>€1400</td>
<td>€627</td>
</tr>
<tr>
<td>Insurance</td>
<td>€600</td>
<td>€-</td>
</tr>
<tr>
<td>Tax</td>
<td>€100</td>
<td>€-</td>
</tr>
<tr>
<td>Yearly costs (operating costs)</td>
<td>€3,500</td>
<td>€762</td>
</tr>
<tr>
<td>Costs per km travelled</td>
<td>€0.35</td>
<td>€0.08</td>
</tr>
</tbody>
</table>
2.4.2 Disadvantages of cargo cycles in urban freight transport

The disadvantages of (electric) cargo cycles in UFT are mostly associated with the limited cargo capacity, limited travelling range and lower speed. Firstly, cargo cycles’ cargo capacity (payload and volume) varies a lot based on the model of the cargo cycle. The average payload of most frequently used models is between 150kg and 300kg, however, it can reach up to 500kg (Saenz et al., 2016). Additionally, the limits are also in terms of volume of the freight. This, of course, represents significant limitations for urban logistics operators who are moving heavier and larger volumes of goods as cargo cycles utilisation may be prohibitively expensive due to the need of using more vehicles for the same amount of freight (Conway et al., 2017). However, it is argued (Lenz & Riehle, 2013; Schliwa et al., 2015; Wrighton & Reiter, 2016) that the share of larger volumes of goods does not represent the highest proportion of urban deliveries. Moreover, that due to ever-growing e-commerce of small volume/weight goods, the payload capacity does not necessarily restrict the use of cargo cycles for urban deliveries. Lenz and Riehle (2013) estimated that cargo cycle freight logistics and deliveries can be around 25% of city commercial traffic, while Wrighton & Reiter (2016) predicted even higher number, around 51% of all motorized trips moving goods.

Secondly, another possible constraint of electric cargo cycles is their limited speed which is averaging 16km/h, however, the legal framework in most countries allows them to be electrically assisted up to 25km/h (Gruber et al., 2014). That is significantly lower than the speed of traditional diesel vans, however, Rudolph & Gruber (2017) argued that the speed differences are not that significant in densely populated areas where vans cannot utilise their speed potential. While the manoeuvrability of cargo cycles enables them to overcome congestions and be potentially even faster. A study by Gruber et al. (2014) which compared both types of vehicles’ speed in urban areas demonstrated this. In average, the cruising speed of vans was 17.3km/h and 15.9km/h for electric cargo cycles. Therefore, in dense and congested urban areas the similar cruising speed can be reached by electric cargo cycles to meet the markets’ temporal requirements. However, the competitiveness of electric cargo cycles in free-flow conditions is much lower (Tipagornwong & Figliozzi, 2014).

Thirdly, the range of electrically assisted cargo cycles represents another limitation for UFT (Saenz et al., 2016; Tipagornwong & Figliozzi, 2014). The current range standard of cargo cycles manufactured is between 50-100km in terms of electric mileage (Gruber et al., 2014). This limits the utilisation of electric cargo cycles for various freight operators which require vehicles with longer range. However, the possible use of cargo cycles lies predominantly in last-mile UFT in dense areas where the distances do not necessarily exceed the provided range of electric cargo cycles. This is illustrated in Gruber et al. (2014) which focused on courier deliveries by cars and electric cargo cycles. The results showed that 78% courier car trip chains are below 100km (42% under 50km) and would, therefore, be manageable by electric cargo cycles. Moreover, the range is possible to increase through battery swapping if the conditions allow that. The contribution of human operators is also not insignificant as the power exerted by riders can reduce the necessary battery size by roughly 500W-h (battery capacity is around 850W-h) during seven-hour day (Saenz et al., 2016). Nevertheless, the range is still limited in comparison with traditional diesel vans.

Lastly, another limitation of cargo cycles is their exposure to the weather due to their absence (in most cases) of protection for riders which may result in discomfort for the rider (Rudolph & Gruber, 2017). However, Gruber et al. (2014) argued that, based on their findings, even though the riders of cargo cycles are more exposed to weather, they did not find substantial fluctuation concerning the amount of shipment by cargo cycles throughout the year. However, this does not have to be necessarily applicable for every context as the weather condition vary dramatically depending on geographical location.
2.4.3 Potential segments for utilising cargo cycles

Above-mentioned advantages and disadvantages of cargo cycles in UFT illustrated that they are not possible to utilise for every segment of UFT. Thus, Wrighton & Reiter (2016) categorized the potential segments where cargo cycles are applicable into three main groups: (1) commercial delivery to business (B2B) and customers (B2C); (2) transport of goods associated with communal and business services; and (3) private goods transport with a focus on shipping and errands. Moreover, Rudolph & Gruber (2017) and Gruber et al. (2014) identified that cargo cycles utilisation lies predominantly in postal service, courier service, parcel service and home delivery service. However, they can be also partly utilised in internal/on-site transport and for service trips.

2.4.4 Factors which affect the utilisation of cargo cycles

As was mentioned above, it is argued that cargo cycles have the potential to be competitive and beneficial for the city, residents as well for the urban delivery companies. However, cargo cycles thrive only in a certain environment and when several preconditions are met. Rudolph & Gruber (2017) identified three main factors (environment-specific; company-specific; and product-specific) and their sub-factors which affect the adaptation and utilisation of cargo cycles in UFT (see table 2).

Table 2 Factors and sub-factors affecting cargo cycles in UFT (Rudolph & Gruber, 2017), modified by author

<table>
<thead>
<tr>
<th>Factors</th>
<th>Sub-factors</th>
</tr>
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<tbody>
<tr>
<td>Environment-specific factors</td>
<td>Political and legal environment</td>
</tr>
<tr>
<td></td>
<td>Socio-spatial context</td>
</tr>
<tr>
<td></td>
<td>Economic environment</td>
</tr>
<tr>
<td>Company-specific factors</td>
<td>Corporate fleet decision-making</td>
</tr>
<tr>
<td></td>
<td>Companies’ strategic orientation</td>
</tr>
<tr>
<td></td>
<td>Decision-makers’ individual attributes and attitudes</td>
</tr>
<tr>
<td>Product-specific factors</td>
<td>Compatibility</td>
</tr>
<tr>
<td></td>
<td>Trialability</td>
</tr>
<tr>
<td></td>
<td>Relative advantages</td>
</tr>
<tr>
<td></td>
<td>Complexity</td>
</tr>
<tr>
<td></td>
<td>Observability</td>
</tr>
</tbody>
</table>

Firstly, environment-specific factors consist of political, socio-spatial, cultural, technological and economic factors which frame the adoption process. The political and legal environment pressures companies to adopt alternatives to traditional means of transport through regulations for motorized vehicles such as delivery time constraints for freight, city tolls and corporate car taxation. The interest groups and commercial associations have great influence, together with active promotion of alternative means of delivery vehicles such as cargo cycles by the municipality or chambers of commerce. Another environment-specific factor is socio-spatial context which represents the urban morphology (e.g. gradients, the density of population/businesses, weather etc.), traffic-specific infrastructure (e.g. availability at bicycle retailers, bicycle lanes, bicycle racks etc.) and local cycling cultures. Moreover, Rudolph & Gruber (2017) mentioned the economic environment as another sub-factor. The economic environment follows in many cities similar trend, thus, significant growth of e-commerce in recent years. That is characterized by the increasing volume of smaller deliveries, narrow delivery time windows and increase of same-day deliveries. These changes are driving force for using smaller delivery vehicles such as cargo cycles.

Secondly, according to Rudolph & Gruber (2017), company-specific factors with three sub-factors (corporate fleet decision-making; companies’ strategic orientation; and decision-makers’
individual attributes) play an important role in the adaptation process. These factors are often driven by individual preferences and rational consideration of corporate decision-makers. Therefore, they depend on individual factors such as attitudes, socio-demographics and experience as well as on company characteristics (e.g. size, objectives and financial resources).

The corporate fleet decision-making is in many cases a complex process which consists of various actors, thus, the adoption of innovations is often a lengthy and complicated process. The companies’ strategic orientation is also one factor which determines the utilisation of cargo cycles. Cargo cycles are environmentally friendly vehicles, thus, utilisation of such vehicles is often considered positively for the image of the company. Rudolph & Gruber (2017) argued that companies often utilise cargo cycles in order to associate themselves and their marketing strategy with sustainable principles. The adaptation of cargo cycles is also affected by the decision-makers’ individual attributes and attitudes. (Fleet) Decision makers are often unaware of the potential and abilities of cargo cycles. Additionally, companies’ fleet consisting of cars and vans might be considered as status symbols which negatively affect the adaptation of cargo cycles or other environment-friendly vehicles.

Thirdly, product-specific factors composed of compatibility, relative advantage, trialability, complexity and observability represent another major part of adaptability (Rudolph & Gruber, 2017). The compatibility factor is determined by companies’ transport demands, thus the main criteria are material quality, electrical assistance, loading capacity (volume and weight), and range of the vehicle. The trialability is associated with the possibility to test the adapted innovation (e.g. cargo cycles) for a purpose to assess its relative advantages and the possibility of wider adaptation. The complexity represents the difficulty to assess, understand and implement a certain innovation. Finally, the observability is how the adapted innovation is already visible for members of the same community, therefore, associated with transferability of knowledge and innovations from “best practice” examples and implementations. However, the product-specific factors are associated with limited information concerning cargo cycles by fleet managers who are unaware of the possible implementation (2017).

2.4.5 Planning for cargo cycles

However, certain aforementioned preconditions and factors are unchangeable (e.g. the geography of cities) other might be adjusted through carefully planned actions and plans by public authorities. Rudolph & Gruber (2017), Schliwa et al. (2015) and others (Conway et al., 2017; Gruber et al., 2014; Koning & Conway, 2015; ‘Tipagornwong & Figliozzi, 2014) presented recommendations for public authorities concerning planning decisions which foster commercial cargo cycles utilisation. Overall, the recommendations can be classified into six groups: regulatory framework; strategic planning; infrastructure; network building and knowledge transfer; facilitation of cargo cycle testing; and utilisation of cargo cycles for municipal purposes (Rudolph & Gruber, 2017).

Firstly, the regulatory framework has a significant impact on the utilisation of cargo cycles in urban logistics and deliveries. However, it is noticeable that policies to promote the deployment of cargo cycles and human-powered vehicles are rarely addressed by public authorities (Lenz & Riehle, 2013). Thus, there is a need for greater recognition of these policies by urban planners and public authorities (Schliwa et al., 2015). Generally, cargo cycles will thrive in areas, which are densely populated, where parking or access to customers is difficult for traditional vehicles, where the travel speed is low, and with a constrained delivery period (Tipagornwong & Figliozzi, 2014). Therefore, public authorities should implement the regulatory framework and local policies which increase the direct and indirect costs of driving and parking of traditional urban freight vehicles. As a consequence, this can encourage the adoption of alternative and more environmentally friendly means of delivering, such as cargo cycles. Specifically, implementing policies for: access restrictions; congestion zones and tolls; road pricing; maximum parking times; on-street speed limits; narrowing traffic lanes; and extending bicycle mobility (Koning & Conway, 2015; Rudolph & Gruber, 2017; Schliwa et al., 2015; Taniguchi et al., 2016; Tipagornwong & Figliozzi, 2014). Overall, these policies are already often used for increasing
liveability of downtown areas. However, they also significantly affect the competitiveness of cargo cycles as they limit the motorized traffic while improving accessibility and the speed of cargo cycles. In turn, cargo cycles might improve the liveability by reducing emissions, noise and the number of heavy commercial vehicles (Tipagornwong & Figliozzi, 2014).

Secondly, the possible utilisation of cargo cycles in urban logistics and deliveries should be considered in strategic planning. Therefore, municipalities should implement plans for cargo cycle UFT into their (sustainable) urban mobility plan and other strategic documents such as bicycle transport strategy, roads design manuals, environmental plans, freight strategic plans etc. (Rudolph & Gruber, 2017). It is argued, that through the implementation of cargo cycles into strategic planning, public authorities can achieve wider recognition of the possible application among themselves as well among other stakeholders (Koning & Conway, 2015; Rudolph & Gruber, 2017).

Thirdly, public authorities should acknowledge specific material and immaterial infrastructure measures which are necessary for promoting cargo cycles in urban logistics. In terms of material infrastructure, current planning manuals often do not take into consideration the dimension of cargo cycles and their specific demands. Hence, the planning manuals do not acknowledge the need for more space for parking in bicycle racks, longer braking distance, vulnerability to slopes, steps and vibration, the width of bicycle lanes, levelling kerb to street level etc. (Rudolph & Gruber, 2017; Schliwa et al., 2015). Infrastructure measures, which reduce motor vehicle capacity and consequently increase the number of dedicated bicycles network increase the competitiveness of cargo cycles (Conway et al., 2017). However, only if the legal framework allows electric cargo cycles to use bicycle networks. Furthermore, the measures for immaterial infrastructure (e.g. systems for traffic information; freight capacity exchange systems; route optimization and scheduling services; collection of precise data) can help increase the effectiveness and precise setting of measures related to cargo cycles and other alternative delivery vehicles (Schliwa et al., 2015; Taniguchi, 2014).

Fourthly, Rudolph & Gruber (2017) argued that network building and knowledge transfer play a crucial role in fostering cargo cycles in UFT. Public authorities can help facilitate the change of mindset of logistics managers and other stakeholders which is essential for promoting sustainable city logistics (Gruber et al., 2014; Schliwa et al., 2015; Taniguchi, 2014). The study by Rudolph & Gruber (2017) revealed that even relative soft measures can be very effective, e.g. active promotion of sustainable city logistics solutions and learning from best practice examples. Additionally, public authorities, companies, industrial associations and research partners can form local cargo cycle network for the purpose to raise awareness among the potential users of cargo cycles and the general public (Rudolph & Gruber, 2017). This phase can be complicated due to the different interest of public authorities (decrease the negative impacts of UFT) and private companies (profitability) (Schliwa et al., 2015). However, through incentives and collaboration, the economic argument can be fulfilled as well. For example, Rudolph & Gruber (2017) mentioned the importance of public-private partnership in order to create micro-consolidation centres. The municipality can facilitate the micro-consolidation centres through offering suitable plots, however, it is very important to grant non-discriminatory access to all companies interested in participating in these facilities.

Fifthly, facilitating cargo cycles testing facilities can broaden the public-private partnerships, awareness and increase the chance for implementing cargo cycles by companies (Rudolph & Gruber, 2017). Testing programs provided by municipalities or other associations might decrease the financial obstacles especially for small companies for testing the competitiveness of cargo cycles for their demands. Moreover, it can simultaneously increase the acceptance of cargo cycles among stakeholders (Rudolph & Gruber, 2017). For example, the city of Bremen (as well as some other German cities) provided 34 e-bikes and 4 electric cargo cycles for local companies. The companies could test their applicability for their daily utilisation without financial risks.

Finally, the use of cargo cycles by municipalities for internal purposes can increase the acceptability and visibility of cargo cycles for UFT and therefore potentially motivate other
stakeholders (Rudolph & Gruber, 2017). The municipality can act as best-practice examples and implement cargo cycles into municipal vehicles fleet for their internal transport, deliveries within the city, street cleaning, waste collection, public libraries and facility management.
3. Methodology

This chapter presents the methodological approach that was used to fulfil the aim of the thesis and answer the research questions. Furthermore, the research approach, data collection, data analysis and ethical considerations are addressed in this chapter.

3.1 Case study approach

In this thesis, a case study approach was used in order to research facilitating factors and obstacles for utilisation of cargo cycles in UFT in Stockholm. This approach was selected as the thesis was intensively focused on the single phenomenon in its bounded context, therefore, a situation where case study approach can be best utilised (Bryman, 2016; Miles & Huberman, 1994; Mills, Durepos, & Wiebe, 2010). Moreover, the approach had elements of exploratory case study principles since an exploratory case study is appropriate when a relatively young and context-dependent research field with limited in-depth knowledge is explored and researched (Yin, 2003).

Furthermore, Mills et al. (2010) argued that in order to investigate certain specific phenomenon, researchers must consider all possible sources of data that might help to understand the case. This notion was valuable for this study since the researched problematics required several different methods in order to investigate the complexity of factors which affect the utilisation of cargo cycles in UFT. Thus, the case study consisted of three methods: qualitative content analysis, semi-structured interviews and observations. Each method had its reasoning which is further explained below. Moreover, employing more than one method enabled to triangulate the findings, thus, helped to overcome the weakness of single method study. That consequently helped to enhance the validity and reliability of the research and enabled a holistic understanding of the complexity of the researched problematics (Bryman, 2016; Yin, 2003).

Additionally, it is argued (Bryman, 2016; Merriam, 2014) that a qualitative approach is preferred when exploring a relatively young research field with limited insights. The qualitative research enables to describe an observed reality and consequently provides comprehensive findings with a deeper understanding of the researched phenomenon (Golafshani, 2003; Merriam, 2014). Thus, since the utilisation of cargo cycles in UFT is relatively novel problematics which has not yet been researched in the context of Stockholm, the master thesis applied the aforementioned qualitative methods. Moreover, the inductive approach was employed. The inductive approach is commonly used within qualitative research since it allows researchers to interpret findings with the help of theories and previous studies that initiated the research (Bryman, 2016). Thus, the results are crosschecked with theories and previous research.

3.2 Research design

In terms of research design, as introduced above, the case study approach consisted of three methods which together contributed to investigating the research problematics from different perspectives (from broad to detailed perspective of selected aspects). By combining methods, different factors were investigated, thus, it enabled a more holistic overview of the research problematics. Moreover, such an approach provided triangularity of the findings. The individual methods and their strategy will be now described.

3.2.1 Qualitative content analysis

Firstly, qualitative content analysis was employed as part of the case study. As identified in the literature review, the strategic planning and regulatory framework are considerable factors which may positively or negatively affect the utilisation of cargo cycles in UFT. Thus, in order to
identify such factors in Stockholm, the content analysis focused on the city’s strategic and planning documents and manuals. The qualitative content analysis was considered as a most appropriate method to investigate such factors since the method allows researchers to understand the meaning of the analysed documents, thus understand the phenomenon through them (Bryman, 2016; Hsieh & Shannon, 2005). Moreover, strategic and planning documents are considered a good source of information as they tend to fulfil the quality criteria of authenticity, credibility, representativeness and meaning. (Bryman, 2016; Scott, 1990).

The literature review provided the researcher with a necessary understanding of factors associated with strategic and planning documents which can affect the utilisation of cargo cycles in UFT. Thus, the focus of the content analysis was to identify planning and strategic decisions in Stockholm which directly or indirectly shape the utilisation of cargo cycles, for example, the overall direction of the city in terms of transport and mobility; UFT and promotion of specific vehicles; environmentally friendly vehicles; bicycle infrastructure measures. However, other strategic decisions were also taken into consideration during the content analysis.

Hence, the content analysis identified the most crucial documents affecting UFT and utilisation of cargo cycles, which were consequently analysed more thoroughly: the Urban Mobility Strategy; Freight Plan; The Strategy for a Fossil Fuel-free Stockholm by 2040; The Strategy for Green Vehicles and Renewable Fuels; Bicycle Plan (Cykelplan); and Regional Bicycle Plan (Regional Cykelplan för Stockholms län). However, other documents were also analysed in order to gain a deeper understanding of the whole structure of strategic plans and the overall direction of the city which affects UFT as well. Lastly, the content analysis served as a source of empirical findings, however, it also served as a source of a deeper understanding of researched context. That consequently contributed to better structuring and sampling of the interviews as it provided necessary background information.

3.2.2 Semi-structured interviews

Secondly, semi-structured interviews were conducted as part of the case study. Overall, the interview method was selected since it enables to gain an in-depth understanding of research problematics (Bryman, 2016). Moreover, the researcher decided to utilise semi-structured interviews since such an approach gives the flexibility to focus on valuable areas which were not anticipated before the interview. However, this approach, where the interview guide is usually prepared in advance, still provides a structure which guides the interviewer (Bryman, 2016; Merriam, 2014).

The literature review and content analysis helped to identify the actors which were valuable to be interviewed in order to understand the problematics. Specifically, the literature review provided the author with an understanding of actors who are involved in UFT in general, however, also actors who are directly connected to cargo cycle UFT. Consequently, the content analysis helped to identify such actors in the research context as it provided the researcher with the necessary context.

In total, four interviews were conducted with four different actors who directly or indirectly shape the UFT in the city and factors which affect the utilisation of cargo cycles (see table 3). First, an urban freight strategist was interviewed to obtain a deeper understanding of UFT situation in the city. Moreover, to identify what is the position of the Transport Department towards cargo cycles utilisation for UFT and how they are addressed. Thus, the interview enriched the findings from content analysis concerning strategic documents and planning. Second, a regional bicycle coordinator (Regional cykelsamordnare) was interviewed. This interview provided valuable information concerning bicycle infrastructure which significantly affects cargo cycles’ potential and competitiveness. Moreover, it helped to acquire knowledge concerning how are cargo cycles and their requirements addressed in bicycle planning. Thirdly, the CEO of UFT company MOVEBYBiKE, which utilise cargo cycles, was interviewed. Thus, the findings concerning the
experience of utilising the cargo cycle in the researched context were acquired together with perceived obstacles and facilitating factors. Lastly, the Department Manager (“Sektionschef”) of public-private collaboration Älskade stad was interviewed which broadened the findings of first-hand experience with cargo cycles in UFT. Moreover, it provided valuable information concerning the involvement of public authorities in public-private partnerships concerning UFT.

Table 3 Interview scheme

<table>
<thead>
<tr>
<th>Date</th>
<th>Interviewee</th>
<th>Position</th>
<th>Form</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>22nd March 2019</td>
<td>Interviewee 1</td>
<td>Urban Freight Strategist, City of Stockholm, Transport Department</td>
<td>Face-to-face</td>
<td>60 minutes</td>
</tr>
<tr>
<td>28th March 2019</td>
<td>Interviewee 2</td>
<td>Regional bicycle coordinator (Regional cykelsamordnare), Region Stockholm</td>
<td>Face-to-face</td>
<td>45 minutes</td>
</tr>
<tr>
<td>29th March 2019</td>
<td>Interviewee 3</td>
<td>CEO, MOVEBYBIKE</td>
<td>Over the phone</td>
<td>35 minutes</td>
</tr>
<tr>
<td>1st April 2019</td>
<td>Interviewee 4</td>
<td>Sektionschef, Ragn-Sells AB and Älskade stad</td>
<td>Face-to-face</td>
<td>50 minutes</td>
</tr>
</tbody>
</table>

Selected sample provided the researcher with valuable insights and enabled to investigate various perspectives. Thus, the findings from semi-structured interviews, together with findings from other methods, were considered as reasonably saturated. However, the researcher recognizes that there are many other actors involved in shaping the UFT, transportation and bicycle infrastructure. Moreover, there are other companies in Stockholm which utilise cargo cycles in UFT. However, due to the nature of the study, other actors were not included.

Lastly, the content analysis, as well as literature review, helped to compile the questions included in the interview guide. The interview guide differed for each interview since each respondent represented a different perspective (see interview guides in Appendix). Moreover, findings from interviews conducted earlier contributed to adjusting the questions for following interviewees in order to further investigate potentially interesting findings. Overall, the length of interviews spanned from 35 minutes to one hour and were conducted in person except for the interview with the private company MOVEBYBIKE which was conducted over the phone due to the interviewee’s time limitation. Additionally, all interviews were recorded and consequently transcribed in order to enable thorough and repeated examination of findings and limit the loss of information (Bryman, 2016).

3.2.3 Observations

Lastly, observations of bicycle infrastructure in Stockholm were conducted in order to investigate, identify, and exemplify the obstacles and facilitating factors connected with bicycle infrastructure. The observation method was selected based on findings from interviews, content analysis and literature review where bicycle infrastructure was identified as a crucial factor for utilising cargo cycles in UFT. Thus, this factor was worth to further investigate which was allowed due to the flexibility of the selected case study approach (Bryman, 2016; Yin, 2003). Lewis-Beck & Bryman (2007) and Bryman (2016) argued that there are three main types of observational research (participant observation; reactive observation; and unobtrusive (nonreactive) observation). However, since the focus of these observations was an inanimate object, it is problematic to classify the carried-out observations as one of these types. Thus, unconventional observational approach was selected. This approach is according to the researcher justifiable since the approach fitted the chosen context specification and its requirements. Moreover, in order to
ensure the accountability of the selected approach, the carried-out observations are thoroughly described.

Overall, the focus of observations was bicycle infrastructure in the city centre of Stockholm with a strong emphasis on bicycle lanes and paths. Based on findings from interviews, the city centre of Stockholm was identified as a location with the highest potential for researched cargo cycles. However, also as a location which is subject to the greatest demands in terms of bicycle infrastructure. The selection of locations for observations was partly based on findings acquired from interviewed companies, however, also from the interviewed regional bicycle coordinator. These interviews provided information concerning general locations in Stockholm where, according to them, bicycle infrastructure is sufficient or insufficient for the requirements of cargo cycles. Additionally, other locations were selected based on the researcher’s knowledge of the city’s bicycle infrastructure and in order to represent different types of bicycle lanes and paths. Thus, observations were not exhaustive for the whole bicycle network in Stockholm. The aim of observations, however, was not to observe and map the whole Stockholm’s bicycle infrastructure. It was to identify and exemplify the types of obstacles and good examples of bicycle infrastructure which either limit or facilitate utilisation of cargo cycles in UFT.

The process of observations was as follows. Firstly, the literature review provided the researcher with a necessary overview of factors associated with bicycle infrastructure which negatively or positively affect cargo cycles. Secondly, the interviews with UFT companies and regional bicycle coordinator provided context-specific information of perceived good and bad examples. Thirdly, based on literature review and experience of interviewed companies, parameters of average cargo cycles were taken into consideration. The selection of average cargo cycle was important for observations (especially for the factor of bicycle lane width) since there are various types of cargo cycles which differ in parameters (e.g. width, weight; length; payload). However, the research aimed to consider the parameters of the cargo cycle representing types which interviewed companies utilise. Thus, electrically assisted cargo cycle with more than one track (tricycle or four-wheeled cargo cycle) with a width of 90 cm and a length of around 3 meters was considered as average. Since it characterized the cargo cycles which are utilised by interviewed companies. Additionally, for the purpose of observations, aspects of weight and other parameters were not considered as vital by the researcher based on knowledge from interviews. Fourthly, observations were conducted during a period of four days. Observations were carried out in a way that the researcher walked along bicycle lanes and paths and focused on the quality of it for the above-mentioned average cargo cycle. It was argued (Bryman, 2016; Lewis-Beck & Bryman, 2007), that one possible way to approach observation is to attain maximum flexibility of research design, thus, to use additional means to collect data to enhance basic observation data. Therefore, since width and differences in surface height were identified as one of the most important aspects based on interviews, measurements were carried out. The width and differences in surface height were measured by measuring tape and consequently recorded in field notes together with description and location of observation. Thus, observations were combined of narrative (description of observant aspects) and numeric (measurement results) depictions of physical setting (Lewis-Beck & Bryman, 2007). Every recorded observation was photo documented in order to ensure accountability and to demonstrate the findings. Lastly, the documented material was analysed in order to exemplify the aspects of bicycle infrastructure which is sufficient or insufficient for cargo cycles in Stockholm.

3.3 Quality assurance and limitations of chosen methods

In order to ensure the quality of the research, four criteria of trustworthiness (credibility; transferability; dependability; and confirmability) were considered in this study. Firstly, in terms of credibility, the researcher aimed to “demonstrate that a true picture of the phenomenon under scrutiny is being presented” (Shenton, 2004, p. 63). The above-mentioned technique of
triangulation ensured that the researched phenomenon was reflected according to reality since the employment of more than one method provided greater confidence in findings. Secondly, since the case study approach, consisting of qualitative methods, was selected, the purpose of the study was not to generalise the findings to the population. However, it is argued (Bryman, 2016; Shenton, 2004) that profuse description of one context can generate context knowledge which consequently enables transferability to other situations and environments. Thirdly, the draft manuscript of this thesis was discussed with peers and supervisor, thus, the external audit was ensured. Therefore, the dependability of the study was achieved (Shenton, 2004). Lastly, the technique of triangulation increased the confirmability of the study. However, it is argued (Bryman, 2016; Shenton, 2004) that ensuring the complete objectivity is not possible since some extent of the researcher’s bias is inevitable.

In terms of limitation of chosen methods, Bryman (2016) argued that qualitative research has been criticised for the lack of transparency. However, he argued that when a thorough description of the methodology and methods is provided this limitation can be overcome. Thus, this study thoroughly described the selected methodology and methods and their processes in order to overcome this limitation. Moreover, the generalizability of this study is limited since the case study approach employing qualitative methods was selected (Bryman, 2016; Yin, 2003). However, the generalizability to other contexts was not the aim of the thesis and is not in the abilities of the selected approach. Thus, this study only acknowledges such limitation. Lastly, the study reflects on the possible factor of a language barrier since interviews were held in English which is not the native language of neither interviewees nor interviewer. However, the opportunity for clarification was provided, thus the limitation is not considered to have considerable effect.

3.4 Ethical considerations

Overall, in terms of ethical consideration, this thesis followed the principles of research integrity and its main pillars: honesty, accountability, professionalism, and stewardship described in Resnik & Shamoo (2011). In terms of the collection of empirical material, the thesis strived to ensure four principles discussed by Dill, Diener & Crandall (1980) and Bryman (2016), thus, do not harm participants; not invade their privacy; have their informed consent; and ensure no deception is involved. Specifically, the thesis conducted interviews, thus in order to ensure that all ethical considerations are well-thought-out and that the research integrity was maintained, the following measures were taken. All respondents were informed about the purpose of the interview and the overall purpose of the thesis. The interview with each participant was recorded and transcribed in order to ensure the accountability of the research. However, each respondent was informed and asked whether they agree with the recording. All respondents gave verbal consent with the recording. Furthermore, each respondent was offered the possibility of anonymity which concerned their personal name and name of the organisation. All respondents gave consent that their name and name of the organisation can be mentioned in the thesis. Furthermore, another source of empirical data of the thesis were observations. The focus of observation was on material objects (bicycle infrastructure), however, photo documentation of the bicycle infrastructure was produced. In order to ensure that the privacy of bystanders was not breached, the author of the thesis ensured that no person is recognisable and visible in the pictures. Therefore, all recognisable faces of bystanders as well as registration plates of vehicles were blurred.
4. Empirical Data

This chapter presents the empirical findings obtained from the document analysis, interviews, and observations. Therefore, this chapter provides prerequisite understanding before the empirical findings are analysed and discussed.

4.1 Companies utilising cargo cycles in Stockholm

In this section, two interviewed companies which utilise cargo cycles in UFT in Stockholm will be presented. Moreover, their experience with the cargo cycle as urban freight vehicle will be explained, thus, how are cargo cycles used and how they perform in the research context.

4.1.1 MOVEBYBIKE

MOVEBYBiKE is a cargo cycle UFT company founded in Malmö, Sweden by enthusiastic cyclists Johan and Nils Wendin in 2012. Based on their self-description, they offer an environmentally friendly, inexpensive and modern way of transporting goods in urban areas by using cargo cycles. Since 2012, MOVEBYBiKE has expanded to several Swedish cities and at the time of writing, they operate in Malmö, Lund, Stockholm, Umeå, Uppsala and Göteborg (MOVEBYBiKE, 2019). Furthermore, the company is aiming to establish themselves in other Nordic cities in upcoming years (interviewee 3, personal communication, 2019). The growth of the company and expansion to other cities was partly caused by the fact that MOVEBYBiKE operates as a franchise, thus, the company consists of several branches which use the same name and principles. This strategy consequently helped to launch faster and more securely the concept in other cities. Additionally, the expansion was also enabled by fixed assignments which spanned geographically and therefore, helped start the concept in different cities. The company presents themselves as a good alternative to traditional UFT companies due to their minimal emissions, absence of noise and lower accident risk. Furthermore, they claim to be cheaper since cargo cycles have lower operating costs and are more effective due to their ability to overcome traffic through bicycle lanes. (MOVEBYBiKE, 2019).

The Stockholm branch of MOVEBYBiKE was established as a local chapter (franchise) of MOVEBYBiKE in 2014 by two entrepreneurs. However, in the beginning of 2019, the Stockholm branch was merged with the original company MOVEBYBiKE after the company acquired investors (interviewee 3, personal communication, 2019). Nevertheless, the Stockholm branch of MOVEBYBiKE was growing fast since its establishment and it is now, according to CEO the biggest branch within whole MOVEBYBiKE. In terms of types of utilised cargo cycles, the company is using mostly electrically assisted tricycles (see picture 2 in chapter 2.4), however, they have also two-wheeled, four-wheeled and six-wheeled cargo cycles. In total, the company has around 18 cargo cycles, however, only around 16 cargo cycles are used on everyday basis while others are used less frequently as a backup or for special purposes.

The cargo/payload capacity is often perceived as limiting for utilising cargo cycles in UFT. However, the company does not share this view to large extent: “…there is so much job [for UFT] that is smaller than the capacity of vans anyway” (interviewee 3, personal communication, 2019). Thus, even though the cargo capacity is smaller, the company can still utilise their cargo cycles for various UFT in Stockholm. According to CEO of the company, the limitation associated with the cargo/payload capacity will even decrease since they are now starting more intensively use four-wheeled cargo cycles with a capacity of 300 kilograms (previous cargo cycles had a capacity of 200kg) (interviewee 3, personal communication, 2019).
Furthermore, in terms of speed and range competitiveness with traditional urban freight vehicles, the CEO perceived the situation in Stockholm positively for cargo cycles. Moreover, the lower speed of the vehicle was considered even as a positive aspect. He argued: “...during rush hour we are even faster than cars and it is cheaper as the cars are stuck in the traffic. However, we don’t see our main competitiveness in time…we have low emissions, low energy, low accidents number. We have a lower speed which is a good thing as many delivery vans are going sometimes even 50km/h and they are also speeding...so the impact power is much lower with our vehicles that with the traditional one. That’s our competitiveness.” (interviewee 3, personal communication, 2019).

In Stockholm, the company is mostly transporting food related goods, goods related to e-commerce and home deliveries. The biggest sector is the transport of food-related goods, mostly associated with catering (delivering of food for 20-500 people in large cargo cycles) and distribution of food between schools “...we have a contract that every morning we bring food to kindergartens and schools...so, we transport it with cargo cycles with these approximately 100kg catering wagons which are filled up with food”. The food is then” ... served in the school kitchen, because some schools and kindergartens don’t produce food by themselves, or they are renovating or some other reason...we transport to around 20 of those schools here in Stockholm for the Stockholm municipality” (interviewee 3, personal communication, 2019). Moreover, according to CEO another potential sector for them may be shared electric scooters: “...they [providers of shared electric scooters] are really growing and they don’t have so much logistics solutions” (interviewee 3, personal communication, 2019). The electric scooters need to be transported around the city for which cargo cycles can be utilised. Such transport is already provided by the company in Malmö, Sweden, where the company experienced significant growth due to this. Additionally, the company offers services for the personal moving of goods (moving of personal belongings and furniture). In such cases, customers can either rent cargo cycles and transport the freight by themselves or the freight can be transported by the company´s rider. According to CEO: “…it was always easy to find jobs for us in Stockholm...sometimes we have contacted companies to collaborate ...but lot of them contacted us directly” and the positive situation with job acquisition prevails until now: “...if I could hire hundred people and get a hundred bikes, I can get them into work within a month as the jobs coming in...” (interviewee 3, personal communication, 2019). Thus, this illustrates that there is a demand for cargo cycle UFT in Stockholm.

Lastly, the company delivers mostly within the area illustrated in figure 3. According to CEO, the average delivery distance is difficult to estimate since the distance varies according to the assignment. However, in terms of parcel transport, the average delivery route can be illustrated as follows: “…we pick up the goods...and then we go on distribution round which can be around 300metres between each stop...or we pick up at one place and then deliver it to another and then we pick it up at another place and deliver it elsewhere. So, there can be for example one bike at Östermalm [district in central Stockholm] and delivering and working over there and other bikes work somewhere else...we make the route according to where we need to be” (interviewee 3, personal communication, 2019). Thus, the company does not use micro-consolidation centre, however, picks up the goods directly from their suppliers and partners. The absence of micro-consolidation centre reduces the operational costs associated with renting or purchasing the property, however, they see the potential of using micro-consolidation centre for their future growth.
4.1.2 Älskade stad

Älskade stad ("Beloved City") is a lasting collaboration of the city of Stockholm, Ragn-Sells (a company focused on waste management, environmental services and recycling), Bring (a company focused on the transportation of parcels, cargo and mail) and Vasakronan (real estate company). The underlying idea of this collaboration is to reduce the negative impacts connected to UFT by introducing principles of circularity into the transportation of goods in urban areas. Thus, the collaboration connects the transportation of goods (parcels, restaurant materials etc.) with simultaneous collection of waste materials within the same distribution/collection round. This approach aims to reduce the number of trips with empty urban freight vehicles (e.g. urban freight vehicle is empty on the way back to consolidation centre after it distributed all goods; opposite with waste collection) (interviewee 1 and 4, personal communication, 2019).

The city of Stockholm with the help of EU funds was the initiator of the collaboration: “…we [Stockholm municipality] invited the broad spectre of stakeholders to engage with them and this led to several companies being interested in working together. It was a process of several years…getting to know each other…some companies left and others came on board and were trying to develop something. We [Stockholm municipality] have always been the neutral part…we were facilitating the whole networking process and finally after approximately four years of work we could launch the collaboration” (interviewee 1, personal communication, 2019). In practice, the company Ragn-Sells and Bring share vehicles for delivering goods and simultaneous collection of waste materials. Moreover, they share distribution centre in the city centre of Stockholm (Klara Norra Kyrkogata) provided by real estate company Vasakronan (interviewee 1 and 4, personal communication, 2019). Hence, the collaboration Älskade stad is distributing Bring’s parcel deliveries and restaurant materials, while at the same time and with the same vehicle collecting waste materials for the company Ragn-Sells. That consequently contributes to fewer vehicles on streets and reduce the number of unnecessary trips with empty vehicles, moreover, limits their negative environmental impact by utilising only environmentally friendly vehicles.

The collaboration uses three vehicles: two electric trucks and one four-wheel electric cargo cycle (see picture 3 in chapter 2.4) with a notion to use: “…whatever vehicle is optimal for each case” (interviewee 1, personal communication, 2019). Therefore, each vehicle has a different purpose as the capacity and ability differ. The electric cargo cycle is mostly used in Gamla Stan (Old Town) where: “…are many narrow streets and you cannot drive with a motor vehicle after 11
o’clock because they stop the traffic...you can only have small electric vehicles” (interviewee 4, personal communication, 2019). Thus, the cargo cycle is utilised for a specific location where the traditional urban freight vehicles would be difficult to use.

However, the cargo cycle is used in a different way than electric trucks due to its limited cargo/payload capacity. The smaller capacity of the cargo cycle does not allow to transport larger parcels, moreover, the possibility to collect waste material is also limited (interviewee 4, personal communication, 2019). Thus, the cargo cycle transports mostly smaller parcels and collects electronic recycling material (e.g. cables and printers) since the: “...electronic waste is usually hit smaller items and not picked up that often like paper and plastic” (interviewee 1, personal communication, 2019). Nevertheless, the cargo cycle is perceived as useful urban freight vehicle by the interviewed representative of the collaboration since it enables to transport goods in areas which would be otherwise very difficult to access with traditional urban freight vehicles. Moreover, the speed and range abilities of the cargo cycle itself are not perceived as limiting by the interviewee since it is sufficient for their purposes.

Lastly, as was mentioned above, the collaboration uses micro-consolidation centre in the city centre of Stockholm. In practice, the urban freight vehicles, including cargo cycle, start their delivery/collecting round in the consolidation centre where parcels and restaurant material is loaded and consequently return with collected waste material. According to the interviewee the consolidation centre is a crucial aspect for their operations and operating without it would be nearly impossible. Moreover, due to collaborating nature of the project, the property is rented free of charge by real estate company Vasakronan, which dramatically reduces their operating costs.

### 4.2 Strategic orientation, planning and institutions related to urban freight transport

In this section, the strategic orientation of the city is presented together with other findings related to institutions and organisations, their position and policies related to UFT and cargo cycles. Thus, this section provides necessary findings for analysing the obstacles and facilitating factors related to institutions.

#### 4.2.1 Strategic documents and plans

Overall, in Sweden, strategies, plans and issues concerning UFT are addressed on different levels and by various stakeholders. Firstly, on a national level, the government is concern with a number of major infrastructural investments which for upcoming years aim to contribute to the shift of Sweden to a fossil-free welfare state (Regeringskansliet, 2018; Stockholms stad, 2018b). Furthermore, the Swedish Transport Administration (Trafikverket) is responsible for long-term infrastructure planning of road transport, rail transport, shipping and aviation together with the construction and management of public roads and railways. Secondly, on the regional level, commercial freight transport is addressed through a number of collaborations and regional development plan with a supplement of regional freight strategy. Thirdly, the municipal level has the most direct influence on UFT. The city of Stockholm has relatively good opportunities to influence freight transport through regulations and other instruments. For example, the city can utilise the local traffic regulations and therefore, restrictions can be imposed on the length and weight of vehicles. Moreover, the city can apply regulation concerning delivering time, emission requirements and environmental zones. These restrictions can be applied to the entire municipality or only locally, for example only for certain streets. The city can also require certain types of vehicles which follow set requirements (e.g. emissions and efficiency) through public procurement of vehicles. The city can also influence UFT through long-term land use plans. In addition to these levels, many other stakeholders (various departments, institutions, private sector etc.) are involved in UFT and its planning. Figure 4 exemplifies the interconnectedness and complexity of involved stakeholders.
Within the Stockholm municipality, there are various administrations/departments with differing responsibilities in terms of UFT. The Traffic Administration (Trafikkontoret) is ensuring safe and accessible urban mobility. The City’s vehicle and fuel management experts under the Environmental and Health Protection Administration (Miljöförvaltningen) are influencing central procurements which affect the vehicle fleets for urban freight movement and their requirements. The Urban Planning department (Stadsbyggnadskontoret) deals with land use which also affects UFT. Moreover, the City is a major property owner which represents considerable aspect for UFT, for example, in terms of ports and/or consolidation centres. Additionally, there are other departments and administrations which are shaping UFT, such as the Development Administration (Exploateringskontoret), Stockholm Business Region etc. (Stockholms stad, 2018b).

In terms of planning and strategic documents, the city has various documents which shape or will shape the form of UFT. The strategic goal of the city of Stockholm is described in the document Vision 2040 – A Stockholm for Everyone which is further elaborated with Stockholm City Plan which provides support how the goals will be achieved (Stockholms stad, 2018a). Moreover, the Urban Mobility Strategy concerns with specific principles and support for the planning regarding transport in Stockholm (Stockholms stad, 2012). Furthermore, the Urban Mobility Strategy is further developed through a number of direction plans where Stockholm Freight Plan is one of them (Stockholms stad, 2018b). The hierarchical structure of the plans is presented in figure 5. Additionally, other strategies and plans are at least partly concerned and/or touch the problematic of UFT: The Environmental Programme, The Strategy for a Fossil Fuel-free Stockholm by 2040, The Strategy for Green Vehicles and Renewable Fuels, The Quay Strategy for the Port of Stockholm, The Waste Plan, Word-class Business Parks and Strategy for Stockholm as a Smart and Connected City. Two of these strategic documents, Stockholm Freight Plan and The strategy for a Fossil Fuel-free Stockholm by 2040, will be now further presented since they considerably affect the utilisation of cargo cycles in UFT.
Stockholm Freight Plan

Stockholm freight plan is part of the Urban mobility strategy and it is one of the most crucial planning documents related to UFT. The document itself addresses and explains the overall situation concerning UFT and the importance to focus on this issue. The plan acknowledges the pressure placed on urban freight system caused by increasing population and other factors and moreover, recognises that "...the situation is reaching a critical point in the inner city, where the road infrastructure of the future will largely remain the same as it is now. This requires new thinking and innovation in developing new solutions for commercial freight transport. Together with numerous other key stakeholders, the City is jointly responsible for this development. The necessary deliveries must reach their destination while commercial freight transport needs to reduce its impact on the environment and climate." (Stockholms stad, 2018b, p. 3). Therefore, the main aim of the plan and overall strategy of the City is to ensure the prevalence of the benefits connected with UFT while eliminating to minimum its negative aspects connected to climate change, environmental problems, congestion levels, safety and health risks (Stockholms stad, 2018b). Overall, Stockholm city has three planning directions in terms of UFT, all of them partially affect utilisation of cargo cycles in UFT. First, accessibility and predictability for freight transport must increase, through this planning direction the city wants to increase the efficiency of urban freight and achieve better mobility around the city. Second, the negative impacts of freight transport on the environment and the city’s attractiveness must be reduced which represents the need to create freight transport which is sustainable in terms of accessibility, safety, environmental and climate requirements. Thirdly, freight transport must be developed through close collaboration between the City and other key stakeholders (Stockholms stad, 2018b).

Furthermore, the key message of the Stockholm Freight Plan is its action plan for 2018-2022. The action plan is organised into six focus areas and each area comprises of several concrete activities. The action plan for 2018-2022 consists: Regulation and instruments; Freight transport expertise; Strategic land use; Space-efficient urban logistics; Freight by rail and water; and Innovation and new technology (Stockholms stad, 2018b). Although most of these focus areas affect the possibility to utilise cargo cycles in urban logistics to some extent, the Space-efficient urban logistics and Innovation and new technology focus areas are the most influential and will be
further explained. The city wants to promote space-efficient urban logistics which directly affects cargo cycles since they are one such solution. Within this focus area, cargo cycles are explicitly mentioned, however not to a large extent, as one of the possible solutions for last-mile transport in a competitive and dense environment. As one of such examples, the plan presents collaboration Ålskade stad which utilises slow-moving electric trailer and electric cargo cycle (see above) (Stockholms stad, 2018b). Moreover, focus area Innovation and new technology is also influencing the utilisation of cargo cycles in urban logistics. The focus area stresses the importance to promote new technologies in order to achieve fossil-fuel free transport system which will contribute to quieter, cleaner and safer urban environment. The plan emphasises the importance of electrification, digitalisation and automation for this goal (Stockholms stad, 2018b).

**Strategy for fossil-fuel free Stockholm by 2040**

Another important strategic document which affects utilising of cargo cycles in UFT is the *Strategy for a fossil-fuel free Stockholm by 2040*. The document provides strategic tools and goals to help transform the city of Stockholm to a fossil-fuel free city. Furthermore, the strategy presents a framework of what the City can do in the short- (by 2020) and long-term (by 2040) perspective. Importantly for UFT, the strategy identifies the transport sector as the most urgent and consequently the toughest sector to transform. This applies not only to UFT, however, also to passenger traffic, aviation, shipping and construction transport. Furthermore, the strategy recognises road traffic as a challenging sector which needs to be changed due to its heavy dependence on fossil fuels. This should be achieved through the replacement of vehicles and investment into new and more environmentally friendly infrastructure. In terms of urban goods movement within the road traffic, the strategy acknowledges that the goods traffic is and will experience growth due to the increasing population and their needs. The City expects growth especially in light vehicles urban freight traffic. It is predicted that in 2040, light goods vehicles will represent 20% of the traffic mix while heavy goods vehicles 4%. Moreover, it is expected that the mileage of freight movement on Swedish road, in general, will increase by 53% between 2006 and 2030 (Stockholms stad, 2016b). That has to be addressed by ensuring that goods vehicles use renewable fuels and alternative fuels in order to reduce the negative impacts of the sector.

Furthermore, the strategy identifies the most urgent areas and measures in achieving fossil-fuel free road traffic by 2040. Firstly, measures which encourage the transition to renewable fuels and improve the energy efficiency of vehicles should be adapted through a long-term regulatory framework. For example, the change should be stimulated through taxation which favours environmentally friendly vehicles and alternative fuels. Secondly, measures can concern directly road mileage of vehicles through new models of taxation for company vehicle fleets, taxes in fuel or CO₂ emissions, congestion charging and kilometre taxes. Furthermore, improvements have to be done in terms of parking and un/loading in order to reduce the search time of vehicles. Thirdly, the City wants to promote sustainable travel alternatives which can be achieved for example through environmental zones, parking spaces only for fossil-fuel free vehicles and other measures which favours environmentally friendly vehicles. Lastly, the document identifies a need for a national strategy for goods transport modes which will, for example, include rules to report fuel consumption and carbon dioxide emissions from heavy goods vehicles’ traffic (Stockholms stad, 2016b).

4.2.2 Public-private partnership, collaborations and position of public authorities

Moreover, the empirical findings from interviews with urban freight strategist, however also with private companies, helped to explore the position of the public authorities towards cargo cycles utilisation in UFT and their involvement in public-private partnerships and collaborations. The
position of urban freight department affects utilisation of cargo cycles in UFT. Overall, even though the department or the city does not directly promote cargo cycles, they are promoting environmentally friendly UFT: "It is not like we have big campaign for cargo cycles specifically but we want to have emission-free and space efficient logistics solutions, so we believe that cargo cycle is one way how to achieve that. So, in that way, we are promoting it." (interviewee 1, personal communication, 2019). This claim is also supported by the above-mentioned plans. Furthermore, the close networking and collaboration of the municipality with the private sector might be beneficial for the cargo cycles companies. The municipality, more specifically the urban freight department: "...has a lot of meetings with transport companies, with manufacturers, with property owners and so on. We are always trying to promote sustainable freight solution, having an open discussion on how we could maybe collaborate to find new solutions.” (interviewee 1, personal communication, 2019). These networking and collaboration are very appreciated by both interviewed companies. Both companies are in direct contact with the urban freight department and they are mutually collaborating (interviewee 3 and 4, personal communication, 2019). Additionally, the facilitating factor of the municipality towards cargo cycles can be viewed in their own efforts to implement cargo cycles for their own purposes. The environmental department: “...own[s] a cargo cycle that the other departments and municipal companies can borrow; for two weeks for example, and they can try it if it fits their own needs and maybe decide to buy one if they believe that it works well for their purposes.” (interviewee 1, personal communication, 2019). Thus, they spread awareness among the organisations.

4.2.3 Hidden obstacles connected to institutions and policies

However, the institutions and their policies are not only associated with aspects which facilitate the utilisation of cargo cycles in UFT. The interviews revealed aspects which are perceived as obstacles for the cargo cycle utilisation by interviewees. Such obstacles are mostly associated with the persistence of old structures, specifically fixation on traditional urban freight vehicles. Notwithstanding such perceived hidden obstacles have various forms, this thesis exemplifies it on the case of public procurement.

It was identified that public but also commercial procurements for UFT services tend to be designed only to fit traditional urban freight vehicles such as vans and trucks. This can be illustrated by the public procurement for transporting food between schools in Södermal (a district in central Stockholm). This procurement was designed in a way that the requirements for the transporting vehicles applied only to vans and small trucks and did not acknowledge the different parameters which cargo cycles have (interviewee 1, personal communication, 2019). The above-introduced company MOVEBYBiKE wanted to apply for this procurement, however: “.... at first we couldn’t apply because there were a lot of specific requirements which applied only to cars...like reversing camera which we don’t need because we don’t reverse...we only turn around.” (interviewee 3, personal communication, 2019) and many other van’s specific equipment. However, after the first round, no one qualified for the procurement, moreover, the municipality was advised about other possible vehicles for the job and their requirements. Thus, the procurement consequently changed its requirements and acknowledged the cargo cycles parameters. These small adjustments of procurement in terms of vehicle requirements, which were not less optimal for the task, allowed the participation of cargo cycles. As result, the company MOVEBYBiKE was able to get the procurement since their services were considerably cheaper in comparison with traditional urban freight vehicles (interviewee 1 and 3, personal communication, 2019). Moreover, even though this example concerned only one procurement, based on an interview with the urban freight strategist: “... there are many such cases where we [the City] can have more bikes, so this was sort of a wake-up call for the City that we need to think in new ways so we can include new innovative transport services” (interviewee 1, personal communication, 2019). Thus, the city might rethink and adjust their approach in terms of public procurements in the near future, however, it still presents an obstacle for the companies utilising cargo cycles. The policies, procurements, and regulations concerned with UFT often automatically assume that only traditional urban freight vehicles should be addressed. Hence,
according to interview with the company MOVEBYBiKE, it would be beneficial for cargo cycle logistics providers if this was addressed on the governmental level: “...they should have some directive that all public procurements allow bikes to apply...like it was here in this case.” (interviewee 3, personal communication, 2019).

### 4.3 Traffic situation and transport sector

This section presents situation concerning the transport sector in Stockholm, moreover, its environmental impacts, as well as traffic situation, will be presented. This enables to research and consequently analyse the researched context from a more holistic perspective.

#### 4.3.1 Environmental impacts of the transport sector

Figure 6 presents the total greenhouse gas emissions in thousands of tonnes in Stockholm between 1990 and 2015. Specifically, the figure illustrates that in the 1990s and beginning of 2000s the most emitting sector of greenhouse gas emissions was heating followed by the transport sector and other electricity and gas usage. Nevertheless, since the 1990s the heating sector and other usages of electricity and gas were steadily decreasing. However, the levels of greenhouse gas emissions emitted by transport sector have remained almost the same throughout the period. The transport sector was responsible for 44% of greenhouse gas emissions in Stockholm in 2014 (Stockholms stad, 2016b). Therefore, this illustrates that the transport sector is still facing challenges for reducing the levels as other sectors, which symbolize a good starting point for promoting space efficient and environmentally friendly urban freight vehicles such as cargo cycles and others solution.

![Figure 6 Total greenhouse gas emissions in thousands of tonnes in Stockholm (Stockholms stad, 2016b), modified by author](image)

#### 4.3.2 The traffic situation in Stockholm

In Stockholm, the road traffic is since 2012 steadily increasing which can be explained by the increasing population and increasing car ownership. Between 2016 and 2017 there was a 0.8% increase in terms of car ownership which represents 375 vehicles per 1000 inhabitants in 2017. Moreover, for 2016, the vehicle mileage in Stockholm increased by 2%. Furthermore, the accessibility for cars declined in the inner city, however, increased in the suburbs. This can be
explained by reduced mobility in the inner city due to construction work (Slussen; Sergelstorg) and by road improvements in suburban areas of Stockholm (Stockholms stad, 2018c). Notwithstanding it is problematic to distinguish passenger traffic from urban freight traffic and other types of traffic, these statistics present the overall trends and situation in the researched context.

### 4.3.3 Environmentally friendly vehicles

Even though the increase of environmentally friendly vehicles can be seen over the past years both in private and commercial sector, the share of environmentally friendly light trucks (<3.5 t) in traffic circulation is still minimal (Stockholms stad, 2016a). At the turn of 2015/2016, only 2.3% and 3.1% of total light trucks in traffic in Stockholm county (Stockholms län) and city of Stockholm (Stockholms stad) respectively were classified as environmentally friendly. That corresponds with 1461 environmentally friendly light trucks (vans) in city of Stockholm (2 559 in Stockholm county). Similar tendencies can be seen with heavy goods vehicles (> 3.5 tonnes) where the share of environmentally friendly vehicles was 5% in Stockholm and 2.5% in Stockholm county. For comparison, the share of passenger vehicles classified as environmentally friendly was 21% in Stockholm and 19% in Stockholm county (Stockholms stad, 2016a). However, these statistics are problematic in terms of determining which of these vehicles are used for commercial purposes and which for private use, moreover, some vehicles can be registered in a different county. Nevertheless, it shows the overall tendencies where environmentally friendly light trucks and heavy trucks represent only fraction of the total share, therefore, this sector requires increased attention in order to address its negative environmental impacts.

### 4.4 Bicycle infrastructure: planning, experience and observations

Overall, the city of Stockholm is aiming to promote and increase cycling as a mode of transport (Stockholms stad, 2012, 2015; Trafikverket, 2014). The strategic planning for cycling and cycling infrastructure in Stockholm is addressed by several documents: Urban Mobility Strategy, Bicycle Plan (Cykelnät), and Regional Bicycle Plan (Regional Cykelplan för Stockholms län). Especially the last two mentioned further elaborate the city’s (region’s) strategic orientation in terms of cycling. Moreover, they present guidelines for the quality of the bicycle paths, for example in terms of width, curve radius and overall standards. Overall, the plans do not explicitly focus on cargo cycles and their requirements, however, the presented standards, when average size cargo cycle is considered, fulfil the requirements of cargo cycles, especially in terms of width and curve radius.

Table 4 illustrates what the city of Stockholm wants to achieve in terms of the width of commuter bicycle lanes (thus lanes often used by cyclist whose destination is in different municipality or neighbourhood). The width standards are divided into several groups according to the type and location of the bicycle lane, however, all of them are sufficient for the requirements of the average cargo cycle (approximately 90 cm). Moreover, even the narrowest standards, thus, bicycle lanes in the city centre with a width of 1.75 m are wide enough to accommodate cargo cycle and provide necessary space for other cyclists to overtake it, if necessary. The importance of providing enough space to allow overtaking in order to ensure natural flow is even directly addressed in the plans (Stockholms stad, 2015; Trafikverket, 2014).
Furthermore, table 5 shows the planned widths for bicycle lanes classified as bicycle highways (“Huvudstråk”), thus main routes used by cyclists. Although such bicycle lanes are narrower than commuter lanes, they still have enough space to accommodate average sized cargo cycles.

**Table 4 Width of commuter bicycle lanes (Trafikverket, 2014), modified by author**

<table>
<thead>
<tr>
<th>Type</th>
<th>Width</th>
<th>Width of lanes with heavy flows &gt; 15 000 c/ d</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-way bicycle path</td>
<td>2.25 m</td>
<td>3.25 m</td>
</tr>
<tr>
<td>Bidirectional cycle track</td>
<td>3.25 m</td>
<td>4.5 m</td>
</tr>
<tr>
<td>Bidirectional path</td>
<td>5 m</td>
<td>7 m</td>
</tr>
<tr>
<td>Cycle lanes in the inner city</td>
<td>1.75 m</td>
<td>3 m</td>
</tr>
</tbody>
</table>

Furthermore, findings from an interview with the regional bicycle coordinator at Region Stockholm helped to understand the situation of and planning for the bicycle infrastructure in the Stockholm region. Overall, as identified in bicycle plans, the interview confirmed the assumption that the plans do not directly address cargo cycles in any part. The plans and strategy of the city of Stockholm and the Region aim mostly on commuter cyclists and their requirements, however, as mentioned during the interview: “... we [the Region] are promoting cycling in general...and cargo bikes are one of the bikes which are there.” (interviewee 2, personal communication, 2019).

However, even though, the cargo cycles and their requirements are not explicitly planned for in the strategic materials, the city and the region: “... want to have an attractive bicycle infrastructure and it must be safe when there is a lot of cyclists and for that, it has to be very wide.” (interviewee 2, personal communication, 2019). Therefore, even though the parameters of bicycle paths are not directly planned for cargo cycles “...they are wider than we usually see today, so it should be better for cargo cycles as well.” (interviewee 2, personal communication, 2019). Moreover, during the interview, other infrastructure requirements were discussed such as kerbs, curve radius and “turning boxes”. The City is aiming to improve such aspects of bicycle infrastructure as well since these improvements also directly affect regular cyclists (interviewee 2, personal communication, 2019). Hence, improvement of these aspects might be beneficial even for cargo cycles which tend to be more prone to insufficiencies in terms of bicycle infrastructure. Furthermore, public authorities concerning bicycle infrastructure have a positive attitude towards revising such parameters in the future, especially if the share of cargo cycles increases (interviewee 2, personal communication, 2019). Moreover, interviewed companies considered recently built bicycle lanes with the above-mentioned standards rather positively for their needs: “... they [the City] are really trying to lift things up...so I think they are slowly getting there” (interviewee 3, personal communication, 2019); “...when they [the City] are building new bike lanes, these are very good for our cargo bike, so on these we can go much easier and faster [interviewee is comparing the new build infrastructure with older types of bicycle infrastructure]” (interviewee 3, personal communication, 2019).

Additionally, as stated in the literature review, some cities (e.g. London) addressed increased numbers of electric bicycles and related problems (e.g. the problem of higher speed) on bicycle infrastructure by not allowing such cycles to use bicycle infrastructure when using electric assistance. Based on an interview with a regional bicycle coordinator, such actions are not expected in Stockholm. Even though a set of rules and laws apply to electrically powered bicycles
(e.g. maximum speed and performance), any other intervention in terms of not allowing such cycles on bicycle lanes is not planned in a reasonable time horizon.

4.4.1 Good standards of new bicycle network

Moreover, examples of good and/or sufficient bicycle infrastructure for cargo cycles can be demonstrated and exemplified by findings from observations. Overall, good examples can be mostly seen on relatively newly renovated or developed bicycle lanes, these tend to be wide enough even for cargo cycle requirements and moreover leave space for overtaking by other cyclists. Furthermore, such good examples often include lowered kerbs or ramps which allow cargo cycle to enter the sidewalk. Picture 4 illustrates newly built bicycle lane in the central area of Stockholm, on Klarabergsgatan. Overall, the bicycle lane fulfils most of the requirements for cargo cycles as the width differentiate between 2.1 and 2.5 meters which not only is sufficient for the cargo cycle parameters, but it allows other cyclists to overtake cargo cycle with a safe distance. Moreover, kerbs are lowered on several parts of the bicycle lane which allows cargo cycle to enter the sidewalk without a problem, which consequently helps them when delivering. Similar situation, however, different design can be seen also on picture 5 and 6.

![Picture 4 Good example of bicycle infrastructure: width](image)

*Location: Klarabergsgatan, Stockholm; source: author*
Picture 5 Good example of bicycle infrastructure: width
location: Östra Järnvägsgatan, Stockholm; source: author

Picture 6 Good example of bicycle infrastructure: width
location: Odengatan, Stockholm; source: author
Secondly, picture 7 and 8 illustrate a “turning box” on a bicycle lane on two locations in central Stockholm. Such “turning box” favours (not only) cargo cycles, as they are able to wait for the possibility of turning in designated lane, therefore, do not block other cyclists. The turning box on both pictures is approximately 2.8 meters wide, where turning lane is 1.6 meters while the regular lane is around 1.2 meters. Therefore, there is enough space for average-sized cargo cycle for turning as well as for continuing.

*Picture 7 Good example of bicycle infrastructure: "turning box" location: Karlbergsvägen, Stockholm; source: author*
Thirdly, pictures 9 and 10 show good solutions for cargo cycle requirements for overcoming different levels of the surface. Both pictures show wide enough ramps (around 1.5 meters) which enable to overcome kerbs and surface with different level. Such ramps are usual when the bicycle lane changes level, however, they are often not wide enough (less than 1 meter) which limit cargo cycles to comfortably use them. Therefore, presented examples illustrate wide enough solution of such ramps. Moreover, picture 11 and 12 show a good example of lowered kerb on sides of bicycle lane. This is particularly important for cargo cycles in order to comfortably enter the sidewalk area for delivering goods.
Good example of bicycle infrastructure: ramp
location: Karlbergsvägen, Stockholm; source: author

Good example of bicycle infrastructure: ramp
location: Odengatan, Stockholm, Sweden; source: author
Picture 11 Good example of bicycle infrastructure: lowered kerb
location: Birger Jarlsgatan, Stockholm; source: author

Picture 12 Good example of bicycle infrastructure: lowered kerb
location: Sergels torg, Stockholm; source: author
4.4.2 Limitations of the current bicycle network

During interviews with urban freight companies, some obstacles for cargo cycles associated with bicycle infrastructure were identified. The limitations and obstacles were mostly connected with older bicycle lanes and paths which were not yet renovated or updated as exemplified above. Such situation and the need to address it was acknowledged even by regional bicycle coordinator: “...the current network for cycling as a whole needs to be improved even for regular cyclists. There are things that really need to be improved in many locations and that not least is valid for cargo bikes which have even bigger requirements” (interviewee 2, personal communication, 2019). Specifically, all three interviewees (interviewee 2, 3 and 4, personal communication, 2019) identified similar infrastructural obstacles, mostly concerned with the width of bicycle lanes, however, also with gravel, kerbs and physical obstacles. Moreover, findings from observations helped to identify additional obstacles. In the following part, individual obstacles related to bicycle infrastructure will be presented and further illustrated.

Narrow bike lanes

Firstly, the width of bicycle lanes was identified as one of the infrastructural obstacles for utilising cargo cycles in UFT in Stockholm. However, the problem cannot be viewed as universal for all bicycle lanes’ widths within Stockholm. The limiting factor is mostly associated with the inconsistency which means that the bicycle lane width differs in many places. Overall, the limited width of the bicycle lanes represents an obstacle for cargo cycles since cargo cycles tend to be wider and longer than regular bicycles. Thus, when the bicycle lane is too narrow for the need of cargo cycles, it limits the possibility to operate it on the bicycle lanes. This can be illustrated by the claim of one interviewee representing a company which uses cargo cycles: “...the problem I see is, that sometimes the bike lane is too narrow and because of that we have problems to overtake or overcome the traffic. They [the cargo cycle riders] have to stop and wait just as cars because it is too narrow there and the cargo cycle is too wide to pass other vehicles” (interviewee 4, personal communication, 2019). Furthermore, when the cargo cycle is forced to suddenly stop and/or exit bicycle lane in the narrow part, other cyclists are forced to stop as well, even though it might be wide enough for their purpose. Additionally, regional bicycle coordinator also identified the width of some bicycle paths as insufficient for the needs of cargo cycles. However, in a sense that the bicycle lanes do not provide enough space for safe overtaking by a faster cyclist.

Moreover, during observations selected bicycle lanes were measured. These observations helped to identify and understand the inconsistency of bicycle lanes’ widths in Stockholm. Overall, during the observations it was identified that the width can differ dramatically, it can span from 0,4 meter to more than 3 meters. The problematic areas, where the bicycle lanes are narrower, tend to be very short or even limited to a certain spot of the bicycle lane. However, even a short section of the bicycle lane with insufficient width for cargo cycles presents considerable problems. Examples of obstacles related to width can be divided into two groups. First, width which is sufficient for parameters of average cargo cycles (around 90 centimetres), however, limiting in terms of speed of cargo cycles and insufficient space for overtaking by other cyclists. Second, width which represents a significant or even unbeatable obstacle for cargo cycles. Both of these groups will be explained and exemplified.

First, obstacles in terms of relatively sufficient bicycle lane width. Overall, bicycle lanes with widths around one meter were classified as relatively sufficient. Cargo cycles parameters differ according to type, however, the width average around 90 centimetres. Therefore, bicycle lanes which are around one meter wide are relatively sufficient for them, however, some safe distance around cargo cycles has to be also considered. This distance is hard to estimate as it differs from case to case. Nevertheless, bicycle lanes with a width around one meter do not provide enough additional space for cargo cycles. This can present an obstacle for them in several situations. For example, when an unexpected obstacle is located on some part of bicycle lane (e.g. broken glass, hole), the cargo cycles do not have space to bypass the obstacle, especially when the bicycle lane
is separated by kerbs. Following examples with pictures can illustrate such problematic bicycle lanes. Picture 13 shows a bicycle lane next to the bus stop. Even though the cargo cycle fits on the bicycle lane, the rider might need to reduce speed dramatically due to the bus stop located directly next to the bicycle lanes. Furthermore, in order to maintain a safe distance from the bus stop, cargo cycles might need to ride with one wheel on the cobblestones, which might cause vibration and possibly harm the freight.

![Picture 13 Relatively sufficient bicycle lane width location: Torsgatan, Stockholm; source: author](image)

Moreover, an obstacle which forces the rider of cargo cycle to dramatically reduce speed or even swerve is shown in picture 14. The drain has different level than other parts of the bicycle lane surface which would probably force the rider to swerve to the left. However, due to the limited width of the bicycle lane (one meter), this is not necessarily possible as a road with heavy traffic is located directly next to the bicycle lane. Therefore, the cargo cycle has to either partly enter the road which might be a risky situation or continue on the bicycle lane, however, significantly reduce speed to prevent vibration and possible damage on goods. A similar situation is also visible in picture 15.
Picture 14 Relative sufficient bicycle lane width
location: Birger Jarlsgatan, Stockholm; source: author

Picture 15 Relative sufficient bicycle lane width
location: Sveavägen, Stockholm; source: author
Additionally, picture 16 illustrates a situation where the width (one meter) does not necessarily limit the cargo cycle to operate, however, it does not provide enough space for overtaking cargo cycles by other cyclists, thus, limits other cyclists. This is even intensified by kerb separation between the road and bicycle lane due to which the possibility to use the road for overtaking is reduced.

Picture 16 Relatively sufficient bicycle lane width
location: Birger Jarlgatan, Stockholm; source: author

Second, some obstacles connected to width of bicycle lanes represent significant or even unbeatable obstacle for cargo cycles. Such examples are bicycle lanes which are not even one meter wide, therefore do not meet the width requirements of cargo cycles. These situations are rarer than the above mentioned, however, when they occur, they are much more limiting. In situations when bicycle lane does not meet the width requirements, cargo cycles are forced to find alternative routes, use roads or sidewalks and/ or dramatically reduce speed. Moreover, when a bicycle lane is two-way it can present even risks for other cyclists. Picture 17 shows frequently used two-way bicycle lane through Stockholm’s Old Town. The combined width of the bicycle lane is approximately two meters (left side= 90cm; right side= 110cm) when the paving on the left side is considered as part of lane and around 1.7 meter (left side= 55cm; right side= 110cm) without the paving. Therefore, the width of the left lane is not sufficient (in both situations) for the parameters of cargo cycles. This can cause dangerous situations as the cargo cycle has to use a considerable part of the bicycle lane in the opposite direction while using the left lane, thus limit the space of cyclists in the opposite direction. Moreover, pictures 18 and 19 illustrate the same bicycles lane, however, in different parts. In these parts, the bicycle lane is even narrower due to pillars which reduce the space of the bicycle lane by more than 20 centimetres, thus to approximately 1.8 meters in total (approximately 1.5 meters without paving). This means, when the safe zone next to the sides of the bicycle lane (approximately 15 centimetres) is considered, the cargo cycle (approximately 0.9 meters wide) leaves less than one-metre wide space in opposite direction. This, especially when considered that cyclist in the opposite direction should also have
some safe zone from the side and also from the dividing line (approximately 30 cm together), represents a significant risk of an accident. Furthermore, when the paving on the left side is not considered a bicycle lane, the width is minimal for cyclists in the opposite direction. Moreover, in such location, two passing cargo cycles riding in the opposite direction would not fit. Additionally, this location was also identified as insufficient by interviewee representing Älskade stad. As was presented above, their cargo cycle delivers goods mostly in Gamla Stan (Old Town) area, thus around this bicycle lane. This bicycle lane would be very convenient for them to get across the Old Town, however, due to its limited width, they have to search for other routes and are often forced to use car infrastructure instead. Thus, for them, this presents a physical obstacle which limits their accessibility.

*Picture 17 Insufficient bicycle lane width
location: Gamla Stan, Stockholm; source: author*
In insufficient bicycle lane width location: Gamla Stan, Stockholm; source: author

Picture 18 Insufficient bicycle lane width location: Gamla Stan, Stockholm; source: author

Picture 19 Insufficient bicycle lane width location: Gamla Stan, Stockholm; source: author
Physical obstacles on bike lanes

Secondly, other obstacles associated with bicycles infrastructure, which limit cargo cycles utilisation for UFT, are physical obstacles on bicycle lanes. These are usually related to the quality of the surface of bicycle lanes, however, also to the behaviour of other road users. In general, as was identified in the literature, cargo cycles carrying freight are much more exposed to surface irregularities as it might harm the freight or force them to dramatically reduce the speed in order to prevent the damage of goods. The problem of kerbs and other physical obstacles can be illustrated by findings from an interview with regional bicycle coordinator:” *...when you ride a cargo bike and you want to go to some address, where should you stop? If it is a heavily loaded cargo bike it is probably pretty tricky to pick it up [the cargo cycle] when you want to go over the kerb. You can’t stay in the middle of the bike lanes because that would stop the traffic...So if you want or need to take your cargo bike on another surface closer to the entrance, then the kerb needs to be lower.*” (interviewee 2, personal communication, 2019). Such situation refers to kerbs which are next to bicycles lanes and may limit the cargo cycle to exit the bicycle lane in order to stop and delivery the freight. However, such situation is not limited only to kerbs which are dividing the sidewalk and bicycle lane. Several obstacles were identified from interviews with companies and from observations, mostly associated with holes in the road/bicycle lane, kerbs and nature made obstacles (such as roots of trees which deform the bicycle lane surface).

Pictures 20 and 21 illustrate obstacles which are caused by the uneven surface of the bicycle lanes. Picture 20 shows water drain located in a way that it crosses the bicycle lane. The height difference between the bicycle lane surface and water drains is only around 2 to 4 cm, however, even this uneven surface can present an obstacle for cargo cycles as they need to reduce their speed otherwise risk damage of their cargo. Furthermore, picture 21 symbolizes another obstacle associated with an uneven surface. The picture represents kerb which is dividing bystreet with sidewalk located next to road and bicycle lane. Companies utilising cargo cycle for UFT often deliver goods into bystreets, thus, have to use this type of infrastructure. However, these kerbs (in this example around 5cm high) may cause some complication since it is more difficult to pass kerb with cargo cycle loaded with heavy goods. These locations are not rare in Stockholm and often are equipped with a ramp which, however, is, in many cases, not sufficient in terms of width for cargo cycles, only for regular cyclists (see picture 22). This was also identified during interviews with MOVEBYBiKE:” *...one big problem is that they [the municipality] like to put a kerb on many places which is kind of bad...we need ramps there. It is good that they want to slow down the cars and prioritize pedestrians...I like that...but they should build ramps around 1.2 meter wide, so we can bike over it without having problem.*” (interviewee 3, personal communication, 2019).
Picture 20 Uneven surface of the bicycle lanes
location: Sveavägen, Stockholm; source: author

Picture 21 Absence of ramp over kerb
location: Birger Jarlsgatan, Stockholm; source: author
Additionally, roots of trees located nearby bicycle lanes might cause unevenness of the surface as well (see picture 23). For the city, these issues are hard to predict and plan for, however, that does not change the fact that they present an obstacle for cargo cycles. The roots often lift the surface of the bicycle lane. In many cases only on one side of the bicycle lane. This height difference between different levels can be even around 15-20 centimetres. Therefore, when passing such locations, cargo cycles (especially tricycles and four-wheelers) might experience very sudden elevation on one side which can cause harm to goods they carry or even cause a crash. Moreover, these obstacles are often not very visible, therefore the risk is even higher as the predictability of such situations by cargo cycle riders is very limited.
Lastly, the behaviour of other road users can present a physical obstacle for cargo cycles as well. Pictures 24 and 25 show illegally/inconveniently parked cars which block bicycle lane. These situations might be problematic even for regular cyclists, however, cargo cycles which are wider and longer might have even bigger problems to overcome such obstacles. Vehicles parked on bicycles lanes force cyclists in general to overpass it, usually through road. This is more problematic for cargo cycles as their width does not allow them to be as flexible as regular bicycles in such situations. Therefore, conflicts with other cyclists and vehicles might occur, furthermore, it slows down the cargo cycle.

*Picture 24 Vehicle parked on bicycle lane  
location: Sveavägen, Stockholm; source: author*

*Picture 25 Vehicle parked on bicycle lane  
location: Vasagatan, Stockholm; source: author*
Gravel

Thirdly, gravel (small and rounded stones) were identified as another infrastructural obstacle. Generally, the gravel is used in Stockholm in winter months on roads, sidewalks and bicycles lanes in order to prevent and/or reduce the slipperiness of the surface caused by snow and ice. The gravel is picked up from the streets usually around the beginning of spring. One interviewee representing cargo cycles company believed that the City is too slow when it comes to cleaning the streets from the gravel after the snow is gone. The gravel causes a significant problem for cargo cycles: “... we are getting punctures because of the gravel when there is no ice and snow...and it is really messing everything up, for example, the two-wheelers are very easy to crash when there is a gravel” (interviewee 3, personal communication, 2019). This present considerable problem for the company as the delivery can be delayed due to wheel puncture and its necessary repair. Moreover, the slipperiness of gravel when there is no snow on the streets presents not only danger for the riders of the cargo cycles but also to the cargo itself. Problematic aspects of gravel were also found during the observations. Picture 26 and 27 illustrate how some bicycle lanes look like with gravel. Furthermore, the highlighted part of picture X symbolizes the problematic area for cargo cycles, especially for cargo tricycles and four-wheelers. These cargo cycle types have to ride through the gravel due to their larger width and more wheels, while regular bicycles might use only the highlighted part where the gravel is rutted. Therefore, the cargo cycles are even more affected by the gravel than regular bicycles. Gravel also tend to be cumulated in areas where cyclists make a turn, which can be beneficial when the bicycle lane is covered with snow, however, without snow, the presence of gravel might cause contradictory results. Lastly, the provider of cargo cycle UFT services MOVEBYBiKE believed that even though the gravel has benefits when there are ice and snow on the bicycle lanes, the overall downsides of it are greater than its upsides, at least for their services. Therefore, the company often calls for faster action of the municipality when it comes to cleaning of the gravel or to rather clean and salt the surface instead of putting gravel.

*Picture 26 Gravel on bicycle lane
location: Lindhagensgatan, Stockholm; source: author*
Lastly, observations identified another obstacle for cargo cycles which relate to bicycle infrastructure. These obstacles are connected with construction work which is carried out near to or on bicycle lanes. Throughout observations, several such areas were identified, for example, Slussen/Gamla Stan, Torsgatan and many others. The problem can be demonstrated on individual cases, however, such locations are spread throughout the city and differ. Firstly, pictures 28 and 29 show the bicycle lane located on Gamla Stan near to Slussen. The area around Slussen is as a whole undergoing redevelopment, therefore, the limitation can be seen for road traffic, pedestrians and cyclists. However, this example shows how temporal obstacles can be caused by construction work in terms of width and curve radius. Overall, previous parts of the bicycle lanes are sufficient for the parameters of the cargo cycle (width around 1.5-2 meters) However, in this very short part of the bicycle lane, the width is reduced significantly due to construction work, specifically only to around 0.7 meter in the narrowest part of the curve. This represents a significant problem for cargo cycles since they are considerably larger than the provided width. Furthermore, the curve is relatively sharp which presents another obstacle for cargo cycles as they can exceed even 4 meters in length, thus, the manoeuvring in such sharp curve might be very difficult or even impossible. These two aspects create unbeatable obstacles due to which the cargo cycle has to stop and find a different route. This situation is highly problematic as the cargo cycle can block other bicycle traffic, moreover, it prolongs the delivery time and distance of the cargo cycles.

Construction work
Obstacle caused by construction work
location: Slussplan, Stockholm; source: author
The second example of such obstacles is located on Torsgatan (central Stockholm). Some parts of this area are also under construction work which affects road traffic, pedestrians and cyclists in both directions. Picture 30 illustrates the bicycle lane which leads towards the city centre. Similar to the previous example, the bicycle lane under normal situation is sufficient for the cargo cycle parameters, however, as visible in the picture, certain parts are affected by constriction work, in this case by rocks and gravel from the construction located on the bicycle lane. This reduces the width of highlighted bicycle lane to half of its regular width. Consequently, the reduced width is no longer sufficient for the cargo cycle parameters, therefore, the cargo cycle has to partly enter the road. Even though this obstacle is not that limiting as in the previous example, the cargo cyclist has to expose considerable part of the cargo cycle to the traffic which can present a dangerous situation for the traffic. While the reduced width is still sufficient for regular cyclists. Furthermore, in the opposite direction, a similar situation can be seen with concrete roadblocks placed on the bicycle lane (see picture 31).

*Picture 30 Obstacle caused by construction work
location: Torsgatan, Stockholm; source: author*
Obstacle caused by construction work
location: Torgatan, Stockholm, Sweden; source: author
5. Analysis and Discussion

This chapter analyses and discusses the empirical data in relation to previous literature and theories. Thus, the aim of this thesis is addressed, and the research questions are answered.

5.1 Experience of utilising cargo cycles in urban freight transport in Stockholm

The empirical findings from interviews enabled to understand and describe the experience of companies utilising cargo cycles in UFT in Stockholm. Thus, the research question "What is the experience of utilising cargo cycles in urban freight transport in Stockholm, Sweden?" was answered. This research question was purposely overlapping with other ones. Thus, this section analyses and discusses the experience concerning both examples how the cargo cycles are used in researched context and the experience with the vehicle itself (e.g. speed, competitiveness, cargo capacity etc.) = product-specific factors (Rudolph & Gruber, 2017). While aspects relating to facilitating factors and obstacles are further addressed in respective chapters.

Overall, the experience of both interviewed companies has many similarities even though both companies utilise cargo cycles for different purposes and in a different way. Moreover, both have a mostly positive experience of utilising cargo cycles in Stockholm and consider cargo cycles as suitable vehicles for UFT in researched context, especially in congested areas with delivery restrictions. Specifically, Älskade stad utilises cargo cycle with other urban freight vehicles with the notion to utilise the optimal vehicle for each case according to their ability. Thus, the cargo cycle is utilised only for transporting smaller goods in the city centre of Stockholm. On the other hand, the company MOVEBYBiKE is specialized solely on transporting goods with electric cargo cycles and their operating area is greater. Both companies transport goods related to e-commerce (small packages). Moreover, MOVEBYBiKE transports goods related to the food industry and catering and provides moving services. Additionally, it is worthy to individually discuss the experience of interviewed companies with often argued limitations associated with cargo cycles in UFT such as speed, range, cargo capacity and micro-consolidation centres.

The speed of cargo cycles

The speed of cargo cycles is often considered as one possible constraint for utilising cargo cycles in UFT as it is considerably lower than the speed of traditional urban freight vehicles (Gruber et al., 2014; Tipagornwong & Figliozzi, 2014). However, the interviewed companies did not consider the speed of the vehicle itself as an obstacle. From their experience, the speed of cargo cycles is even competitive compared to urban freight vans and cars, especially during rush hours when streets are congested. However, lower outside of rush hours. Such findings correlate with what Gruber et al. (2014) and Rudolph & Gruber (2017) argued. According to their research, the cruising speed of electrically assisted cargo cycles is similar to the speed of traditional urban freight vehicles in a congested environment, however, in free-flow conditions is much lower. Nevertheless, both interviewed companies did not consider the speed of their vehicles as a determining factor for their purposes. For them, the shortcomings in terms of speed are relatively irrelevant. Especially when their advantages in terms of low emissions, low energy use and low accidents numbers are considered.

The range of electrically assisted cargo cycles

Furthermore, Saenz et al. (2016) and Tipagornwong & Figliozzi (2014) argued that the range of electrically assisted cargo cycles may represent a limitation for companies which are using them for UFT. However, both interviewed companies do not consider the range of their electric cargo cycles as insufficient, even though it is lower than the range of traditional urban freight vehicles.
Such findings also correspond with what Gruber et al. (2014) argued, thus, that cargo cycles are predominantly used in last-mile deliveries where the distances do not necessarily exceed the range of electrically assisted cargo cycles.

**Cargo capacity**

Moreover, it is argued that limited cargo/payload capacity of cargo cycles may be a disadvantage for urban freight companies (Lenz & Riehle, 2013; Saenz et al., 2016; Schliwa et al., 2015). The experience of companies utilising cargo cycles differed in this aspect. While Älskade stad considered the capacity of their cargo cycles somewhat limiting, MOVEBYBiKE did not share this view. In the case of Ålskade stad, the cargo capacity limitation was mostly viewed in the reduced possibility to collect recycling material while distributing goods which their other vehicles do. However, the limitation was not viewed for the regular distribution of goods related mostly to e-commerce. Moreover, MOVEBYBiKE argued that even though the capacity of cargo cycles is smaller, from their experience, there is more than enough jobs which can be transported by cargo cycles, especially by cargo cycles with a payload capacity between 200-300kg. Such notion was also argued by Lenz & Riehle (2013), Schliwa et al. (2015), and Wrighton & Reiter (2016) who estimated that the share of large volume/weight goods does not represent the highest proportion of UFT. Furthermore, due to ever-growing e-commerce and with that associated higher proportion of smaller goods, the cargo capacity does not necessarily limit the use of cargo cycles. Moreover, they estimated that around 25% (Lenz & Riehle, 2013) or 51% (Wrighton & Reiter, 2016) of all motorized trips moving goods in urban areas fits the cargo capacity of cargo cycles. Thus, the experience of companies suggests, that even though the cargo capacity might be limiting for transporting certain goods, the market offers a variety of jobs where the capacity of cargo cycles is sufficient, mostly connected with e-commerce. Moreover, such findings correlate with previous researches.

**Micro-consolidation centre**

Additionally, the experience with micro-consolidation centres differs between interviewed companies. Rudolph & Gruber (2017), Koning & Conway (2015), and Schliwa et al. (2015) argued that micro-consolidation centres can increase the potential of cargo cycles. The experience of Älskade stad correlates with such notion. The company uses micro-consolidation centre in the city centre of Stockholm and considers it as a crucial aspect for their operations. However, as they argued, having consolidation centre would not be possible without the help of their partnering property owner which provides them with the facility for free. On the other hand, MOVEBYBiKE does not have micro-consolidation centre as their operations are usually consist of picking up goods on certain locations and consequently distributing it around the city. Thus, the consolidation centre is not necessary, however, the company see its potential in future. Hence, from the experience of interviewed companies, consolidation centres can increase the potential of cargo cycles in urban freight, however, it is not always necessary. Moreover, it may represent an unfeasible investment for companies.

### 5.2 Facilitating factors for utilising cargo cycles in urban freight transport in Stockholm

The empirical findings enabled to identify facilitating factors for utilising cargo cycles in UFT in Stockholm. Therefore, factors which directly or indirectly contribute to creating such conditions in which cargo cycles as vehicles for UFT thrive. Hence, the research question *What are the facilitating factors for utilising cargo cycles in urban freight transport in Stockholm, Sweden* was answered. Overall, the facilitating factors were strongly associated with the promotion of sustainable development and with that aligned sustainable UFT. The main facilitating factors were identified as the overall road traffic situation; strategic orientation and planning of the city; public-private partnership and network building; bicycle infrastructure; and experience with product-specific factors. Each facilitating factor will be now presented and discussed with
previous researches and studies. However, they cannot be viewed only as individual factors since they interrelate with each other.

**The overall road traffic situation**

Firstly, the *overall road traffic situation* in Stockholm can be viewed as one facilitating factor for utilising cargo cycles in UFT. As presented in the previous chapter, the road traffic (the number of vehicles and vehicle mileage) in Stockholm is steadily increasing due to the growing population and increasing car ownership. Moreover, the accessibility of road traffic has declined in the inner city. That presents a significant challenge for the city as the transport sector is the most emitting sector in Stockholm, it is responsible for 44% of all greenhouse gas emissions. Additionally, the share of environmentally friendly light trucks (vans) is very small (only 2.3% in 2015/2016), especially in comparison with passenger vehicles (21% in 2015/2016) (Stockholms stad, 2016a). Furthermore, the city expects growth in the urban freight-related light trucks, and it is estimated that the light goods vehicles will represent 20% of the whole traffic mix in 2040.

Even though it is problematic to distinguish between passenger traffic and urban freight traffic, it illustrates that the transport sector is still facing challenges to reduce its environmental impact. Such a situation is facilitating cargo cycles for several reasons. Firstly, lower accessibility for regular vehicles in congested and dense inner-city favours utilisation of cargo cycles as their speed and accessibility competitiveness is high in such environment (Gruber et al., 2014; Tipagornwong & Figliozzi, 2014). Secondly, as the general trend in Stockholm is to promote environmentally friendly vehicles and consequently reduce the environmental impact of road traffic, the pressure to increase the share of environmentally friendly light trucks (e.g. urban freight vans) is expected to intensify. Especially, when the prediction related to the increase of light goods trucks will be fulfilled. This situation is potentially a good starting point for utilising cargo cycles as they are sufficient for a large proportion of the tasks traditionally done by vans (Gruber et al., 2014; Lenz & Riehle, 2013; Wrighton & Reiter, 2016). Moreover, their lower purchasing and operating costs (Conway et al., 2017; Rudolph & Gruber, 2017; Schliwa et al., 2015; Tipagornwong & Figliozzi, 2014) can encourage some urban freight operators to purchase cargo cycles instead of new environmentally friendly light trucks.

**The strategic orientation and planning**

Secondly, *the strategic orientation and planning* of the city of Stockholm is another facilitating factor for utilising cargo cycles in UFT. Overall, the city’s strategic position (in relation to urban freight and transport), which is described by various planning and strategic documents, is to reduce the negative impacts connected with UFT and with transport sector in general. Thus, the City directly acknowledges the need to implement the principles of sustainability into UFT.

Facilitating factors for cargo cycles are mostly associated with the aim of the City to become fossil-fuel free by 2040. To become fossil-fuel free, the city also acknowledges the need to reduce the negative impacts of UFT. To reach such a goal, the city wants to adopt, and is continuously adopting, measures which will encourage the transition of urban goods vehicles to renewable fuels. Such measures include taxation which favours environmentally friendly vehicles; fuel and/or CO₂ emissions taxes; congestion charging; kilometre taxes; improvements in parking and un/loading areas; environmental zones; and parking spaces for fossil-fuel free vehicles. Moreover, the City has a relatively good position to implement these measures as they are mostly in their competency (the municipal level has a direct influence concerning regulations and other instruments). Rudolph & Gruber (2017) identified such measures as the political and legal environment which pressure companies to adopt alternatives to traditional urban freight vehicles such as cargo cycles. Furthermore, other authors (Koning & Conway, 2015; Schliwa et al., 2015; Taniguchi et al., 2016; Tipagornwong & Figliozzi, 2014) argued that cargo cycles thrive in areas, where traditional urban freight vehicles are constrained, and environmental vehicles are promoted. Thus, such strategic orientation and its implementation can facilitate and stimulate the use of cargo cycles in UFT as the above-mentioned measures increase the competitiveness of cargo cycles.
The strategic orientation and planning documents acknowledge the complicated situation for urban freight vehicles in the inner city of Stockholm. Moreover, the need to addresses the situation concerning limited space and negative environmental impacts while ensuring the prevalence of the benefits associated with UFT. Therefore, as one solution, the city promotes space-efficient urban freight vehicles such as cargo cycles together with innovative and new technological solutions. Rudolph & Gruber (2017) and Koning & Conway (2015) argued that through the implementation of the concept of cargo cycles logistics into the strategic planning, public authorities can achieve wider recognition of the possible utilisation among themselves and other stakeholders. Thus, facilitate the utilisation of cargo cycles in UFT. However, not all strategic documents directly acknowledge cargo cycles and space-efficient urban freight vehicles which can consequently limit the use of cargo cycles as will be further developed in the section concerning obstacles.

Public-private collaboration and network building

Thirdly, public-private collaboration and network building practised by public authorities were identified as another facilitating factor. Overall, Rudolph & Gruber (2017) argued that network building and knowledge transfer is an important aspect of fostering and facilitating cargo cycles for UFT. Their study found that even relatively soft measures practised by public authorities in terms of active promotion of sustainable city logistics solution, learning from best practice examples, and close collaboration with the private sector can be very effective.

The public authorities in Stockholm directly acknowledge the need for close collaboration between the City and other urban freight stakeholders in their plans and strategic documents. Moreover, findings from interviews suggested that public authorities concerned with urban freight are actively trying to collaborate with a vast spectrum of urban freight stakeholders. This collaboration is naturally not limited only to cargo cycles, however, they are included. Within such collaborations and network buildings, public authorities aim to promote sustainable UFT with emission-free and space efficient solutions. To achieve that, public authorities organise meetings with transport companies, manufacturers, property owners and other stakeholders.

These activities might help facilitate cargo cycles in UFT as companies who are already utilising such solutions are also participating. Hence, mutual learning from best practice examples is enabled together with the overall raising of awareness (Rudolph & Gruber, 2017; Schliwa et al., 2015). Moreover, urban freight public authorities are in direct contact with users, which can help them to identify possible obstacles and consequently address them which was also identified as an important factor by Schliwa et al. (2015) and Taniguchi (2014).

Additionally, as was presented in the previous chapter, interviewed companies evaluated such cooperation and networking with the municipality as very positive and helpful which support the claim of such practices as facilitating. The previously presented collaboration of the City within the project Älskade stad might serve as an example of such facilitating factor. Since the collaboration is using environmentally friendly solutions for UFT including one cargo cycle.

The bicycle infrastructure

Fourthly, bicycle infrastructure in Stockholm was identified as another facilitating factor for the utilisation of cargo cycles in UFT. Overall, the facilitating factors of bicycle infrastructure are mostly connected to the existence of a relatively vast network of bicycle infrastructure (bicycle lanes and paths); promotion of cycling as a mode of transport; quality of newly developed bicycle infrastructure; and bicycle planning manuals in relation to the quality of the bicycle lanes and paths.

Previous studies identified that competitiveness and overall potential of cargo cycles in UFT is closely connected to existence of bicycle infrastructure which is suitable for the dimensions of cargo cycles and their specific demands (Conway et al., 2017; Gruber et al., 2014; Rudolph & Gruber, 2017; Schliwa et al., 2015; Tipagornwong & Figliozzi, 2014). Stockholm has a relatively vast network of bicycle lanes and paths which in general give an opportunity for cargo cycles
urban freight companies to use them. Moreover, the legal framework allows using bicycle paths and lanes even by electrically assisted cargo cycles.

Specifically, empirical findings from observations identified that newly developed bicycle lanes and paths tend to be sufficient for the requirements of cargo cycles as they usually provide sufficient width; ramps for overcoming kerbs; turning boxes; lowered kerbs to street level; and absence of steep slopes and vibrating materials. Thus, fulfil requirements which were identified as crucial by previous studies (Rudolph & Gruber, 2017; Schliwa et al., 2015), however, also by interviewed companies and public authorities.

Moreover, Rudolph & Gruber (2017) and Schliwa et al. (2015) stressed the need for planning manuals to take into consideration the dimension of cargo cycles for the future development of bicycle infrastructure. The standards of bicycle lanes and paths presented in planning manuals concerning bicycle infrastructure in Stockholm are sufficient for the requirements of cargo cycles. Specifically, the standards provide adequate width of bicycle lanes and paths for cargo cycles (even for bypassing the cargo cycles by faster cyclists). Moreover, the curve radius, lowered kerbs, ramps and other specific requirements are acknowledged in the plans. New bicycle infrastructure which will be developed in near future according to these planning manuals, will, with high probability, fulfil these standards (as it was visible with newly developed bicycle lanes and paths presented above). Thus, the cargo cycles will be able to use it, which facilitates their utilisation in UFT.

Additionally, the facilitating factor connected with bicycle infrastructure can be also viewed in the overall promotion of cycling by the city and with that connected intensification of improvements concerning bicycle infrastructure. Rudolph & Gruber (2017) identified the overall cycling culture as part of the socio-spatial context which facilitates the utilisation of cargo cycles in UFT. Thus, due to the city’s strategic orientation to promote cycling as a transport mode, the overall cycling culture may be improved. That consequently facilitates the use of cargo cycles in UFT, as investments into improving the bicycle infrastructure can be expected and normalization of cycling may intensify.

**Experience with product-specific factors**

Lastly, experience with product-specific factors is considered as another facilitating factor for utilising cargo cycles in UFT in researched context. Rudolph & Gruber (2017) described product-specific factors as factors directly connected to the product (cargo cycle) itself (e.g. speed, cargo capacity, range of the vehicle). Thus, these factors relate to how the cargo cycle as an urban freight vehicle performs for the needs of companies and in context within which is used. This consequently determines the use of cargo cycles. These aspects were to large extent addressed by the first research question.

As was presented above, the interviewed companies had in general positive experience with the cargo cycle itself. Factors of speed and range were not considered as a limitation by both companies, moreover, in many cases, cargo cycles were considered as competitive to traditional urban freight vehicles. The cargo capacity was partially considered as limiting for certain types of UFT by company Ålskade stad. However, in the overall perspective, it was considered sufficient for various other types of UFT, especially related to e-commerce. Additionally, the geography, weather and morphology of the city were not considered as obstacles for cargo cycles. This positive product-specific experience can be considered as a facilitating factor, as it showed that urban freight transported by cargo cycles is possible in Stockholm. Thus, that the vehicle specifications are compatible with the researched environment.
5.3 Obstacles for utilising cargo cycles in urban freight transport in Stockholm

The empirical findings also provided an answer for the third research question: “What are the obstacles for utilising cargo cycles in urban freight transport in Stockholm, Sweden?”. Therefore, factors and the City’s characteristics which directly or indirectly contribute to creating conditions in which cargo cycles as vehicles for UFT are not thriving. Overall the main obstacles were associated with the inconsistency of bicycles infrastructure absence of direct planning for cargo cycles and lack of recognition. Moreover, the obstacles are mostly connected with lack of recognition which consequently creates hidden obstacles due to lack of specific knowledge concerning cargo cycle use within UFT. In the broader perspective, the path dependence related to cars explains such a lack of knowledge and infrastructure obstacles. That will be further address at the end of this chapter.

Absence of direct planning for cargo cycles

Notwithstanding the strategic orientation of the city and its planning materials are above identified as one of the facilitating factors, the absence of direct planning within these plans is considered as one of the obstacles for cargo cycles utilisation. Overall, it is argued (Koning & Conway, 2015; Rudolph & Gruber, 2017) that cargo cycles should be implemented into the strategic planning of cities to facilitate their use in UFT. Thus, the cargo cycles and their requirements should be addressed in, for example, (sustainable) urban mobility plans, bicycle transport strategy, road design manuals and environmental plans.

Such direct addressing of cargo cycles in Stockholm’s strategic plans is only visible in Freight Plan. Where the cargo cycles are addressed explicitly, however, only briefly, in relation to space-efficient urban freight vehicles. Other strategic documents do not directly address or plan for cargo cycles and their requirements. However, as was argued above, the strategic documents facilitate the use of cargo cycles, as they promote environment in which cargo cycles thrive. Nevertheless, Koning & Conway (2015) and Rudolph & Gruber (2017) argued that direct implementation of cargo cycles into strategic documents and plans can achieve wider recognition of possible applications and requirements among themselves and other stakeholders. Thus, the absence of directly addressing cargo cycles in planning is considered as an obstacle, moreover, it can partly interpret other obstacles which will be presented below.

Lack of recognition

Overall, it is argued (Gruber et al., 2014; Rudolph & Gruber, 2017; Schliwa et al., 2015) that public authorities, however, also urban freight managers and general society have insufficient knowledge concerning cargo cycles as urban freight vehicles. This lack of knowledge may lead to unintentional exclusion of cargo cycles in various situations and consequently represents a hidden obstacle for cargo cycle utilisation in UFT. The lack of recognition was identified also in the researched context. The example concerning public procurement in chapter 4 illustrated such situation. In this example, companies utilising cargo cycles were not able to compete for the public procurement as when the procurement was designed at first, the parameters of cargo cycles were not considered. Thus, the procurement favoured traditional urban freight vehicles as it was tailored for their parameters and requirements. This situation may relate to the previously introduced absence of direct planning for cargo cycles. According to Koning & Conway (2015) and Rudolph & Gruber (2017), addressing cargo cycles in strategic documents and planning manuals might increase the knowledge concerning their requirements, parameters and possible applications. Thus, it can consequently prevent these situations where cargo cycles are unintentionally excluded. Moreover, it relates to path dependence on previous structures connected with traditional urban freight vehicles.
**Inconsistency of bicycle infrastructure**

Even though the bicycle infrastructure was identified as one of the facilitating factors, it can also constitute an obstacle for them. As acknowledged above, the relatively vast network of bicycle infrastructure; quality of newly developed bicycle infrastructure; and bicycles manuals in relation to the quality of the bicycle lanes and paths are considered as facilitating factors. However, from experience of companies, the expertise of public authorities, and findings from observations it was identified that current bicycle infrastructures in Stockholm have aspects which limit the potential of cargo cycles. The limiting factor of Stockholm’s bicycles infrastructures is mostly associated with its inconsistency.

The inconsistency of bicycles infrastructure can be characterized as bicycle infrastructure (mostly in relation to paths and lanes) where some sections have high or sufficient quality for the cargo cycles’ requirements, while other sections do not fulfil these requirements. Thus, the bicycle infrastructure does not maintain the same standards throughout the city. In general, the bicycles infrastructure tends to be sufficient and maintains the standards identified as facilitators. However, the network of bicycle lanes and paths consists of a variety of different types and quality standards. These quality standards differ throughout the parts of the city, however, often also on the same bicycle lane or path. This situation may be explained by different stages of development and/or different morphology of the parts of the city. Nevertheless, the inconsistency is limiting for the cargo cycles operators as they are unable to use the bicycle infrastructure network to full extent and with the same experience.

Specifically, the main obstacles associated with the parts of bicycles infrastructure which do not fulfil the cargo cycles’ requirements are: insufficient width of bicycle lanes and paths; physical obstacles on bicycle lanes and paths; gravel; and limitation connected to construction work. Previous researches (Conway et al., 2017; Gruber et al., 2014; Rudolph & Gruber, 2017; Schliwa et al., 2015; Tipagornwong & Figliozzi, 2014) identified similar insufficiencies of bicycle infrastructure as potential obstacles. Moreover, they argued that these obstacles reduce the considerable advantage of cargo cycles, thus limit their potential. However, their findings lacked a detailed analysis and description of these obstacles. Thus, each infrastructural obstacle will be now analysed and discussed.

Firstly, the obstacle related to insufficient width of bicycle lanes and paths was identified by various authors (Gruber et al., 2014; Rudolph & Gruber, 2017; Schliwa et al., 2015). This study identified two types of insufficient width of bicycles lanes and paths in Stockholm. First, bicycle lanes and paths with relative sufficient width. These can be characterized by width around one meter, thus they are sufficient for the requirements of the average cargo cycle. However, they do not provide enough space for avoiding unexpected obstacles on the bicycle lanes. Moreover, they do not provide enough space for overtaking cargo cycles by faster cyclists which is considered by Rudolph & Gruber (2017) and Schliwa et al. (2015) as an important aspect for preventing conflicts between regular cyclists and cargo cycles. Hence, even though cargo cycles can use these bicycle lanes and paths, they are forced to use it with increased caution which limits their ability to use it effectively and consequently limits their competitiveness. Second, bicycle lanes and paths with insufficient width. These bicycle lanes and paths are relatively rare in Stockholm, however, they are very limiting for their utilisation. The width less than one meter does not provide enough space to accommodate cargo cycles, thus, they are unable to use it or have to significantly reduce their speed and consequently limit other traffic. Therefore, the competitiveness of cargo cycles is significantly reduced (Conway et al., 2017; Saenz et al., 2016; Schliwa et al., 2015).

Secondly, it is argued in previous studies (Conway et al., 2017; Rudolph & Gruber, 2017; Schliwa et al., 2015) and by interviewed companies that cargo cycles are vulnerable to uneven surface which causes vibration and consequently limits their speed or even damages carried goods. These obstacles were classified as physical obstacles on bicycle lanes and paths. In Stockholm, these obstacles are in form of, for example, water drains across bicycle lanes; absence of ramps over kerbs or narrow ramps; and unevenness of the surface due to natural cause (e.g. lifting of bicycles lane surface by roots of trees). Moreover, physical obstacles can be also in temporally form, for
example illegally/inconveniently parked vehicles on the bicycle lane. All presented obstacles limit also regular cyclist, however, cargo cycles due to their higher weight and greater width are affected even more. These obstacles consequently force cargo cycles operators to reduce their speed or bypass it (often by using infrastructure not dedicated to cycling) which consequently reduce their ability to use a bicycle network, thus reduce their advantage.

Thirdly, the gravel, which is used to prevent slipperiness on ice and snow in winter months is considered as another obstacle related to bicycle infrastructure. Such obstacle was not identified by previous studies, however, that may be explained by the specification of the researched context. Specifically, the experience of interviewed companies and observations identified, that the gravel has often contradictory effect. Thus, cause slipperiness when there is no snow and ice on bicycle paths and lanes. Moreover, it often causes punctures of cargo cycles’ wheels. Thus, it limits their ability to use the bicycle network as the operators may need to reduce their speed to avoid crashes or are delayed due to necessary repairs.

Lastly, the inconsistency of bicycle infrastructure is often associated with areas where bicycle paths and lanes are disrupted by construction work. The construction work which takes place in the proximity of bicycle lanes and paths often reduces their quality (e.g. reduced width; physical obstacles: different level of the surface). In general, the construction work limits not only cargo cycles. However, the observation identified that cargo cycles are often affected significantly more than other users. For example, when a bicycle lane is narrowed due to construction work, the regular cyclists still have the possibility to use it, however, with reduced speed. Nevertheless, the narrowed bicycle lane does not necessarily correspond with the needs of cargo cycles. Thus, they are unable to use it. It can be argued that such situations might be connected to a general lack of recognition and absence of direct planning for cargo cycles (see above). Since these situations might originate from unintentional exclusion of cargo cycles due to lack of knowledge of their requirements. Moreover, in many cases, these situations might be relatively easily overcome when the parameters and requirements are known (e.g. widen the narrowed part only by 20cm; install ramps for easier overcoming of obstacles). However, it is understandable that maintaining such width and other standards is not always possible when surrounding is under construction.

5.4 Path dependence and sustainable urban development

The selected theoretical framework introduced in chapter 2 helped to understand and discuss the researched problematic from a broader perspective. Overall, the city of Stockholm is implementing principles of sustainable (urban) development into its strategic planning and consequently applies these practices in many areas, including UFT and transport in general. These strategies were above identified as facilitating factors for utilising cargo cycles in UFT. Moreover, previous studies (Conway et al., 2017; Gruber et al., 2014; Rudolph & Gruber, 2017) identified similar tendencies in other contexts, thus that measures promoting liveability and sustainability of urban areas facilitate an environment in which cargo cycles thrive. Hence, this study argues, that from the holistic perspective, the implementation of sustainable principles and sustainable urban development into strategic planning and practice, facilitates the utilisation of cargo cycles in UFT in researched context. This situation stems from cities’ effort to implement sustainable principles into their development which consequently force UFT and transport in general to implement sustainable principles as well. That positively affects utilisation of cargo cycles. Since cargo cycles are a desirable solution for such a framework as they have a small environmental impact while still addressing the material demand of cities.

However, the path dependence of the city in relation to car transport embodies the identified obstacles for utilisation of cargo cycles in researched context. Low & Astle (2009) argued that there are three elements of path dependence particularly relevant to urban and transport planning: technical path dependence; institutional path dependence; and discursive path dependence. This
study argues that in Stockholm, the obstacles for cargo cycles are mostly connected to elements of technical path dependence and institutional path dependence.

The technical path dependence relates to how the physical form of the urban area can be shaped by the requirements of a particular mode of transport (Low & Astle, 2009). UFT is strongly connected to car/road infrastructure (Kauf, 2016; United Nations, 2014). Moreover, in Stockholm, the car/road infrastructure is well developed and fulfils the requirements of traditional urban freight vehicles (e.g., vans and trucks). This situation favours traditional urban freight vehicles, while cargo cycles, which do not primarily use car infrastructure, are limited by such factor. Cargo cycles are not intended to be used on car/road infrastructure, however, their potential is fulfilled when they are using bicycle infrastructure which satisfies their requirements. The car infrastructure was preferred and prioritized in the past, however, the differences between how developed car infrastructure is, in comparison to bicycles infrastructure, prevail until today. It is argued (United Nations, 2014) that infrastructure is one of the three most important elements of UFT. Thus, when cargo cycles do not have their own infrastructure which fits their requirements, their utilisation in urban freight is limited. Hence, technical path dependence in Stockholm partly limits the utilisation of cargo cycles in UFT.

Moreover, the above-presented obstacles associated with the absence of direct planning for cargo cycles and lack of recognition can be partly explained by institutional path dependence. Thus, path dependence related to institutions and organisations which shape the form and structure of cities (Low & Astle, 2009). In Stockholm, the institutional path dependence can be identified, for example, in above-mentioned absence of direct planning for cargo cycles which consequently leads to the unintentional exclusion of cargo cycles in urban freight. This situation was illustrated by the example concerning public procurement, where the old structures (traditional urban freight vehicles) were unintentionally favoured based on previous states and decision. However, it can be argued that in terms of discursive path dependence, the researched context is partly freeing itself from the path dependence connected to cars and consequently traditional urban freight vehicles. Low & Astle (2009) described discursive path dependence as “storylines” used within the organisation to explain and identify problems that policy is trying to address. In Stockholm, the current strategic orientation is not justifying the old structure related to cars and their infrastructure. On the contrary, it addresses it by implementing principles of sustainability and sustainable urban development. However, it can be opposed that the implementation of sustainable principles and sustainable urban development is only a reaction to old structures. Thus, that the new principles only attempt to repair the old path dependent structures. Nevertheless, such opposition to the old structures is indirectly facilitating the utilisation of cargo cycles as urban freight vehicles.

Thus, this study argues that there are contradictory forces which affect the utilisation of cargo cycles in UFT in Stockholm. In terms of facilitating factors, the cargo cycles benefit from implementing principles of sustainability and sustainable urban development. While in terms of obstacles, the path dependence related to cars, their infrastructure and policies limit the possible utilisation of cargo cycles in UFT with the notion that: “…current and future states, actions, or decision depend on the path of previous states and actions, or decisions.” (Page, 2006, p. 88). Figure 7 visualizes the above-presented contradictory forces.
5.5 Limitations of the study

In terms of limitations of the study, the study utilised a case study approach, thus the generalizability of the findings is limited since the factors affecting cargo cycles might differ in dissimilar context. However, since the aim of the study was to investigate the case of Stockholm, the applicability of findings to other contexts was not the primary focus. Moreover, the study unintentionally excluded companies which do not yet utilise cargo cycles in UFT. The exclusion was caused due to their unwillingness to participate in the research. Experience of these companies could provide valuable information concerning the adaptation of cargo cycles and associated obstacles. Nevertheless, this limitation can motivate further research which would address the knowledge gap concerning this problematics even more. Additionally, not all companies which utilise cargo cycles in the researched context were included in the study. This was, again, caused by their unwillingness to participate. Their experience might differ and would be valuable for the research, however, it was not in researcher’s abilities to acquire this information. Lastly, a different approach in terms of methods could investigate the researched problematics from a different perspective. However, it is believed by the researcher that selected methods were appropriate under the circumstances and nature of the study.
6. Conclusion

This chapter summarises the main findings of the thesis. Furthermore, it presents concluding remarks as well as contribution and suggestions for further research.

The utilisation of cargo cycles in urban freight transport is a viable solution to address negative connotations associated with the urban freight sector, however, at the same time to ensure that material demands of urban areas are fulfilled. In Stockholm, Sweden the population is predicted to grow which will even intensify current demands for urban freight transport. Thus, cargo cycles represent one possible solution to reduce the negative impacts of urban freight transport and transport in general. Moreover, it can contribute to achieving the aim of the City to become fossil fuel-free by 2040. However, the abilities and advantages of cargo cycles are not inherent to every urban environment and under all conditions. In Stockholm, contradictory forces which affect the utilisation of cargo cycles were identified. The implementation of principles of sustainable development and with that allied sustainable urban freight transport contributes to facilitating an environment in which cargo cycles thrive. These factors are in the researched context associated with the reaction to current traffic situation; promotion of environmentally friendly transport solutions; public-private collaboration; improvements in bicycle infrastructure; and promotion of cycling. On the contrary, the path dependence related to traditional urban freight vehicles represents an obstacle for the utilisation of cargo cycles. The path dependence related to traditional urban freight vehicles is visible on the institutional level where requirements of traditional vehicles are considered much more than the requirements of cargo cycles. Moreover, it can also be identified in conjunction with infrastructure. The infrastructure for cargo cycles, thus bicycle infrastructure, does not have the same quality as the infrastructure for traditional urban freight vehicles. Thus, the obstacles for cargo cycles utilisation for urban freight transport in Stockholm predominantly lies in the absence of direct planning for cargo cycles; lack of recognition; and inconsistency of bicycle infrastructure.

6.1 Contribution and further research

Overall, the thesis contributed to the wide scope of the audience since the focus of the thesis, utilisation of cargo cycles in urban freight transport, is not sufficiently researched and generally not well recognized. Firstly, the thesis contributed to the academic field of urban planning, mostly in relation to sustainable urban mobility and sustainable urban freight transport. In academia, the concept of cargo cycles in urban freight transport is not sufficiently researched, thus, the thesis contributes to filling the knowledge gap. Moreover, the findings can broaden the understanding of not only cargo cycles, but also for other new vehicles which are facing obstacles caused by the prevalence of old structures and path which was taken by the city. Secondly, the thesis identified obstacles and facilitating factors for utilisation of cargo cycles in urban freight transport in Stockholm, Sweden. This knowledge can be valuable for practitioners to understand the situation and consequently address it. Lastly, the identified obstacles and facilitating factors can be valued by companies which utilise cargo cycles in urban freight transport. However, even more by companies which are undecided in this matter.

It would be valuable to further investigate the factors related to companies which are undecided or unwilling to utilise cargo cycles in urban freight transport in the researched context. Their experience would provide knowledge which was not investigated by this study. Thus, further research would increase the understanding of the research problematics. Moreover, since the researched problematics is strongly context-dependent, investigation of different cities is desirable. Lastly, this study provided prerequisite knowledge of the context which was previously missed. Thus, further research can focus on the researched context and problematics from a different perspective and with different methodology. That can contribute to deeper understanding
and filling the knowledge gap concerning the utilisation of cargo cycles in urban freight transport and to sustainable urban freight transport in general.


Appendix

Interview guide: urban freight strategist

Can you please explain your position and work?
Are you familiar with the cargo cycle concept and how it can be used in UFT?
Overall, what is the city’s/department’s position towards the use of cargo cycles in UFT?
   Is this something that you are (actively) trying to promote?
   Is this something what you want in future?
Are cargo cycles somehow addressed in strategic or other planning documents?
What are the measures that you are implementing?
Are you aware of any project or company who use cargo cycles in UFT in Stockholm?
What is the potential of cargo cycles and other space-efficient urban freight solution in Stockholm?
What might be an obstacle to utilizing them?
In your opinion, is the city suitable for the utilisation of cargo cycles in UFT?
   What are the problem areas? (weather, infrastructure, geography, legal framework etc.)
   What are the benefits and potentials for the city in this sense?
Do you perceive some obstacles for utilising cargo cycles in Stockholm?
What is your approach towards public-private partnership and network building in terms of freight transportation in general, and is there some specific cooperation concerning cargo cycles?
Who initiated the cooperation Älskade stad?
What was/is the City’s/department involvement?
Do you have information about the cargo cycle which the cooperation uses (experience/performance)?
In terms of promoting environmentally friendly UFT solution (or specifically cargo cycles), what is the role of public authorities/ your department in Stockholm?
Is the municipality or one of the departments using cargo cycles for their purposes?
Do you think that there is something that the City/department can do more in future to facilitate cargo cycles?

Interview guide: regional bicycle coordinator

Can you please explain your position and work?
Are you familiar with the cargo cycle concept and how it can be used in UFT?
Are cargo cycles and their requirements somehow implemented into strategic documents, planning manuals? For example, in bicycle plan or road design etc.?
Are you/your department somehow (actively) promoting different types of cycles (such as cargo cycles) or mostly regular cycling?
In terms of specific infrastructure requirements, does the city directly acknowledge the dimension and requirements of cargo cycles, for example, in terms of:
   Width of bike lane
   Levelling of kerb to street level
   Steps and vibration
   Longer braking distance
   Vulnerability to slopes
   Curve radius
In your opinion, is the city suitable for the utilisation of cargo cycles in UFT?
What are the problem areas/aspects? (weather, infrastructure, geography, legal framework etc.)
What aspects of the City are good for cargo cycles?
In terms of bicycle infrastructure, what are the types of problems with current network?
What should be improve (in general/for cargo cycles)?
In the “extreme” scenario, when the use of cargo cycles would increase according to prediction (between 20-50%), how it would affect the bicycle situation in the city?
   Can the current bicycle network accommodate an increase of larger cycles?
   From the legislative perspective, what are the chances of prohibiting them to use bicycle lanes?
Can you identify some areas, streets where the use of cargo cycles can be problematic due to insufficient infrastructure for cargo cycles?
Are you in contact with some companies, association or even private person who are using cargo cycles (for commercial purposes) in order to understand their needs for bicycle infrastructure?

Interview guide: MOVEBYBiKE

Can you please tell me more about the company?
How did it start?
How does it work?
What types of cargo cycles do you use and how many do you have?
What are their parameters (range; load capacity etc.)?
Are cargo cycles competitive with traditional urban freight vehicles (vans) from your experience?
What is your experience with cargo cycles´ performance in Stockholm?
What is the main sector you are transporting for?
How the regular transporting route looks like (distance/area)?
What are the average size and weight of the freight?
What is your experience with the bicycle infrastructure in Stockholm?
   Width of bicycle lanes
   Levelling kerb stone to street level
   Steps and vibration
   Longer braking distance
   Vulnerability to slopes
   Curve radius
What do you perceive as obstacles for utilizing cargo cycles in UFT in Stockholm?
What are the facilitating factors?
Can you identify some areas or streets where the use of cargo cycles is problematic (bicycle infrastructure or other)? And areas where it is good?
Are you in any way cooperating with public authorities?

Interview guide: Älskade stad

Can you tell me more about Älskade stad and your role in it?
What type of cargo cycle do you use and for what purposes?
What is the role of the cargo cycle in comparison with other vehicles you use?
Where it operates and how?
How often?
On average how many stops and km?
What is the volume and type of freight the cargo cycle transports?
What was your experience with the cargo cycle so far (benefits/limitations/detailed experience)?
What was the process of implementing the cargo cycle into this project?
   When was it?
   Who initiated it?
   Who operates it?
   How did you decide which type of cargo cycle to purchase (parameters)?
What is your experience with the bicycle infrastructure in Stockholm?
Width of bicycle lanes
Levelling kerb stone to street level
Steps and vibration
Longer braking distance
Vulnerability to slopes
Curve radius

What do you perceive as obstacles for utilizing cargo cycles in UFT in Stockholm?
What are the facilitating factors?
Can you identify some areas or streets where the use of cargo cycles is problematic (bicycle infrastructure or other)? And areas where it is good?
Are you in any way cooperating with public authorities?