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An assessment of Park & Ride in Gothenburg

A case study on the effect of Park & Ride on congestion and how to increase its attractiveness

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Abstract

Traffic congestion is with environmental pollution one of the main cost externalities caused by an increased usage of cars in many cities in the last decades. In many ways, traffic congestion impacts the everyday life of both drivers and citizens. In this thesis, the authors study how one solution designed to tackle congestion, the Park & Ride service, is currently used in the city of Gothenburg, where it is referred as *Pendelparkering*. This scheme allows commuters to park their car outside the city and then use public transport to their destination, thus avoiding having more cars in the city centre and reducing congestion. The goal is to know to what extent it helps solving the problem of congestion as well as how it can be ameliorated to make it more attractive. In order to do so, an analysis of the theory on Park & Ride and traffic congestion is performed, including a benchmark of three cities using the system and different views on its effectiveness in reducing congestion. Then, an empirical study relating to the City of Gothenburg is realized. The challenges around Park & Ride and the way different stakeholders organise themselves to ensure the service is provided in a satisfying way are thoroughly investigated. Interviews with experts and users, on-site observations and secondary data collection were used as different approaches to answer these questions. The main conclusions of the thesis are that in the case of Gothenburg, Park & Ride plays a relevant role in helping reducing congestion, considering the infrastructure available and the commuting patterns of workers. However, even though the general satisfaction is high, the lack of space available came as the most important challenge. The authors therefore elaborated a solution following a Design Thinking approach in partnership with the innovation platform Coboom, as a suggestion to how digital tools could be used in Park & Ride to improve urban mobility in Gothenburg, but also potentially in other cities.

Keywords: Park & Ride, commuter parking, traffic congestion, urban mobility, public transportation, Smart Cities

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Glossary

Business Region Göteborg: Organisation responsible to promote business in the region, representing 13 municipalities in the area. (Business Region Göteborg, n.d.)

Göteborgs Stad: Municipality of Gothenburg governed by the City Council.

Göteborgs Stads Parkerings AB / Parkering Bolaget / P-bolaget: Public company owned by Göteborgs Stad, whose responsibility is to manage parking spaces, both in the street and in closed buildings. (Göteborgs Stad Parkering AB, 2019)

Trafikkontoret: Traffic office within Göteborgs Stad, responsible for building the Park & Ride sites and also in managing traffic within the municipality borders.

Trafikverket: The Swedish Transport Administration. They are responsible of long-term planning for all modes of transport (road, rail, sea and air). Also, they build and maintain public roads and railways. (Trafikverket, 2019a)

Västlänken: Promoted by Trafikverket, it consists in an underground tunnel at Gothenburg with 3 stops in different parts of the city centre (Central Station, Haga and Korsvägen). This solution would allow trains to continue south after Central Station, leaving passengers closer to their workplace. (Västsvenska paketet, 2019)

Västra Götalandsregionen: Public organisation that includes 49 municipalities in the west coast of Sweden, with a government elected democratically. (Västra Götalandregionen, 2016)

Västsvenska paketet: Agreement between local and national governments that consists in a big infrastructure investment to improve Gothenburg's region communications. It includes Västlanken, a bridge and a tunnel as the biggest investments, and half of it is financed by the congestion charge to access Gothenburg city centre. (Börjesson and Kristoffersson, 2015)

Västtrafik: Regional public transport operator. Formed in 1998 alongside with the Västra Götalands region by merging the four traffic operators in the region. (Drakenfors, 2013)

VKT: Vehicle Kilometres Travelled. Like Vehicle Mile Travelled (VMT), it measures the total amount of distance travelled during a given time by all vehicles within a specific area. It is obtained by adding up the distance travelled by every vehicle. It is used for planning purposes, and it identifies the areas that contribute to have more traffic congestion. (Williams et al., 2016)

1 Introduction

Improving mobility by investing in an adequate transport system is a prerequisite to ensure sustainable development. Indeed, this positively impacts access to social and educational services, as well as economic opportunities by easing access to jobs and export markets (United Nations, 2014). However, it has also been associated with negative effects, mostly visible in large cities. These perceived externalities have been well documented by the scientific literature and are hardly debatable. Among those are the increasing traffic congestion, increasing air and noise pollution, which current policies are aiming to control (European Environment Agency, 2015a; Stopher, 2004). To a large extent, these effects can be imputed to a growing usage of cars as a mode of transportation.

On the other hand, solving the problem of an increasing demand for cars by investing in road infrastructure is becoming less popular. This is due to the risks for worsening environment conditions and also other factors, such as putting in danger historically important buildings (Downs, 2004a; Lindberg, 1995). Moreover, different experiences have shown the counterintuitive effects of providing more capacity in the road system when the objective is to reduce traffic congestion. Evidences in the literature even demonstrate unanticipated traffic growth after the roads have been improved (Goodwin, 1996), hence the commonly accepted idea that the supply of additional road capacity results in an increase in traffic volume. In addition, in recurring congestion (the one that happens on a regular basis), maximum demand for travel happens in short periods of time, e.g. when drivers leave the office in the afternoon. In consequence, it is inefficient to try to meet all the demand by building more roads, since these peaks of demand are limited in time (Stopher, 2004). Other mechanisms have thus witnessed a growing interest among politicians but also among the public (Cairns et al., 2008; Lindberg, 1995; Steg and Gärling, 2007). These mechanisms can be classified into hard and soft policies. Mechanisms in hard policies include distance-based road pricing and congestion tolls, making drivers to pay for using the car, and "nudging" them to try other alternatives. Soft policies are on the opposite incentive based. Programs in which employers encourage tele-working, virtual meetings or car-pooling, or campaigns by local authorities to switch toward more sustainable travel habits are examples of such soft policies (Friman et al., 2013).

Despite the cost externalities associated to their usage, cars are nowadays still a major element of the transportation system, as it was foreseen decades ago in the literature (Lindberg, 1995; Stopher, 2004). Nevertheless, more recent views strongly believe that technological development

will bring a major change in the way cars are used. Specifically, autonomous driving is suggested to be a technology that will disrupt the car industry, because it will answer the drivers need for safety in a better way (Connected Automated Driving Europe, 2019). Even if in the future the role played by cars might change, it is still necessary to alleviate gridlocks, which appears to be challenging by using other solutions than infrastructure investments. Traffic congestion is a phenomenon occurring globally and all of the major cities in the world have been witnessing increasing traffic intensities (Downs, 2004a; INRIX, 2017). It is also frequently viewed that it might never be possible to entirely suppress congestion (Downs, 2004a; Stopher, 2004). For instance, an essential need for efficient economic and educational systems is that people interact with each other, for example by having the same schedule, which explains why congestion to a certain extent could be considered as a necessary evil (Downs, 2004a). Encouragingly, experiences have shown that reducing the effects of congestion is possible. For example, Moscow, one of the most congested cities in Europe, succeeded in increasing the average speed of traffic by 12 % over a period of 5 years by implementing several measures (ITF, 2016). But the solutions applicable to Moscow may not be used elsewhere for numerous reasons. Indeed, several factors can lead to gridlock, and different cities have different problems regarding that issue. Causes of congestion can include high density population living in a small area, which is the case of New York and San Francisco for instance. In other metropolises, high traffic intensity can be explained with low density settlement patterns coupled with employment decentralization (Downs, 2004b).

In this thesis, the focus is on one specific solution designed to reduce congestion, namely the commuter parking, also called Park & Ride. It is a service that allows commuters to park their cars outside the city centre and switch to public transportation to complete the trip (Song and Heaslip, 2015). It is a solution that directly addresses several external costs linked to increasing mobility. The resulting benefits from intercepting car trips and diverting the users to public transportation include a decreased fuel consumption, less emissions of air pollutants and a reduced traffic congestion. But in order to attract drivers, Park & Ride must be appealing enough. Thus, Park & Ride as a concept is a mechanism that has as a main basis to provide free or low-cost parking lots as an incentive for motorists to leave the cars outside the city (Bullard and Christiansen, 1983). In consequence, Park & Ride can be considered as a service that an organisation or a municipality offers as part of soft transportation policy measures. In this thesis, the topic covered is the Park & Ride service provided within the Gothenburg region borders.

2 Purpose of the thesis and Research Question

This section will establish what this thesis aims to answer, also clarifying the scope and stating clearly the research questions.

2.1 Purpose

While researching on the topic of reducing congestion, it was found that Park & Ride could be a good solution. This system allows the commuters to park their car outside the city centre and then use a collective mode of transport to end the journey. The topic of Park & Ride is one that has been extensively discussed in the literature, which includes case studies on different major cities in the world. However, although implemented in the city for several years, the literature did not research on the specific case of Park & Ride in the city of Gothenburg. Also, the future of Park & Ride, its weaknesses and how it can be improved are aspects that are hardly covered by the literature. For these reasons, it is interesting to understand what the current situation of the Park & Ride service in Gothenburg is, and what the main trends affecting this service are, considering the opinions of both experts and the users. Therefore, the general purpose of this thesis is to determine if Park & Ride is an adapted solution to help reducing congestion in Gothenburg, and how it can be improved.

2.2 Scope and delimitation of the thesis

The thesis will study what recurring congestion is, how it can be reduced, and the role of Park & Ride in such a reduction. As suggested in the literature, the authors think that in order to find suitable solutions to address the traffic issue in Gothenburg, the city's particularities and traffic patterns must be understood. Therefore, traffic patterns in Gothenburg are analysed. The authors also attempt to explain what the main challenges are when it comes to provide this service and its usage, and whether it will still be a relevant solution for the future. Gothenburg is a city that fulfils the criteria for a need in Park & Ride service. Such criteria include an important number of people living in low-density locations and commuting to the city centre every day for work, and with high parking fees in this area. Considering these specificities, it was chosen to focus on one solution in this thesis, which is the concept of Park & Ride.

The thesis does not evaluate the level of usage of each Park & Ride site because of there is no available data on such matter. The Park & Ride site of Delsjömotet has cameras that count the number of cars, but this is not the case for most of the sites. Therefore, there are no official statistics that comprehensively cover the Park & Ride service in Gothenburg and that would indicate the

level of usage or the precise time of arrival and departures in the sites. This thesis is also not a quantitative study on the satisfaction of users, nor does it suggest where Park & Ride sites should be located to optimize this service.

2.3 Research question

Developing a research question is a process where the researcher is progressively narrowing down from a general to a more specific topic. Criteria for a suitable research question include clarity, whether the question is researchable and a connection between existing theory and empirical study (Bryman & Bell, 2015).

Following the same principles, the literature on different solutions was thoroughly reviewed, as well as issues relating to traffic congestion including experiences in different parts of the world. So, the general research area of traffic congestion has been progressively narrowed down to focus on a potentially adapted solution for the purpose of this thesis. The research question and the two sub-questions that seek to understand the elements of interest discussed around the Park & Ride service in Gothenburg are presented hereafter:

What is the current situation of Park and Ride in Gothenburg?

- What are the different features affecting its operation?
- What are its prospects for the upcoming years?

3 Theoretical framework and results of literature review

During the following section, the basis for the study will be presented. Starting from what congestion is and how to reduce it, the topic will be narrowed down to the Park & Ride solution. Subsequently, this system will be presented, analysing its implementation in other cities, and concluding by presenting the implications of the literature review.

In the context of car traffic, congestion can be described as a phenomenon that occurs when the input volume of a facility surpasses its output capacity. Therefore, one implication of congestion is the use of roads in a way that exceeds the capacity it has been designed for. Another implication is that as density of vehicles increases, the speed will diminish. Maximum congestion is when the speed reaches zero (Stopher, 2004).

Traffic jams generally occur in specific road segments, although in some cities such as Mexico City or Bangkok, the phenomenon is systemic and wider. Also, two types of congestion can be considered: the recurring and the non-recurring types of congestion. The recurring type of congestion occurs routinely at the similar time and place, particularly during the weekdays at peak-hours. The non-recurring type of congestion is a more random type of congestion generated by exceptional situations, such as temporary landscaping works or car accidents. Policies aiming at reducing congestion principally pay particular attention to the recurring type of congestion (Stopher, 2004).

Recurring congestion might be caused by many reasons, and many experts have tried to name them. Downs (1992) did a research of several metropolitan areas in the United States, and according to him, there are four main reasons causing traffic congestion. First, population and job growth lead to having more people in a metropolitan area and more job spaces, which increases the number of trips and the cars in the road. Second, and especially in the United States, the number of miles travelled per car increased dramatically in the 70s and 80s, directly affected by the entrance of women to the job market and the growth of the suburbs. Third, during the period 1981-1989 the number of cars increased by 24%, but the miles in the highway only did by 0,6%, making the lack of building new infrastructure a big cause for increasing congestion. Another reason is the failure of administrations to make drivers pay for the cost they generate, either by installing tolls in highways, congestion charge, or similar initiatives to make it less beneficial to travel by car. Finally, Downs also mentions some long-term causes, such as the concentration of work trips at peak hours, the desire to choose where to live and work, or the desire for living in low density neighbourhoods.

Twelve years later, Downs published a second book in which he updated his previous research on the reasons leading to increased traffic. Although the main causes remained the same, he added some more like the lower vehicle prices, a decrease in fuel cost per mile and the complexity of metropolitan areas. Nevertheless, all of these reasons must be put in the context of the United States, and some of them might be different in Europe (Downs, 2004b).

It is essential to reduce car congestion because it causes many problems that affect people's daily life. The impacts are especially strong in cities, and affect the economy, the fuel consumption and the environment. In the case of the economy, it affects not only the time that citizens spend in congestion and in travel delay, but also has an impact on local commerce and industry. Second, fuel consumption increases with congestion, which rises the expenses on fuel, and is particularly important in countries with high dependency on foreign resources. Finally, and probably the most important of all, is the impact on environment, through noise and air pollution. The cars emit a series of pollutants that contribute directly to increasing air pollution in cities and Climate Change. More information of the effects of congestion can be found in Appendix 1.

3.1 How to reduce congestion?

Many ways of tackling car congestion have been tried during the past decades. For the purpose of this paper, the authors have opted to divide these measures in three different fields: Policy, Road Infrastructure and Technology. Throughout the next section, these fields will be discussed, analysing different initiatives and their applicability.

3.1.1 Policy

After the World War II, there was a significant difference between the management of public transports in the United States and in European countries. Indeed, the United States focused on policies aiming at encouraging the usage of private cars especially until the 70's, while Europe heavily subsidized public transit systems. In addition, it is interesting to note that public transport typically targets niche markets, for instance the commuters traveling to the downtown of major cities. Nowadays, a lot of transport policies aim at expanding the usage of public means of transportation. Indeed, public transport still plays a significant role, particularly for trips towards the business city centres for which personal cars are less convenient, and for populations that cannot or do not want to drive cars, such as the young people and the elderly. Nevertheless, and despite heavy investments in railroad in the United States starting from the seventies, market shares of public transport companies witnessed a decline in both the United States and Europe. It appears that inciting people to use public transport to reach targeted shares of usage with specific policies

has not been successful so far. One factor mentioned is the lack of political courage, which would be a prerequisite if a significant increase in public transport is to be desired. But a suitable mix of hard and soft policies comparable to "*carrots and sticks*" can engender a shift in public transport (Stopher, 2004).

The main differences between a hard and a soft policy as intended here is the actions undertaken by authorities on prices of a given service or product. The hard policy restrains the opportunities of users to access a product or a service by increasing related taxes or reducing subsidies. On the opposite, a soft policy rather focuses on the behaviour of users by encouraging them to adopt certain actions without intervening in the set of choices available (Glaeser, 2016). A hard policy therefore corresponds to the "*stick*" idea that supposes nudging the users. Soft policies correspond to the "*carrot*" idea where users are incited to do something.

One hard policy that is sometimes considered is congestion charging, which can be viewed as a tool to relieve congestion and increase ridership of public transport or walking. This policy consists in increasing the price of traveling during periods of potential traffic jams. Mechanisms include paying when crossing a cordon around an area or a toll ring placed in specific roads. After investigating on whether congestion charging has an effective impact, Stopher's position is that it does but only on the short-term. He recognizes that some users will shift to public transport. But he also explains that since congestion will be reduced on the short-term, other users will consider that it is less costly to drive a car in terms of time needed, which will translate to an increase in car travels (Stopher, 2004). Congestion charge is politically unpopular in the United States because it is thought that only rich or subsidized motorists would be favoured while poor ones will be disadvantaged. The other reason mentioned is the fact that congestion charge is perceived as another tax adding up to the gasoline taxes (Downs, 2004).

Another alternative to reduce the demand for car commuting would be to expand current public transit operations. Some researchers are not in favour of that solution. In the United States, only 4,7% of commuters were using public transport in 2000. This is explained by the fact that public transport is normally limited to densely populated areas. Even by increasing three-fold the then existent public transport capacity in the United States, morning trips with private cars would be reduced only by 11%. Therefore, that alternative is very costly in regard with the limited results on congestion (Downs, 2004). Plus, Stopher (2004) shows that in order to double the market share of public transport companies in a typical western region, public transport trips need to be multiplied by three. This implies that enormous investments are required. In the case of the United States and taking into account the region's growth, investments in additional public transport

capacity would have an impact on congestion lasting only 5 years (Stopher, 2004). Nevertheless, there are some countries willing to heavily invest in public transport. Sweden adopted in 2007 a similar strategy. The country's goal was to multiply by two the market share of public transport by 2020 (Friman et al. 2013).

Many other types of programs that target congestion reduction exist, which are called Travel Demand Management (TDM) measures. Friman et al. (2013) reviewed 32 different soft-policy programs that have been applied in Sweden. Cairns et al. (2008) and Friman et al. (2013) provide examples of such soft measures, presented in the table hereafter:

Table 1 - Examples of soft policy (Friman et al., 2013) and (Cairns et al., 2008)

Example of soft policies measures	Objective
"Travel policy at workplace"	"Promotes car-pooling between employee"
"Travel policy at school"	"Choosing other alternatives for school runs"
"Personalized travel planning"	"Personalized travel information"
"Information and marketing"	"Increased knowledge via advertising campaigns and simplified ticket availability"
"Campaigns for alternative transport modes"	"Increasing understanding of problems with certain transport choices"
"Car clubs"	"Offering cars that are paid for upon actual use"
"Car cooperatives"	"Reducing the number of car trips through joint ownership"
"Tele-working"	"Reducing the number of trips by, e.g., offering Internet access"
"Tele-conferencing"	"Reducing the number of work trips via phone meetings"
"Shopping from home"	"Reducing the number of purchasing trips via home deliveries"

In their approach, Cairns et al. (2008) analysed the literature and case studies in the United Kingdom, where these soft measures were used to determine their effectiveness. They observe that in one decade, traffic on the national level in the United Kingdom was reduced by approximately 11%, and that the period for congestion during peak-hours has lowered by 21%. Additionally, they indicate that it is a profitable investment with a benefit-cost ratio higher than 10:1. Thus, their

overall conclusion is that soft policies can be significantly effective if the scale of implementation is wide enough, and that the value earned from it is worth the costs.

Friman et al. (2013) focused on programs of personalized travel planning in Sweden. The way such programs are implemented can vary a lot. Typically, one target group is offered incentives to change its travel routines. In exchange, the target group receives personalized information along with incentives. The targeted groups differ depending on the programs. Targeted groups can be located in companies, in schools or in residential areas, and would respectively target work trips, parents dropping their kids or general types of trips. Additionally, the incentives used, and the goals can be defined differently. Communication wise, the frequency of contact and communication tools used are important aspects to consider, but also the post-program communication efforts to see if participants kept their new habits. In Sweden, those programs typically take the form of a collaboration between a municipality and Trafikverket, that is responsible for planning and financing the program. These programs can be implemented in workplaces, in residential areas or in schools and thus target different groups of users. Concepts such as “a car-free day”, “smart pedestrians” or “health pedallers” are predetermined with the objective to change people’s ways of using cars in favour of using bikes or public transport instead. However, due to a lack of transparency on how the studies were conducted, the absence of control groups and lack of advanced statistical analyses, Friman et al. (2013) conclude that the outcomes of such programs are not reliable. In addition to that, they indicate that there was a lack of following-up measures.

3.1.2 Infrastructure

Infrastructure measures are normally taken by applying a supply-side approach, which is the main solution adopted by politicians with the aim of reducing car congestion. This approach focuses on increasing the capacity of the current transport systems and in offering more options to the drivers. Some of the ways of increasing the supply are increasing road capacity, building new roads, making it faster to remove accidents or by increasing competition in public transport via deregulation (Downs, 2004b).

Another example is to build High Occupancy Vehicle Lanes (HOVs), which are lanes that can only be used by cars with at least the driver and one more passenger. In this case though, it can be also considered as a demand-side measure, as it encourages people to share the vehicle and, consequently, reduce the demand for cars on the road (Downs, 2004b).

Many authors think that increasing highway capacity only works in the short-term. Once the capacity has been increased in a highway and hence, congestion and travel time are reduced, other people will notice it and start using it. This will result in an increase of cars in that highway and it will make it congested again. This effect is known as Induced Demand, and can be generative (New trips from modal shift or by doing longer trips) or redistributive (Route shift to expanded road or schedule change to peak hours) (Cervero, 2003).

Apart from Downs (2004), the induced demand theory is backed by most of the experts in the matter. For example, Naess et al. (2012) did a research on the omission of induced demand when forecasting traffic and the importance of considering it. On the other hand, van der Loop et al. (2016) carried out a research on the Netherlands, which concluded that although not many new trips would be created after expanding an existing road, route choice and adapting departure time would result in an increase in demand bigger than the new capacity.

Indeed, the new expensive roads would not be used outside the peak-hours and it may require that an important number of buildings and trees are eliminated, which makes the measure not practical and unsustainable (Downs, 2004a). In another literature review paper, calculations show that travel time after road improvement was higher than the forecasts made by the traffic authorities when presenting the expansion project, both in the short-term (10%) and long-term (20%) (Goodwin, 1996).

Consequently, expanding road capacity does not provide a solution in the long-term with the aim of reducing congestion, and could even make it worse, as more people might use the expanded road.

3.1.3 Technology

It is difficult to talk about the impact of technology in mobility without resorting to the term *Smart Cities*, which is being used by many political figures to promote their cities as a futuristic and pleasant place for the citizens. But when it comes to explain this term, there is not a single definition, but many.

As the goal of this paper is not discussing the different definitions available, the definition used will be the one of the European Commission, who defines the smart city as "*a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business.*" (European Commission, 2019).

There are several Smart Cities fields, but they can be divided in “hard domains” and “soft domains”. In the first case, these are the areas in which Information and Communication Technologies (ICT) can make a real difference towards increasing its sustainability, by using sensors, wireless standards or managing data correctly. Some examples of hard domains are energy grids, water and waste management, environment, transport and healthcare. On the other hand, soft domains are those in which the role of ICT is more limited, and act as a support tool, for example by making education more interactive, by increasing the administrations’ transparency, or by making museums more attractive. In this section we can find education, culture, social inclusion, public administration and economy (Neirotti et al., 2014).

When focusing on the hard domain of *Transport and mobility*, it can be divided in three sub-domains: city logistics (improves logistics flows in cities), info-mobility (uses information to increase efficiency of traffic and transport) and people mobility (innovations to improve transport of people in cities) (Neirotti et al., 2014).

More importantly, one of the priorities established in the Smart Cities framework is on how to develop mobility in a sustainable way, which is usually named as *Smart Urban Mobility*. This term also has many definitions, and it is summed up by Lyons (2018) by using the next three explanations:

- “*Using technology to generate and share data, information and knowledge that influences decisions*”
- “*Using technology to enhance vehicles, infrastructure and services*”
- “*Deriving improvements for transport system operators and users and for shareholders*”

There are many applications for which ICT can be used with the aim of improving traffic in cities and avoid congestion. Below, a list of main ICT applications for the upcoming years will be briefly presented. The list was elaborated by Sotra (2017), and will be presented with a short explanation provided from scientific sources, when possible:

1. VANET / V2I / V2V: The term of Vehicular Ad Hoc Networks (VANETs) is gaining a lot of importance in the last years, as cars are getting more connected and equipped with computational tools. VANET is the architecture that disseminates and processes the data gathered through different methods (Xiao et al., 2019). Two of the most important subsets are Vehicle-To-Infrastructure (V2I) and Vehicle-To-Vehicle (V2V) communication, which are referred together as V2x. V2I allows a vehicle to communicate with the road elements and traffic-lights, for example, and download data from them. On the other hand,

V2V communications allow two vehicles to communicate without needing further infrastructure (Parrado and Donoso, 2015).

2. Dynamic traffic light: Traditionally, traffic lights are programmed in a way that the time that they are set in each colour is prefixed. With the use of technology, it is possible to have an adaptative system that responds to the amount of traffic in real-time. Old systems use weight as a trigger to change the colour, whereas newer systems use sensors that detect motion, together with algorithms that optimise the intersections affected. In the near future, V2I communication will allow cars to be in constant communication with the road infrastructure. By processing all the data of upcoming vehicles, the traffic system will be able to optimise the timing of traffic lights (Djahel et al., 2015; Fleck et al., 2016; Mohamed et al., 2015).
3. SMART corridors: SMART stands for "Safety, Mobility, Automated, Real-time Traffic management" and consists in applying IoT technologies to current roads. By using sensors, cameras, and Artificial Intelligence (A.I.), the system is capable to detect real-time and future traffic levels, accidents, congestion, and also be in communication with the drivers. This allows drivers to reduce travel time, emergency teams to respond faster and increase safety for pedestrians and cyclists, as they are in the network too (Holly Beilin, 2017).
4. Autonomous Driving: A lot has been said about autonomous driving in these past years. V2x communications, together with a wide range of sensors installed on the vehicle will allow in the near future to have 100% driverless cars and with a greater safety than nowadays cars. Nevertheless, autonomous driving impact on congestion is uncertain unless a sharing ownership approach is taken, as it might add empty cars to already congested areas. It might also have a great impact on autonomous public transport efficiency and costs, making it more attractive to users (Metz, 2018; Talebpour and Mahmassani, 2016).
5. Real-time traffic feedback: Similar to dynamic traffic lights, smart cities are equipped with several sensors and connecting information like available parking spots, traffic in every street, and cars entering the city. This effect can be enhanced by using V2I communication in both ways. Makino et al. (2018) describe different uses for this data: adjusting traffic-lights, dynamic pricing for congestion charge, live traffic data, check available parking, etc. These measures would help to decrease congestion.
6. Tracking pedestrian traffic: There are many reasons why cities track pedestrians' movements through sensors and cameras. Some of them are to increase mobility (detect when people are waiting for a traffic light), improve urban planning, measuring events and track them with retailing purposes. These are some of the examples tested in Manchester

(United Kingdom), Melbourne (Australia) or Chicago (United States) (Retail Sensing, 2018).

7. Car-Sharing & Multi-modal solutions: People's access to connected devices and internet has increased the use of apps to share vehicles, which allows users to drive a vehicle without owning it, paying a monthly fee or depending on the distance and time used. In Europe, some of the most famous ones are Car2Go, Sunfleet or Free2Move. On the other hand, there are a few multi-modal solutions like Ubigo (tested in Gothenburg) and Whim (in Helsinki), that by paying a monthly fee, offers the user special prices for using different modes of transport. For example, for 49€ per month, Whim includes unlimited public transport and bike, and reduced prices for car rental and taxi. This way, it allows the user to avoid owning a car but still have different mobility options depending on the type of trip (Whim, 2019).

Nowadays, except Autonomous Driving, these technologies are available and are being implemented in different cities around the globe, or will be in the next years. There is probably not only one 'miraculous' technological solution for congestion, but a combination of them, and other ones not listed, could improve greatly the traffic situation in big cities.

Most of the measures adopted by politicians involve either policy, infrastructure or technology. Nevertheless, Park & Ride could potentially combine the three of them and make commuting easier and more sustainable. Inciting people to use Park & Ride by making it free or with other actions would constitute a soft policy. Ensuring the infrastructure necessary for Park & Ride to target a substantial number of people can be done by prioritizing the constructions of parking lots in targeted areas. Alongside, technology could be used to make the scheme better, for example by offering real-time information of the free parking spots and recommending routes with less traffic.

3.2 Park & Ride solution

Park & Ride can be defined as an intermodal exchange platform, where the goal is to transfer drivers from Single Occupant Vehicles (SOV), mainly cars, to High Occupancy Vehicles (HOV), normally public transport, but also trains or carpooling. The main goal is to reduce car traffic in the city centres or specific areas (Spillar, 1997).

As stated by Parkhurst and Meek (2014), there are two main reasons why the commuter would use Park & Ride. The first one is because his/her preferred method of transport is public transit but going by car is the best way to connect to its network. On the other hand, car might be the preferred

mode, but using the parking might have some advantages, like avoiding congestion, not worry about finding parking in the city centre, not paying congestion fees, etc.

Spillar (1997) divides the Park & Ride facilities in 6 different types depending on its function:

- Informal Park & Ride lots: These are places close to a public transport stop, where drivers park their cars in close streets or properties. There is no public funding or organisation behind it.
- Opportunistic or Joint Use Lots: These parking lots were not conceived for Park & Ride use, but are rather for other activities, such as an event hall or a church. As parking for these other activities are normally not used during peak hours, the two parts need to reach a long-term deal to use it as a commuter parking.
- Park & Pool Lots: Dedicated smaller lots, usually with a carpooling purpose. These facilities can also be called Park and Pool.
- Suburban Park & Ride lots: Normally funded by public entities, suburban Park & Ride lots are those built in the outskirts of cities and with the aim of collecting private drivers and transferring them to a public transit mode.
- Intermodal Transit Centres: Built for higher transport demands than the suburban ones, its main goal is to exchange people from local to regional or express transit transport. Nevertheless, although is not the main goal of these facilities, there are also used for Park & Ride purposes.
- Satellite parking facilities: Also known as remote parking lots, its location is in the surroundings of a big activity centre, like an airport or a business district. It allows the user to park near the airport in a cheaper facility, and then be driven by the staff of the satellite parking to the destination.

On the other hand, Spillar (1997) also provides another Park & Ride classification, which depends on its distance from the primary destination, which would be the Central Business District (CBD):

- Local Urban Park & Ride lots: Located within the metropolitan area, at a distance between 1 and 4 miles (1.6 - 6.4 km) from the CBD. They are often shared facilities or opportunistic lots. Its connections are normally by local public transit but are usually more focused on an exchange between non-motorised mode (i.e. bicycles) and public transit.

- Suburban Park & Ride lots: Normally between 4 and 30 miles (6.4 and 48.3 km) from the primary destination and normally have intermodal service. Some of the modes offered are bus, train, bike, pedestrian and private vehicle.
- Remote Long-Distance Lots: Very similar to the suburban lots, but the distance from the primary destination is between 40 and 80 miles (64.4 and 128.7 km) and are usually located in a secondary metropolitan area.
- Peripheral Park & Ride lots: Just like the satellite lots, the final type is those built around specific traffic-generator cores, such as airports or business centres. After they park, the drivers take a shuttle or other means of public transport to go to the destination. However, this type of Park & Ride has been said to not reduce car use to reach these centres, but only slightly reduces congestion around them.

This study will analyse organised Park & Ride sites, therefore Informal lots will be excluded. On the other hand, as the aim of this thesis is to focus on congestion in city centre or close to them, and not the one in specific buildings or districts, satellite parking facilities and peripherical lots will also be omitted.

Effectiveness of Park & Ride on reducing congestion

When it comes to the effectiveness of Park & Ride to reduce both congestion and its external effects, there is not a unanimous opinion among researchers. The controversy comes from drivers' behaviour when they are impacted by both time and price incentives.

For example, Karamychev and van Reeven (2011) focus in their study on the role that Park & Ride has on reducing car traffic, in which the users can choose among car, public transport or combining them by using Park & Ride. In the same paper they reflect on the debate of some authors or authorities in whether the parking facilities should be closer to the origin or the destination. The study assumes that the sites are located in the edge of the cities and concludes that the reducing-traffic effect is lower if Park & Ride is only a cheaper alternative than city driving, but that this effect could be enhanced by offering also a cheaper public transport.

In the United Kingdom, the *Department of the Environment, Transport and the Regions* (Nowadays named *Department of Transport*), included Park & Ride in its main strategy for the years 2000-2010. They stated that it is an effective way to reduce congestion in the city centre, especially when dedicated public transport from these facilities was established. That is, when buses going from the sites to the city centre have priority, for example by setting up bus lanes in

the access roads to the centre. Another important aspect in the report is that the location of the parking and its safety is of essence to attract users (DETR, 2000).

On the opposite side, there are some authors who argue that Park & Ride can increase car traffic. For example, Meek et al. (2009) position is that since Park & Ride was established in the United Kingdom, reasons have arisen leading to believe that the scheme not only does not reduce car use, but rather increases it. Although the paper focuses on Park & Ride schemes using bus as High Occupancy Vehicle, and not train or other alternatives, they state that "*by providing a service superior in quality and lower in price, existing evidence shows a significant degree of transfer from conventional public transport*". Consequently, it becomes easier for people that already own a car to start using Park & Ride instead of the bus.

Supporting this theory, Mingardo (2013) names the causes for this increase in car traffic as *unintended effects*. In his paper, he analysed literature from different authors in five different countries (United Kingdom, Netherlands, Germany, Switzerland and the United States), and then described the four effects as it follows:

- Abstraction to public transport: People that used to take public transit all the way from home to their destination might choose now to use the Park & Ride scheme instead, due to its attractiveness.
- Abstraction from bike: Similar to the first one, some Park & Ride users are those that used to bike to their destination.
- Trip generation: As Park & Ride makes it cheaper to go to the city centre, more people would feel encouraged to increase their trips there.
- Park and walk users: Given that some users' destination might be close to the Park & Ride facility, some users might use them as a normal parking lot.

Finally, Parkhurst and Meek (2014) discuss in their research the effectiveness of Park & Ride by analysing different literature and empirical researches. They conclude that although Park & Ride can be a good way of reducing the use of cars towards the city centre, it also contributes to continue having an 'automobile culture', instead of shifting towards a public transit society. Because of this and based in the limited effects the system has on congestion, European authorities have reduced their interest in Park & Ride over the years. They defend that Park & Ride should be part of a bigger package that encourages people to use public transport, and only use the car when necessary, to avoid the 'Abstraction to public transport' effect mentioned before. Though potentially an interesting solution to reduce congestion, building parking lots remains quite

expensive. Moreover, as Park & Ride requires valuable urban land, the facilities should be planned and constructed with a rational approach based on a well-thought definition of priorities (Krasic and Lanovic, 2013). In the case of Sweden, the country is scarcely populated and covers a large area, which implies that it is expensive to invest in adequate public transportation (Friman et al., 2013). Park & Ride provides the possibility to gather trips from a large market area towards a common point. This engenders enough demand in the gathering point to justify the existence of a public transport service such as bus or rail transit. Accordingly, the concept of Park & Ride particularly suits areas that have a low-density population that could not otherwise support a fixed-route public transport service. Consequently, Park & Ride can help to merge the usage of cars and public transportation. At the same time, for Park & Ride to be an attractive and successful service, several conditions must be met. These conditions are the existence of a traffic congestion problem and high fees in ordinary parking sites, and on whether commuting journeys are in the direction of major activity centres (Bullard and Christiansen, 1983).

As a conclusion, there is no general answer on whether Park & Ride is a good system to reduce congestion. Most opposing authors emphasize on the increase of car traffic around the parking sites and about the 'Abstraction to public transport' effect. Accordingly, the main objective when conceiving a Park & Ride scheme should be on how to make public transport users to continue their routine, while attracting those drivers that nowadays do all the trip to the city centre by car. More on this issue can be seen in the next section, where case studies on three cities are analysed.

3.3 Applications of Park & Ride in other cities

It is interesting to discuss about the characteristics of the Park and Ride service in different parts of the world as well as what type of profile and expectations the users have. This allows to understand some of the main forces driving the evolution of this solution and have a better understanding of how the local context influences it. For this reason, it was chosen to discuss the cases of one northern American city and two European cities, for which the literature also provided sufficiently detailed information. One of the main findings when comparing the cases of Northern American and European cities is that in Europe, space constraints have played an important role in limiting the development of Park & Ride. On the opposite, in Canada and the United States, larger-sized Park & Ride facilities were created because there was more land available. Another main difference between countries is whether the Park & Ride lots are generally connected to the railroad network, to the bus one or both. In the following section, implantation of Park & Ride in different cities will be discussed. The cities chosen are the following: Calgary (Canada), Bath (United Kingdom) and Rotterdam (Netherlands).

Calgary

Calgary is a city in the province of Alberta, in the southwest of Canada. Bolger et al. (1992) explained how Park & Ride was integrated in Calgary's Light Rail Transit (LRT) system in Canada. At the time Bolger et al. (1992) wrote their paper, the city of Calgary had a population of 708,000 in an area of 672 km², and there were approximately 6,800 available parking spots. Nowadays, the population of Calgary is around 1,2 million (The City of Calgary, 2017). Bolger et al. (1992) describes the development of the Park & Ride facilities that has been established along the LRT system in Calgary. The detail the construction of the LRT system between 1981 and 1990, progressively developed by, first, building a 20 km line towards the south, then a 10 km line in the northeast direction and finally a 5.6 km line to the northwest. Each line would be served with parking lots at most of the stations adding up to nearly 6,800 spots by 1990, as detailed in the following figure (1):

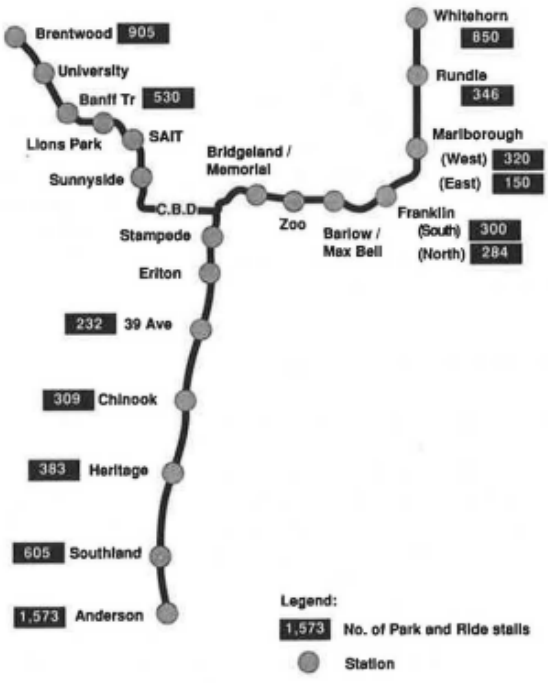

Figure 1 - LRT system and Park & Ride facilities in Calgary in 1990 (Bolger et al., 1992)

Bolger et al. (1992) suggest that the design of the Park & Ride facilities has been developed in a strategic way. For example, a minimum distance of 5 km to the city centre was generally a common rule to select new Park & Ride facility sites, even though there were some exceptions due to land characteristics in some areas. This way, the transportation department of the city of Calgary discouraged trips by private cars to the city centre. For 46% of the users surveyed, Park & Ride was perceived quicker and more convenient than taking a feeder bus. The usage of Park &

Ride appeared to be popular in Calgary under the nineties. Overall, the utilization of Park & Ride facilities reached 90% of the total capacity, and 100% at terminal stations. Most of the parking spots (97%) were in LRT stations, and the bus system was only served by 260 parking spaces. A proportion of parking lots for short-term parking (maximum of 4 hours) was provided, as well as for passengers picked up by car (maximum of 15 minutes) and others for handicapped (Bolger et al., 1992).

Some insights are learnt from the experience of Calgary with the Park & Ride service. First, the overall ridership gains in public transport reaching the city centre was limited. Indeed, a survey performed with the users of the Northeast LRT showed that 60% of the Park & Ride users used to take the bus to reach the city centre. In other words, the Park & Ride facilities built in the Northeast LRT sector attracted more public transport users than private car drivers. Secondly, the Calgary experience shows that it is very practical to plan in advance for an eventual expansion, reserving sufficient space to that end. The Calgary LRT system has been designed to have the option to add 5,900 spots, for a potential total of 12,700 Park & Ride spots. Bolger et al., (1992) suggest that the financial cost for reserving land on the long run can be mitigated through temporary usage of the land, such as having a mobile home park.

Nowadays, the Park & Ride service in Calgary is a mixed system with both free and paid parking spaces. The user can choose to use the free ones, or otherwise pay a monthly fee of $85 (at the time of study, around 56€) that would allow him/her to forget about stressing on the mornings to find a free place (Calgary Transit, 2019).

Bath

Bath is historical a city located in the South West of England in the United Kingdom. Much of the city is classified as a conservation area, attracting tourists and job seekers. This makes it particularly difficult to balance between the needs for road infrastructure and travel demand on one hand and protecting the historical buildings and the environment on the other hand. The city has a population of 60,000 and provides services for the area managed by the local authority of Bath and Northeast Somerset, that has a population of 170,000. On a national level, the context is that in the United Kingdom, Park & Ride has been widely promoted by the government since the early 1970’s. In 2007, 60 cities across the country had Park & Ride facilities with a total capacity of 70,000 lots and 400 buses connected to the system. Parking spots near rail lines are not signalled as Park & Ride. This opposes other cities such as Calgary or Rotterdam, where Park & Ride is generally located near the railroad system. Introduced in the 1980s in Bath, the Park & Ride

scheme was suggested to find the balance between the need for a better accessibility while reducing the number of car journeys (Clayton et al., 2014).

The three sites of Lansdown, Odd Down and Newbridge are dedicated to Park & Ride, and are respectfully located in the southern, northern and western outskirts of Bath. This scheme follows the typical peripheral Park & Ride design where the parking lots are built close to the principle roads on the edge of the city, in a range of 2 to 6 km from the centre. There were approximately 2,600 available lots offered in these three Park & Ride facilities. Parking lots are accessible for free while charges apply for bus usage (Clayton et al., 2014).

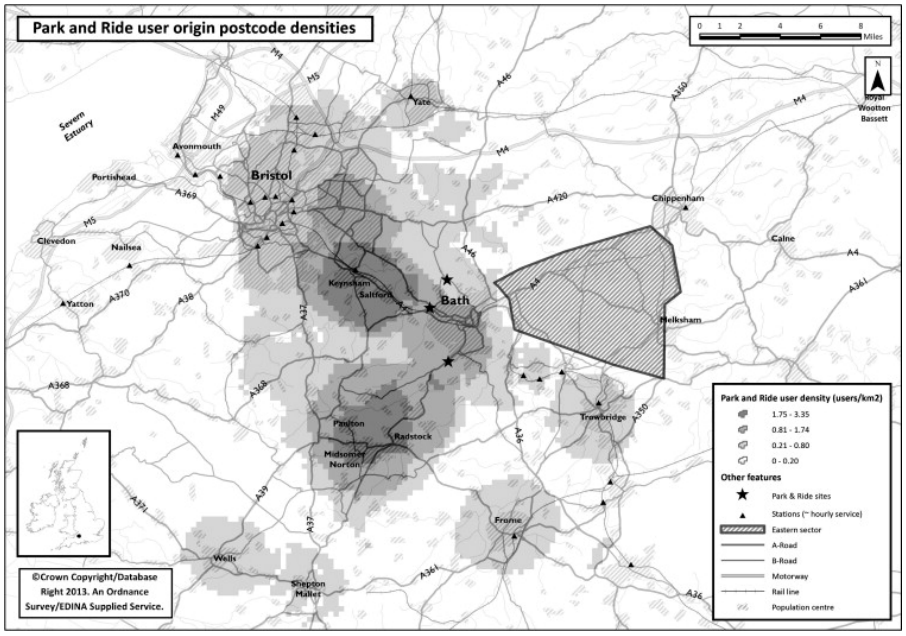

Figure 2 - Park & Ride sites in the city of Bath, United Kingdom (Clayton et al., 2014).

Adding a fourth Park & Ride site in the Eastern city outskirt would have been the 'logical' next decision in order to "finalize the ring". However, the demand for accessing to the city centre in this area is lower than in other areas. Indeed, the eastern area is rural and has a sparse population, thus relatively contributing little to travel demands in Bath. Consequently, the reduction in traffic benefits were thought to be limited if a fourth Park & Ride facility was added in the East outskirt. Questions were thus raised by politicians on whether this decision would be viable considering investment costs. It was also considered that car dependency in this area would be reinforced and the rural-to-urban transport system negatively impacted. For Clayton et al. (2014), Bath was facing a dilemma. Removing current Park & Ride sites would increase the number of motorists driving to the city centre. On the other hand, increasing those would potentially lead to reduced level of public transport usage. They thus suggest a solution in which the current provision of edge-of-city Park & Ride is maintained. Simultaneously, the focus should be on strategies around increasing

the bus frequencies and building localised Park & Ride capacity near a new railway station and in other areas served by buses.

The analysis of the Park & Ride usage in Bath by Clayton et al., (2014) show several interesting insights about the users' profiles. First, it indicates that women were more likely to use Park & Ride than men. A second finding was that travellers aged over sixty represented almost half of the users. One explanation to this is the existence of a policy offering free bus services after morning peaks to senior citizens in the UK, which tend to make Park & Ride more attractive for them. Also, travellers using Park & Ride were most likely to be alone than accompanied. Finally, users coming from middle income areas were more inclined to use Park & Ride while users of city centre parking came from high income areas (Clayton et al., 2014). In the case of Bath, parking at the Park & Ride facilities is for free and the user only has to pay for the bus ticket (Travelwest, 2019).

Rotterdam

Rotterdam is the 2nd largest city of the Netherlands and it is located in the South-West of the country. It has a population of 638,000 (Statista, 2019a, 2019b). In the Netherlands, the first Park & Ride was installed in 1979, as part of the Transport Demand Management (TDM) strategic actions implemented by the authorities. According to Mingardo (2013), Park & Ride significantly developed in the following decades, reaching 386 official Park & Ride lots in 2003. Mingardo (2013) analysed surveys commissioned by the city of Rotterdam in order to evaluate the impact of Park & Ride on traffic by measuring the Vehicle Kilometre Travelled (VKT) and emissions. The questionnaires helped understanding the travellers' behaviour, how they perceived the quality of Park & Ride service and how they would react if fees were introduced.

The main findings in Rotterdam indicated that 90% of motorists using Park & Ride drove alone. This corroborated the fact that approximately 75% of the users' journeys were work-related. A further finding was that approximately 39% of the respondents said they would not do the trip without the Park & Ride service. Mingardo explains that Park & Ride has been provided for a long time in Rotterdam and therefore these users had not known any other ways of transportation. Surprisingly, only 23% of the respondents said they would start using their cars to reach destination, like it would have been the intuitively expected. Unexpectedly, around 30% of respondents answered that they would take the public transportation, and 4% their bikes. Using the postal codes of the cars' license plates, Mingardo (2013) estimated the impact on the VKT, which directly impacts emissions levels. Mingardo concludes that in Rotterdam the Park & Ride

service does not necessarily contribute in reducing emissions and traffic. Considering that more than 34% of the respondents would take the public transport or the bike without Park & Ride, he explains that savings in VKT are less important than the additional VKT generated.

In general, Mingardo (2013) points out specifically to the unintended effect of 'Abstraction from bikes', which is a lost opportunity due to the positive effects on healthcare that biking provides. He also emphasizes on the "Park and walk" users, who use Park & Ride as a simple parking lot, instead of using it to switch to public transport. He believes that introduction of a fee would reduce these unintended effects and better regulate the improper usage. The survey conducted by Mingardo (2013) shows the low level of acceptance of new fees for Park & Ride. The local authorities considered introducing new daily fees of 1 to 2 euros. Mingardo's survey showed that only half of the current users would continue to use Park & Ride in Rotterdam if such fee was introduced. Currently, when it comes to pricing, Rotterdam Park & Ride is free if the users own a public transport card. If this is not the case, it costs 2€ daily, offering a cheap service when it is not free (City Guide Rotterdam, 2019).

Learnings from the experiences of Calgary, Bath and Rotterdam with Park & Ride

The experiences of the cities of Calgary, Bath and Rotterdam show several insights. Park & Ride in Calgary shows that planning in advance to have the option of adding more lots helped the city building more of these when needed. It also showed that the new users of Park & Ride service can be previous users of buses, and these are not the types of users this service intends to attract. Indeed, the intended expectation is to attract those drivers that use their cars the entire way to the city centre in order to reduce congestion and increase usage of public transportation. It is thus interesting to consider this limitation that Park & Ride can have when it comes to attract the targeted users.

Bath city case informs extensively on the profiles of the users: many of them are women and users over 60. One learning here is that local policies are thus to be considered in Park & Ride, because if those encourage seniors to use public transportation it may impact the usage of commuter parking. Facing a dilemma, the case of Bath also teaches that Park & Ride on its own cannot constitute a holistic solution. It must rather be considered as one tool among others to help preserving the historical city centre by avoiding too much traffic there, especially by improving the efficiency of public transportation.

Rotterdam gives another view on the efficiency of this service in reducing VKT and in consequence, emissions and traffic, by assessing the unintended effects of Park & Ride. Those are

mainly about the important proportion of users who would have used public transports and bikes if Park & Ride did not exist. It suggests that introducing a fee would help reducing those unintended effects.

All these different experiences can be useful to consider some aspects when implementing the Park & Ride service. For example, marketing campaigns can be used to target those specific users that are less likely to use Park & Ride (men rather than women) or that are specifically targeted (drivers using their cars to the city centre). Also, policies in public transport can be thought upon to positively impact on Park & Ride.

3.4 Implications of the theoretical framework

The end of the theoretical framework is to establish a general overview of the different aspects researched during the thesis. These are congestion, its consequences, possible solutions and the role of Park & Ride in reducing congestion. It also helps to identify those important elements that should be researched in the empirical part and the analysis section.

In the first part of the theoretical framework, apart from obtaining a general outlook on what congestion is, the different solutions in the literature to reduce congestion were studied, divided in three fields: Policy, Infrastructure and Technology. Especially important for Park & Ride are the use of policy to attract users, and technology to enhance availability of information to users.

Furthermore, Park & Ride arose as an answer that would combine the three types of solution, although the different authors do not agree on whether is effective or not to tackle congestion. This is one of the main focus when discussing about setting up Park & Ride schemes in different cities. Finally, the case studies of different cities served as an example on how Park & Ride is established in other countries. Plus, it contrasted the different pricing methods that cities have, from free to fully charged, and also having mixed models.

To sum up, the theoretical framework helped to determine which items should be included in the results and analysis sections: Park & Ride usefulness in reducing traffic congestion, impact of technology, how to attract new users and pricing.

4 Methods and methodology

In the following section, it will be explained how this research has been conducted and the different aspects of it. It is divided in: Research strategy, Research design, Data collection, Outcome results, Data analysis, Research quality problems and Problems that may arise.

4.1 Research strategy

In order to determine how the research will be conducted, it is interesting at first to think about whether an inductive or a deductive approach should be adopted. Congestion is a complex phenomenon that can occur for several different reasons depending on the area, as explained in the introduction. Consequently, it is difficult to find very specific literature on congestion in the case of the city of Gothenburg. Moreover, the authors of this paper started the research process by drawing a general inference out from observations and findings about the city of Gothenburg, its specificities having an influence on traffic congestion as well as the city's traffic patterns. This approach, in which observations and findings lead to theory generation, can be described as an inductive approach, as opposing to the deductive approach where the connection between observations and theory is reversed. On the other hand, inductive approach also entails some aspects of the deductive approach (Bryman and Bell, 2015). There has been a broad range of studies in the literature which sought to analyse the different policies and programs and their impact on congestion in different parts of the world. By comparing what the literature specifically says on Park & Ride and by analysing the usage of this solution in Gothenburg through data collection, an iterative strategy is also adopted by the authors of this paper.

An inductive approach generally leads to a qualitative research strategy, even though this should not be taken as a rule of thumb. Other than the employment of measurements in the qualitative strategy and its absence in the qualitative one, other more profound differences exist between the two strategies. For example, one important question is the epistemological doctrine, which is a theory of knowledge. Epistemology can be defined as the admissible knowledge in a field of study. Positivism, realism and interpretivism are some of the main epistemological positions. With an inductive approach, the emphasis is typically put on the interpretivism. With the interpretivist doctrine, social scientists are expected to seize the subjective reason behind social action. Indeed, it is commonly considered in the existing theory that social sciences and natural sciences require fundamentally different research logics. This can be explained by the fact that social sciences focus on people and their institutions. On the opposite, natural sciences focus instead on natural order that can be scientifically modelized, thus adopting a positivist doctrine.

Another aspect to consider is the ontological orientation, which is concerned with the essence of the social organization. Objectivism and constructionism are some of the main doctrines in the ontological theory. Qualitative research is typically associated with constructionism, which considers that social actors are having an active role in the establishment of organization and culture (Bryman and Bell, 2015).

It can be considered that the transportation system in Gothenburg and its future are influenced by decisions coming from different groups of individuals in the society. For that reason, the authors of this paper find suitable to adopt a qualitative research strategy.

4.2 Research design

Within the qualitative research strategy, one can choose among a broad range of research design approaches to apply to a study. It is important to determine what will be the research design, because it is supposed to help the investigator in guiding him/her and think about how the data will be analysed early enough. Another crucial reason to think on the research design is that it will have an impact on the research quality. The criteria commonly applied to determine if a qualitative research is of quality are the credibility, the transferability, the dependability and the confirmability. These criteria respectively answer the questions of whether the research findings are believable, if they can possibly apply to other contexts and times, and if the researcher's values are interfering to a high extent with the study (Bryman and Bell, 2015).

Bryman and Bell (2015) identify five different research designs. These are the experimental, the cross-sectional, the longitudinal, the case study and the comparative designs. Choosing to focus in how involved organizations in Gothenburg organized the Park & Ride system as well as their future strategy, it appeared clear for the investigators that the case study design was adapted. The other research designs generally require substantial resources and time that are not available for the investigators of this study. This is for example the case of the longitudinal research design, that would require to realize qualitative interviewing in several periods of times. Another example is the experimental design, as the researchers would need to manipulate the independent variables affecting for example the likelihood to use Park & Ride. It would be very complex and time consuming to realize such an experiment, or maybe not possible at all. For instance, if we consider gender as being an independent variable having an impact on Park & Ride usage, it would not be possible to manipulate that independent variable. Therefore, the case study design that can be organized in the form of qualitative interviewing is the chosen method.

Characteristics of case study designs are that they intensively analyse the setting targeted by the researchers, they focus on a bounded system or situation, and they are associated with a specific location or an organization (Bryman and Bell, 2015). The authors' objective is to analyse the Park & Ride system in Gothenburg as a solution to reduce congestion. They aim to determine if this solution can be enhanced and gather more users, since it is expected that this has a positive impact on traffic congestion by reducing it as stated in the thesis purpose. The case can thus be associated with one geographical location, which is the city of Gothenburg and the Park & Ride system.

4.3 Data collection

Several stakeholders are involved in the Park & Ride system in Gothenburg, but the authors chose to prioritize those who have an important role in it. With the aim of interviewing them, two distinct categories of stakeholders were chosen. The first category comprises the experts, who are the employees from organizations involved in the management of the Park & Ride system, plus others in related organisations. The other category of stakeholders are the users themselves. This way, the authors want to have a good understanding of what is currently done to enhance Park & Ride in Gothenburg, as well as the challenges of it. The objective is also to understand what the expectations and the need of the users are, and what would make them use the Park & Ride alternative more frequently or make it part of their daily routine.

This thesis was developed in partnership with Coboom, an innovation platform involving the companies CGI, Volvo Cars and Stena AB. They helped finding different experts by using a snowball sampling approach as an addition. Indeed, Coboom has contacts with several organizations which are relevant to the study. Bryman and Bell (2015) define snowball sampling as an approach were a first contact is initiated with a small number of people linked to the research question that are then used to reach out to other contacts. Besides, secondary data has been used in order to evaluate the current use of Park & Ride in Gothenburg. For example, this includes documents about users' satisfaction, statistics on Park & Ride, as well as statistics on traffic in Gothenburg. This data helped enhance the authors' knowledge on the topic and design a better interview guide to gather primary data.

As in most qualitative research studies, the authors of this paper used a purposive sample, in which sampling is generally conducted in relation to the goals of the research question. More specifically, this is a clear case of a fixed purposive sampling strategy, in which the sample is chosen early in the study based on the research question that needs to be answered. The investigators chose not to perform a probability sampling, which is mostly used in quantitative

research. This is due to feasibility constraints, as it would be very difficult to target a big amount of random Park & Ride users with a minimum of statistical significance. As Bryman and Bell (2015) explain, mapping the population and generating a random sample linked to the paper's research question would be difficult in the field. They also state that one form of purposive sampling is the theoretical sampling, which is adopted here. Indeed, as cited by Glaser and Strauss (1967), theoretical sampling is "*the process of data collection for generating theory whereby the analyst jointly collects, codes and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges*".

Table 2 – Experts interviewed during the thesis

Name	Role	Company	Method	Date	Duration
Erik-Wilhelm Graef Behm	Area & Investment Manager ICT	Business Region Göteborg	Face-to-face	8th March 2019	45 min
Gunnar Lanner	Senior lecturer and consultant	Chalmers University of Technology	Face-to-face	20th March 2019	40 min
Lars Bern	Area Manager of Innovation	Business Region Göteborg	Face-to-face	25th March 2019	60 min
Jonas Lidén	Coordinator for Pendelparkering	Göteborgs Stad – Trafikkontoret	Face-to-face	25th March 2019	55 min
Marie Albihn	Project manager in Strategic Planning	Västtrafik	Face-to-face	4th April 2019	55 min

In order to collect data, the authors adopted several approaches. On one hand, experts that were chosen have a direct (Traffikontoret, Västtrafik) or indirect role (Business Göteborgs Region, Chalmers) in the Park & Ride service, or at least a certain level of knowledge on matters relating to city mobility. The experts' interviews, as well as their roles and other relevant data, can be found in Table 2. A particular effort was made to contact experts that have a direct role in the Park & Ride service. Nevertheless, in order to diversify the points of view, the authors judged interesting to interview other experts, even though they would have less expertise in the very specific question of Park & Ride. These experts could bring a contribution in understanding the different challenges and opportunities surrounding this service, and also in portraying an overview of the traffic situation in Gothenburg. To conduct these interviews, a guide was developed, which is presented in Appendix 2. Even though this guide was used as a base, it was also adapted to each person

interviewed, depending on his/her organisation and role, and especially in the link they had with Park & Ride.

The interviews were semi-structured, which means that even many of the questions were written in the interview guide, also new questions arose during the meetings (Collis and Hussey, 2013). This was the case if the discussion with the expert brought to light some new aspects that were assessed as potentially interesting for the understanding of this paper's topic. The questions were open, so they could not be answered with a 'yes' or 'no', but rather with a more elaborated answer that led to more fluid conversations (Collis and Hussey, 2013). Interviews were planned for a period of 30 to 45 minutes, but they generally lasted between 45 minutes and 1 hour. All the interviews have been recorded with the computer after asking the permission of the experts in order to be able to transcribe and analyse them. In addition to the interviews with experts, it was asked to Västtrafik and Traffikontoret if it was possible to have access to recent documents and data with the objective to use them in this paper's empirical phase as secondary data.

Table 3 - Information about the visits to parking sites

Parking site	Date	Type	Time spent	Users interviewed
Amhult Resecentrum 2	13th March 2019	User interviews	16:30 - 18:15	8
Eriksdal	20th March 2019	User interviews	16:00 - 17:30	8
Delsjömotet	19th March 2019	On-site observation	7:00 - 8:30	-
Authors' acquaintances	-	Phone and face-to-face interviews	-	2

On the other hand, primary data was also obtained by carrying out surveys to the users of Park & Ride, as seen in Table 3. The surveys were carried in the parking lots of Amhult Resecentrum 2 and Eriksdal, and they were based on a second interview guide that was developed, that can be found in Appendix 2. In order to carry out those interviews, the authors went to the parking lots in the afternoon, when people are coming back from work, and interviewed them on their way from the bus to the car. But being two interviewers, the authors could only stop a maximum of two people each time a bus arrived. Therefore, most of the time spent in these parking lots was idle time waiting for the next bus to arrive. Also, after introducing the survey, most of them did not

accept to do the interview. For these interviews, a semi-structured approach was also chosen, with open questions, but more specific and required shorter answers. The reason for this is that the interview needed to be short, so people would accept to do it. It was believed that if a long time was required, people would be less inclined to accept answering the questions. Therefore, the interviews lasted normally around five minutes, but that depended on the willingness of each person to develop their answers. The objective was mainly to determine what were the main reasons for using Park & Ride and to be able to determine if there were any gaps between the speech delivered by experts and the users themselves. A field observation has also been conducted in one Park & Ride facility in order to gather additional information on the functioning of the service.

4.4 Limitations

Due to a series of constraints, the thesis has some limitations. First, with more time available it would have been possible to increase the number of on-site observations. This involves visiting more Park & Ride sites located in different municipalities, with different sizes and different types of connections. Next, another important aspect would have been having a more extensive evaluation of the potential involvement of Parkering Bolaget in the service, including an interview with them. Nevertheless, since they are not involved yet, it was not possible to find the right person to interview, and they recommended talking with Västtrafik and Trafikkontoret. Finally, having a focus group had to be also discarded from the final thesis. During this activity, all the experts interviewed would sit down in the same table and discuss about several topics relating to traffic management and Park & Ride. The reasons of not doing so were the lack of time and the complexity of coordinating the schedules of all people involved.

4.5 Data analysis and outcome results

One of the challenges with qualitative strategy is the substantial amount of data that is quickly generated. Contrary to the quantitative strategy, however, the rules to cope with that issue are less established and there is no strong consensus on it (Bryman and Bell, 2015). The outcomes of this research are three. The first one is an analysis of Gothenburg, obtained from secondary sources, which includes a description of traffic patterns in the city, based on data provided by organisations such as Trafikverket (The Swedish Transport Administration), Göteborgs Stad (Gothenburg municipality) and Västtrafik (Regional traffic operator), among others. The goal of this section is to summarise in the same paper how do citizens commute and including also an explanation of how Park & Ride works in Gothenburg.

The second outcome result, based on primary sources, is the empirical functioning of the parking sites. On one hand, one parking (Delsjönsmotet) site was visited in the morning to see how users behave and to understand better how the system works. On the other hand, the opinion from users was gathered, by visiting two more parking lots (Amhult 2 and Eriksdal) and asking users about their insights about the Park & Ride scheme.

Finally, interviews with experts and organisations involved were held, with the aim of knowing how the different stakeholders cooperate and what are the plans for Park & Ride in the upcoming years. As well, some of the users' concerns obtained from the surveys were included in these interviews.

4.6 Research quality problems

As explained in Bryman and Bell (2015), reliability and validity are important criteria used to determine the quality of a research. These criteria are a parallel to the criteria of credibility, transferability, dependability and confirmability mentioned earlier. These criteria just mentioned are preferred by some qualitative researchers because they are more adapted for that type of research strategy, while reliability and validity are said to be more adapted to quantitative research (Bryman and Bell, 2015). In this paper, great importance is given to the sample. The paper's authors believe that credibility of this study is dependent on the experts that are targeted to help answer the research question. These experts are ideally senior managers from companies that are responsible for providing the Park & Ride solution in Gothenburg, such as Göteborgs Stad (Trafikkontoret) and Västtrafik. In addition, the investigators wish to interview users or persons that use Park & Ride or used it in the past, in order to better understand what drives their choice to use this service. Credibility for this group of stakeholders will depend partly on the size of the sample. An enough number of users is necessary for the authors to understand different aspects such as what the users are primarily looking for in Park & Ride, what they think can be enhanced, what their opinion on the pricing policy is, etc.

Transferability is concerned with how a research study can be generalized (Bryman and Bell, 2015). Considering that the authors chose the case study as a research design, it is true that the context of Gothenburg in how the Park & Ride is organized here plays an important role. For example, if one wants to investigate to what extent Park & Ride will impact traffic congestion, the results will not likely be the same in different cities because of the context. Indeed, as explained in the introduction, different cities have different traffic problems and therefore different solutions should be considered to try to reduce the externalities of traffic congestion. In Gothenburg for

example, the authors must take into consideration that the city already implemented congestion tolls. But similar hard policies, considered by drivers as additional taxes, have been used in few cities in the world since it is politically not a popular choice (Downs, 2004a). Accordingly, it could be considered that the impact of incentives to use Park & Ride as a soft policy in other cities may not be similar in cities that lack congestion tolls.

Dependability is concerned with the trustworthiness of a given study for which the researchers should make sure that all the phases of the research process are recorded (Bryman and Bell, 2015). When it comes to the dependability aspect, this paper sought to ensure that the interviewing process, how participants have been contacted and selected as well as the analysis process are explained in a transparent manner. However, due to time constraints, it is acknowledged that keeping an exhaustive written registry of all the decisions made is challenging and demanding. For example, the decision process guiding the authors is shaped among other things through meetings held with the academic supervisor and Coboom, who both provided very useful feedbacks. But when adding these meetings with the large amount of data to analyse both from primary and secondary sources, it can be challenging to be entirely transparent on the research process. This may be the reason why Bryman and Bell (2015) indicate that dependability is not pervasive to validation.

Confirmability is about ensuring that the authors acted in good faith during the writing of the thesis (Bryman and Bell, 2015). The authors believe that interviewing two different groups of stakeholders, which are the experts and the users, is a first important step to adopt a position that is as objective as possible in this thesis. The authors also make sure that the theoretical framework includes different points of view for the same reason. In addition, the authors adopt an approach where they try not to present a solution that would be the perfect one, but rather one solution that certainly has its flows and could be enhanced to help solving one problem, which is traffic congestion in Gothenburg.

5 Results

As said in the methodology part, the results of this research are as follows. The first section consists in a study of Gothenburg traffic situation and an explanation of the Park & Ride scheme. Second, a summary of the user interviews, as well as the visit to observe the operation of one of the parking lots. Finally, an overview of different topics treated with experts on the interviews.

5.1 The Gothenburg Case

Gothenburg is the second biggest city in Sweden. It is located on the west coast, within the Västra Götaland region. It has an area of around 448 km^2, with a population of approximately 564,000 inhabitants and 1,000,000 in the region. There are 344,000 people working within the city borders, and in the last years the city and the region have been experiencing a big growth in both population and jobs, planning to build 80,000 new households and job spaces by 2035. Therefore, mobility appears as one of the main challenges for the next decades (Göteborgs Stad, 2017).

With the aim of understanding the following section, a summed-up explanation of Gothenburg region's territorial organization is required. The municipality (Göteborg Stad) is divided in 10 districts, depicted in Figure 3. As the goal of this study is to avoid traffic going into the city centre, this section will focus in the district "*Centrum*", although parts of other districts, specially Majorna-Linné (Includes Haga, Linnegatan, etc), could also be considered part of the city centre. This decision was taken due to being unable to discern different areas inside one district, which would mean that the whole district would have to be included as part of the city centre.

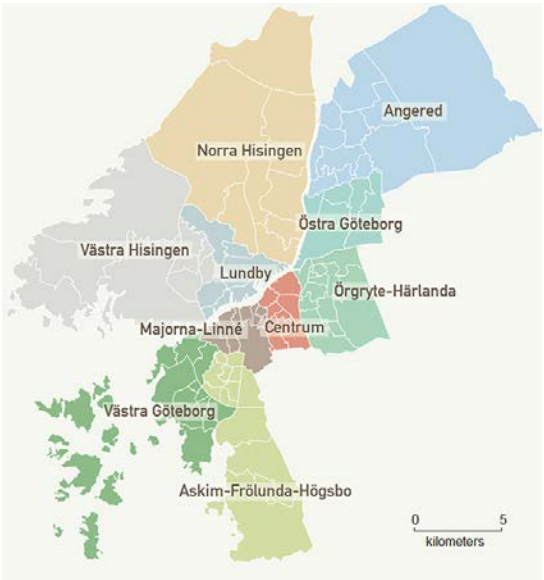

Figure 3 - Gothenburg districts (Boplats, 2019)

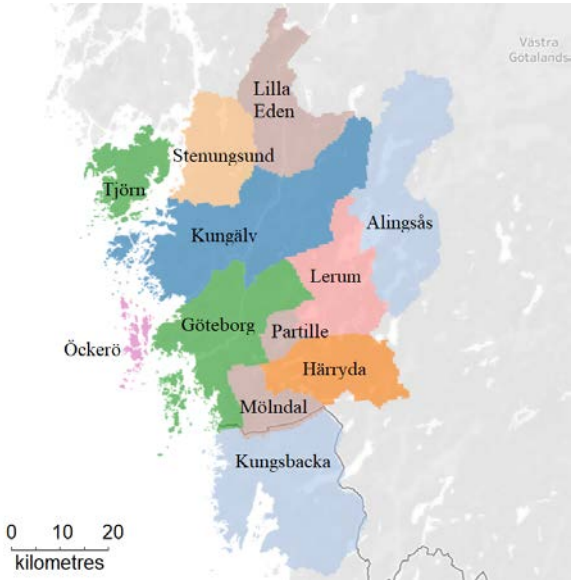

Figure 4 -Greater Gothenburg (Juel Jensen, 2014) / Own edit

On the other hand, Greater Gothenburg (Storgöteborg), in Figure 4, includes Gothenburg municipality plus 13 other ones surrounding the city. Together, they add up to more than one million inhabitants, and many people living in other municipalities commute daily to Gothenburg (Göteborgs Stad, 2015a).

With the aim of having a general understanding on how traffic flows are in Gothenburg, five main topics will be addressed next. The first one will talk about where people who work in the city centre live, that is, where do people commute from. Next, an explanation about the public transport network, which plays an essential role in the operation of Park & Ride. Third, a quantitative analysis of the most used roads in Gothenburg, in order to evaluate the convenience of Park & Ride for Gothenburg traffic patterns. Following, a brief introduction to the congestion charge in place to access the city centre, which has an impact on Park & Ride. Finally, the current Park & Ride system, called *Pendelparkering* in Gothenburg, will be explained.

Employees and people living in the city centre

According to Göteborgs Stad (2015), of all the work spaces within the Gothenburg municipality, 93,680 of them are located in the Centrum district, which represents 30.66 %. By crossing the data provided by the municipality, in Figure 5, it has been calculated that 85,63% of the people working in the city centre commute from other districts or municipalities.

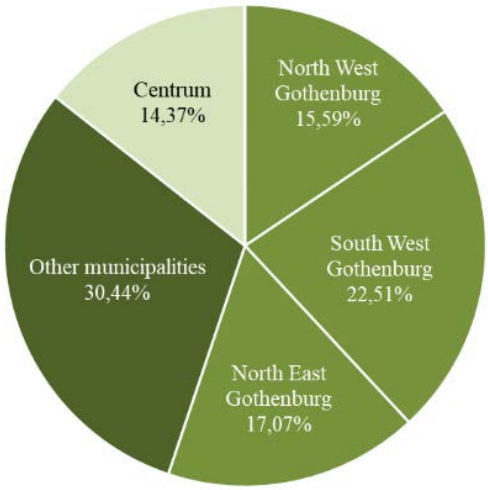

Figure 5 - Place of residence of city centre workers (Göteborgs Stad, 2015b)

In the chart above, it is displayed where do people working at the Centrum district live. In order to not overload the graph, the different districts have been grouped in areas, using the Centrum district as the origin and using the Göta river as a divider. Therefore, the districts have been divided in North West Gothenburg (Norra Hisingen, Västra Hisingen and Lundby), North

East Gothenburg (Angered, Östra Göteborg and Örgryte-Härlanda) and South West Gothenburg (Majorna Linné, Västra Göteborg and Askim-Frölunda-Högsbo). Disaggregated data per district can be found in the Appendix 3.

In order to target the potential users of Park & Ride, some assumptions must be made. The first one is that people living in the Centrum district will always commute walking, by bike or by public transport, due to its closeness. The second is that it is very difficult how many people from the other districts have the ideal conditions to use Park & Ride (closeness to public transport, own car, etc). Therefore, the only group that can be targeted as potential users of Park & Ride are the ones living in other municipalities. As observed, 30,44% of the people working in the city centre commute from outside the municipality borders, which amounts for around 28,000 commuters. This means that Park & Ride could potentially target this group of people. Nevertheless, it must be considered that many of these commuters live close to the public transport stops, or in the case of Mölndal, its city centre could be considered as being part of Gothenburg city because of its closeness and public transport connections. Accordingly, this number of 28,000 potential users would be reduced. On the contrary, commuters leaving within the municipality borders but far away of the city centre would also be potential users of Park & Ride. To sum up, there is potentially a strong demand for Park & Ride services in the region of Gothenburg.

Public transport infrastructure

The city of Gothenburg offers different modes of public transport: boat, tramway, commuter train and bus. Also, rental bikes are available for the users, although it is not the public company that manages it, but a private one that got the permit. The boats are mainly used to cross from the river's northern bank to the southern one, or vice versa, and to communicate the mainland and the islands of the archipelago. On the other hand, trams are used to move around the city centre and connect some stations outside the city, like Mölndal.

Next, the commuter trains consist in three train lines, that go towards Gothenburg central station, from the North (Älvängen), East (Alingsås) and South (Kungsbacka). This public transport mode is included in the Västtrafik subscription, and as it goes on train tracks, it is faster than the express buses or trams. Also, its frequencies are high, departing in the mornings every 10 to 20 minutes in the case of the Alingsås line, and every 15 minutes in the Älvängen and Kungsbacka lines (Västtrafik, 2019a).

Finally, the buses can be either normal buses or express buses. The normal ones have many stops along the way, which causes them to be more accessible but slower. On the other hand, the

Express Buss communicate Gothenburg with other surrounding municipalities, such as Partille, Kungälv or Kungsbacka, for example. This type of buses are the ones used in many Park & Ride sites due to its convenience and speed.

All these services are managed by Västtrafik, which is the region's public transport operator. It was formed in 1998 alongside with the Västra Götalands region by merging the four traffic operators of the region (Drakenfors, 2013).

An important fact about Gothenburg is that its citizens depend much on cars. According to Göteborgs Stad (2017), up to 45% of the trips in the region were done by car. Although, this number has been decreasing steadily in the last years, descending a 3% from 2011 numbers. The report also states that this decrease in car traffic could be due to the difficult access to parking spaces in central Gothenburg. As also seen in Figure 6, bike trips account for 7% and people walking reaches a 20%.

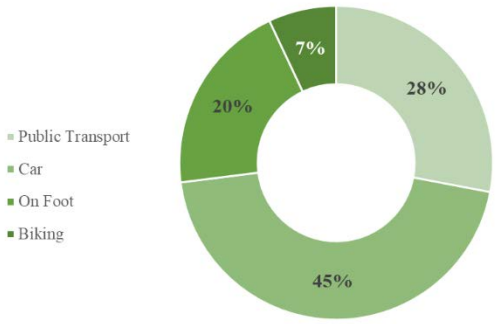

Figure 6 - Trip share by transport mode (Göteborgs Stad, 2017)

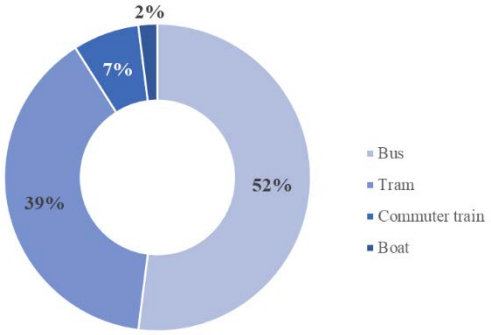

Figure 7 - Trip share by public transport mode (Västra Götaland Region, 2017)

On the other hand, 28% of the trips are made by public transport. Breaking down these numbers (Figure 7), it is observed that more than half of the trips, 52%, are done by bus, whereas tramway trips represents 39%. Finally, commuter trains represent 7%, and boats crossing the river and towards the islands represent 2% (Västra Götaland Region, 2017).

The region, together with Västtrafik and municipalities, has a long-term strategy in place, called K2020. By 2025, the K2020's main goal is that 40% of the total trips will be done by public transport. This plan includes several infrastructure investments to improve public transport accessibility in several areas, making it easier and faster for commuters to access the different areas of the city, and renouncing to have a network that almost always goes through the city centre (Västra Götaland Region et al., 2007). The plan has a series of guidelines that includes increasing

the number of express buses, and at the same time provide with bus lanes in all roads approaching the city centre. Also, have better connections between the so-called GoFast (Express Bus) and GoOften (Tram and buses) networks, as well as guarantee a higher capacity at the bus stops, that should be enlarged to cope with 24-meter buses and 45-meter trams. Finally, it is also a part of the strategy to have Park & Ride facilities along the railway corridors (Västra Götaland Region et al., 2007).

Another important aspect about public transport that affects Park & Ride directly is its zoning system, dividing the city in different areas. Depending on the origin and destination, the user needs a different type of card (Göteborg, Göteborg+, Göteborg++ or whole region), which also varies substantially in price. Therefore, many users living outside the Gothenburg area, who they need to pay for the more expensive tickets, prefer to use one of the Park & Ride sites within the Gothenburg municipality and take the public transport from there towards the city centre. Nowadays, there are up to 70 zones. However, the number of zones will change in 2020, when they will be reduced to three, as displayed in Figure 8. This measure should also decrease the difference of prices between tickets, which might influence Park & Ride usage (Västtrafik, 2018a).

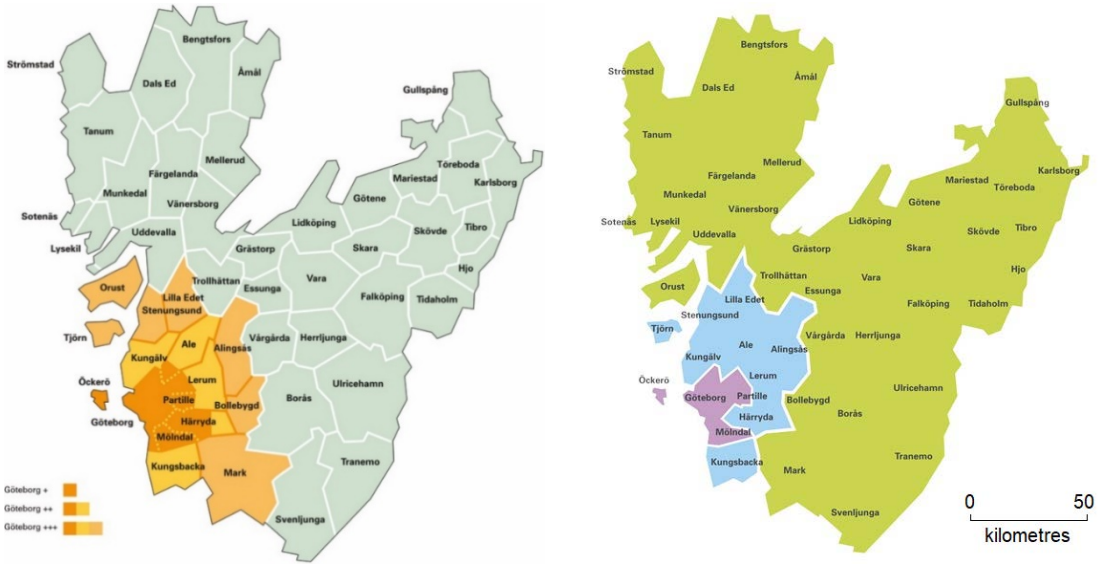

Figure 8 - Old and new zoning system (Hallandstrafiken, n.d.; Västtrafik, 2018a)

Traffic patterns

In order to evaluate the potential of Park & Ride, it is essential to understand the traffic flows in Gothenburg. More specifically, it is sought to find out in which roads the highest traffic intensity is, and other specific patterns that might arise. It is quite easy to find real-time traffic data, but it requires more effort to find historical information. Sources from both Trafikverket and Göteborg Stad were analysed in the following section.

In the first case, Trafikverket (n.d.) provides an interactive map of the city with different information of the roads. To measure the flows, they use the Annual Average Daily Traffic (AADT), which is the total traffic in a specific area during a year, and then divided by 365 days, obtaining a daily average (Trafikverket, 2019b). The map also provides several filters to classify the different types of vehicles or the range of the AADT, for example. The maps in Figure 9 show the AADT of the most congested roads in Gothenburg. The map on the left displays those roads with more than 50,000 vehicles per day, whereas on the right one, those with more than 70,000 are shown. The purpose of the second map is to make it easier for the reader to distinguish the most congested roads. The numbers for each segment are depicted as it follows: "AADT (MeasurementYear) ± ErrorMargin"

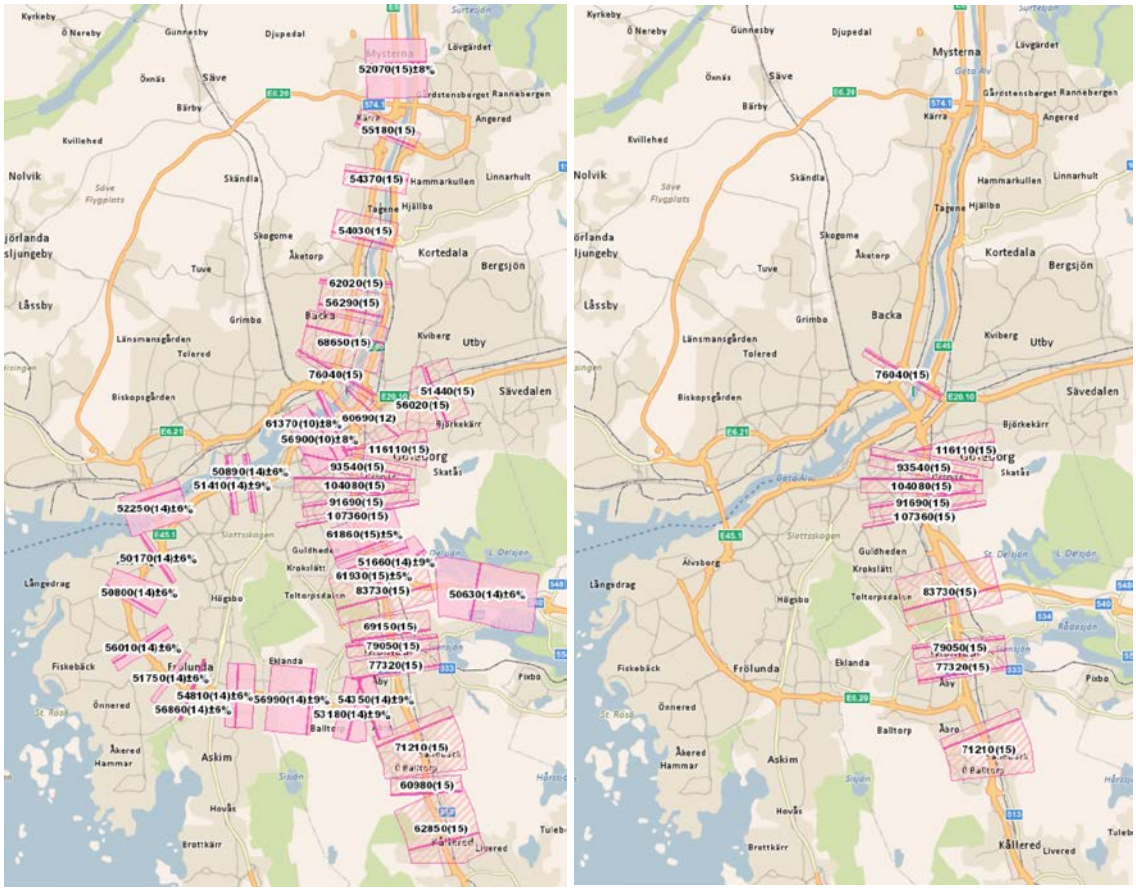

Figure 9 - Roads with the highest AADT in Gothenburg. On the right, only roads with AADT >70,000 (Trafikverket, n.d.)

As observed, the roads with more than 50,000 vehicles daily are the ones either leading or surrounding the city centre. On the other hand, as the filter is risen to 70,000 vehicles per day, only the axis that goes from south to north is displayed. It is important to note that this road not only acts as an entrance to the city, but it is also part of the European highway E45. The highway E45 crosses Europe from Italy to Finland, and it is a relevant transport axis in the continent. Therefore, it can be observable how traffic increases the closer the roads are to the city centre. On the other

hand, it is also of essence to review whether the number of cars in these roads have increased or decreased over time. To that end, data provided by Göteborg Stad (n.d.) has been used to see the historical evolution of traffic in different roads leading to the city centre. The data available for each road varies, some of them just having data for specific years, while most of them have information for every year during the last 4 decades. This data is presented in Figure 10, and it clearly shows that traffic in all the city centre entrances has been steadily increasing since the eighties, except Dag Hammarskjödsleden, which has decreased overtime. In many of them there is a decrease in the years 2007-2009, probably caused by the economic crisis, and in others like Älvsborgsbron, there is a small decrease in 2013, which might be caused by the beginning of the congestion charge scheme that is described in the next section.

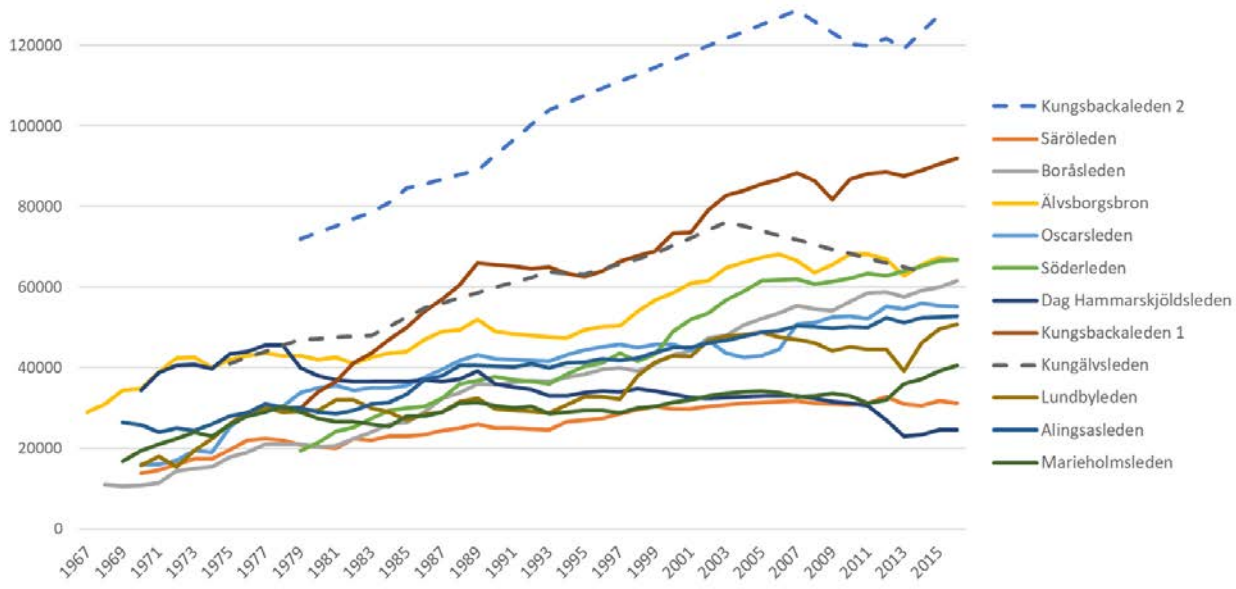

Figure 10 - Traffic evolution (AADT) in access roads to Gothenburg city centre | Data: (Göteborgs Stad, n.d.) | Own graphic

For the data related to Kungsbackleden 1 and Kungälvsleden 2, presented with dash lines, data for every year was not available, so the gaps were filled using linear mathematical formulas in order to make visualisation easier. Please refer to Appendix 4 for more information related to where each road is located, and also to see the table with all the data.

In conclusion, as Gothenburg main congestion problems are in the entrance of the city centre, the authors of this thesis believe that Park & Ride has a big potential to tackle this problem. By removing people from cars and promoting public transportation, the flows of these roads could be greatly improved overtime.

Congestion charge scheme

Included in a larger infrastructure investment package (Västsvenskapaketet), and to help finance it, a congestion charge was introduced in 2013. It is formed by a perimeter of different non-staffed tolls, that delimitate an area in Gothenburg's city centre. When a car crosses the toll, a camera reads the plate number and automatically charges his owner. The goal of the system is to encourage drivers to use public transport or bike, instead of the car (Börjesson and Kristoffersson, 2015). The system works from 6:00 to 18:30, and never on weekends, the day before a holiday or during July. The quantities to pay range from SEK 9 to SEK 22 (at the time of study, approx. 0.9 to 2.2€) per passage, with a maximum of SEK 60 per day. If a car crosses more than one toll in an hour, only the higher price will be paid (Transportstyrelsen, 2019). The scheme had a relevant effect on traffic intensity. In general terms, the traffic inside the congestion area ring decreased about a 12-13% in the charged hours and a 2% in the uncharged hours. (Börjesson and Kristoffersson, 2015).

The importance of this scheme relating to Park & Ride is that most of the parking lots are located outside the congestion charge area. Therefore, many commuters are willing to use the scheme in order to avoid paying the congestion fee.

Park & Ride system

The City of Gothenburg has a Park & Ride scheme, known as *Pendelparkering*, which means commuting parking in Swedish. Before doing the interviews with the experts, and by researching on the websites of both Göteborg Stad and Västtrafik, information about who has responsibility regarding the Park & Ride scheme was not available. For example, it was not possible to find who builds the new parking lots, who maintains them, and it was not easy to know who to contact regarding Park & Ride.

The municipality of Gothenburg has around 2,700 parking spots for Pendelparkering, distributed in 42 parking lots. The size of the parking varies greatly, from Eriksdal, with 392 spots, to Hornkamsgatan, with only 9 (Göteborgs Stad, 2019). Moreover, each of the other municipalities surrounding Gothenburg have their own commuting parking lots, but only a detailed list of the Gothenburg ones can be found. In order to create a list of all Pendelparking spots available in the region (Table 3), information from Västtrafik (2019b) and from all the surrounding municipalities' websites has been merged. To see the disaggregated list of Park & Ride sites in every municipality listed in Table 3, please refer to Appendix 5 (Ales kommun, 2019; Bollebygds Kommun, 2019;

Kungälvs Kommun, 2019; Marks kommun, 2019; Mölndals Kommun, 2019; Öckerös kommun, 2019; Stenungsunds kommun, 2019; Tjörns kommun, 2019).

To select the municipalities included in the list, the Göteborg++ region from Figure 8 was taken as a reference. In addition, it has been made sure to include all municipalities analysed in Figure 5, which represent the main origins from City Centre commuters living outside Gothenburg municipality.

Table 4 – Pendelparkering sites in the municipalities surrounding Gothenburg (Appendix 4)

Municipalities	Parking spots	Parking lots
Gothenburg	2700	42
Kungsbacka	1725	21
Lerum	1116	18
Härryda	819	14
Ale	696	9
Mölndal	547	7
Kungälv	508	6
Stenungsunds	413	8
Alingsås	401	9
Öckerö	274	3
Mark	271	11
Lilla Edet	212	4
Tjörn	173	4
Partille	153	6
Bollebygd	53	1
Total general	**10061**	**163**

As seen above, there are a total of 163 Pendelparkering lots, with up to 10,061 parking spots available for commuters. Most of them are built along the main corridors leading to Gothenburg and have express buses or commuter train connection. Nevertheless, other types of bus or even trams in some cases are used as the commuting method, which are normally slower, and thus, less attractive. There can be several parking lots under the same name, like Eriksdal (P1 and P2), or Delsjömotet (P1 to P4). As these parking lots are a few minutes away, they should be counted as only one parking lot each, decreasing the number of parking lots to 116. Of these, a 72% (84) have less than 100 spots, which might be not enough in some places. The biggest parking of the region is Hede Station, in Kungsbacka, with 754 parking spots, and connection to the southern commuter train (Kungsbackapendeln). The smallest ones are four parking lots with only 6 parking spots located in different municipalities. In Figure 11, a map with the Pendelparkering sites around Gothenburg is presented. For visualisation purposes, not all of the parking lots presented in Table

3 are shown. Nevertheless, it clearly shows how most of the Park & Ride sites are located nearby a main road or access to the city centre, although it is not always the case.

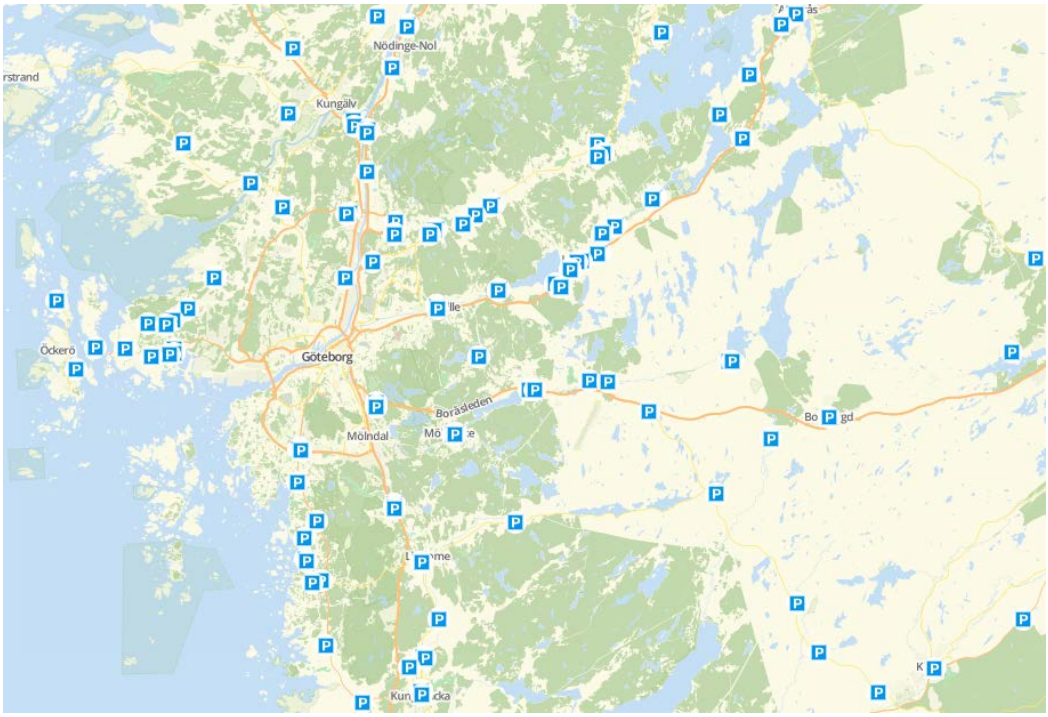

Figure 11 - Park & Ride in the Gothenburg region (Västtrafik, 2019b)

In general, most of the parking lots are Suburban and Intermodal Transit Centres. That is, they are normally built outside the city, and have either a bus stop, a bigger transport centre or are located next to a train station. Examples of Intermodal Transit Centres with train connection are Partille Station, Lerum Station or Lindome station, with most of them having a high number of parking spaces. On the other hand, there are also a few opportunistic lots, such as Amhult Resecentrum 2 or Bäckebol, both shopping malls but with Park & Ride spaces. Finally, only one Park & Pool site was found, Frillesås E6 (Kungsbacka), with capacity for 25 cars.

In the Gothenburg region, all Pendelparkering lots are free of charge. Depending on the municipality, they have different allowance of time in which the car can be parked there. In the case of Gothenburg municipality, for example, the cars can be in the parking lots up to 24h during weekdays. During the weekend, the users can leave it from Friday night to Monday morning without paying a fee (Göteborgs Stad, 2019). Currently, the users of Park & Ride do not benefit from specific public transport discounts. Plus, due to the different pricing zones described on Figure 8, many commuters living outside the Göteborg+ area travel every day to its border, in order to avoid paying more for the public transport card. Therefore, many of the parking lots next to the Göteborg+ border are normally full. The clearest example the people from Kungälv

(Göteborg++) that park at Eriksdal (Göteborg+), even if they have in their municipality parking lots with available space. (Liljedahl, 2018)

5.2 Västtrafik analysis of Park & Ride users

The following data was provided by Västtrafik (2018), and its origin is a research carried out by them on 2018. One critical aspect for a person to be a user of Park & Ride is that he must think that using the service will make him save time and/or money. Most of the users choose the Park & Ride facility that is the nearest to their house, but many others do not. The users mainly use it for commuting to their work and typically use it in classic working hours between 8 and 17. According to this research, some of the factors that impacts the usage of a given Park & Ride facility for a potential user are:

- Its proximity to the congestion tolls area
- Whether the frequency of public transport operations in the Park & Ride site is satisfying
- Whether there is a willingness to avoid the stress of traffic
- Whether there is a willingness to seek for the comfort of public transport

For an important part of the users, the question of whether they will find a free spot in the targeted Park & Ride facility is a daily moment of stress. This is because there is a limited time to get to the parking facility since it gets full around 8:00. Therefore, the user needs to think about which Park & Ride is the best to choose, which itself is a factor of stress. It also can cause anxiety on whether the user will get an acceptable spot in the Park & Ride. Many of the users drop their kids at school in the way between their homes and the parking lot, which reduces even more the time margin.

Västtrafik identifies several insights on how the users behave with the service. The first insight is that for them, adopting this multimodal transport solution is a habit. Users get used to a certain routine. When they realize that on a given day, they cannot use Park & Ride (e.g., the parking is full), they only have few other alternatives and generally they drive the whole way to the city centre. The usual journey is rarely planned by the Park & Ride users, and they value the fact that they do not have to actively prepare their journeys regularly. Indeed, being used to the routine, travellers using Park & Ride generally have in mind the schedule of the public transport mean they take after reaching the parking.

5.3 On-site observation and surveys in Park & Ride sites

During the realisation of this thesis, three visits were carried out to different Park & Ride facilities. The aim of two of these visits, to the parking lots of Eriksdal and Amhult Resecentrum 2, were to interview the users to gather their opinion on the service. In the case of Delsjömotet, the goal was to perform an on-site observation on how Pendelparkering works and to study the behaviour of the users. In this section, both the conclusions from the visit to Delsjömotet and from the opinion with users will be summarised.

The map below (Figure 12) indicates the positions of these three Park & Ride sites. The reason why these parking lots were chosen are diverse. First, Delsjömotet and Eriksdal are two of the biggest within the municipality, with 368 and 392 places respectively, and they are located in the border with neighbouring municipalities (Kungälv and Mölndal). Finally, Amhult is one of the few that are indoors, and it also has access to a supermarket. For more information about the parking sites, when the visits were carried out, etc, please refer to Appendix 5.

Figure 12 - Map of Gothenburg indicating the location of the visited Park & Ride sites (Google My Maps, 2019)

In the case of Delsjömotet, the observation on-site mainly permitted to show how the different parking lots (Delsjömotet is formed by 4) became full. It was observed that P1 and P2 were full by 7:00. As for the other parking lots, P3 was full at 7:55, and finally at 8:10 P4 was also full. In addition to that, it was interesting to see that there were cameras in the parking, but that their function was to count the number of cars to indicate to drivers whether the lots were full or how many places were still available. This mechanism has not been observed in the two other Park & Ride sites that were visited.

Other insights from this visit were seeing that some people did *Car and Pool*, which consists in people parking in the Park & Ride facility and then getting on the car of another person and drive together to the city centre by car. Interestingly, there was not a specific area to carpool, but users did the change wherever they could. Besides, it was observed that some people used the facilities to travel from Gothenburg towards other municipalities to the East.

Main findings from interviews with Park & Ride users

The following section will present a summary of the answers collected from the Park & Ride users at Amhult Resecentrum 2 and Eriksdal. The summary has been divided in the following topics: Usage of Park & Ride and satisfaction, the reasons of using Park & Ride and main issues with Park & Ride.

Usage of Park & Ride and satisfaction: Regular usage with a high level of satisfaction

All the users interviewed indicated that they have been using Park & Ride for a long period of time, from 6 months to 5 years. This shows that the users adopt a routine in the way they choose to commute to their jobs or activities. Likewise, it demonstrates that generally speaking, the users are satisfied since many of them have been regularly using the service over a long period of time. Most of the interviewed users declared that they were satisfied with the service. Particularly, in the case of Amhult Resecentrum 2, users were very happy to have the Park & Ride site shared with a supermarket parking, as they could do their shopping when coming back from work and then go home from there.

The reasons of using Park & Ride: Free service, convenience and environment

The absence of fees to park the car in the Park & Ride lots coupled with a satisfying connection to the city centre of Gothenburg are the main reasons why drivers use Park & Ride. Some users specifically mentioned the congestion tolls or the price for parking in the city centre that discourage them to drive all the way there. In addition, the comfort of public transportation and the avoidance of stress related to car traffic were also important factors inciting the usage of Park & Ride. Environmental motivations by reducing gas emissions was to a lesser extent also mentioned by some of the users, but did not appear to be the main reason to use Park & Ride.

Main issues with Park & Ride: Lack of space and safety

Many of the users interviewed mentioned the lack of space as being the primary issue with the system. They do not think that authorities have been particularly improving the Park & Ride service in the last years. In particular, after the usual starting office hour in the morning after 8:00,

it is not possible to find free spots in many lots anymore, and if one needs to go to a meeting (e.g. with the doctor) after that time it is very difficult to use Park & Ride. It was mentioned that some drivers park their car illegally especially when they arrive in the morning at a time when the parking is already full, and that they can get fines for this, especially if they block access. In addition, some users mentioned safety issues, as they are concerned about it, in particular if they leave their cars overnight in the Park & Ride lots. There is also the case of users who have night work shifts and have to use Park & Ride and who do not always feel safe when there are groups of people meeting in the parking at night. Some users suggest that more lights could be installed and that could help users feel safer.

5.4 Interviews with experts

Other main pillars of the thesis are the interviews with several experts and organisations involved, that were introduced in Table 2. In order to describe the interviews, common topics present in all of them have been identified. The topics are as it follows: Park & Ride as a method of reducing congestion, Park & Ride pricing, Parking lots size, Safety, Future trends, Cooperation between organisations and Challenges.

In this section, a summary of the different topics is presented. More specific information about the interviews, the dates, including the role of the people interviewed, their opinion on each topic, etc, can be found in Appendix 7.

Park & Ride as a method of reducing congestion

All of them agreed that Park & Ride is a good solution for reducing traffic congestion, avoiding many cars entering the city centre. Nevertheless, most of them argued that authorities should do more to promote it, offering more parking lots and better and faster connections.

Some of them defended that people still need to have a car depending on their family situation, for example to take their kids to school. However, they add that Park & Ride offers a flexible way of having both the comfort of using the car and at the same time avoid the nuisance of taking it to the city centre. Also, they are mostly in favour of using soft-policies to make people going to the city centre, rather than just forcing them to stop.

Park & Ride pricing

In relation to this topic, there is not a unanimous opinion. The first important fact learned from these interviews is that the municipality owns the parking sites, and that they are financed by

national government grants. Therefore, by law, the municipality is not allowed to control who uses the parking lots, and neither to charge for using the service.

Considering this, they all realise that users value that the service is for free, but they also state that building parking lots has a cost, even if it is in low-value land. Another proposal laid out by some of them was that maybe a small fee should be implemented in order to maintain and improve the service.

Size of the parking lots

One of the main proposals to deal with the lack of land is making double-decked parking lots. Nevertheless, most of them also agree that doing so would be very expensive, which would not be compatible with the current free model. It was also agreed that there is not an ideal size for the parking sites, as it depends on the area, and sometimes many small parking lots are preferred to have few big ones.

On the other hand, the use of opportunistic lots appears as an option both from the organisations involved and the independent experts. They propose that parking lots of shopping malls, such as Frölunda Torg and other supermarkets, are used as Pendelparkering. This would benefit both the Park & Ride scheme and the businesses, as they would attract clients. In Gothenburg, this system is already used in certain parking sites, such as Bäckebol or Amhult Resecentrum 2.

Safety

Although there is a concern for the security of the parking lots, as many users reflected, there are not many things that the municipality can do to solve them with the actual situation. The ideal measure would be to have fenced parking lots, and control the access, but as said before this is not possible since they need to be open to everyone due to the government grants.

The municipality and Västtrafik are now focusing in improving the illumination of the sites, as well as building them closer to the main roads, which would have a psychological effect on both users and thieves. On the other hand, the installation of cameras is also an option, but in Sweden the legislation in this matter is very restrictive. Other experts propose to have guarded parking lots, but this would certainly increase the cost of the Park & Ride scheme.

Future trends

In a general scope of reducing congestion, Autonomous Driving was mentioned several times, although they agree that it will take time before they start driving around cities. As for its effect on Park & Ride, its consequences are unclear, because the car could leave the users in the bus stop and go back home to park. Therefore, the parking lots would not be necessary. It was also mentioned that Gothenburg is now transitioning from a radial towards a circular network regarding public transport, which will allow users to go around the city centre instead of going through it.

In terms of the Pendelparkering service, the main potential disruptive change would be the involvement of Parkering Bolaget in the business, as it would affect the pricing of Park & Ride, but probably offering a better and more attractive service. Other important fact in the upcoming years would be having more *Smarta Pendelparkering*, which have cameras that count the number of spaces available at each site. Then, this information could be offered to the users so they can optimise their journey. They all defended the use of cheap technology to improve the service.

Cooperation between organisations

They also state that collaboration among the different authorities is essential to reduce traffic congestion. The organisations meet regularly to address traffic issues, especially now that there are a lot of ongoing projects happening. Moreover, when it comes to public transport, there are many crossed interests among the authorities, especially municipalities, and it is complex for Västtrafik to coordinate all of it. Plus, all the organisations that manage traffic, public transport and Park & Ride are public owned, which means that they depend also on the political willingness of each term's government.

One of the insights confirmed during the interviews is that Gothenburg, until now, has lacked a clear long-term strategy in relation with Park & Ride. The responsibilities of each party are not clear, as it is Västtrafik the one managing the parking lots, but they are owned by Göteborgs Stad. Nevertheless, both organisations are now coordinating more to have clearer attributions and achieve a solid strategy for Pendelparkering for the upcoming years.

Challenges

All the interviewees agree that the main challenge for the development of Park & Ride in Gothenburg is the land scarcity. Since the most suitable land for Park & Ride is the one located near the main roads outside the city, these are also the ones that are most valuable for new housing and office projects. Since many of these projects are scheduled to start in a few years, one proposal

from the interviews was to use this land in the meantime as a temporary parking lot. Furthermore, it is difficult to identify those areas where there is more demand for Park & Ride lots and how to expand them if there is not space available.

Another main challenge identified is that authorities need to clearly define what goal is. For example, whether they want to reduce costs, to have a better mobility or to prioritise reducing traffic.

Other issues

Like among Gothenburg population, there is not a clear position among the interviewees regarding the congestion tolls. Some of them defended the system arguing that although the traffic is at the same levels than before its introduction, it would be higher if it was not in place. On the other hand, the opposing group believes that when it comes to reduce the number of cars in the city centre, soft-policy measures should be prioritised. It was also confirmed that most of the Park & Ride lots started to be full after the congestion charge was introduced.

5.5 Implications of the results

The aim of this section was first to clearly lay out a general analysis of traffic in Gothenburg, how the Park & Ride system works in Gothenburg and how the parking lots are distributed. To that end, several sources were used, as such an analysis could not be found on existing research. The purpose of this part was also to acquire and present the knowledge necessary about the topics that were going to be addressed in the interviews.

Then, by combining the learnings from the Gothenburg study and the ones from the theoretical framework, several interviews were carried out with organisations involved in traffic and Park & Ride management in Gothenburg, plus with Park & Ride users. The usefulness of these interviews consists in filling the gaps detected in both the theoretical and the Gothenburg case parts, as well as gathering more data for the discussion in the analysis part.

Also, this section arose other important topics that should be included in the analysis part, adding up to the ones identified in the theoretical framework. These new items are the cooperation between organisations and the concern around safety in the Park & Ride lots in Gothenburg.

6 Analysis

In this section, the aim will be to summarise all the knowledge acquired during the realisation of the thesis, trying to outline the future of Park & Ride in Gothenburg and proposing different ideas that could improve the service. The different aspects that will be analysed originate from the *Implications of the theoretical framework* and the *Implications of the results* sections, and are listed as it follows: Park & Ride usefulness in reducing traffic congestion, cooperation between organisations, safety, business model, pricing, future and impact of technology and attracting new Park & Ride users.

6.1 Park & Ride usefulness in reducing traffic congestion

The conclusion drawn from collected data, different findings from the literature and contacted experts is that Park & Ride in Gothenburg has a non-negligible impact on congestion. Indeed, available capacity with 10,000 lots for Gothenburg and the municipalities surrounding it (e.g. Mölndal, Kungsbacka, Lerum, Partille etc.), totalizes 45% of the 28,000 daily work commuters to the city centre of Gothenburg, who could represent the pool of potential Park & Ride users. But it seems that the system has reached its limit, because the demand for Park & Ride lots is clearly higher than the offer, and space to build more parking lots is becoming scarce. In addition, the general tendency is that number of cars have been continuously increasing in Sweden (Transport Analysis, 2019), even though it seems that Gothenburg is becoming slightly less car-dependant as previously discussed. Also, other factors contribute to the current traffic patterns in Gothenburg municipality, mainly the taxes for congestion tolls during high peak traffic periods enforced in 2014, correlated with an increase of the Park & Ride usage. Future investments in public transportation and infrastructure, mainly in the context of the Västlanken project, will also play a major role in traffic patterns and how congestion will evolve. Therefore, Park & Ride is and will be playing its function but it will do it as a complement rather than a major role.

Presented as a solution specifically meant to help reduce traffic congestion, the literature has shown different positions on whether Park & Ride has or not an impact in that phenomenon. Reducing traffic congestion in a substantial way only by using Park & Ride would imply unreasonable investments in tens of thousands additional parking lots. This scenario is not likely to happen, because the space available for building more Park & Ride sites is becoming rarer, with projects for building more offices and houses being undertaken or prioritized. Another scenario would be to build parking garages that would have a higher capacity, but the discussions with

involved organizations showed that this is also an unlikely scenario because of the very important investments necessary.

Nevertheless, this does not imply that Park & Ride is not important, for several reasons. The first one is that the relation between the number of cars in traffic and the average speed of cars during congestion (the lower the average speed is, the more congestion is generated) is not linear. In other words, reducing the number of cars during peak hours even by a little can have a bigger impact than intuitively expected. The other reason is that a policy encouraging Park & Ride helps improving accessibility for people. Contacted by email, the previous director of the Transport Administration in the City of Stockholm and professor Jonas Eliasson strongly advocates for Park & Ride despite its limited impact on traffic gridlocks. Indeed, he considers that it is highly important to support a policy that improves accessibility, even though its impact on congestion is limited (Eliasson, 2019).

6.2 Cooperation between organisations

The way different actors cooperate and organize themselves to provide the Park & Ride service plays an important role. Without an efficient cooperation between these actors, we can expect that this will likely impact negatively the time and investment necessary in the construction of new Park & Ride sites. Our discussion with Trafikkontoret clearly shows that politicians are currently asking to build more Park & Ride sites in the Gothenburg region. Potentially, in the five coming years, there could be 1,000 additional spots, but this number has been given for information purposes only. Therefore, the first key point to consider here is the role politicians play in the decision-making process in regard with Park & Ride. This does not come as a surprise by itself, and it is actually in line with what the users were expressing, i.e. more space with more Park & Ride sites available. But one can still question on whether this is the best way to approach this matter, because of potential conflict of interests between what could appear to be political popular decision in the short-term (building more Park & Ride sites) and what are the needs in the long-term. For example, the role of independent experts in having more weight in these types of decisions could be discussed.

It has appeared during the investigations made that there is currently a lack of a long-term Park & Ride strategy that takes into account the future needs, considering different aspects (e.g. the impact of autonomous driving). This lack of strategy concerning Park & Ride is the other key point regarding the way this service is provided and how actors cooperate together. If it appears now that there is a shortage of Park & Ride sites and that people and politicians would like to have

more of these in the short-term, this does not imply that in the long run this will still be the case. Nonetheless, it seems that the idea of having a more comprehensive strategy and approach is beginning to emerge. Trafikkontoret created a new job position this year to centralize and coordinate the different tasks related to Park & Ride within Traffikontoret and with other organizations involved. Västtrafik, that plays the crucial role of providing good transit in Park & Ride sites to make them attractive, has recently started a group work with different organisations (Trafikkontoret, P-Bolaget). Maybe the politicians can here play a role by ensuring in a clearer way who is responsible for what in providing an attractive Park & Ride service, as it seemed to be an unsettled question at least until recently. For example, so far, the role of P-Bolaget in regard with Park & Ride remains unclear and undefined, even if there is an interest from this organization. But this could imply lots of changes, for example in the pricing, when Park & Ride is currently offered as a free service.

In general, the cooperation between involved organizations needs to increase. This is especially the case at the moment, because there is an important amount of infrastructure and building projects happening in Gothenburg, in the context of the *Västsvenska Paketet*. Of course, such cooperation currently exists, and Trafikkontoret extensively works with Trafikverket, that undertakes the infrastructure projects related to transport. What is needed, however, is a more structured cooperation between more actors with improved coordination, as well as a holistic strategy that will consider the needs in the long-term. Especially, convincing the municipalities around Gothenburg is also important, because ultimately, they can constitute a bottleneck for Park & Ride if they already decided to prioritize on other projects (e.g. building offices or houses). So, the way they are informed about the funds available and who conducts the meetings with them to find new Park & Ride sites will likely impact the projects to build more of these sites.

6.3 Safety

Generally speaking, most of the users interviewed by the authors said they feel safe when using Park & Ride. Generally, these are users who use Park & Ride at regular working hour times, between 8 and 17. But some users said they feel a lack a security for themselves or their cars. These are users who could, from time to time, leave their cars in the night at the parking lot, or the ones who actually use Park & Ride at that time because they work during the night. These problems of safety in Gothenburg's Park & Ride sites have been documented already since the mid-2000's and are mainly about vandalized or stolen cars. It appears that there have not been any strong actions taken to improve the safety of Park & Ride in Gothenburg in the last years.

Providing a safe Park & Ride is a pre-requisite for this service to be attractive. Several solutions exist to improve safety in the parking lots. More lights can be installed to make sure that all the sites are well lit at night or early in the morning. Security cameras can also be installed, as the only cameras observed on-site have the only purpose to count the cars. However, legal barriers complicate the process, but there is a willingness to install few cameras in specific Park & Ride sites such as in Storås, as explained by Trafikkontoret. As suggested by one of the interviewed experts, having guards can also be a solution and an alternative to the cameras that could maybe be perceived as less intrusive by people. The main issue with having guards is that having them at night when only very few people use Park & Ride can be expensive, while most of the theft cases and the lack of safety feeling occur at that time. Finally, an important number of people use bikes, and if bikes should be more integrated in Park & Ride they could be protected by locked garage, which would encourage their usage more, as suggested by Västtrafik. In addition to have a strategy to tackle the safety situation, having more statistics on the matter can be useful, in order to know how the situation has been evolving lately and be able to take more adapted actions.

6.4 Business model

It has become clear to the authors that the Park & Ride scheme in Gothenburg needs a clear strategy in the upcoming years, and that changes on the scheme are needed to continue attracting users to use it.

First of all, when it comes to the location to the parking lots, it is very important that these are located in the main roads entering the city centre, allowing a faster connection between the parking lot and the city centre. Taking as an example the case of Calgary, train connections seem the best way to facilitate users' commuting. As seen before, in the Canadian city almost every Park & Ride site was located along the train routes. In the case of Gothenburg, the three commuting lines connecting South, East and North with the city centre need to play a more important role, especially considering the construction of Västlanken, an ambitious infrastructure project set to be completed by 2026. It is formed by three underground train stations in the centre of Gothenburg that will connect the north line with the south, and that will make commuting even easier to different points of the city, instead of travelling always to the Central Station. Therefore, the use of Intermodal Transit Centres with Park & Ride parking lots is highly recommended to reduce the travel time from neighbouring municipalities. In the case of those areas without train connection, the users of Park & Ride are very satisfied with the Express Buses, which should be promoted, and also by having bus lanes in the accesses to the city, which allows passengers to skip the congestion caused by cars.

In addition, it is essential to analyse where to build the parking lots, relating to the origin and destination of trips. Assuming that most of the trips are towards Gothenburg city centre, it is clear that many of the users travel as close as possible to the city, as that way they avoid paying the more expensive transport card. This issue not only saturates the parking lots that are closest to the city and outside the congestion toll, but also increases the Vehicle-Km Travelled (VKT), making the whole Park & Ride scheme inefficient. Accordingly, the municipalities need to find a way for travellers to use the Park & Ride sites near to their home, instead of the ones that are the closest to the city. The ideal solution for this would be to have a unique public transport price for all the region, like it happens in Stockholm, but this is unlikely to happen in a near future. Nonetheless, the authorities do not have a clear solution for this issue, and it rests to be seen the impact that the new public transport zones will have on Park & Ride usage, as it will reduce the difference of price for people commuting between municipalities. Plus, it is probable that in many cases, the users spend more money in gasoline or car maintenance to go all the way to the Gothenburg municipality than they would do if they took the more expensive transport card. Accordingly, it is important to find a way to demonstrate the users which way is cheaper for them.

Next, the size of the parking lots has been also an important aspect throughout this thesis, having different opinions from the experts. A thing remains clear and it is the lack of spaces that users experience in many of the parking lots. It seems that by having bigger parking lots, apart from solving this issue, the number of users would increase and, therefore, more frequent routes could be put in service and more business would be interested in opening around these sites. Besides, it would allow authorities to install bike-pooling and scooter services, as more people will use them.

Especially if bigger parking lots are desired, Parkering Bolaget involvement could open new perspectives. Currently, as learnt during the interviews, the municipalities can only build parking lots that are open for everyone. They do not have the option of controlling who uses the parking, for which use, and are very limited when installing safety solutions such as cameras. If these parking lots were managed by P-Bolaget this would change, as the space could be fenced thus increasing security and it would be possible to limit its use only to Park & Ride users. Plus, cameras and security guards could be present. Nevertheless, P-Bolaget is a for-profit organisation and, consequently, the service would probably not remain free.

Another important aspect is if these sites should be built or rented. Until now, most of them have been built by the municipalities in lands of their own. As said before, both parking lots at Amhult and Bäckebol are opportunistic lots rented to a supermarket and a shopping centre,

respectively. As the city keeps changing, and since Park & Ride sites cannot be planned with a life-span of 20 years, increasing the number of opportunistic lots is very interesting. By doing so, the municipalities save in building costs, the new spots are available as soon as the contract is signed, and the shopping centres benefit from attracting users every day of the week. Plus, from the surveys carried out in Amhult, users feel very happy about having the supermarket on their way back home.

6.5 Pricing: Should it be free?

The pricing of the Park & Ride service will probably be one of the main points in the public discussion in the upcoming years relating to the service. Whether the service should remain free or if users will pay, it is an essential topic when talking about the future of Park & Ride in Gothenburg. Building parking lots, maintaining them, installing cameras, etc, has a cost, and perhaps, like in many other cities, the users should pay for it.

On one hand, the current success and satisfaction of the users with the service has its main reason in it being free-of-charge, as most of the people said in the surveys conducted during this research. It is true that parking lots have associated costs, but there is also an external benefit from the cars avoided every day in the city centre, as the air pollution is reduced, delays are less, improves noise, etc. Accordingly, it could be thought that these benefits are a way of 'paying' for the Park & Ride sites. Plus, making the users pay for the service could cause a great decrease in the number of users and increase road traffic to the city centre. Also, this would decrease their acquisitive power by adding one more expense to their accounts, either the congestion tolls or the parking rent.

On the other hand, some experts argue that the service cannot be for free. The revenues of implementing a Park & Ride fee could be used to build bigger parking lots, double-decked, and with better security systems, even guarded. Most of the limitations associated with the service could be solved by applying a reduced charge. Still, the amount charged for using the Park & Ride lots should be inferior than the cost of going by car to the city centre, that is, less than the addition of the congestion tolls and the parking rent in the city centre. In this model, Parkering Bolaget would play a main role, as they are the ones with the authority of building such facilities and charge for the parking. Besides, many cities charge for their scheme. As seen before, other cities like the ones analysed charge for the parking spaces one way or another, offering different options depending on the city. In Stockholm, there are some parking lots that are free if the users access

them with the public transport card, proving that they are actually using the Park & Ride service for what it has been conceived (Stockholm Parkering, 2019).

Another intermediate option is to have a limited number of parking spaces available for pre-booking, like it exists in other cities. (The Hague, 2019). This would offer the option to commuters to rent a place and have the assurance that they would find a space when they get there. As seen in the Rotterdam analysis, a similar system is in place there, paying approximately 56€ per month, and ensuring that even if they go to the parking lot at the last minute, they will have a space. Instead of a monthly fee, the authors thought about a daily one, in a way that when the user knows that he/she will run late, can book it from home and pay for the day. This system gives the user the option to pay for the service, and the money raised from these paying users could be used to make the parking lots better overall.

6.6 Future and Impact of technology

Apart from the role that Parkering Bolaget might play in the near future, and the amount of parking spots being built at the moment, another important aspect that will affect the operations of Park & Ride in the medium-term is the new public transport network. It is expected that by 2035 the public transport network has transitioned from a radial scheme, in which all the transit goes through the city centre, towards a circular one, that allows the users to switch between several concentric circles, depending on their destination. This new system helps avoiding entering the city centre and makes it easier to communicate opposite points in the map. Plus, the rail and the express buses (which will be called Metrobusses) are expected to have a more important role in the city's mobility. When it comes to Park & Ride, this new system is expected to make public transit more attractive, and by having parking lots in functional places, the number of users is expected to increase.

On the other hand, like almost every activity, Park & Ride has already been and will likely to continue to be impacted by technology. One important concept already in place is the so-called *Smarta Pendelparkering*, which has been applied to several parking lots in the city and that counts the number of cars parked and the number of spots available, as seen in Eriksdal. As Marie Albihn said, this concept should be expanded to many more parking lots, and make it easier to users to access this information, as now it is only available through the website travel planner. Related to this tool, even though it does display the locations of the Park & Ride sites, it does not include them in the routes, which does not help to promote the scheme.

On the other hand, one of the most recurring concepts during the conversations with people for this thesis was *Autonomous Driving*. Many people think that this technology will solve the congestion problem in cities, but it could actually increase it, as there would be in the cities many empty cars driving around looking for parking space, for example. On the other hand, how it will impact the Park & Ride scheme is still to be seen. It is possible to imagine a family with two kids that get on the car in the morning, the car leaves the kids in the school, the parents in the bus stop, and goes back home to park. In this situation, the need for parking next to the bus stop seems unnecessary, but rather an area to get on/get off for people might be needed. Besides, if these autonomous cars were shared, and people could call them like a taxi, the parking lots could be used for these cars while they are not being used. Nevertheless, this scenario is still years away, as it will take time before autonomous cars are prepared to drive on common streets.

After the observations realised in Eriksdal, Amhult Resecentrum and Delsjönmotet, it became clear that a majority of the commuters drive to the parking alone, therefore taking one parking space per person. During the collaboration of the authors with Coboom, by using a Design Thinking approach and following an innovation management software process, a solution adapted to the needs of Park & Ride was elaborated. It consists in an app that would allow commuters from the same neighbourhood to share the trip to the parking lot, consequently increasing the capacity of the parking lots without any infrastructure investment. If only the average people per car increased to two, the places available would already double. Apart from this feature, the app would also offer the spaces available in each parking, recommend the best parking lot to go, or include the CO_2 and money saved by using Park & Ride instead of the car to travel to the city centre. The technology needed for developing this app is available, should be cheap and it would enhance greatly the service.

6.7 Attracting new Park & Ride users

Although there is not clear data available about the number of users in the different Park & Ride sites, after all the research done, it can be said that many of them are usually full. Accordingly, it would not make sense to try to attract new users, as there is not enough space for them. Nevertheless, many of the parking lots have not reached yet their maximum capacity and could receive more commuters.

It is not an easy task to target the potential users of Park & Ride and convince them to stop driving the car to the city centre. Besides, a continuous incentive in form of free or cheaper public transport card, although it might be effective to increase Park & Ride use, would not be fair to the

commuters that do not use the car at all, and could even make these people stop doing so in favour of using Park & Ride.

Nevertheless, by applying soft-policy programs, it could be possible to convince car commuters to switch to intermodal transport. In the interviews with Gunnar Lanner and Marie Albihn it was mentioned a program that Västtrafik used to have to attract people to use public transport instead of the car to commute. In this program, they offered them a limited number of free months to try it, experience the service first-hand and hopefully, they would remain using it afterwards. In the case of Park & Ride, it would be possible to apply personalized travel planning, in which travel assistants go to the commuters' house and help them choose the best route and mode to go to their workplace. Apart from this personalised attention, the user would receive a free month of public transport, so he/she would do the personalised trip and see how it works. Even if many of them return to use their car, attracting a significant share of the targeted people to keep using Park & Ride after the trial can make a difference.

7 Conclusions

During the realisation of this thesis, it has become clear that Park & Ride is a good way of reducing traffic congestion in Gothenburg. It is true that the optimal solution would be that people commute by public transport from their homes, but Park & Ride offers a middle-ground alternative. It could help decreasing congestion, delays and pollution in the city centre, although on the negative side, it might increase it in the outskirts of the city.

Despite the positive aspects that Park & Ride has, the scheme in Gothenburg is reaching its limit, as in many parking lots there are not enough parking places, and the users need to hurry in the mornings to reach the sites. This is partially due to a lack of coordination when developing Park & Ride during the last decades and to not have clear attributions for each stakeholder involved. Consequently, the priority is that the different authorities (Göteborgs Stad, Västtrafik, P-Bolaget and politicians) collaborate together and define a clear *Pendelparkering* strategy for the upcoming years, specifying the responsibilities of each party. Several topics need to be dealt with while developing this strategy, namely the pricing and safety. In the case of the pricing, it is a discussion that cannot be delayed anymore. The scheme needs to evolve and offer a better service to the users, and this cannot be done without investing more money in it. Whether this money comes from the public treasury, from the pockets of the users or from other origins, it needs to be decided soon. On the other hand, safety is one of the main concerns of Park & Ride users when they leave their car in the sites during the day and especially, overnight. Nonetheless, improving safety also requires investment in cameras, security staff, enclosing the areas, etc, which leads back to the discussion about pricing.

Another important topic about Park & Ride is how to tackle the lack of space in parking lots. The optimal lands for new parking lots are those located close to main roads and accesses to the city. These lands are currently very valuable for the municipalities to build houses and offices, and this relegates Park & Ride to a second priority level. Many times, these lands are not going to be used in the next 10 years, but for different reasons they will remain unused for a decade instead of being used during this time as a temporary Park & Ride site. Nevertheless, although building more might seem the best idea, during the analysis part it was said that it could be theoretically possible to offer the users an app that would allow them to share the trip from home to the parking. This would allow more commuters to use the service without infrastructure investment. Additionally, using opportunistic parking lots could be a solution in the short and medium-term to increase the capacity of Park & Ride without needing big investments or time to build new sites.

Moreover, when planning where to build a Park & Ride site, it is essential that it is done not only according on where the available land is, but also the public transport connections that the location would allow. Users really value the time that they need to reach the city centre is minimum, and the only transports that can do so are the commuter trains and the Express Buses, so these are the modes that should be prioritized to connect the parking lots with the city centre. But, then again, it is necessary to include Västtrafik in the conversations when planning new constructions or when renting up a space. A good example of this is Bäckebol, a big commercial area in which there are 80 pendelparkering spaces, but the bus connection is insufficient.

When it comes to the use of Park & Ride, one deficiency that the authors have detected in the case of Gothenburg is the data offered to the users and decision-makers. In the visit to Delsjönsmotet, the live information provided on the screens is very useful for the drivers, as they could see on their way to the parking if there were available spots or not. Nevertheless, this information is only offered in a few Park & Ride sites, and the access to the data is not that easy. An app that would contain all this information, as well as recommend the users which parking to go, and offer different statistics by utilising data mining, could enhance the users' experience greatly. On the other hand, having this live information could also be used by decision-makers to evaluate which areas have a higher demand, which parking lots are not big enough, which ones are not necessary, etc. Ultimately, monitoring the parking lots would help balancing the whole Park & Ride network and benefit both the users, the authorities and the citizens.

Finally, assuming that measures are taken to guarantee that there are enough parking spaces for all the Park & Ride users, the authorities will have to focus in attracting more users and avoid them entering the city centre. To that end, a soft-policy approach looks like the best idea, as people usually follow a routine and do what is the most comfortable for them. If the commuters were to be incentivised to change this routine and try a new one, it might happen that after a while, they get used to it and decide to use Park & Ride instead of commuting by car to the city centre.

In conclusion, Park & Ride is a good option to reduce the number of cars present in the city centre of Gothenburg, obtaining environmental and economic benefits for society. The system is already in place, which is a great advantage, and it would require of adjusting it to improve the service greatly and enhance its use.

Future research

This thesis offers an analysis of the Park & Ride scheme in Gothenburg, which until now had been little researched. The authors believe that this could help future researchers to understand

how the system works, how the different actors are involved in the management of Pendelparkering, and what are the plans for the upcoming years. In addition, when doing the thesis, a lack of information relating all the parking sites in the region was found, and it is presented in this thesis after gathering it from several sources. This information could be very valuable to further investigate the network of parking lots, and even for more technical research involving routing systems or network optimisation. Other topics that could be researched are the impact that cameras or guards might have on safety perception, the application of technology to improve the service, a more extensive analysis on a business model proposal or creating a framework for cooperation between the organisations involved. In a more mathematical area, it would be possible to research where should Park & Ride sites be located, including variables like where do people live, where do people work, public transit connections, etc.

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Appendix 1 – Importance of reducing congestion

Apart from disrupting people's daily routines, congestion has other effects in the environment, the consumption of fuel and the economy of both people and businesses.

Environment

From an environmental point of view, cars have a direct effect in the life of citizens in two different ways: By polluting the air, and by generating noise. As explained next, these two factors have a great impact not only on the people's daily life, but also in their health.

Air

When used, cars produce a series of emissions that have an impact in the air quality of cities, and in the Earth ecosystem. Therefore, there are two main reasons why car use must be reduced, encouraging instead the use of more sustainable transport modes: Greenhouse Effect and Air Pollution.

Greenhouse Effect is the increase of temperature on the earth's surface due to an excess of specific gases in the atmosphere that act as a screen, blocking the heat that is being radiated back out to space. This effect is the main responsible of Climate Change. The gases responsible are known as Greenhouse Gases (GHG) and some of the most important ones are Carbon Dioxide (CO_2), Methane (CH_4) and Chlorofluorocarbon (CFCs) (Ali, 2013).

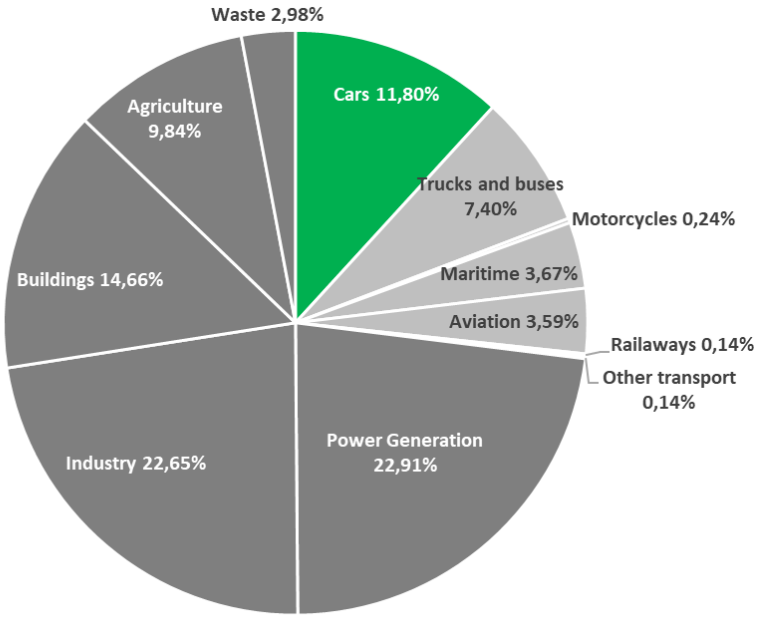

Figure 13 - Greenhouse Gas emissions by economic activity in the European Union. Transport sector is shown disclosed (European Environment Agency, 2016a; Transport and Environment Federation, 2018)

According to the Transport and Environment Federation (2018), with data from the European Environment Agency (EEA), and displayed in Figure 16, transport accounted in 2016 for 27% of total GHG, of which around a 41% correspond to passenger cars, meaning that more than 11% of the total GHG emissions in the European Union are caused by cars.

Another aspect that needs to be considered is that GHG emissions from transport have experienced an almost continuous increasing trend since 1990, on the opposite of the rest of the economic activities, that have reduced their impact on environment. As seen in Figure 14, transport is the only sector that has increased its emissions in the last 29 years together with Biomass, which is not officially included in the national measures (European Environment Agency, 2016b).

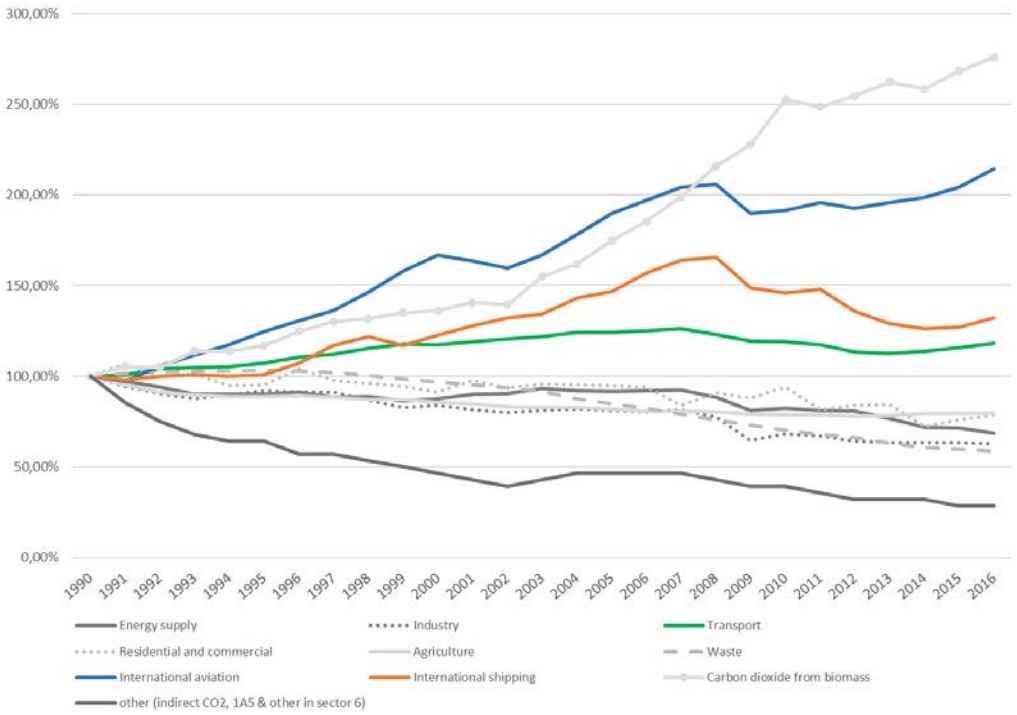

Figure 14 - Evolution of GHG emissions in different economic activities. Baseline = 1990 (European Environment Agency, 2016b)

Mainly, from the global freight perspective, this constant increase in transport emissions is due to an escalation in transport demand, a constant economic growth and globalisation, which makes journeys from origin to destination longer, and that affect especially shipping (McKinnon et al., 2012). On the other hand, in a more local scale, the increase in urbanization has caused an increase in urban sprawl, increasing Vehicle-Miles Traveled (VMTs) and emissions (Lafourcade and Blaudin de Thé, 2016).

On the other hand, air pollution is the other main environmental effect of transport. According to the World Health Organization, around 4.2 million people die every year because of exposure to air pollution, causing heart diseases, strokes, respiratory diseases or lung cancer. Plus, around 91% of the global population live exposed to higher pollution levels than recommended (WHO, 2019). Combustion engines are responsible for contributing to several air pollutant, like ground-level Ozone, NOx and Particulate Matters (MP) (Levy et al., 2017). As observed in Figure 15, road transport is the main NOx pollutant, and has a significant share in CO or PMs, among others.

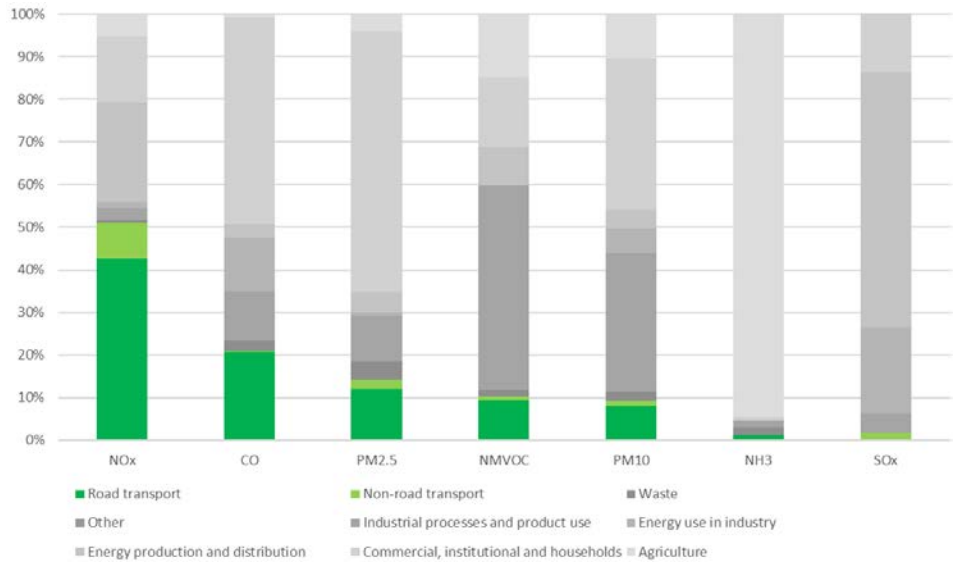

Figure 15 - Main air pollutants attribution to different sectors (European Environment Agency, 2015b)

The big share of cars in GHG emissions, the increasing emissions from the transport sector, and the big impact that air pollutants such as NOx or PMs have on human health. This are some of the aspects that demonstrate why it is important to reduce the number of cars in the road, if society wants to stop climate change and make the cities 'breathable' again.

Noise

Road traffic is the most important contributor to noise pollution in Europe. Recent data show that 100 million people in the EU are exposed to an average noise level of 55 decibels (dB) or higher due to road traffic, during the day, evening and night. This figure is 20 million for noise caused by railway, 4 million for aircraft and 1 million for industries. During the night, 75 million people are affected by noise from road traffic in the EU, making road transport also the biggest source of noise pollution in night time (European Environment Agency, 2018).

When exposed to considerable noise pollution, populations are under risk of stress reaction, worsening sleep quality, hypertension and cardiovascular diseases. The World Health Organization estimates that during the night, negative health effects can appear at noise levels of 40 decibels (dB). Noise pollution is estimated to be the cause of 10,000 early deaths in the European Union, a number that is thought to be largely underestimated (European Environment Agency, 2015a).

In addition to impacts on human health, noise pollution can harm terrestrial and marine wildlife. An important number of species rely on acoustic communication to look for food or a mate. This has direct implications on those species' population size and richness (European Environment Agency, 2015a).

In the EU, the main legal tool framing the monitoring and the development of actions on land-based noise emissions is the Environmental Noise Directive (END). Two principal indicators enabling the assessment of noise levels are used in accordance with the END's requirements (European Environment Agency, 2015a):

- (Lden): this is the indicator measuring the decibel level of 'annoyance' during the day, evening and night, for which the END sets a threshold of 55 dB.
- (Lnight): this is the indicator measuring the decibel level of 'sleep disturbance' during the night, for which the END sets a threshold of 50 dB.

The literature has extensively studied how the usage of cars and congestion impacted the environment.

It is interesting to remind what the concept of external costs is. Mayeres et al. (1996) define external costs as the costs that are supported by other people than the car user himself. They came up with a function model to determine what the marginal external costs could be in terms of noise level and air pollution for every additional car. Their conclusion is that the noise impact is much more considerable during off-peak hours rather than when congestion levels are high. It is explained by the fact that the noise disturbance from an extra car is higher during a calm moment than during periods of important traffic jams. In addition to that, they show that heavy vehicles cause a 10 times higher marginal external noise cost than personal cars (Mayeres et al., 1996). However, it should be considered that the numerical results shown in that paper are valid only for the case of the city of Brussels that has been studied in their paper and which has specific characteristics and policies in terms of speed imitations, for instance.

Fuel consumption

Another important aspect to consider is fuel consumption. It is difficult to classify this strictly as an environmental or economical consequence of traffic congestion, as it has implications in both fields.

In the environmental one, apart from the burning of fuel in the car itself (Tank-To-Wheel, TTW), fossil fuels generate emissions since their sourcing, which is known as Well-To-Tank (WTT). These emissions are those generated during the extraction, production, refining, generation and distribution of the energy necessary to source the fuels (McKinnon et al., 2012). In the case of road transport, the sector consumed 66% of the total consumption of petroleum, and the impact of sourcing petrol, diesel and biofuels equals around a 25-30% of the ones generated Tank-To-Wheel. This fact reflects the importance of reducing the consumption of fuel, not only because of the emissions while burning in combustion engines, but also because of the ones emitted since the extraction (Transport and Environment Federation, 2018).

On the other hand, it presents a direct impact to economy. Fossil fuels are imported in most countries of Europe, with a dependency rate of 54%, which means that more than half of the energy resources necessary are imported (European Commission, 2016). This dependency rises the prices of oil and directly impacts the budget of citizens and companies. In the case of the first ones, a monthly allocation for fuel must be assigned in order to be able to drive their cars, and this could be reduced by using other means of transport. On the companies' case, a reduced congestion would make trips more efficient and, therefore reduce the consumption of fuel in their operations. In both cases, the volatility of oil prices creates uncertainty on forecasting costs related to transport.

Economy

Apart from having an impact in environment, congestion also has impacts on both particular users' daily life and in the businesses' economy. One way of dividing the effects is by dividing them in First-order and Second-order impacts (Sweet, 2011).

In the case of first-order impacts, it refers to the impact that congestion has on the daily life of the citizens. Two main categories can be distinguished. The first one, called *Travel delay*, is the amount of extra travel time that drivers need to reach their destination. For example, there more congestion there is, the higher it will be the commuting time to their workplace. The second, is the *reliability of travel time*, which is caused by non-recurring congestion due to crashes or weather conditions, for example. Due to this unreliability, the driver must allocate more time than needed

for the trip in order to make it in time. Plus, this unreliability also causes an increase in travel time. It is very difficult to measure it, and a way is to compare travel time delays of both recurring and non-recurring congestion days (Sweet, 2011).

On the other hand, second-order impacts refer to those that are not an immediate effect of congestion, like travel delay, but rather analyses how congestion is affecting the geographical growth, competitiveness and the economic geographies. Several studies have proved that increasing congestion results in a lower employment growth, and that reducing congestion in roads would imply economic benefits. Sweet (2011) also discuss how congestion might impact 'the agglomeration theory', that stablishes that companies benefit from being close to each other. As these companies grow, and so it does their economic activity, more increases the congestions around this area, making the companies to move to less congested areas. On the other hand, as congestion and commuting time increases, the employees and companies will move to areas that allow commuting time to remain stable, which is known as *Employer and employee cosuburbanization* (Sweet, 2011).

In a different article, Sweet (2014) analyses 88 of the largest and most congested metropolitan areas (Metropolitan Statistical Areas – MSAs) in the United States with the aim of studying the relationship between congestion and economic activity. The study measures congestion in two ways: The first one, by using the travel delay as a KPI, whereas the second one uses the Average Daily Traffic (ADT) on the analysed freeways. The research concluded that, when congestion is measured as travel delay, higher congestion leads to a decrease in employment rate, but there is no relation with the productivity per worker. On the other hand, if congestion is measured as the increase in ADT, it leads to a decrease in employment rate and a decrease in the growth of productivity per worker. The research also stablishes from 35 to 37 hours of delay per commuter per year as the threshold at which congestion starts affecting employment growth (Sweet, 2014).

As for the impact of traffic congestion on local commerce, the literature on this matter is very limited and inconclusive. Measuring the effects of traffic reduction in stores' sales at a given point is normally carried out before and after implementing some measure (i.e. congestion charge). The effects of these measures are normally observed in the long-term and might be also affected by other circumstances like the economic situation, seasonal trends or even the weather. Still, some studies that have been carried out on this matter will be described briefly next.

The first case takes place in Edinburgh and evaluates the impact of a potential congestion charge in the city, that was to be implemented in 2006 and finally rejected on a referendum. The

research concluded that it would result in a reduction of shopping trips to the city centre. Nevertheless, the surveys carried out also concluded that the main reason was a lack of parking, and that by introducing the measure, accessibility to parking lots would be improved, traffic congestion would be reduced, and therefore, public transport performance increased, making the city centre more attractive to shoppers (Hu and Saleh, 2005).

In the second case, Quddus et al., (2007) did a research on the impact that London's congestion charge, which reduced car movement by 30%, had in the retailer John Lewis different stores in London. The research concludes that the store located inside the congestion charge area was the one most impacted by the system, with lower sales and shopping frequency. The surveys carried out also revealed that customers were not likely to spend more money in each visit as a result of the reduced frequency. However, the article also states that normally traffic management measures have a bigger impact on the short-term, and that pedestrianization normally reduces sales in the first place, but in the long-term makes the area more pleasant for shoppers (Quddus et al., 2007).

Finally, a Nordic consultancy company called Future Place Leadership, elaborated a report analysing the impact that pedestrianization had in different cities in which some streets were closed to car traffic. In the case of New York and London, the stores located in these streets saw an increase in turnover of 22% and 25%, respectively (Pere, 2017).

Appendix 2 – Interview guides

In this appendix, the interview guides for both experts and users, mentioned in the *Data collection* section (4.3), will be presented. It is important to remember that in the experts guide, this was adapted for each interview, doing some changes in the questions.

Expert interview guide

- Could you introduce yourself, what is your job at the organisation?
- What is the impact of congestion on Traffikkontoret activity and how do you address this issue?
- How would you describe traffic patterns in Gothenburg?
- What is your organisation strategy for the next 10 years related to reducing car use?
- How does Traffikkontoret cooperate with other stakeholders such as politicians, Västraffik or customers in order to reduce traffic congestion? Do you organise regular meetings?
- What do you think other public organisations can do to reduce traffic congestion?
- Västtrafik wants to double the number of users by 2025, reaching a 40% of trip share done by public transport. Do you think this is possible?
- What is your opinion about Park & Ride as a way of reducing traffic congestion?
- What has been done in the last years to make the scheme more attractive?
- Do you think there are enough parking spots for the users? Is there a plan for building new ones?
- Do you think that building bigger parking lots could create congestion around it?
- How would you solve the Gothenburg municipality border issue, where there are problems finding free parking? [People park at Eriksdal instead of Kungälv because the transport card is 400kr cheaper, and both parking are only 5 minutes away by car. So, there is no enough parking places at Eriksdal]
- It seems according to a survey from 2007 that customers are not satisfied with safety and security of their vehicles and bikes, and another requirement was a better protection against the weather. What has been done so far about this? Did you see an increase in the number of users? Were there more recent customers survey on this issue? (see document Attraktiva pendelparkering K2020 from august 2008)
- Is there currently any program to attract new users to use Park & Ride?
- If more parking places are built and the use of Park & Ride becomes more accessible and convenient, how can it be avoided that people that nowadays use public transport all the way

from origin to destination (Home to work, for example) start using Park&Ride (Car from home to the parking and then public transport to work)? This would be counterproductive.

- We saw that although there are some big Pendelparkering places, there are a lot of them that are very small, even less than 20 places. What do you think it is the ideal size of these parking lots, given that the bigger they are, the higher the demand of users, and the better the services (bus frequencies, bike stations, etc) can be? Why are not bigger parking places being built?
- In a recent visit to Amhult Resecentrum 2, people were really happy about having a Willys in the same building, as it was very convenient for them. Is this a strategy that Göteborg Stad wants to pursue? Integrate Pendelparkering in buildings that have associated services, such as supermarkets?

Users interview guide

- Are you a user of Park & Ride?
- What is your origin and destination? How long does it take door-to-door?
- Is your connexion by bus, tramway or train?
- How long have you been using the system?
- Why do you use Park & Ride? (e.g. cost, time, not owning a car, environment, etc)
- Would you say you are happy with Park & Ride?
- What are the things you like the most about it?
- What are the things you like the less? Main flaws
- Do you have any concern relating safety or weather conditions?
- Do you think authorities have been improving Park & Ride?
- What do you think can be done to improve Park & Ride?

Appendix 3 – Data from commuting

In the following Table (4), information of city centre workers can be found. The data specifies where do these people live. The total workers in the city centre is 93,680 people. Then, in the next level, the place of residence of these workers is displayed. The places that start with a series of numbers and are underlined (i.e. '002 Partille') correspond to other municipalities, whereas the rest are districts of the City of Gothenburg as explained on Figure 3 in section 5.1. The data was obtained from the statistics database of Göteborgs Stad (2015)

Table 5 – Where do city centre workers live

Place of work	Employees
Centrum	**93680**
Centrum	13463
Majorna-Linné	10075
Örgryte-Härlanda	9350
Lundby	6306
Askim-Frölunda-Högsbo	5895
1481 Mölndal	5875
Västra Göteborg	5113
000 Kungsbacka	4957
Västra Hisingen	4306
Norra Hisingen	3989
Östra Göteborg	3942
002 Partille	3516
1441 Lerum	3256
001 Härryda	3074
Angered	2701
1482 Kungälv	2336
1440 Ale	1765
1489 Alingsås	1355
015 Stenungsund	1033
007 Öckerö	612
1419 Tjörn	414
1462 Lilla Edet	319
Ospecificerat Göteborg	28

Appendix 4 – Data from different roads accessing Gothenburg

In this Appendix, the data shown in Figure 10 in the section 5.1 will be presented in Table 5. Before the table, a map with all the specific segments analysed in each road is presented, as the data for each item does not represent the whole road. In the first raw of the table it can be seen which number represents each segment of the map.

As for the table, the rows represent the years, while the columns are the different roads that were analysed for this thesis. The values correspond to the Annual Average Daily Traffic (AADT). Values shown in red were not available and were calculated by joining the two closest values in a straight line.

Figure 16 - Map with roads analysed

Table 6 – Traffic (AADT) in roads leading to Gothenburg city centre

	1	2	3	4	5	6	7	8	9	10	11	12
Year	Älvsborgsbron	Oscarsleden	Söderleden	Dag Hammarskjöldsleden	Kungsbackaleden 1	Boråsleden	Kungsbackaleden 2	Kungälvsleden	Lundbyleden	Alingsasleden	Marieholmsleden	Säröleden
2016	66800	55200	66700	24700	92000	61600			50700	52800	40500	31300
2015	67400	55300	66500	24700	90500	59900	127500		49500	52500	39100	31800
2014	65600	55900	65200	23500	88900	59200	123300	63800	46200	52400	37200	30700
2013	62800	54600	64000	23100	87500	57500	119100	64927,3	39200	51200	35900	31000
2012	66900	55200	62800	27000	88500	58800	121700	66054,5	44600	52400	32000	32900
2011	68200	52200	63400	30700	88200	58500	119900	67181,8	44600	49900	31200	31200
2010	68200	52800	62200	31200	86700	56300	120300	68309,1	45200	50200	33000	30800
2009	65600	52500	61400	31600	81700	54100	123100	69436,4	44100	49800	33700	31000
2008	63500	51100	60700	32400	86300	54600	125900	70563,6	46100	50100	33000	31200
2007	66600	50700	61900	33000	88300	55400	128700	71690,9	46900	50400	32900	31900
2006	68200	44500	61800	33000	86800	53600	126935,7	72818,2	47600	49200	33800	31700
2005	67400	42900	61600	33000	85500	52200	125171,4	73945,5	48800	48800	34200	31500
2004	66100	42600	58900	32800	83900	50500	123407,1	75072,7	48200	47800	34100	31200
2003	64700	43600	56700	32600	82800	47900	121642,9	76200	47800	46800	33600	30900
2002	61500	46800	53500	32500	79200	47300	119878,6	74225	46800	46200	33100	30500
2001	61000	44400	52000	32600	73500	44200	118114,3	72250	42800	45000	32100	29800
2000	58600	45700	49000	33400	73400	43200	116350,0	70275	43000	45000	31400	29800
1999	56700	45700	43400	34200	69000	41000	114585,7	68300	41300	43800	30500	30500
1998	53900	45000	41500	34800	67800	39200	112821,4	67000	38000	42400	30100	29600
1997	50400	45800	43500	34000	66400	39900	111057,1	65700	32300	41800	28900	28600
1996	50100	45100	41200	34200	64000	39600	109292,9	64400	32800	42200	29500	27500
1995	49300	44400	40400	33800	62600	38400	107528,6	63100	32800	41400	29500	27000
1994	47300	43200	38300	33100	63300	37600	105764,3	63400	30900	41100	29000	26700
1993	47500	41600	35900	33100	64900	36600	104000	63700	28800	40000	28600	24600
1992	48000	41700	36600	34600	64500	36700	100250	62428,6	29300	40900	30500	24800
1991	48400	42000	37000	35100	65100	36300	96500	61157,1	29400	40200	30100	25000
1990	49000	42100	37700	36000	65500	35800	92750	59885,7	29900	40300	30700	25000
1989	52000	43200	36700	39200	66000	36000	89000	58614,3	32400	40500	31500	26100
1988	49400	41800	35900	37100	60600	33800	87875	57342,9	31700	40500	31300	25100
1987	49000	39500	32500	36500	57000	32500	86750	56071,4	29000	38000	29000	24500
1986	47000	37500	30500	37000	54000	29000	85625	54800	28500	37000	28000	23500
1985	44000	35500	30000	36500	50000	26500	84500	52533,3	27000	33500	28000	23000
1984	43500	35000	29500	36500	47000	26000	81000	50266,7	29000	31500	25500	23000
1983	42500	35000	27500	36500	43500	24000	78500	48000	30000	31000	26000	22000
1982	41000	34400	25300	36500	41200	22500	76875	47750	32000	29400	26600	22400

1981	42500	35600	24200	37000	36500	20600	75250	47500	32000	28700	26600	20000
1980	42000	35000	21500	38000	34000	20500	73625	47250	29500	29000	27500	20500
1979	43000	33900	19500	40000	30000	21000	72000	47000	29300	30000	29000	20800
1978	43000	30500		45500		21000		45500	29000	30000	30500	22000
1977	43500	31000		45500		21000		44000	30000	31000	29000	22500
1976	43000	28700		44000		19100		42500	29000	28900	28100	22100
1975	42000	25200		43400		17800		41000	26000	28000	25800	19600
1974	40000	19000		39700		15500			22500	26000	23000	17500
1973	42500	19500		40700		15000			19500	24500	24000	17500
1972	42300	17000		40600		14500			15500	25000	22500	16000
1971	39000	16100		38800		11500			18000	24000	21000	14700
1970	34800	16100		34400		10800			15800	25800	19400	13900
1969	34400					10700				26500	16900	
1968	31000					11000						

Appendix 5 – All Park & Ride places in the Gothenburg Region

List with all the Parking lots in Gothenburg municipality and its neighbouring municipalities, including the number of parking lots per place and parking spots. Information obtained from Västtrafik (2019b) and from the different municipalities' websites (Ales kommun, 2019; Bollebygds Kommun, 2019; Kungälvs Kommun, 2019; Marks kommun, 2019; Mölndals Kommun, 2019; Öckerös kommun, 2019; Stenungsunds kommun, 2019; Tjörns kommun, 2019).

Table 7 – Park & Ride lots and number of spots in the Gothenburg region

Municipalities	Parking spots	Parking lots
Gothenburg	2700	42
Delsjömotet	368	4
Olofstorp västra	101	3
Radiomotet	182	3
Amhult resecentrum	163	2
Angered kyrka	35	2
Eriksdal	392	2
Skra Bro	134	2
Lillebyväge,	45	1
Högstensgatan	40	1
Säve station	30	1
Björsared	64	1
Klareberg	102	1
Brottkärrsmotet	15	1
Batterivägen	59	1
Burmans Gata	38	1
Hjälbo	42	1
Angered Centrum	30	1
Hornkamsgatan	9	1
Askimsbadet	150	1
Körkarlens Gata	80	1
Skintebo	25	1
Lyckhem	144	1
Storås	92	1
Billdals kyrka	17	1
Bäckebol Köpcentrum	80	1
Bingared	22	1
Hembygdsgatan	14	1
Gunnilse skola	24	1
Torslandakrysset	97	1
Hällsviksväge,	42	1
Hästebäck	64	1
Kungsbacka	1725	21
Hede station	754	4
Kungsbacka resecentrum	143	4
Annebergs station	124	2
Oskarsberg	25	1
Bolsheden	32	1
Vallda Trekant	18	1
Fjärås Station	35	1
Onsala kyrka	27	1
Fjordskolan	18	1
Snipen	130	1
Varla	62	1
Bukärr / Särö Centrum	20	1
Åsa Station	297	1
Frillesås skola	40	1
Lerum	1116	18
Floda station	230	5
Lerum station	370	2
Aspedalen station	215	2
Stenkullen station	78	2
Lerum Hulan centrum	26	1
Sjövik busstation	10	1
Aspen station	126	1
Aggetorpsvägen	6	1
Hjällsnäsvägen	35	1
Gråbo busstermina	14	1
Hede Äng	6	1
Härryda	819	14
Landvetter motorvägshållplats	338	4
Mölnlycke station	218	3
Hindås station	118	2
Skårtorpsvägen	15	1
Härryda kyrka	20	1
Vägskillnaden	42	1
Källarbacken	48	1
Rävlanda station	20	1

Ale	696	9
Älvängen	299	3
Nol station	41	1
Albotorget	48	1
Nol station	66	1
Surte norra	69	1
Bohus centrum	52	1
Nödinge station	121	1
Mölndal	547	7
Lindome station	273	3
Kållered station	264	3
Hällesåker	10	1
Kungälv	508	6
Kode station	57	2
Ytterby station	231	1
Kodemotet	156	1
Kode Brandstation	39	1
Kärna bussterminal	25	1

Mark	271	11
Hyssna handel	28	1
Berghems station	6	1
Skene station	11	1
Björketorps station	10	1
Horreds station	10	1
Björlanda	10	1
Kinna järnvägstation	95	1
Fritsla station	6	1
Skephultsvägen	8	1
Gästgivaregården	67	1
Hjorttorp	20	1
Lilla Edet	212	4
Lödöse södra station	166	2
Skansenvägen	16	1
Lilla Edet busstation	30	1
Tjörn	173	4
Myggenäs korsväg	82	1
Myggenäs centrum	14	1
Häggvall	20	1
Källekärr bussterminal	57	1
Partille	153	6
Jonsereds station	32	3
Partille station	97	2
Kommunhuset	24	1
Bollebygd	53	1
Bollebygd järnvägstation	53	1
Total general	**10061**	**163**

Stenungsunds	413	8
Stenungsunds station	143	4
Svenshögens station	14	1
Störa Höga station	168	1
Jörlanda	71	1
Stenungsunds station (5 lots)	17	1
Alingsås	401	9
Alingsås station	178	2
Kärrbogärdevägen	30	2
Sollebrunns Busstation	15	1
Norsesund	99	1
Västra Bodarna station	29	1
Brobacka	13	1
Långareds	37	1
Öckerö	274	3
Björkö - Grönevik	56	1
Hönö - Pinans färjeläge	158	1
Hälsö - Burö färjeläge	60	1

Appendix 6 – Information about the Park & Ride sites visited

Amhult Resecentrum 2: Users interview in the afternoon

Date and time: March 13th, 2019 from 17:00 to 19:00

Description: The commuter parking of Amhult Resecentrum 2 is one of the very few covered Park & Ride in Gothenburg. It has a capacity of 63 spots. There is another one close to it, called Amhult Resecentrum 1, with a capacity of 100 places, but it is not covered. It is in the urban district of Torslanda, in Gothenburg Municipality.

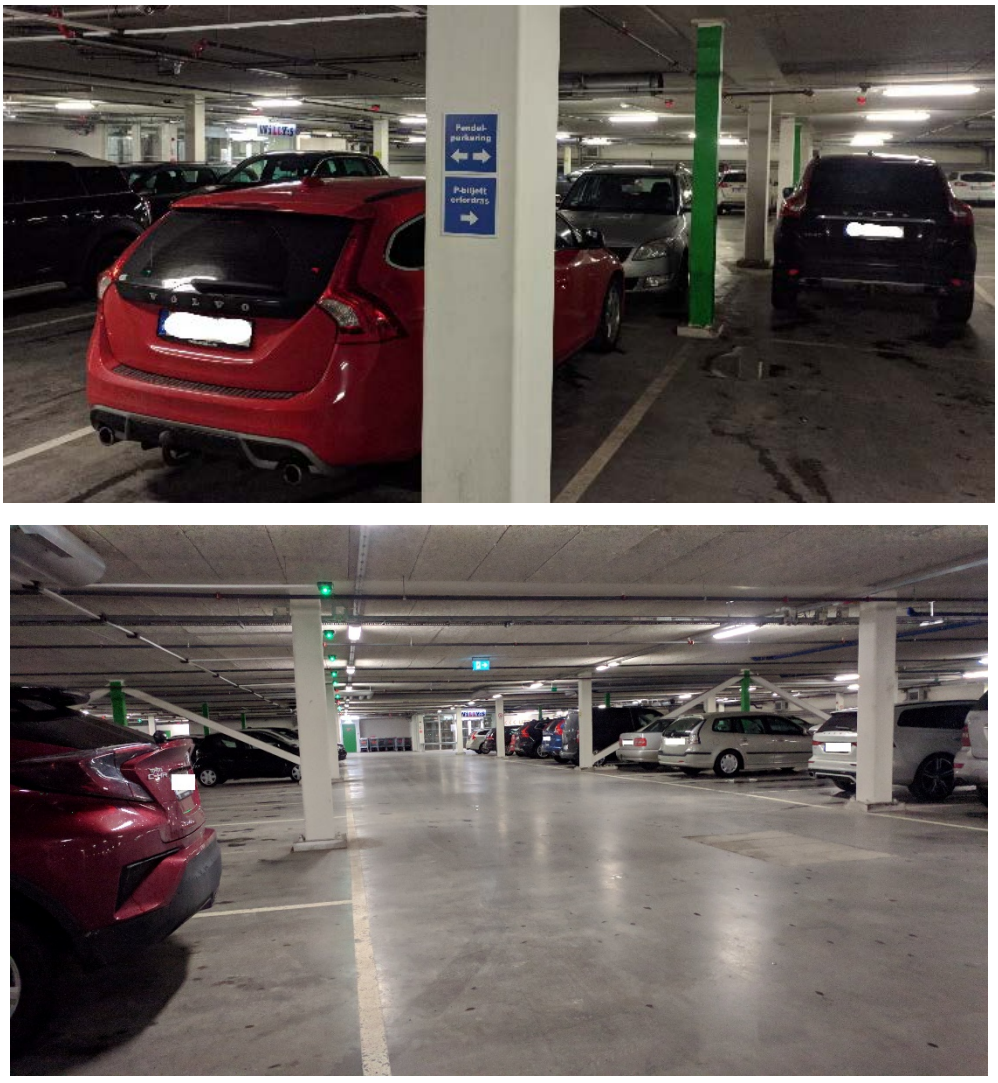

Figure 17 - Photos taken in the commuter parking of Amhult Resecentrum 2

The particularities of the commuter parking in Amhult Resentrum 2 are that it is a covered space, and that there is a direct access to a big grocery store within the parking. This facts have an impact in the attractiveness of this specific Park & Ride facility among the users interviewed.

Eriksdal: Users interview in the afternoon

Date and time: March 20th, 2019, from 16:30 to 18:30

Description: The spots available at Eriksdal totalize 299. Another smaller commuter parking, a few hundred meters away from this Park & Ride facility, has been constructed in the last years and has a capacity of 93 spots.

Figure 18 - Picture taken in the commuter parking of Eriksdal

Eriksdal is one of the biggest commuter parking in the municipality of Gothenburg in terms of number of spots (Göteborgs Stad, 2019).

Delsjömotet: On-site observation in the morning

Date and time: March 19th, 2019 from 07:00 to 08:30

Description: There are 4 Park & Ride sites in Delsjömotet located close to each other, for drivers going in the direction of Central Gothenburg or leaving it. The total capacity is 368 spots which are distributed as follow in four different sites close to each other: P1 (79 spots), P2 (54), P3 (71) and P4 (164).

Figure 19 - Picture taken in the commuter parking of Delsjömotet, and map with the four parking lots (Google Maps)

The commuter parking of Delsjömotet is characterized by the activity around the site. The companies SAAB and RUAG Space are close to it. There is also a fast food store with its own parking, and a football club. The place is in the middle of a forest.

Appendix 7 – Interviews with experts

Interview with Erik-Wilhelm Graef Behm

Date and time: March 8th, 2019, from 14:00 to 15:00

Organisation: Business Region Göteborg. "*Business Region Göteborg is responsible for business development in the City of Gothenburg and represents thirteen municipalities in the region.*" (Business Region Göteborg, n.d.)

Interviewed role: Area & Investment Manager ICT

Park & Ride as a method of reducing congestion

He defends Park & Ride as a good method to reduce congestion. He believes is necessary to build more sites, but also talked about the fact of having better commuter trains. Concretely, he thinks that both trains and buses must be comfortable for the user, and have WiFi on board, so commuters can use that time to work making the trip useful.

Park & Ride pricing

This issue was not addressed in the interview.

Size of the parking lots

Erik says that the authorities need to build more parking places, and even build double-decked parking lots if there is a lack of space and land. He stated that the users should not be worried about finding a parking space every morning and that the sites should be well connected with the city centre. He also talks about using existing parking lots as Park & Ride facilities, such as Frölunda Torg (A shopping mall in south-west Gothenburg), benefiting the municipality, the users and the shopping mall, as it would potentially attract more shoppers.

Safety

He thinks that there were safety issues many years ago, but that nowadays are solved. On the contrary, if these problems were still to occur, he proposes having guarded parking lots.

Future trends

He says that congestion can be tackled by applying existing and cheap technology in a simple way. For example, by having signals or screens that inform the drivers about the available parking spots on different sites, or by having dynamic speed limits depending on the traffic. He also says that a lot of business have a lot of optimisation margin when it comes to organise their routes, and this could be improved easily by using apps such as Google Maps.

When asked about autonomous cars, he thinks that it will still take a decade to have them in the cities. Maybe in five years it will be normal to see them in the highway, but in a complex environment such as a city, with pedestrians, bicycles, etc, it will take more time. He also thinks that it will not have an impact on congestion, and that a better public transport is still needed.

Cooperation between organisations

This issue was not addressed in the interview.

Challenges

He thinks that the main challenge is to define the goals. It is important to define what is the priority: Is it having less traffic? Better mobility? Or reducing costs?

Other issues

He does not believe in the general trend of making cities bigger and bigger but rather invest more in communicating better the countryside and allowing people to work from home. He also said that it has been demonstrated that for a small reduction in traffic (10%), the driver perceives a bigger one (15%) and can feel the difference.

When it comes to public transport, he believes that standardising tickets of different modes and facilitating intramodality by synchronising schedules should be a priority to make it more intuitive for the user. He does not believe either that public transport should go not only through the city centre, like it happens in Gothenburg nowadays, and that there should be different alternatives.

Interview with Gunnar Lanner

Date and time: March 20th, 2019, from 10:00 to 11:00

Organisation: Chalmers tekniska högskola - Department of Geology and Geotechnology

Interviewed role: Senior lecturer, consultant for Road and Traffic Group

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Park & Ride as a method of reducing congestion

Gunnar thinks that Park & Ride is a good method to reduce congestion, as it would avoid having more car commuters in the city centre and thinks that Trafikkontoret and Västtrafik need to do more to promote it. In addition, he does not think that by building big parking lots there will be a congestion problem in its accesses.

Park & Ride pricing

This issue was not addressed in the interview.

Size of the parking lots

He believes that giving people more choices, like having the Park & Ride site next to a shopping mall, could help them change their habits, but it is not possible to force them to do so. On the other hand, he defends that building parking lots with more than one floor would be too expensive for a free service.

Safety

He proposed to check if Västtrafik has done surveys on the topic.

Future trends

Focusing in congestion on a bigger scope, he believes that Autonomous Driving will improve the efficiency of the traffic flows, as time reaction will be lower than humans. He states that this would allow cars move like trains in intersection, with very little space between them and a constant speed.

Cooperation between organisations

The different municipalities, region, companies, etc, need to coordinate themselves and try to spread the traffic. For example, by having different starting schedules in each company, schools, universities… This way, the traffic would not be focused in the same time. He believes it can be done and that it is necessary.

Challenges

He thinks one of the biggest challenges regarding Park & Ride is on how to expand parking lots in certain areas where there is a demand for it, as the land might be owned by other municipalities or companies and have plans for them and do not want to renounce to them.

Other issues

He thinks that the congestion charge in Gothenburg fulfilled the expectations. Although traffic is now at the same level than when it started, he states that it would be much higher if it had not been implemented.

When talking about the public transport operations, he believes that the network should be more flexible, alternating buses that stop in different places, and assuring that people do not have to worry about the schedules, having very high frequencies. Also, he believes that it could be facilitated that people use carpooling to the Park & Ride in areas where public transport connections are not good.

Interview with Lars Bern

Date and time: March 25th, 2019, from 12:30 to 13:30

Organisation: Business Region Göteborg. "*Business Region Göteborg is responsible for business development in the City of Gothenburg and represents thirteen municipalities in the region.*" (Business Region Göteborg, n.d.)

Interviewed role: Area Manager of Innovation at the Cluster & Innovation department. He works with the innovation program for the whole city, with the industry development program and promoting testbeds with the city, Chalmers, University of Gothenburg and RISE.

Park & Ride as a method of reducing congestion

Lars views it as a brilliant solution for congestion. He states that people still have the flexibility of having their own car, but they avoid bringing it all the way to the city centre. Nevertheless, he believes it needs to be elaborated in some way.

Park & Ride pricing

On one hand, commuter parking lots are usually built in the access to the cities, where land is not highly demanded and, therefore, cheaper, which allows the authorities to offer the service without great costs. But, on the other hand, he argues if the service should be for free or a small fee can be charged, which can be used to help the costs and improve the service.

Size of the parking lots

He defends that it would be beneficial if there were more parking spaces in the commuter parking lots and proposes to use existing parking lots of shopping malls as Park & Ride facilities. By doing this, it would also provide new services (Groceries store, shopping, etc) to the users, which would make it more attractive.

Safety

He said that we should talk with Västtrafik about this topic.

Future trends

In terms of Park & Ride, he believes that in the near future there will be services more tailored for the users, which would allow them to have different modes (car, Park & Ride, bus, bikepool, etc) in a single app. He also uses as an example how Google recommends nowadays different routes, informs about the traffic conditions, etc, and how that could be used together with machine learning to inform the user when to leave home, which route to take, etc.

He also believes, in the case of Gothenburg, that the waterways will be used much more in the upcoming years, for goods, trash and passengers. Finally, he mentions Autonomous Driving and how might they reduce the cars in the city centre, by taking the kids to school, the parents to the bus stop, and returning home.

Cooperation between organisations

He explains the challenge of coordinating all different organisations when it comes to public transport. Because the majority of Västtrafik is owned by Västra Götalands Region, there is a lot of crossed interests between the municipalities when it comes to public transport, and to solve these issues a lot of coordination is required.

Plus, he states that Göteborgs Stad works together with Trafikverket, Västtrafik and Västra Götalands Region by having a common communication strategy for the citizens, especially now that the city is constantly changing. Additionally, they collaborate by building provisional Park & Ride sites, as they need to move them when that area is affected by works. Finally, he emphasises on the role that Västtrafik plays in promoting not only public transport, but also bikes, walking or scooters for example.

Challenges

He thinks that one of the big challenges in Park & Ride development is how to find land, because nowadays the land available in accessible areas is prioritised to build houses and offices.

On the other hand, he remarks again the important role of coordinating among the authorities, especially because Park & Ride sites are normally on the edge of Gothenburg municipality and it is unclear who should build them and who should pay for it.

Other issues

He is not clearly in favour of the congestion toll, as he believes that congestion should self-regulate itself by offering the citizens other alternatives to cars, not by imposition. When talking about public transport, he mentions the fact that users always go by car to the edge of Gothenburg municipality to avoid paying the Göteborg++ card, and that is the reason why these are always full early.

Interview with Jonas Lidén

Date and time: March 26th, 2019, from 13:00 to 14:00

Organisation: Göteborgs Stad – Trafikkontoret | Traffic Office at Gothenburg Municipality

Interviewed role: Coordinator for Pendelparkering (Park & Ride). Until now, it was not clear who owned the responsibility for Pendelparkering in Göteborgs Stad. A few months ago, he was appointed to take charge of this issue.

Park & Ride as a method of reducing congestion

He sees Park & Ride as a good way for reducing congestion, and he states that is working well. He remarks that the mentality towards car use is changing, especially in young people, who do not need to go everywhere with it. He also uses his own experience to say that there are many less cars since he moved to Gothenburg many years ago.

Park & Ride pricing

An important insight obtained from this interview is that by law, the municipality cannot charge for the use of these facilities, as they must be accessible and free for everyone. This is the case only when the project is partly financed by the government, in this case included in the Västsvenska paketet.

Size of the parking lots

He does not believe that bigger parking lots will lead to a better operation of Pendelparkering, as he thinks that by having bigger parking lots people will always go to those ones and then they will be full. On the contrary, he defends that having a cluster of smaller parking lots close to where people live and where there is a need for it could spread more the users and balance the overall

capacity of the system. Also, he remarks the importance of people living far away from Gothenburg but park in the border to avoid paying the Göteborg++ public transport card. From his point of view, these commuters do this because they are used to it, but they might not realise that they are spending more in gasoline than the extra-cost of the card. When asked about why are not parking lots with more than one floor being build, he states that is much more expensive.

Safety

In terms of safety, the municipality has not been considering that issue when building Park & Ride sites. Nowadays, they are focusing in having a better illumination in them, as this might 'scare' thieves. But, in order to have a fully secure place, it would need to be a closed space, and the municipality cannot do that because it would imply going against the law, which states that the facilities built by municipalities have to be open for everyone. Besides, no cameras have been installed because it is very restricted by law, although he says that they are nowadays discussing this issue for some of the parking sites.

Future trends

Regarding Park & Ride in Gothenburg, there are plans for building around 1,000 more spaces in the next years within the municipality, as some new development areas have the obligation of including a Park & Ride facility. In addition, he believes that P-Bolaget will get involved in building and managing Pendelparkering sites, which might mean that commuters will have to pay to use the scheme, but also get a better service.

When talking about public transport, he mentions the fact that Gothenburg is transitioning towards a network formed by several circles one inside another, and that commuters will not have to go through the city centre if they are going to the other side of the city.

Cooperation between organisations

One of the first things that arose in this interview is that, as it is part of the municipality, Trafikkontoret depends on the will of the political parties in power on each term, and the current government has decided to focus on Pendelparkering. The second thing is that, while the communication among the different authorities is good, everyone has their own projects and therefore, are focused in finishing them in time, leaving little time for issues with other authorities.

In terms of Park & Ride, he acknowledges that there might have been a lack of a clear attribution of responsibilities, but both Västtrafik and Trafikkontoret have started to meet periodically to address this issue. At the same time, P-bolaget has showed their interest in

participating in such talks. Besides, Västtrafik is supposed to be the sole responsible for managing Pendelparkering, but the municipalities got involved because when building a parking lot there are tax incentives for them, so the cost of the sites decreases.

Challenges

The main challenge relating Park & Ride is on how to find available land, as the ones near the main roads are owned by companies or other public authorities, even different branches of Göteborgs Stad, and they normally have plans for them. On the other hand, as said before, the parking sites built by the municipality are open to everyone, so they cannot control that they are actually being used for commuters only and not by people working close by.

Other issues

Park & Ride facilities started to be really full when the congestion charge was introduced.

Interview with Marie Albihn

Date and time: April 4th, 2019, from 13:00 to 14:00

Organisation: Västtrafik. Public transport operator in the Västra Götalands Region

Interviewed role: Project manager on the department of Strategic Planning. She works mostly with electrification of buses, and also Pendelparkering / Park & Ride.

Park & Ride as a method of reducing congestion

She believes it is necessary and a good way of reducing congestion, but she acknowledges that some people defend that the authorities should force people to stop driving. From her point of view, this is not possible, because depending on the family situation, job, having kids or not… sometimes the car is necessary.

Park & Ride pricing

She knows that people really value that the service is free, but also states that in a future, people need to realise that it cannot be that way, because the land is not free and building garages is not free either. She uses the example of some municipalities in the Stockholm area, where it is only free for people with at least the 30-day subscription for public transport.

Size of the parking lots

She does not think there is an ideal size for the parking lots, but rather it depends on the area, and the demand. She also uses the example of Eriksdal or Delsjön, where she believes is possible to continue expanding it almost indefinitely, because there will be always a demand for them.

Nevertheless, they are focusing now on convincing shopping centres with parking lots to use them as Pendelparkering, as the example of Bäckebol, or a new one opening in Kungälv.

On the other hand, she also remarks the importance of considering the access when building parking sites, as it might create congestion around them. She exemplifies it with the parking at Nordstan, in the city centre, that has a parking with a lot of available spaces, but that it is difficult to reach because of the traffic, works, etc.

Safety

She states that some of the parking lots have cameras, but in general they lack. She also emphasises on the importance of, in the near future, how to guarantee the safety of the electrical bikes that might use the parking lots. Plus, she proposes trying to build all the Park & Ride facilities close to big roads, so it dissuades thieves from robbing the cars.

Future trends

The main trend affecting Park & Ride in the short-term has to do with the lifespan of the parking lots, as the city keeps changing constantly, authorities cannot think that a parking will stay in the same place for 20 years, and rather are starting to work with 'temporary parking lots' that last only a few years.

Secondly, she remarks the interest of P-bolaget in entering the market and how this might change the whole system. As parking spaces keep disappearing from the city centre, they have difficulties building new ones and less cars might enter the city centre in the future, P-bolaget needs to find new ways of diversifying its business, and Park & Ride might be one of them.

Finally, she talks about what they call *Smarta Pendelparkering*, which are about 20 of them. They are more costly to build, and the difference is that they have cameras and they can count the number of available spots in the parking lots, among others.

Cooperation between organisations

In general, Västtrafik does not build Park & Ride facilities, as they do not have the mission to do so, and municipalities can get subsidies. Nevertheless, they have an active role in it, helping municipalities to apply for subsidies and doing the paperwork.

They also have meetings with other organisations involved, such as Trafikkontoret or Trafikverket, but are not specifically focused on Pendelparkering, but rather on how to organise the traffic in the city with all the works going on, establishing priorities, etc. Västtrafik stresses

that it should be the cars the ones that have to take the detours and that the public transport should have the priority.

Challenges

The main challenge she identifies is finding land, especially when it comes to the one close to main roads, because municipalities have other plans for them, like housing and offices. She remarks the importance of working together with them, make them see that if they want people to move there, they need to give them facilities to commute to Gothenburg, like Park & Ride. Another issue is that if these areas are going to be developed in 10 years, why cannot the municipality use it for Pendelparkering on the meantime?

Other issues

She thinks that they have to improve the information they give to Park & Ride users, by telling them how many parking spots are free in each facility or recommend which parking to go. For this, more parking lots should be transformed into *Smarta Pendelparkering*.

Another important topic comes when planning bus routes, and deciding where to stop, as if they add many Park & Ride facilities and the bus has to stop in all of them, this would worsen the bus service and make people less eager to take it.

Finally, she says that the congestion charge had a strong effect on the traffic in the city centre, but that it has been increasing for the last years again. She also believes that a part of society thinks that by using electric cars this kind of systems will not be necessary anymore, and this is not true because the external effects from congestion, except pollution, will still be there.