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NAVIGATING JÄRFÄLLA

A PATHWAY TO A SUSTAINABLE TRAFFIC STRATEGY

Composed *by*:
H. Arroum, M. Cambray, D. Hjorth, E. Stratopoulou, H. Sundbom, M. Wallin

Supervised *by*:
Jenny Lindblad

CORRESPONDING AUTHOR:

Henrick Sundbom: henrick@kth.se.

ABSTRACT

The purpose of this study is to form a basis for the development of a well informed traffic strategy in the Järfälla region.
The goal is to combine knowledge of the current state of the network and contemporary research on the field of sustainable transport with a sustainable future in mind.
For this purpose, we review the present state of the transport network in Järfälla along with the current travel habits of its inhabitants and expected future developments of society.
Drawing from the comprehensive plan's goals and the current relevant research in the field of sustainable mobility we outline suggested content for a future traffic plan and propose relevant, overarching strategies to achieve them.
Furthermore, we suggest a process for developing the traffic strategy and what concerns the municipality should take in terms of goal conflicts and indicators.

05 EXECUTIVE SUMMARY

The Järfälla municipality has pointed out the need for a comprehensive traffic strategy to guide its traffic planning. A traffic strategy is needed to ensure that day-to-day traffic planning contributes to political goal achievement and to provide decision support for the planners. The purpose of this project is to form a basis for the development of such a traffic strategy. The goal is to combine knowledge of the present state of the transport system and contemporary research on the field of sustainable transport with a sustainable future in mind.
Traffic strategies are a response to the rise of the goal-oriented traffic planning paradigm. They became popular among Swedish municipalities in the early 2000s in response to the Swedish national TRAST guidebook publication and the later Sustainable Urban Mobility Plan (SUMP) project from the EU.

In this project, we have performed a **review and analysis** of the **present transport system** to establish the Järfälla context and enable us to develop suggested contents for the municipality to iterate upon in the process of developing a traffic strategy. Reviewing the transport system, we find an emphasis on large trunkline based topologies, successful reductions of traffic accidents and progressive parking management policy. **Reviewing trends that will affect Järfälla**, we find the development of a regional city center, changes in commerce and work behavior, new vehicle technologies and expansions of inter-municipal road network. **Reviewing the comprehensive plan goals and strategies**, we find a set that we deem relevant to the transport system.

Based on the methodology proposed in TRAST and SUMP, we suggest an adapted process of developing a traffic strategy for Järfälla. The process serves to **guide the development of the traffic strategy** to **ensure political feasibility**, but also to **build political support in itself**.

> *This report is to propose a starting point for a long term work on a traffic strategy for the Järfälla municipality.*

The initial steps consider the need for the project to define its scope, to get support and funding.
The next step concerns reviewing the present state of the transport system. After this, the municipality needs to develop the actual contents of the future traffic strategy document. This constitutes visions of the future of the transport system, analysis of what needs to change from the present state to achieve these visions, and how it can be done. This needs to be an iterative process where the planners collaborate with voters and politicians. Once sufficiently developed, and passed by the local parliament, continuous long term work with action plan development, goal achievement assessment and review of the traffic strategy should ensure and continue indefinitely.
Based on the review and analysis of the transport system in Järfälla, we provide a starting point in terms of the content of the future traffic strategy. We suggest three goals, prioritized in order of appearance: 1. Zero territorial carbon emissions within the municipal boundaries; 2. Ensure access to public transport for everyone, everywhere in Järfälla; and 3. Optimized transport system in terms of travel time and traffic safety. To realize these goals, we suggest three (sub-) strategies. The first, “Strategy A: Long term land-use changes and transport network topology shift”, proposes using Transit oriented development and changes to a more grid-like network structure to influence transport behavior. The second, “Strategy B: Improvements to sustainable modes of transport and integration between them”, proposes improving the sustainable transport system through infrastructural and digital technology modal integration improvements. The third, “Strategy C: Manage car driving demand using parking management and other behavior influencing measures”, proposes using even more progressive parking policy and inducing cultural shifts to reduce the demand for private car use. Finally, we discuss what considerations the municipality needs to make and what type of indicators it could use to assess the goal achievement.

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1. Zero territorial carbon emissions within the municipal boundaries;
2. Ensure access to public transport for everyone, everywhere in Järfälla; and
3. Optimized transport system in terms of travel time and traffic safety.

To realize these goals, we suggest three (sub-) strategies.

The first, ‘‘Long term land-use changes and transport network topology shift”, proposes using Transit oriented development and changes to a more grid-like network structure to influence transport behaviour.
The second, “Strategy B: Improvements to sustainable modes of transport and integration between them”, proposes improving the sustainable transport system through infrastructural and digital technology modal integration improvements.
The third, “Manage car driving demand using parking management and other behaviour influencing measures”, proposes using even more progressive parking policy and inducing cultural shifts to reduce the demand for private car use.
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11 INTRODUCTION

TRAFFIC STRATEGY IN JÄRFÄLLA, PURPOSE AND STRUCTURE OF THIS DOCUMENT

PHOTO: ROSIE ALM
FROM: ORMBACKA

In a review and plan for the traffic situation of Järfälla from 2019, the municipality suggests that it is in need of an overarching traffic strategy to be able to plan its traffic system in a cohesive and goal-oriented manner *(Järfälla municipality, 2019b)*. Specifically, the municipality calls for a comprehensive analysis of the needs of the transport system and an overarching agreement on how different planning measures should be prioritized.

With this document, we aim to outline a path for Järfälla to develop and implement a traffic strategy based on insights from transport research and other municipalities' traffic strategies. Based on a review of the current state of the Järfälla transport system, state-of-the-art transport research, and the political standpoints of Järfälla, we also suggest a set of goals and strategies to achieve the goals that we think are a suitable starting point for the contents of the future traffic strategy. In addition, we provide a discussion of important considerations in indicator design.

By section, this document is made up of the following parts:

1. Description of **traffic strategy policy documents** as a concept in the Swedish municipal context
2. Review and analysis of the **present transport system** of Järfälla, its **transport policies** and the **future trends** it is facing to establish the context, identify problems, and guide the design of the traffic strategy
3. Suggested **stepwise development process** which we think Järfälla should use to create a traffic strategy
4. Suggested starting point in terms of contents of a future traffic strategy (with **goals, strategies and sketches of goal indicators**) based on what we've found out about the transport system and policy making of Järfälla. We suggest that the municipality use this and develop it iteratively to arrive at a final traffic strategy that is supported institutionally throughout the municipality.


DIAGNOSIS & LITERATURE

1.TRAFFIC STRATEGIES AS A CONCEPT

> *From predict- and - provide to comprehensive strategic planning.*

Historically, predict-and-provide traffic planning (approximating how the need for car trips would grow over time and attempting to accommodate it with new infrastructure) has been the norm, but since the 1990s this approach has been questioned, and alternatives sought out *(Owens, 1995)*. The key critique of the old method is the challenging of the assumption that there is a predetermined need for a certain number of car trips to/from each destination. The general alternative approach that has arisen instead considers shaping transport policy to contribute to long-term planning goals, while treating the need for car trips as a demand that can be managed by policy (termed predict-and-prevent*; Goulden et al., 2014; Næss et al., 2006)*. This is where the need for comprehensive traffic strategies arise.

While some type of strategy was always needed to predict and provide for transport needs, more formalized traffic strategy policies in the Swedish municipal context became popular in response to a handbook published in 2004 by the Swedish transport administration (Trafikverket) and the Swedish association of local authorities and regions (SKR) – 'Traffic for an attractive city' (TRAST) *(Wärnhjelm & Wallberg, 2005)*. The handbook proposes methods for working with the political goals from the comprehensive plan to develop a long term strategy for their achievement, and then defining a plan for interventions to enact these strategies and to follow up the effects. By 2009, 19 Swedish municipalities had enacted traffic strategies based on TRAST *(Bertheden & Karlsson, 2009)*; by 2012, the number was between 30 and 40 municipalities *(Wendle et al., 2012)*. As a Swedish municipality, when stating the need for a traffic strategy, Järfälla presumably has the TRAST-type traffic strategy in mind used by its surrounding municipalities.

The related concept of Sustainable urban mobility plans (SUMPs) was formalized by the EU in 2013 *(Eltis, 2021)* and is based on traffic strategy concepts from across the union. The key concepts are similar, and traffic strategies developed using TRAST cover all the points needed to be qualified as a SUMP *(Wärnhjelm & Olsson, 2021)*.

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At the end of 2022, Swedish governmental authorities Trafikverket and SKR released a new handbook to replace TRAST, Guidebook for strategic traffic planning *(Handbok för trafikstrategiskt arbete) (SKR, 2022)*. This handbook further harmonizes the methods with the SUMP methodology and shifts the main focus from mobility to accessibility, as well as includes non-urban perspectives (the old name included the Swedish term meaning city*; Wärnhjelm & Sandberg, 2022)*. Therefore, we've chosen to adapt the process from the new Swedish government guidebook to the Järfälla context in order to propose a pathway to a traffic strategy. The proposed process is described in section 3.

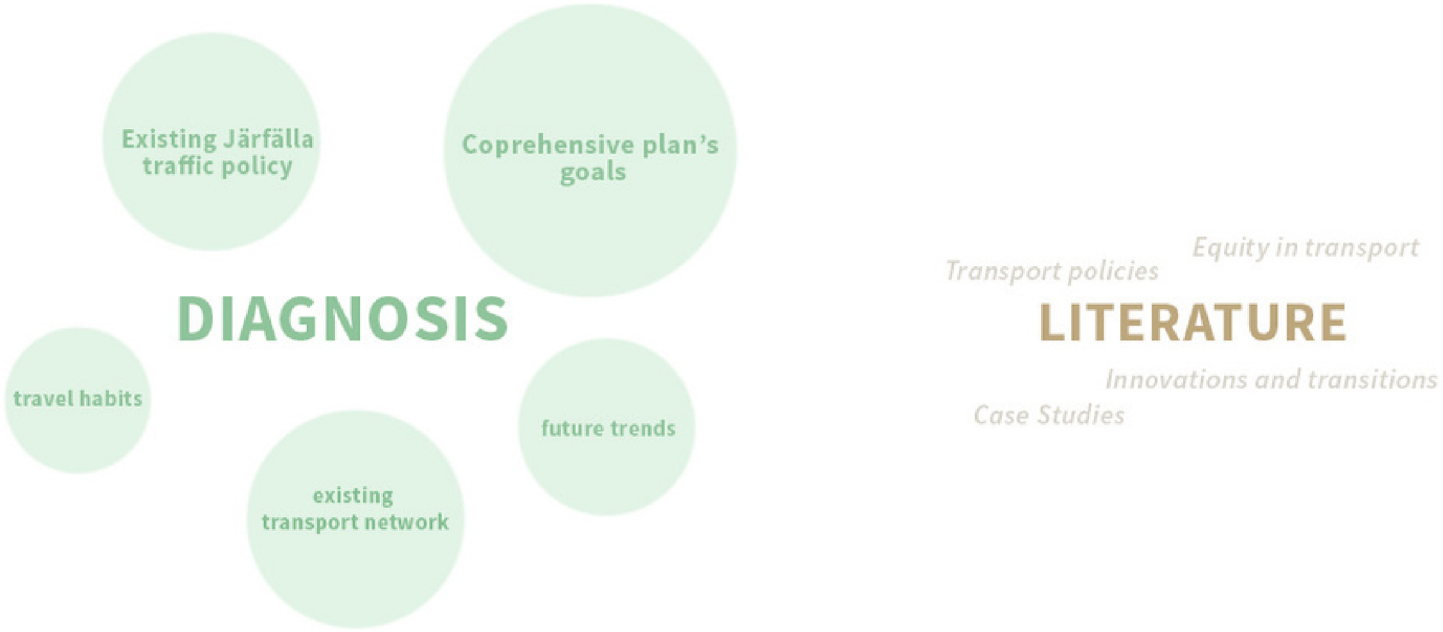

Figure 1: Diagram of our process

2. REVIEW AND ANALYSIS OF THE PRESENT TRANSPORT SYSTEM IN JÄRFÄLLA, DEVELOPMENT TRENDS AND POLITICAL STANDPOINTS

DATA SELECTION AND PURPOSE

In the following chapter, the existing state of Järfälla's transport system will be evaluated. We do this by going through the **current travel habits**, **physical networks**, **traffic safety & policy documents**, as well as **development trend**s and **political standpoints** that could prompt changes in the system. The selection of what to evaluate was made with regard to data availability and its relevance to the transport system.

This review and analysis is produced with the aim of laying the groundwork for the proposed strategy, in particular the second step in the process to develop a traffic strategy (see chapter 3).

CURRENT TRAVEL HABITS

The most recent travel habit data[1] that we have been able to access was collected by the Stockholm regional government in 2019 *(Region Stockholm, 2020)*. According to this data, the modal shares in Järfälla for all trips are **50%** by **private car**, **27%** by **public transport**, **9%** by **bike** and **12%** by **walking** *(Figure 2)*.

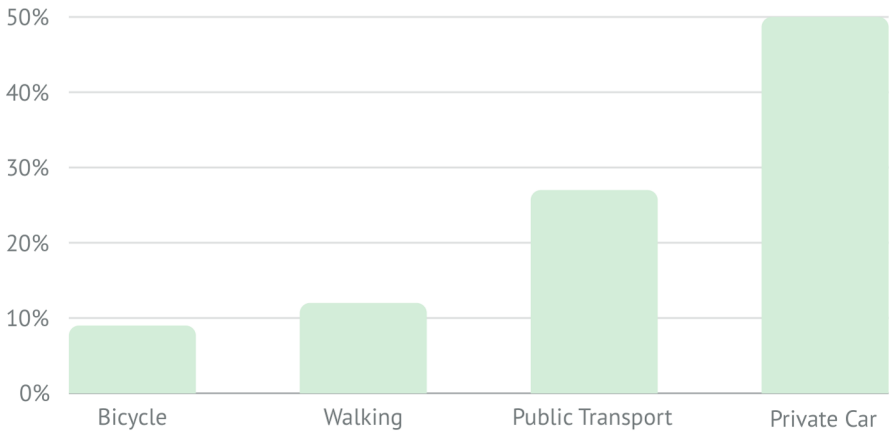

Figure 2: Current Järfälla travel habits, 2019

[1] Travel habit surveys rely on randomly selected transport system users keeping a diary of all trips made during a limited period of time. This gives an indication of behavioral responses in the present transport system.

The region defines Järfälla as an *"inner-ring suburban municipality"*. Comparing its measured shares with the rest of this group, Järfälla has a slightly lower share of trips done with private cars and walking, a slightly higher share of trips done with public transport, and a markedly higher share of trips done by bike (50% greater than the similar municipality average).

Färdmedelsfördelning (genomsnitt för veckan) för boende i olika kommuner och delar av regionen					
Kommun	Bil	Kollektivt	Cykel	Till fots	Annat
Stockholms stad	25%	35%	10%	28%	2%
Innerstad	15%	33%	14%	37%	2%
Söderort	31%	36%	7%	23%	3%
Västerort	34%	38%	8%	19%	2%
Solna	22%	39%	10%	28%	2%
Sundbyberg	34%	31%	8%	26%	2%
Regioncentrum	**25%**	**35%**	**10%**	**28%**	**2%**
Danderyd	57%	22%	10%	9%	3%
Huddinge	52%	27%	5%	14%	3%
Järfälla	50%	27%	9%	12%	2%
Lidingö	52%	30%	6%	12%	1%
Nacka	52%	21%	8%	16%	2%
Sollentuna	54%	22%	3%	19%	2%
Tyresö	55%	26%	4%	13%	2%
Täby	57%	21%	6%	15%	2%
Kommuner i inre förort	**53%**	**24%**	**6%**	**14%**	**2%**

Table 1: Modal share in different parts of the Stockholm region. Järfälla's row is highlighted. Source: Region Stockholm.

The Stockholm region travel habit survey also reveals an interesting difference in average travel times between **public transport** and private car trips, with the former **on average being 60% longer** in Järfälla. This data compares all trips made by the survey respondents to different destinations, and doesn't control for the fact that users choose modes depending on the destination. Therefore, it tells us more about the **attitudes or willingness to travel for a longer time with public transport** among the Järfälla residents, than some actual difference in the physical transport system.

This can be compared to national Swedish data showing that 52% of trips are done by car, 19% by public transport, 13% by bike and 14.5% of trips by walking *(Trafikanalys, 2020b)*. Järfälla has a much **greater share of public transport trips** and a much **lower share of bike trips**. The shares for trips by car and walking are similar but slightly smaller.

In a 2021 statistical review, Järfälla was reported to have a “day population” of 28,500 people working in the municipality and a “night population” of 41,200 people living in Järfälla but working elsewhere *(SCB, 2022a)*. Based on this data, we can note that at least 12,700 people commute away from Järfälla every day. The number could be even higher if part of the day population is made up of people who commute to Järfälla for work, but this review does not offer any insights in that regard.

EXISTING TRAFFIC POLICY DOCUMENTS

Järfälla has a number of plans and documents that relate to its traffic system already in place. All of these are more detailed and more tactical than a traffic strategy.

- Cykelplan - Biking plan *(Järfälla municipality, 2018a)*
- Gångplan - Pedestrian plan *(Järfälla municipality, 2018b)*
- Parkeringsnorm - Parking norm *(Järfälla municipality, 2017)*
- Riktlinjer för säkra skolvägar - Safe routes to school guidelines *(Järfälla municipality, 2018c)*
- Traffic network analysis *(We’ve been unable to access this document, but it is mentioned by other sources; 2003)*

CHARACTERIZATION OF THE PRESENT TRANSPORT NETWORK OF JÄRFÄLLA

Reviewing maps of the municipality's walking, cycling and public transport networks, the general impression is that the municipality has good walking and cycling coverage and decent bus network coverage (see maps in the respective sub-sections below). Jakobsberg and Viksjö have the best coverage, while Kallhäll, Barkarby, Veddesta and Skällby are less well covered. The areas between districts are generally less covered than those within districts. The road network has good coverage, with especially well developed trunk lines, where the larger car flows are located as well as the main bus routes. The same goes for its bike network with its trunk-line being the regional bike path. Between those trunk-lines there are a lot of ’islands’ and cul-de-sacs for the car and bike traffic.

The general network topology will be reviewed in the next part of the section, followed by more detailed reviews of each mode of transport.

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GENERAL NETWORK TOPOLOGY

To characterize the organization or 'topology' of the transport network, we use the concept of a scale between tree-like and grid-like street patterns. The grid-like pattern, forming a largely homogenous square pattern and the tree-like pattern, having a main trail being divided into smaller branches *(Freiria et al., 2015; Han et al., 2020; Sreelekha et al., 2016)*. Han et al. *(2020)* discuss those two concepts and elaborate on other types of network patterns that can be classified based on those two. They suggest two additional patterns which could be described as middle steps between the two initial ones *(Figure 2)*. Having the tree-shaped network as one extreme, one step away from this pattern is described as a cul-de-sacs type where the street network is containing sections with cut of streets forming largely disconnected islands away from the larger trunk lines. Next step towards the grid pattern is called the T-type. It's close to a grid like pattern but instead mainly built up by T-intersections (three-way intersections) instead of X-intersections (four-way intersections) *(Han et al., 2020)*.

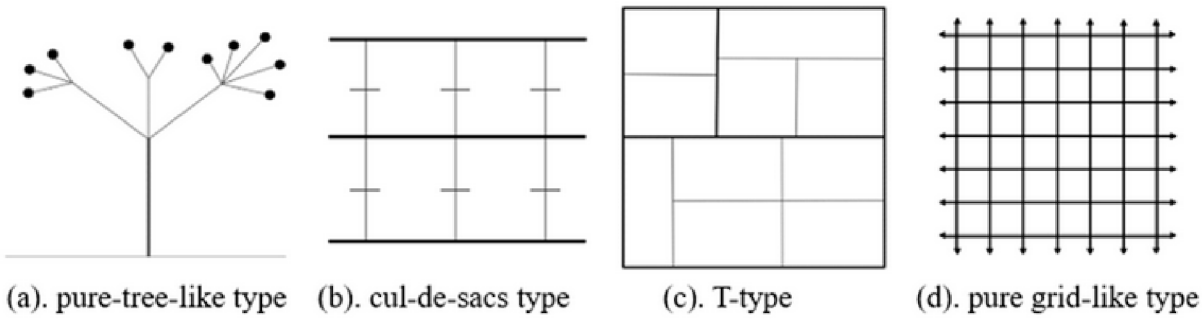

Figure 2: The four network patterns presented in the article *(Han et al., 2020)*.

After a qualitative assessment of the maps, this characterization of the network is suggested for the modes of car, bike, bus and walk. The characterisation was based on the impression of the number of 'islands' and T- and X intersections in the network. The geographical boundaries were based on Järfällakartan *(Järfälla municipality, 2023b)*.

	Viksjö	Jakobsberg	Kallhäll	Barkarby/ Skällby
Car	cul-de-sacs	cul-de-sacs/ T-type	cul-de-sacs	cul-de-sacs/ T-type
Bus	T-type	T-type	T-type	T-type
Bike	cul-de-sacs	cul-de-sacs	cul-de-sacs	cul-de-sacs
Walk	grid/T-type	T-type	T-type	T-type

Table 2: Types of network patterns per neighbourhood.

When assessing the whole pedestrian network from above in the pedestrian plan of Järfälla, it looks largely like a T-type network. This indicates a quite accessible network for pedestrians. The plan, however mentions needs for developing a more unified network, connecting the districts. It suggests new links in the area that intersects Jacosberg, Viksjö and Veddesta *(Järfälla municipality, 2018b)*. Reviewing the bike network we get the impression that this area is in need of more links regarding the bike network. The bike plan mentions a wish to achieve a higher level of continuity in the network *(Järfälla municipality, 2018a)* and the comprehensive plan states a need for better integration between districts *(Järfälla municipality, 2014)*.

need for more links regarding the bike network

Järfällakartan points out an area that expects being affected by the new subway station which will affect the network topology *(Järfälla municipality, 2023b).* The crossing point area for Jakobsberg, Barkarby and Viksjö are located in the middle of this area. Developing this area's transport network for making access to the subway better and maybe for creating circumstances for urban developments in the station's proximity would, therefore, be a necessity. Jakobsberg and Barkarby are also being developed toward a more dense urban structure (*Järfälla municipality, 2023d)*. This further highlights the importance of developing the transport network both within and between those locations.

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Söderhöjden, located almost in the middle of this area, is **without connections** regarding **car** and **bus traffic** in **east and south** going **directions.** This is also considered in the comprehensive plan. **A challenge will be to achieve this in regard to the railway, going along the west and southern** side of Söderhöjden. **To the east it is the E18 which is the barrier, affecting both walk, bike, public transport and car.**

The topology of the network results in a high degree of car dependency since several inefficient connections between districts for walk - and bike traffic makes those options less attractive in relation to the car. Lack of access to a car will keep residents within their neighborhood. Less car dependency together with sustained or increased accessibility will require a breaking of this structure, at least regarding bike and walk. Since the stations of Jacobsberg, Kallhäll and especially Barkarby will offer good opportunities of public transport, good accessibility to those locations will be essential which is also mentioned in the comprehensive plan *(Järfälla municipality, 2014)*. The plan states that public transport will play a role in connecting districts. Based on Han et al. *(2020)*, a somewhat disconnected neighborhood offers a higher amount of privacy and safety but on the other hand less accessibility. Transforming, for example, Söderhöjden to a more grid-like pattern with more connections, crossing the rail in west/south directions would make the network more covering and integrated. This would in turn improve this area's accessibility. On the contrary, if present topology is kept, Söderhöjden will be a more private and silent 'island' in the middle of the traffic.

Making new connections that don't result in more intersections with existing car traffic will keep its efficiency intact. If we intend to promote walk - and bike and thus mainly suggest connections for this traffic this also gets reasonable by the argument of safety because of the separation between those and the car traffic. This might however also result in constructing bridges and tunnels which cost more money and therefore need to be implemented in a careful way.

> *"The topology of the network results in a high degree of car dependency"*

Veddesta located south of the railway is a district mainly consisting of services and has low network coverage regarding car, walk and bike. How to integrate this in the rest will also be something to consider.

The areas between the neighborhoods act like barriers concerning walk, bike and partly buses. Bridging those areas or transforming those into areas that connect instead of disconnects will be necessary. Those areas are often dominated by the railway or the car network. Developing these areas also requires considering those existing infrastructures. The railway fills an important function as a sustainable mode while, regarding the car traffic, we intend to rather promote sustainable modes than oppose less sustainable ones.

In other words, the largest challenge, regarding the topology, seems to be *walk* and *bike* connectivity between districts while connectivity within districts is generally good. Car and bus connectivity are low around Söderhöjden.

“ the largest challenge, regarding the topology, seems to be walk and bike connectivity between districts ”

BIKE NETWORK

The adoption of the new master plan for Järfälla 2030 will modify the landscape to attract investments and inhabitants. With the expansion of the subway to Barkarbystaden and Barkarby station, the current infrastructure will need to be developed and connected in order to shift modes of transportation easily and fast. **Even more, shifting from cars to biking as a main way of transportation is key to reaching the current zero carbon emissions goal.**

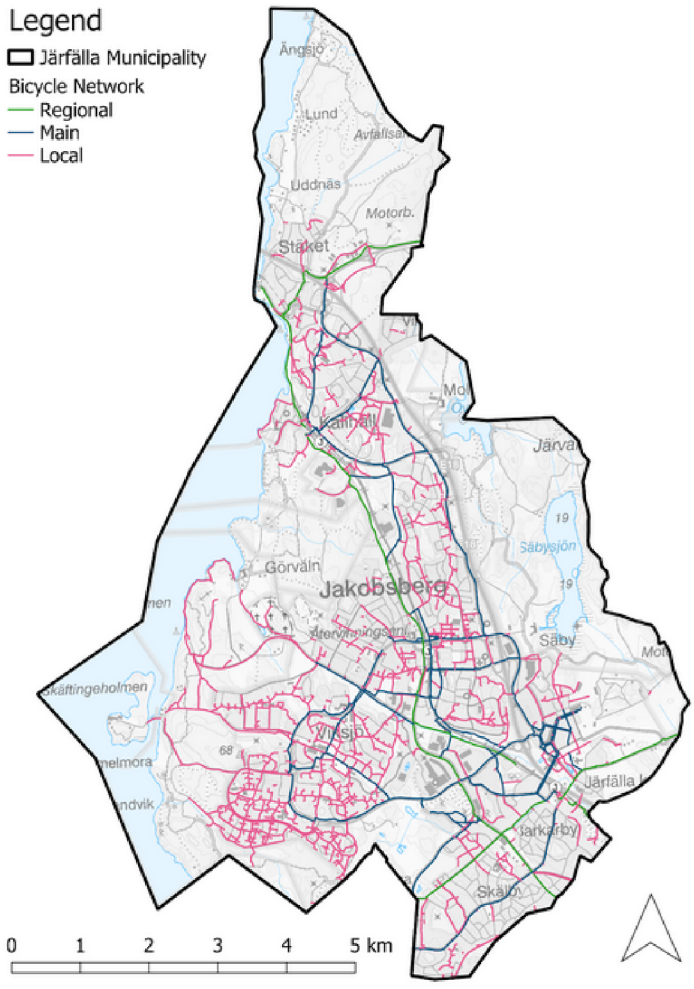
Based on the Järfälla bike plan *(Järfälla municipality, 2018a)*, the current bike infrastructure is not well connected, new bike lanes need to be built, and some others re-desigedn in order to guarantee accessibility to all the new residents. Moreover, the travel habits indicated that a lot of behavioural changes need to be done to increase the bikeability among the population of Järfälla, as well as to embed this bike culture into the new coming inhabitants.

Regarding the amount of trips made, the distribution of the bike as the main means of transportation is low compared to other modes. In 2015, the distribution of means of transport (average for the week) showed that bicycle was the lowest mean with 5%, followed by other means with 6%, by foot with 11%, public transport with 27%, and cars with 52% *(Järfälla municipality, 2018a)*. For 2019, the bike percentage reached 10% and cas went down to 49% meaning that although the number increased, it is not a great number compared to Stockholm for example.

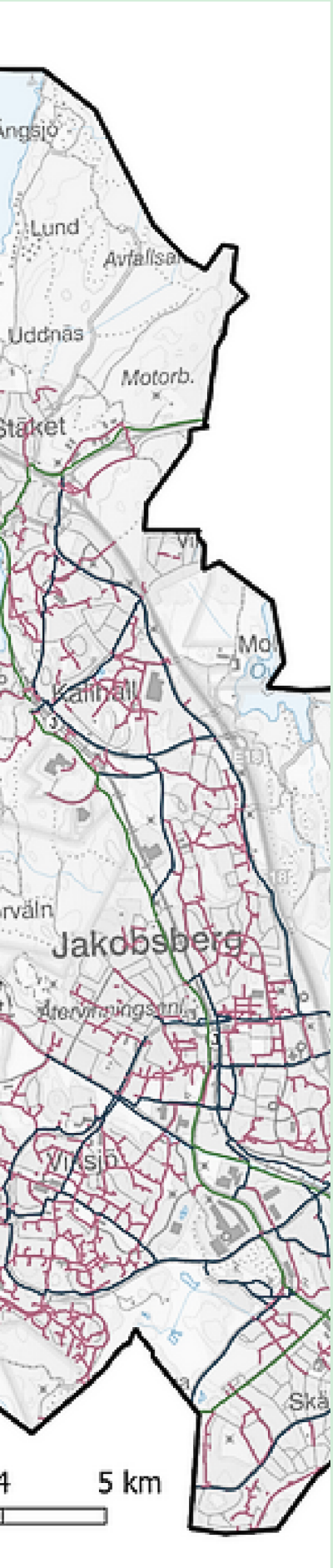
Area	Car	Public transport	Bicycle	By foot	Other
Järfälla	52%	27%	5%	11%	6%
Stockholm	26%	38%	11%	21%	5%

Table 3: Distribution of means of transport (average for the week), *Järfälla municipality, 2018a*

Since the adoption of the first strategic bike plan in 2014, new and better infrastructure has been built to guarantee accessibility within Järfälla and to other municipalities. However, the plan focused on the main cycle network and not so much on the local one *(see Map 1)*. Moreover, although improvements have been made *(new parking spaces, paving new connections, improved bicycle parking)*, the standard of what has been built and transformed varies, meaning that a lot of work is still needed *(Järfälla municipality, 2018a)*.



Map 1: Bicycle network in Järfälla,Source: *SCB, 2020; Trafikverket, 2023a*



According to the **bike plan** *(Järfälla municipality, 2018a)*, the main design **weaknesses of Järfälla's cycle network are:**

- **CONFLICTS WITH THE PEDESTRIAN PATHS**
- **LACK OF INTERSECTION DESIGNS**
- **LACK OF SAFETY IN THE BIKE LANES**

Figures 3a, 3b, 3c: Pictures of conflicts

In *Figure 3a*, the sidewalks and bike lanes exhibit noticeable widening; however, a critical issue persists as many lack clear and safe separations, posing a high risk of accidents and conflicts between pedestrians and bikers. *Figure 3b* highlights a conspicuous absence of signs, particularly concerning the narrow turn radius for cyclists, suggesting that introducing speed reduction signs for cars could enhance safety for both cyclists and drivers.

Additionally, *Figure 3c* underscores the absence of signages and other types of indications for cyclists, potentially resulting in conflicts with pedestrians. Across all three figures, a common theme emerges— the absence of symbols representing various transport choices, contributing to confusion regarding appropriate behavior in diverse environments. Despite some expansion, shared lanes remain narrow, and the delineation between sidewalks and bike lanes is still lacking, presenting ongoing challenges in promoting a secure and organized urban environment.

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Regarding safety it is important to highlight that many accidents are taking place in sites of mixed traffic and due to poor maintenance of the routes:

> *... just over 40% of cyclist's single- vehicle accidents are due to **lack of operation and maintenance** according to the Road and Transport Research Institute VTI and single-vehicle accident make up more than 70% of all bicycle accidents*

(Järfälla municipality, 2018a, p. 36).

The current cycle plan recognizes where improvements are needed and highlights that in future upgrades, it is important to design smarter based on established principles. Moreover, these principles need to ensure accessibility in its broad meaning.

WALKING NETWORK

The stated goal in the pedestrian plan for Järfälla aims to transform the municipality into **one of the most pedestrian-friendly municipalities in the Stockholm region by 2030**. To do so, in the walking action plan, there are proposals for how to upgrade and develop the 42km of the main walking network.

Today's Järfälla pedestrian network is based on traffic separation *"which has led to sparse and in some cases unsafe environments for pedestrians" (Järfälla municipality, 2018b, p. 26)*. Remains of the modernist ideals of cars as signs of freedom are still present and visible in the streets of the municipality.

> *The goal is to become one of the most pedestrian-friendly municipalities in the Stockholm region by 2030.*

In terms of habits, a small percentage of trips are made by walking. Within the municipality, only 17% of the trips are walking trips, and although this number is probably higher since walking to commuter trains is not included, it is still a very low number. Moreover, these trips are mainly leisure travel, 3% of the trips consist of walking, while 17% of all leisure trips are made by foot *(Järfälla municipality, 2018b*).

Regarding who walks, the travel habits survey mentions that women make 54% of the foot trips within the municipality *(Trafikförvaltningen SLL, 2015, cited in Järfälla municipality, 2018b)*. This number is similar in public transportation, however, the gender distribution changes for driving, where 55% of the car trips are made by men. This is important since insecurity is mentioned as a problem where women experience larger insecurity than men.

Based on the SCB's citizen survey *(SCB, 2016, cited in Järfälla municipality, 2018b)*, the residents of Järafälla have a high level of satisfaction with the walking and cycling paths (index value of 61 out of 100). However, these levels are only relevant in terms of design, where aspects like lightning of footpaths, maintenance, snow removal and traffic safety were measured. In terms of the overall experience of navigating across Järfälla, there is no information.

In contrast, a mapping of the status of the pedestrian network *(Map 2)* shows that 40% of the main corridor has a low standard. One of the main issues causing this result is the lack of division between pedestrian and cycling lanes.

Overall, the pedestrian plan states that the network lacks in quality at several links with, for example, too narrow side-walks *(Järfälla municipality, 2018b)*. There are low volumes of pedestrian traffic in central Jakobsberg except at the station. One mentioned reason for existing problems regarding the pedestrian network is the earlier prioritizing of car based traffic.

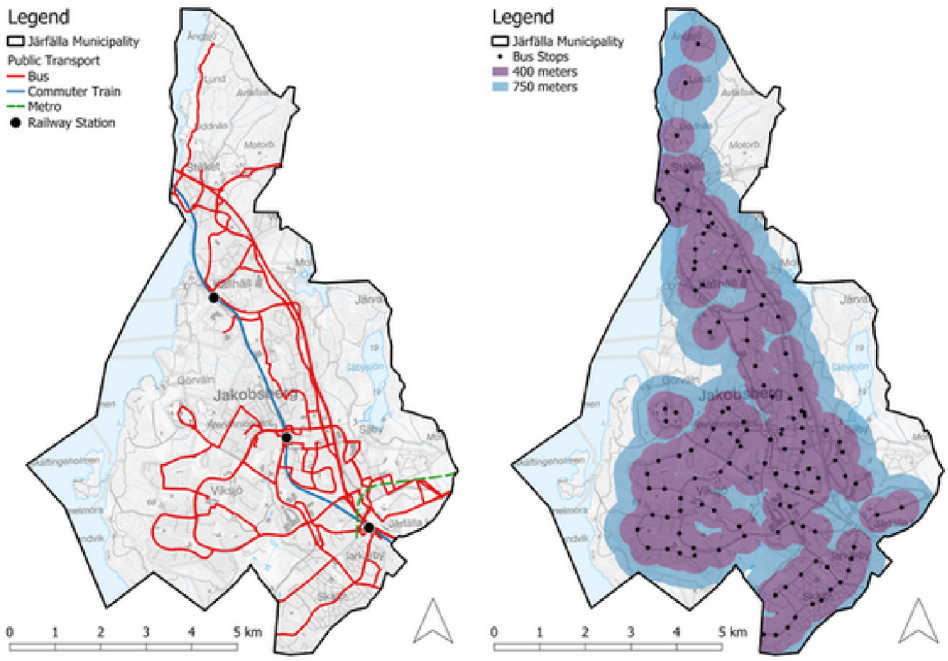
Map 2: Status of the pedestrian network, *Järfälla municipality, 2018b*

The **current strategies** for a more pedestrian-friendly Järfälla are to **improve the connections between city districts**, **level up the standard** of the streets, **prioritization of key areas** which are near stations and primary schools, **improve the social safety** across the pedestrian network and, finally, **quality assurance and follow up.**

PUBLIC TRANSPORT NETWORK

The public transport network currently consists of one commuter train line and a multitude of bus-lines, shown in *Map 3a,3b*, as blue and red respectively. There are three commuter train stations within the municipality located in Barkarby, Jakobsberg and Kallhäll, creating direct connections to Stockholm C. The bus network consists of connections within the municipal borders as well as to other municipalities in the region. Bus terminals are situated next to each of the train stations creating exchange points between different bus lines and between bus and train. For changes between other modes of transport, there are park and ride facilities for bikes and cars available in connection to the stations *(Järfälla municipality, 2019a)*.

During an average winter weekday in 2022, 51 100 people boarded public transport in Järfälla municipality *(AB Storstockholms Lokaltrafik, 2022)*. Jakobsbergs station is one of the 25 biggest stations in the region with 8 600 and 11 400 people boarding buses and the commuter train respectively during an average winter weekday. The two other train stations, Kallhäll and Barkarby, had 5 100 and 4 900 boarding passengers respectively. To evaluate the coverage of the current bus network we looked at the euclidean distance to each of the stops according to RiPlan. The recommended maximum distance *(shown in Map 3b, right)* is 400 meters in multifamily housing areas and 750 meters in urban areas with single family houses *(Trafikförvaltningen, 2018)*. Based solely on distance to bus stops, the majority of the municipality is covered within the recommendations.



Maps 3a,3b: a (Left): Current public transport network in Järfälla. Bus lines shown in red, train line in blue, and future metro expansion in dashed green. b (Right): Euclidean distance to bus stops. Source (Region Stockholm, 2023; SCB, 2020; Trafikverket, 2023a)

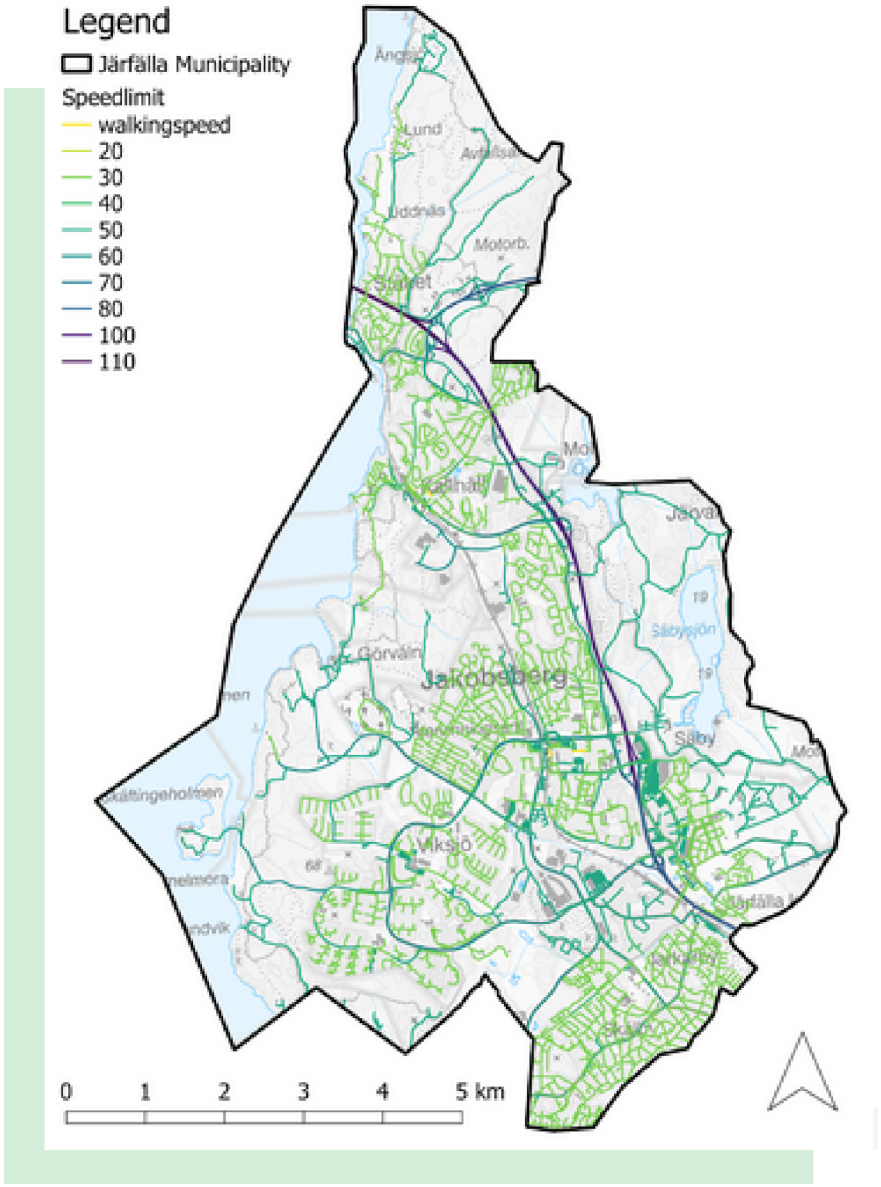
An **expansion to the metro network** with two stations in Järfälla is under construction, shown in Map 3a (left) as a dashed green line *(Järfälla municipality, 2023e)*. One station will be located in the new area Barkarbystaden and the second in Barkarby connecting the metro to the existing train station and bus terminal. To allow high service level transit to the new Barkarbystaden residential area awaiting the metro expansion, an **improved bus system** has been implemented, traversing the path from Akalla to Barkarby station *(Allansson et al., 2023)*. According to the bus operator, this has cut the travel time on the northern part of the route in half, and car trips *to* and *from* the area have been reduced by 900 per day *(Nobina, 2023)*. However, no data has been provided by the operator to substantiate this claim.

The commuter trains in Stockholm have gone through a hard struggle since 2022 with delays and cancellations which has resulted in the Region of Stockholm deciding to not prolong their deal with the present operator *(Johnsson, 2023)*. Before this struggle a drop in service levels had been noticed, with the operation punctuality going from 94% in 2019 to 92% in 2021 & 2022 *(AB Storstockholms Lokaltrafik, 2019, 2021, 2022)*. In 2019 the customer satisfaction rate was at 73% and after a two year break in collecting this data due to the pandemic the 2022 customer satisfaction had gone up to 76% despite the lowered operation punctuality. **These are factors outside of Järfällas control that impact the network and its functions within their borders.**

The railway going through Järfälla (Mälarbanan) was built in 1876 with the purpose of transporting passengers and goods between Stockholm-Västerås-Örebro *(Järnväg.net, n.d.)* Regional trains remain on this route, sharing the railway with the commuter trains.

ROAD NETWORK

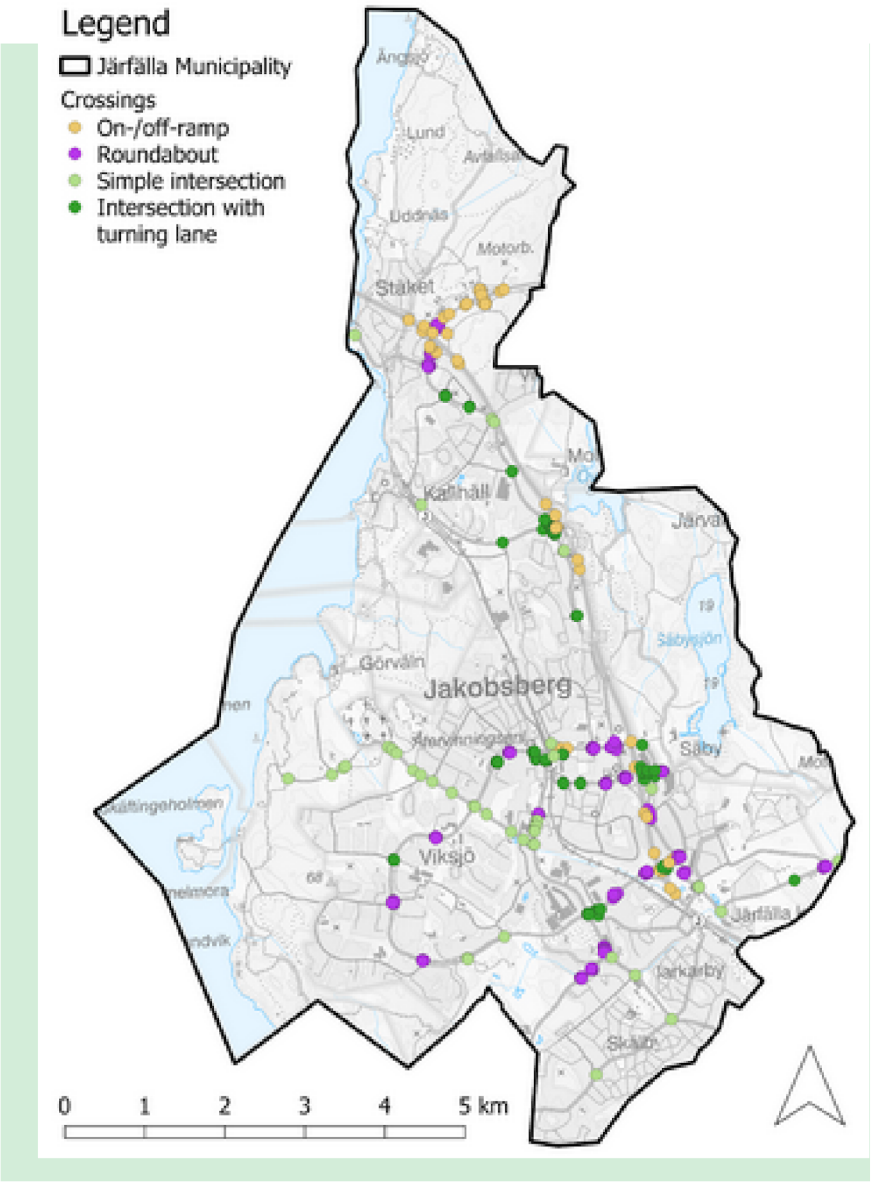
With Järvafältet nature reserve to the east and Mälaren to the west, few alternatives remain to travel in and out of Järfälla by road besides **E18**, the national highway cutting through the municipality stretching northwest to southeast (identified in Map 4 as the purple road with highest speed limit). Connected to E18 in the north, Stäketvägen/Rotebroleden creates a direct link to neighboring Sollentuna as well as the E4 national highway.



Maps 4: Current road network in Järfälla with speed limits *(SCB, 2020; Trafikverket, 2023a)*

Examining the road network based on speed limits as seen in Map 4, three different categories can be identified. Firstly, the light green roads with a limit of 30 km/h that mainly exist within neighborhoods and residential areas. Secondly, the teal roads with a speed limit of 50-60 km/h creating a connection between the low speed neighborhood roads and the high speed main roads. And thirdly the blue/purple roads with a speed limit of 80 km/h or higher making up the main road connections to get in and out of Järfälla. Additionally within Jakobsbergs Centrum some roads have a walking speed limit, creating areas where traffic needs to adhere to pedestrians for speed and giving way *(Transportstyrelsen, 2020)*.

Looking closer at the intersections, the Järfälla road network is characterized by a large number of roundabouts (marked with purple in *Map 5*) on the connecting roads (teal roads in *Map 4*) as well as simple intersections with or without turning lanes (light green and green in *Map 4*) on smaller roads.



Maps 5: Intersection types in the Järfälla road network. Green means intersections (darker green means intersections with turning lanes), purple signifies roundabouts. Yellow signifies motorway on- & off-ramps. *(SCB, 2020; Trafikverket, 2023a)*

Ongoing and upcoming changes to the road network is further discussed in the section *'Trends and future developments affecting the transport system'*.

TRAFFIC SAFETY

In Sweden, traffic safety is centered around ***Vision Zero***, stating “no one should be killed or seriously injured through a road accident” *(Trafikverket, n.d.)*. To achieve this national goal, safe traffic environments are important on all levels of government. Data collected from Strada *(Swedish Traffic Accident Data Acquisition)* shows all accidents that occurred in Järfälla municipality during 2022, grouped by severity and accident type as well as geographic location for the most common accident types. The first takeaway is that no deadly traffic accidents were recorded in Järfälla during 2022 *(STRADA, 2022)*. In the Stockholm Region there were approximately 0,7 deadly traffic accidents per 100.000 inhabitants during the same time period. It’s therefore assumed that Järfälla, with around 85.000 inhabitants in 2022, will have a similar accident rate to the rest of the region. The per capita rate of traffic related deaths and accidents in Järfälla can be seen as low, both when compared to the rest of Sweden and when compared to the EU, where Sweden reported the second lowest amount of road traffic fatalities per capita as of 2021 *(European Comission, 2022; STRADA, 2022)*. Even with a low amount of accidents the desired outcome still remains as zero deaths and zero serious accidents, meaning there's always room for improvements.

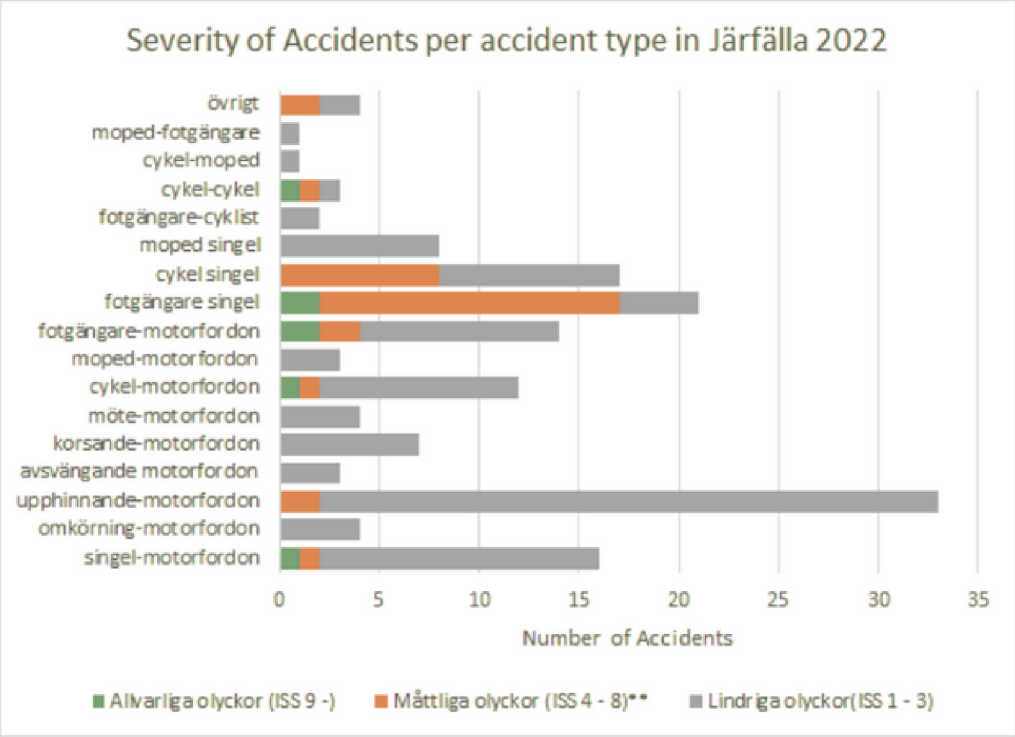
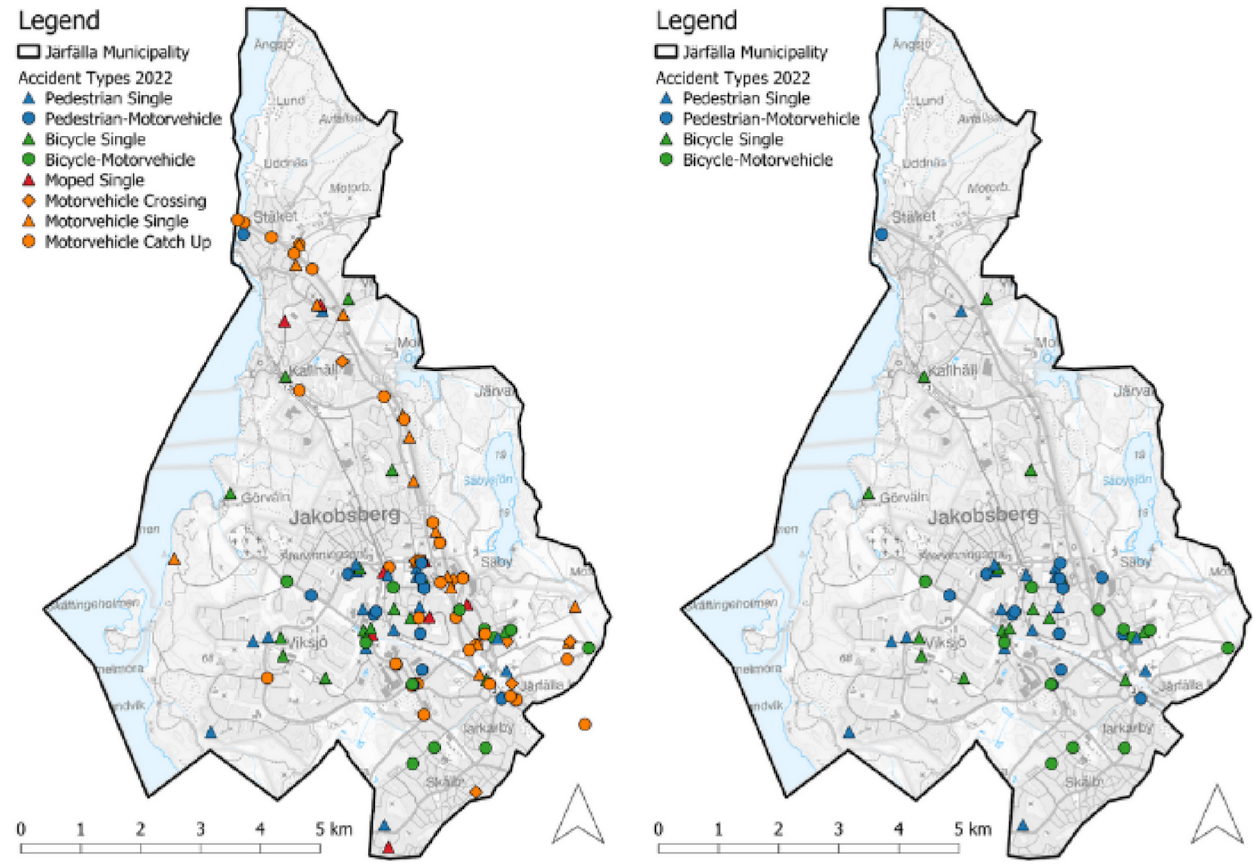


Figure 4: Severity of accidents per accident type in Järfälla *(STRADA, 2022)*

Of those seven serious accidents, two involved cyclists and four involved pedestrians.

When assessing the accidents based on type, Map 6 shows that seven serious accidents (blue) occurred in Järfälla during 2022. Of those seven serious accidents, two involved cyclists and four involved pedestrians. Four of the serious accidents also involved motor vehicles, but in three of the cases it could be assumed that the non-protected traveler (cyclists or pedestrians) is the one that got injured in the accident. Continuing, there were 32 recorded moderate accidents (orange), the most frequently occurring were single accidents by bike or foot. The majority of the 114 minor accidents involve motor vehicles. The diagram shows that single accidents on foot and on bike make up the majority (25 of 39) of serious and moderate accidents in Järfälla 2022.



Maps 6a, 6b: 6a: Accident types with at least 5 accidents in Järfälla 2022. 6b: The accident types involving pedestrians (blue) and cyclists (green). Single accidents marked by triangles and accidents with motor vehicles marked by circles. Source: *Map made using data from SCB & STRADA (SCB, 2020; STRADA, 2022)*

Map 6a shows where the most common accident types occurred in Järfälla during 2022. Because most of the serious and moderate accidents involved pedestrians and cyclists the Map 6b is filtered to only show where these occur. Some of the clusters that can be observed are accidents between bicycles and motor vehicles within Barkarbystaden, as well as generally more accidents concentrated around Jakobsbergs Centrum.

The previously developed *"Safe routes to school guidelines"* (Riktlinjer för säkra skolvägar) looks at the current situation for traffic safety in Järfälla regarding children as well as gives guidelines for improvements. The main areas of improvement from the "Safe routes to school guidelines" are as follows *(Järfälla municipality, 2018c)*:

- Planned placement of new and preliminary schools in regards to traffic safety.
- The design of bike and pedestrian paths and the importance of treating them as two different modes of transport with different conditions and needs for safety.
- Separation from road traffic and direct paths to public transport stations.
- Reducing traffic speed, especially at pedestrian crossings.
- Road signs informing where the main routes for children are crossing the road.
- Placement of school parkings, pick-up and drop-off areas, and delivery areas away from the schoolyard.
- Maintenance of the paths important for year round use.

During 2018 all schools in Järfälla were inventoried and ranked by need for action *(Järfälla municipality, 2018c)*. And every year the municipality works with 2-3 schools to examine the children's travel habits and look at areas of improvements in regards to traffic safety.

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PARKING POLICY

ON-STREET CAR PARKING

On-street parking is the parking space offered on public land by the municipality for anybody to use. In Järfälla, on-street parking along streets is generally provided for the purposes of short stops, deliveries and service traffic *(Järfälla municipality, 2019a)*. Formerly, housing has been developed without associated off-street parking to cover the parking demand generated, expecting residents to park their cars on the street. These legacy residential parking uses on streets remain, but in current and future land use development, car parking demand is expected to be met on the developers own land or in shared parking facilities.

In general, on-street parking in Järfälla is free of charge but using so called 'date-based parking' – i.e. allowing weekday parking on only one side of the street on mathematically even dates, and on the other side on odd dates *(Järfälla municipality, 2019a)*. Since this requires the owner to move the car at least once every day, it works as an alternative to fees for managing demand for on-street parking. In most areas of Järfälla, the municipality has concluded that this regulation is enough to ensure less than 85% occupancy, making it easy to find a parking spot at all times according to a heuristic proposed by Shoup *(2005)* and adopted by the municipality.

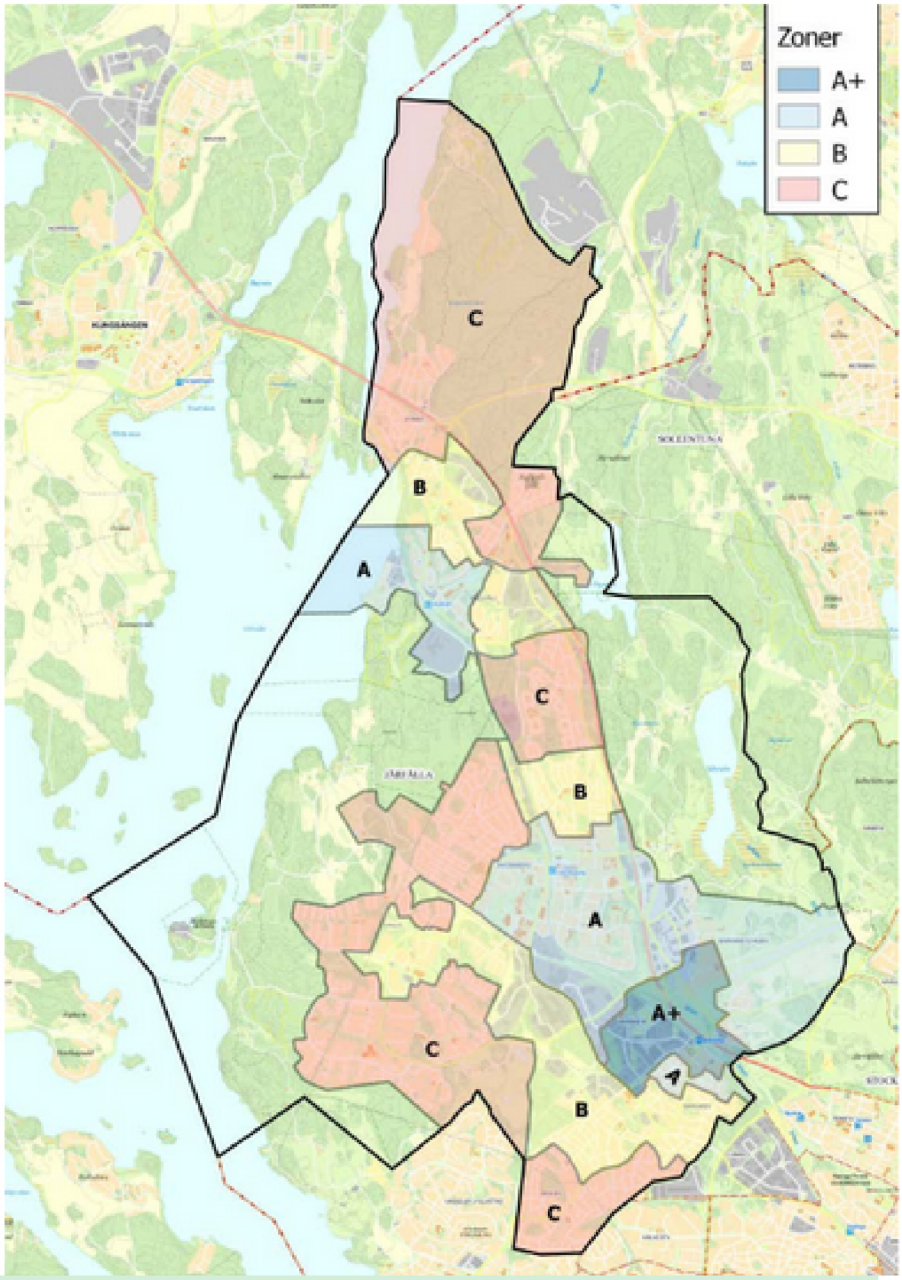
Image 1: *On-street parking in Barkarbystaden and associated fee payment facilities. Source: Google maps.*

> *Implementing fees to on-street parking also has the benefit of limiting 'spillover' parking effects*
>
> *Olus Inan et al., 2019*

Some areas deviate from this practice. In the Barkabystaden and Söderdalen areas currently being developed, the municipality has determined that parking fees for on-street parking is needed to manage the demand *(Image 1; Järfälla municipality, 2019a).* Currently the fee is 10 kr per hour or 40 kr per 24 hours *(Järfälla municipality, 2023c)*. The municipality finds that this does not cause a barrier to mobility, because it considers these areas sufficiently served by bus and rail transport, as well as enough parking spaces for any residential needs on private land. Implementing fees to on-street parking also has the benefit of limiting 'spillover' parking effects *(Olus Inan et al., 2019)*, where users for whom designated (but subject to a fee) parking space exists on private land, instead decide to use free-of-charge on-street parking. The municipality's own investigations into the on-street parking occupancy in Barkarbystaden suggests that the parking spaces are being used by residents after all, suggesting that the fee is not high enough to deter spillover parking entirely *(Järfälla municipality, 2019a)*. Charging for on-street parking might seem uncontroversial, but the suburban Stockholm municipality of Huddinge is an example of a comparable municipality that has struggled and failed to introduce fees on its streets due to political resistance *(Fagerström, 2022)*.

OFF-STREET CAR PARKING AND MOBILITY MANAGEMENT

The municipality requires developers to provide car and bike parking. As noted in the previous section, the Järfälla municipality's parking policy specifies that developers need to provide parking to cover the demand generated by new developers on private land *(Järfälla municipality, 2019a)*. The expected demand generated by different land uses are specified in the municipality's "parking norm", where minimum parking requirements are defined according to the type of land use and the location in the municipality *(Järfälla municipality, 2017)*. In this document, the municipality divides up its districts into parking zones A+, A, B and C to signify the locations' access to public transport and services (Map 7). For example, the parking norm requires that between 0.2 and 0.9 car parking spaces be built per flat depending on the size of flat and which zone it will be in.



Map 7: Parking zones of Järfälla. A+ has the lowest minimum parking requirements of all the zones and has only been designated in Barkarbystaden as of yet.

Parking norms were not always designed this way. What Järfälla has done here might not seem particularly innovative, but before the current parking norm was approved in 2017, the parking norm stated (e.g.) that each flat needed 0.8 parking spaces irrespective of location and size *(Järfälla municipality, 2016)*. The earlier practice follows a typical pattern in the 20th century (both in Sweden and internationally; *Lundin, 2008; D. C. Shoup, 2005*) of adjusting such requirements to the worst case scenario, which in turn resulted in overestimations of the demand for most locations.

Järfälla also offers further reduction to the requirements to developers willing to help manage parking demand. The new parking norm goes beyond locational requirements and offers 'flexible' requirements for the developers if they in return implement so-called "mobility management" tools, such as car sharing services (Image 2) or improved bike parking facilities *(Järfälla municipality, 2017)* that are assumed to reduce demand for car parking. According to the parking norm document, in the A and A+ zones the municipality even offers the possibility of lifting the requirements entirely. For the municipality to allow this, the developer needs to implement enough mobility management interventions and be able to convince the municipality that no parking demand at all is generated because of the implemented measures.

PARK-AND-RIDE FACILITIES

Park-and-ride facilities are those parking spaces nearby railway stations that enable intermodal combination trips with car or bike and commuter rail. Järfälla provides about a thousand such spaces free of charge at the three main railway stations *(Järfälla municipality, 2019a)*. To make sure that nobody uses these parking spaces for other uses, car parking is prohibited during night-time. Such facilities can be beneficial if they enable car trips to be partially performed with public transport, but on the other hand they risk replacing a walk to the station with a drive there. In terms of improving accessibility by public transportation, however, such facilities have been shown to have large positive effects on suburban users *(Carlson & Owen, 2019)*.

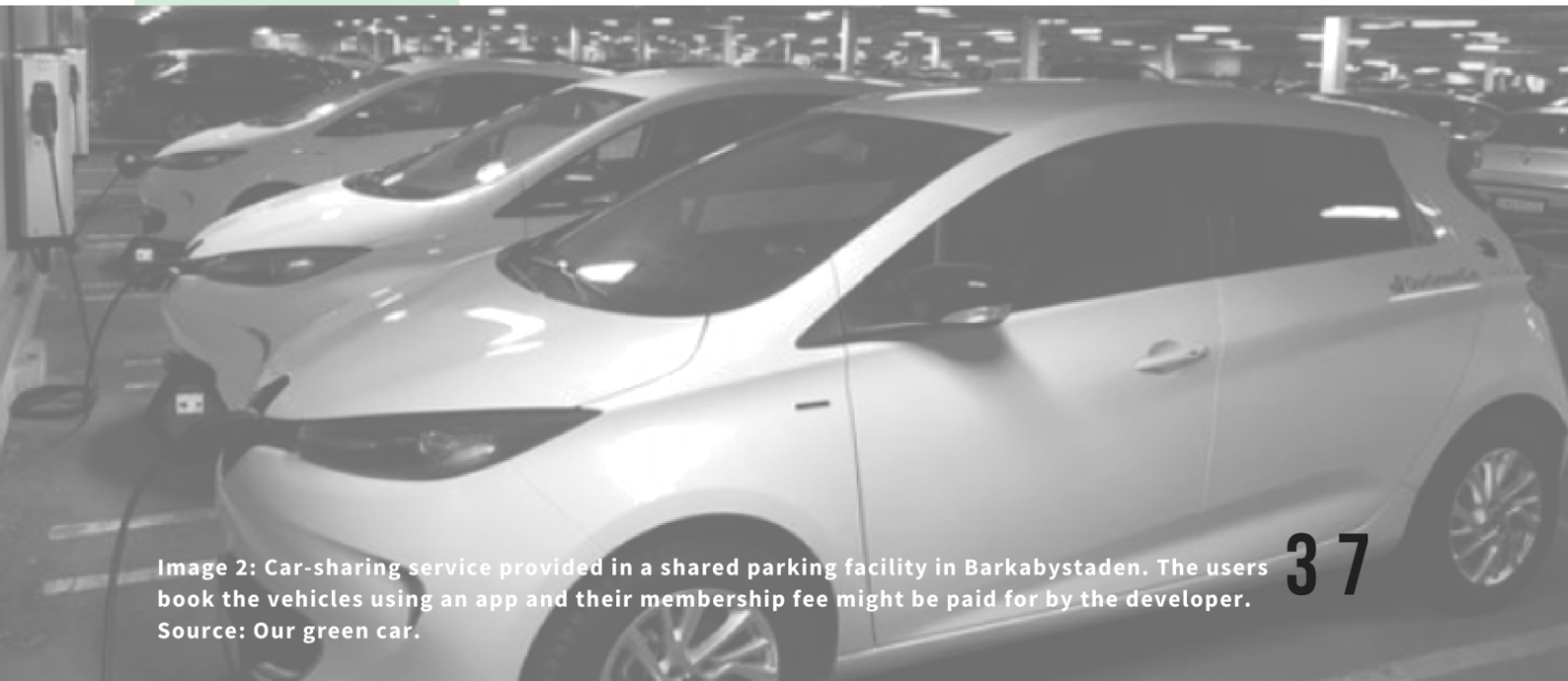
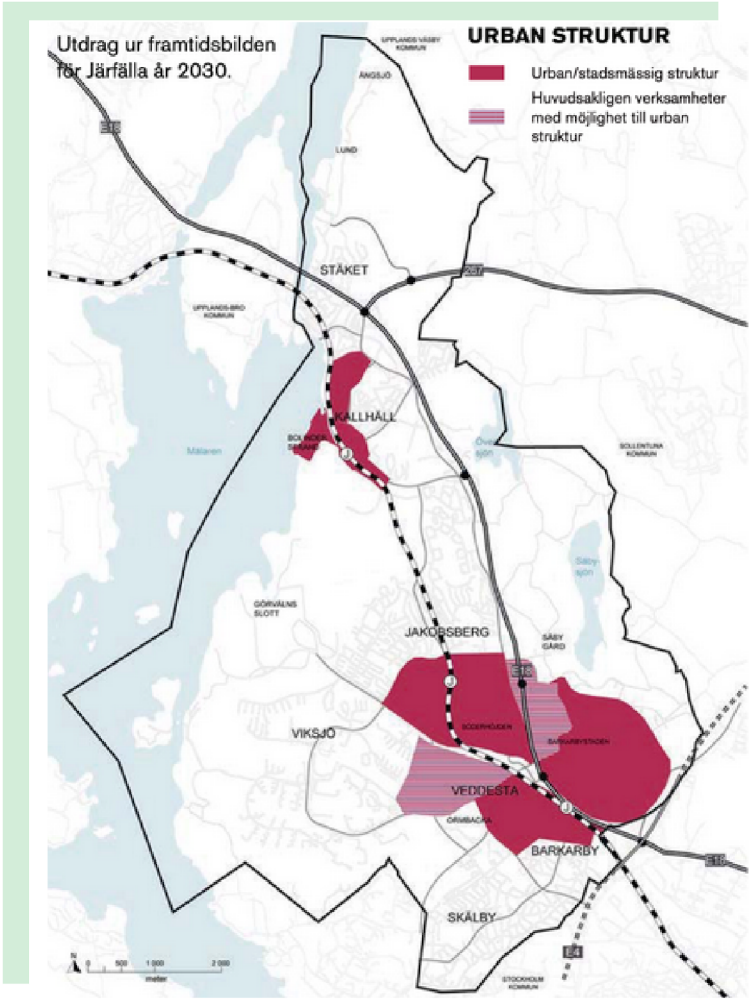


Image 2: Car-sharing service provided in a shared parking facility in Barkabystaden. The users book the vehicles using an app and their membership fee might be paid for by the developer. Source: Our green car.

TRENDS AND FUTURE DEVELOPMENTS AFFECTING THE TRANSPORT SYSTEM

REGIONAL CITY CENTER IN BARKARBYSTADEN AND JAKOBSBERG

The combined area of Jakobsberg and Barkarbystaden has been designated as a regional city center in the Stockholm regional development plan *(Region Stockholm, 2018, pp. 114–117)*, which is likely to inspire and strengthen its role as a transport hub. The area around Barkarby station is planned to be developed with both a subway station *(Järfälla municipality, 2023e)* and with different options of public transport station *(Järfälla municipality, 2023f)*. Järfälla municipality *(2023f)* also writes that a total of 14000 new apartments are planned to be developed here and a bridge is being constructed over E18 which goes through this area. This will on one hand bring economic benefits but, it also concentrates larger amounts of traffic, further contributing to higher emissions. If regional emissions are to be decreased while traffic is increasing, the share of sustainable modes of travel must be even larger to compensate for the increase.



Map 8: Development areas where “urban structures” should arise according to the comprehensive plan. The southern section marked corresponds to the proposed regional city-center. Image credit: Järfälla municipality.

The comprehensive plan of Järfälla aims to develop a both dense and integrated urban environment in central Jakobsberg, Veddesta and Barkarbystaden (Map 8). The general policy of the plan is to develop with a structure of street networks characterized by accessibility and openness. The bike plan points at the more dense character in the newly developed areas in Veddesta and Barkarbystaden and suggests a more fine grained bike-network for adapting to this higher concentration of people and services *(Järfälla municipality, 2018a)*.

If the older areas are going to be successfully integrated to the new ones they will need to adapt this structure as well, transforming those currently separated neighborhoods into one accessible central location.

STOCKHOLM BYPASS MOTORWAY

The Stockholm bypass motorway is a partial outer ring road encircling the western half of Stockholm from Häggvik in the north to Skärholmen in the south, expected to be completed by 2030 *(Trafikverket, 2023b)*. It will connect to the Järfälla E18 motorway in Barkarby at the southern edge of the municipality and provide increased accessibility for road traffic and potential bus lines traversing the route. This will be beneficial economically, allowing greater access to jobs and services for Järfälla's residents, but on the other hand creating greater incentives for private car use and thereby congesting the motorway connector roads in Järfälla.

ELECTRIC AND AUTONOMOUS VEHICLE TECHNOLOGY

Electric Vehicle (EV) technology is becoming popular in new vehicles across the world, as well as in Sweden. In 2020, the Swedish government organ "Transport analysis" predicted that by 2030, the market share for new EVs would be about 60 percent, and that by 2030, 35 percent of the total fleet of Swedish vehicles would be EVs *(Trafikanalys, 2020a)*. Newspaper reports suggest that about one third of all new vehicles sold in may of 2023 in Sweden were EVs *(Törnwall, 2023)*, but this number varies in response to current policy incentives and economic factors. It is clear that vehicles that emit less greenhouse gasses within the boundary of Järfälla will become more common as time progresses. The pace of this transition isn't necessarily fast or constant, and might be lower after the most willing adopters have switched to electric vehicles. Car lifespans of about 15 years *(Nakamoto & Kagawa, 2022)*, also mean that non-EV cars sold in Järfälla today will still be producing emissions in 2030 and beyond.

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While autonomous vehicle technology has proven difficult to implement in reality, experiments in Järfälla *(Njie, 2023)* and elsewhere show that its use can be feasible with major constraints. In an overview article, Duarte and Ratti *(2018)* suggest that as technological development continues these constraints will be overcome gradually as time progresses. Duarte and Ratti suggest impacts in terms of lower parking demand and lower vehicle ownership on the one hand, but higher demand for vehicle travel with autonomous taxi- or ride-sharing-like services. In terms of impacts on city form, the authors suggest that this will lead to an increase in demand for living further away with less density, since the comfort of commuting is increased. Duarte and Ratti also speculate that this will increase the amount of online shopping through reduction of delivery costs.

Tax incentives and other policy decisions relating to vehicle technologies are not within the boundaries of local policy making, meaning that both these developments are to be considered outside trends that Järfälla needs to take into account. However, Järfälla has the control over its own municipal streets and can make local traffic rules (so-called “LTF”) that differentiate between technologies, like Stockholm has done with environmental zones in some of its inner-city core *(Stockholm municipality, 2023)*. The enforcement of such regulations is nevertheless a challenge in itself.

SHIFT TO ONLINE SHOPPING AND REMOTE WORK

Online shopping means making a purchase without needing to travel to a destination. In Sweden, the covid pandemic had a strong relative effect, bringing the market share for retail shopping up to 15% at the end of 2022, from about 10% before the pandemic *(SCB, 2022b)*. While this is very important for retailers increasing their online business by 50%, for the transport system decreasing the need for trips from 90% to 85% is only a marginal change. Trade associations speculate that this share could be down to 60% by 2030, and that other types of shopping are starting to follow the trends in retail *(Svensk Handel, 2023)*, which, if it comes true, will be helpful in achieving societal goals related to transport planning. On the other hand, Hiselius et al. *(2015)*, reviewing online shopper travel in the south of Sweden, find that frequent online shoppers typically use the time saved by online shopping for making more trips, either for more shopping or other errands. This means that Järfälla cannot expect its problems to be solved by the online shopping shift.

Remote working has seen a rise after the covid pandemic. In a 2022 non-peer-reviewed study, Grafström *(2023)* shows that Stockholm region office workers on average work from home 2.1 days per week, i.e. nearly half of the working week. A consultancy report from WSP shows that about 30% of the population in Swedish commuter municipalities near major cities work with types of activities that enable working from home *(WSP, 2021)*. Taken together, this could mean that about 15% of commuter trips in Järfälla from before the pandemic have been replaced by remote work. However, if this is the case, then this change has already taken place and is accounted for in the current state of the transport system. As far as we can tell, there is no particular reason to believe that remote work will become more popular than it already is in Järfälla in the coming years, or that a larger share of the population will start working with the types of jobs that allow remote work.

REVIEW OF POLITICAL STANDPOINTS RELATING TO THE TRANSPORT SYSTEM

GENERAL COMPREHENSIVE PLAN TARGET VISIONS

The comprehensive plan Järfälla 2050 project has defined four guiding target visions politically (as translated by the writers of this report; *Järfälla municipality, 2023d)*:

- A climate positive and innovative society.
- Prepared for the future with reinforced nature and water environments
- An attractive central core and municipal districts with distinct identities
- Inclusive and vibrant (“levande”) residential environments

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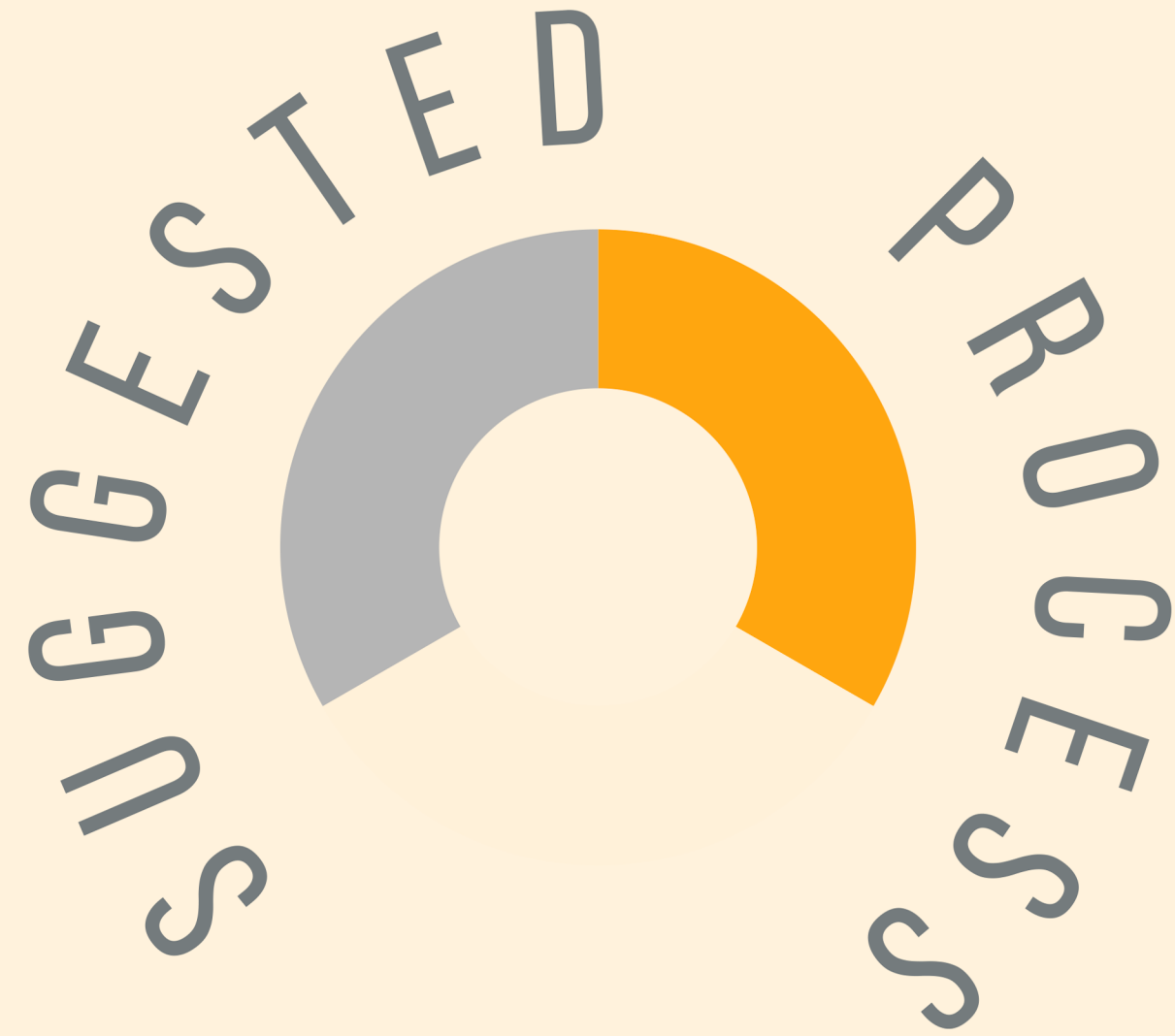
STRATEGIES WITHIN THE COMPREHENSIVE PLAN

Within the comprehensive plan, a series of strategies have been proposed for land use planning (“fysisk planering”). As far as we’ve been informed, these have not yet been formally approved politically. We list a selection of seven proposed strategies that pertain the most to the transport system here (as translated by the writers of this document):

- Planning for an efficient transport system
- Planning to enable everybody to choose sustainable modes of transport
- Remove barriers and transform major roadways into green, social paths
- Allow straight and attractive passages between the municipal districts
- Planning using safety (or perceived safety, “trygghet”), equality and gender equality as a point of departure
- Attempt to provide service access to all residents within a 15 minute walking distance
- Property development near public transport nodes to allow vibrant local centers

Importantly, the document containing the proposed strategies that we’ve received from the municipality contains a crossed-out strategy suggesting the prioritization of pedestrian, cyclist and public transport (however, not explicitly stating what these are being prioritized over), similar to the ‘upside down pyramid” that the Stockholm municipality traffic strategy is known for *(Stockholm municipality, 2022, p. 22)*. We interpret the fact that this strategy has been crossed out in the document, as it not being in line with the political goals of the municipality, and that the traffic strategy needs to not prioritize some modes of transport over others.


SUGGESTED PROCESS

3. SUGGESTED DEVELOPMENT OF A TRAFFIC STRATEGY IN JÄRFÄLLA

> *a review of the most important insights on traffic strategy development from the transport research literature*

SUGGESTED DEVELOPMENT PROCESS

The guidebook for strategic traffic planning *(SKR, 2022)* and its predecessors suggest a step-by-step process for working strategically with traffic planning. In this section we interpret this suggestion for the Järfälla context outlined in the above review, and thereby **propose a pathway toward a traffic strategy for Järfälla**. We separate the suggested process into four steps to clarify the process to the reader, but this should not be interpreted as strict boundaries or "gates" between the steps. The steps are:

1. Political foundation, scope and relation to other documents
2. Review and analysis of the present transport system
3. Development of visions, goals and strategies for implementation
4. Political approval, implementation and continuous review

After delineating this stepwise process, this section then continues with a review of the most important insights on traffic strategy development from the transport research literature that do not fit neatly into any particular step in the description of the process itself.

INITIAL STEP: POLITICAL FOUNDATION, SCOPE AND RELATION TO OTHER DOCUMENTS

The initial step suggested considers the need for the project to define its scope and to lay the foundations for its political support *(SKR, 2022).* A political decision to allocate enough resources to the project is needed at this stage for planners to be able to work on a traffic strategy *(Wendle et al., 2012)*. However, the decision of the local government to "buy-in" to the idea of goal-driven, strategic traffic planning through supporting such a project also serves a greater purpose of creating a coalition of actors who wish to see such a project fulfilled. As Banister *(2008)* shows, creating voter acceptance is central to any shifts towards sustainable mobility policies. Presumably, the idea that the transport system can be affected by the wishes of voters and politicians is attractive to those groups. The implementation assessment practices within the traffic strategies of other municipalities have created a pool of evidence of successful examples that can be used to show the effectiveness of traffic strategies to skeptics (such as the traffic strategies of Växjö, Lund and Gävle cited in *Wendle et al., 2012)*.

> *creating voter acceptance is central to any shifts towards sustainable mobility policies.*
>
> *Banister, 2008*

At this early stage it is also necessary to consider the geographical scope of the traffic strategy *(SKR, 2022)*. In the Järfälla context, the municipal boundaries align fairly well with the agency of the municipality itself. Yet, the transport system does not know these boundaries, and this type of approach will lead to some parts of the transport system, such as the national road network and trips to destinations outside of the municipality as an outside influence that the municipality needs to deal with on its own parts of the transport system. If the purpose of the strategy is to guide the work of the municipal traffic planners, it is the very things that the municipality has agency over, that are the central aspects to consider. On the other hand, the political goals of the Järfälla municipality are closely related to its municipal boundaries.

> *it is the very things that the municipality has agency over, that are the central aspects to consider.*

PLACING THE TRAFFIC STRATEGY IN RELATION TO OTHER POLICY DOCUMENTS

One more aspect that is of initial importance in the relationship of the traffic strategy in development to pre-existing policy documents *(SKR, 2022)*. In Järfälla, the ambitious comprehensive plan under development is the obvious parent of this document, since it outlines the municipality's standpoints in terms of physical development. More detailed plans for measures relating to specific parts of the transport system also exist, such as the bike plan and parking policy documents. These rely on implicit strategic standpoints made at the time of their development, and will need to be updated in relation to the decisions made in the final traffic strategy.

Depending on the issues contained within the scope of the traffic strategy, the guidebook suggests considering the **integration of documents** (such as integrating the traffic strategy into the comprehensive plan; *SKR, 2022*). Our view is that Järfälla's ambitious political goals, complex transport system and its fairly large size in the Swedish context mandates a separate traffic strategy document. Whether or not the document is separate, *piggybacking* on the process related to the comprehensive plan is an efficient way to create public interest in the traffic strategy and to build support for it *(Wendle et al., 2012)*. Wahl *(2013)* shows that Swedish municipalities usually struggle to create such interest, and therefore this opportunity should be utilized if possible.

STEP 2: REVIEW AND ANALYSIS OF THE PRESENT TRANSPORT SYSTEM

The next step concerns reviewing and analysing the present state of the transport system, and the processes suggested by the guidebook for how to do this are straight-forward *(SKR, 2022)*. However, this step has a major importance for the later steps in creating a shared view of what the present state is, that all of the relevant actors can agree on. After an initial review, therefore, the interpretation of the present state needs to be negotiated with those actors, and modified into something that they can all agree on. This document contains an initial review and analysis of the transport system and an overview of the most important external trends that will affect the municipal system (Section 2). Presumably, the municipality has access to more data which should be used to enrich this analysis further, after which it should be shared with the relevant actors and modified to establish a shared understanding of the present situation.

STEP 3: DEVELOPMENT OF VISIONS, GOALS AND STRATEGIES FOR IMPLEMENTATION

The actual contents of the future traffic strategy document comes down to a vision of what the voters wish the future of the transport system to be like, and an analysis of what needs to change from the present state defined in the previous step to achieve these visions (e.g., using some type of backcasting method; *Dreborg, 1996*). To enable traffic planners to use this in day-to-day planning, the guidebook suggests that the traffic strategy should condense the changes needed into specific goals that the transport system should achieve *(SKR, 2022)*. As the Järfälla municipality points out when specifying the need for a traffic strategy, the strategy needs to prioritize between these goals *(Järfälla municipality, 2019b)*.

Defining these visions and goals in relation to the transport system is preferably performed as an iterative, consensus-finding process together with the public to build the support necessary for their later implementation. Yet, as Ibeas et al. *(2011)* notes, generating the required public interest in municipal strategic traffic planning is difficult. We encourage the Järfälla municipality to attempt to do this, but if it is not possible, the iterative process should be directed towards the local parliament. The guidebook suggests that this iterative process can be effectively conducted through producing impact assessments of the previous version of the vision and goals, and then feeding this back to the decision makers *(SKR, 2022)*. Bertheden and Karlsson *(2009)* note that traffic strategies' alignment with the comprehensive plan is essential to their successful goal achievement. Therefore, we believe that the most beneficial starting point for such an iterative process of vision and goal definition is based on the municipality's comprehensive plan. This document contains our interpretation of the "target visions" defined in the ongoing comprehensive plan project and a suggested set of goals that encompasses the changes needed in the transport system to achieve those visions in relation to the transport system (Section 4).

To guide the achievement of these goals, the handbook also proposes that the municipality develop a set of (sub-)strategies that will lead to the achievement of the defined goals, alongside indicators which can show whether the goals are successfully being achieved over time *(SKR, 2022)*. The contents of these strategies are naturally dependent on the goals defined and their internal prioritization, and it should be tailored to contribute to the achievement of the most prioritized goals. If this is done well-enough, this will provide decision support for the individual planner, ensuring that each decision made contributes to achieving the overarching goals of the municipality's transport system. To suggest how this would work, this document provides three outlines of strategies that would contribute to the achievement of the "starting point goals".

As the goals get iteratively re-defined when the municipality develops the traffic strategy, the strategies also need to be re-defined. The document also contains a discussion on what considerations the municipality needs to make as it develops goal indicators to measure its strategies' effectiveness.

STEP 4: POLITICAL APPROVAL, IMPLEMENTATION AND CONTINUOUS REVIEW

Once a sufficiently developed traffic strategy document has been reached, it should be passed to the local parliament for political approval *(SKR, 2022)*. Importantly, this does not mean that the traffic strategy project is completed. Assuming a successful iterative process like the one outlined in the previous section, the approved traffic strategy serves as a comprehensive document outlining what the public wishes the municipal traffic planners to achieve. The planners are tasked with acting based on the defined goals and strategies, and if needed to define more detailed action plans for what projects should be undertaken (as Järfälla has already done with its bike- and pedestrian plans; *Järfälla municipality, 2018a, 2018b*). Bertheden and Karlsson *(2009)* stress the importance of this step and show that failure to perform it is one of the main reasons cited by Swedish municipalities reporting ineffectiveness of their approved traffic strategies.

Furthermore, it is essential that the municipality continually review the goal indicators to ensure the effectiveness of its measures and whether the goals defined are being fulfilled, and to motivate further resource allocation where success is seen *(Wendle et al., 2012)*. Research insights in transport planning are always contextual, and knowing the effects of a certain measure when applied in Järfälla in advance is impossible. Regular indicator measurement allows what Evans *(2016)* terms "urban experimentation" where the municipality can try implementing different measures and note whether they seem to contribute to goal fulfillment or not.

Finally, as society develops and political sentiments in the municipality changes, the contents of the traffic strategy itself needs to be reviewed continuously. The handbook suggests that such a review of the traffic strategy's alignment with societal goals should be performed after every new election *(SKR, 2022)*.

FURTHER INSIGHTS ON TRAFFIC STRATEGY DESIGN AND EFFECTS

Bertheden and Karlsson's *(2009)* review of Swedish municipalities cited in the above also shows that most of the municipalities which had enacted traffic strategies by 2009 stated that they perceived a general effectiveness improvement in the municipalities' traffic planning, because of the holistic approaches that they create *(Bertheden & Karlsson, 2009)*. Some municipalities did, however, report no improvements. Beyond the comprehensive plan connection and failure to implement the strategies cited as reasons above, the authors note that such problems are caused by strategies being too abstract or difficult to understand. This problem is nuanced by Buhler *(2021)*, who uses textual data analysis to review the language employed in 36 French municipal traffic strategies (PDUs). He shows that while vagueness might be a barrier to accountability, it can also be used as a tool to enact more progressive policy in a vague state – to be defined more clearly at a later stage. Reviewing the French traffic strategies, Buhler finds this practice in use even in their most important parts (e.g., the strategies or interventions proposed), and that the use has increased over time from the early 2000s until 2020.

The use of vagueness to bypass political resistance does, however, border on the deceitful. The traffic strategy of Järfälla must be defined with as much clarity as possible to make it useful for day-to-day traffic planning and to make transparent how it interprets the visions and goals defined by its voters. We think it is unethical to go as far as the French local authorities and attempt to push strategies that we know that the voters would reject using vagueness. Yet, for controversial measures, being abstract in the early strategic stages might be a key to get past initial negative gut reactions and reach a democratic decision making process. This echoes Banister's *(2008)* suggestion to implement progressive sustainable mobility policy in stages rather than all at once to improve acceptability.

Wendle et al. *(2012)* have reviewed the effectiveness of enacted Swedish TRAST-based traffic strategies and point to key factors for successful implementation. Beyond the insights noted in the suggested process above, the authors stress the importance of patience and continual work with the traffic plan even if it is less successful than expected initially, because the process of working with it develops over time and is a learning process. Wendle et al. also underscore the need to create institutional engagement and political support for the traffic strategy. In Järfälla, this necessitates the integration of the traffic strategy into the broader activity of traffic planning, and of building a network of actors and activities relating to and returning to the plan over time.

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Reviewing **13 different traffic strategie**s from four different countries (including Sweden), Rye and Hrelja *(2020)* find that the identified problems with the transport systems are similar and mostly relate to overuse of private cars, including issues lack of accessibility as a threat to economic growth, environmental impacts and traffic safety issues. The most varying factor then, is the degree to which the strategies proposed to deal with the problems include measures to directly reduce car traffic and whether these measures only concern the inner city area or the entire municipality. According to Rye and Hrelja, in the cases where these measures are small and located in the inner city only, it leads to an ambiguity as to whether the proposed strategies actually solve the identified problems. None of the examined strategies go beyond using methods of parking management to achieve car traffic reductions.
For the traffic strategy for Järfälla, this means that identifying private car traffic as a problem is nothing controversial in itself and also not something that will cause any change just by the recognition. The municipality needs to be clear about how the strategies proposed achieve the set goals, and recognise it if the strategies are too limited in scope or magnitude to achieve them.

Hrelja and Rye *(2023)* review the effectiveness of different approaches to managing demand for private automobile transport. Comparing the traffic strategies of the "leading" Swedish municipality in terms of modal shift away from cars with the strategy of an "average" one, the authors show that policymaking inducing slower and more long term institutional change within the municipal organization as well as with the public has proven more effective than radical measures to restrict car traffic in the face of a resistant public or local parliament. The authors recognize the dilemma of long term solutions and climate goals like Järfälla's preferably being achieved by 2030, but suggest that breaking the path-dependency of being locked-in to car use and establishing institutions that are, culturally, more restrictive towards car use is essential to achieve any change at all. For Järfälla's traffic strategy, this indicates that even though restrictive measures might be tempting for short-term goal achievement, such measures risk strengthening institutional resistance to the broader changes needed to achieve the goals in the long-term.

> *"the identified problems with the transport systems are similar, and mostly relate to overuse of private cars"*


GOALS - STRATEGIES & INDICATORS

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4. SUGGESTED CONTENT AS A BASIS FOR THE DEVELOPMENT OF A TRAFFIC STRATEGY FOR JÄRFÄLLA

Based on the above review and suggested process, in this section we propose a starting point for step 3 of the development process, in terms of goals, prioritization among them and strategies to achieve them. We also provide a discussion of how indicators to measure goal achievement should be designed.

SUGGESTED GOALS

Based on the target visions (“målbilder”) from the Järfälla 2050 comprehensive plan and its proposed strategies, we have defined three goals that relate the comprehensive plan vision to the future transport system of Järfälla. These are to be negotiated and adjusted in the development of the traffic strategy to build political and institutional support and can be adjusted along the way.

1 **Zero territorial green house gas emissions from the transport system within the municipal boundaries.**

2 **Ensure access to sustainable transportation for everyone, everywhere in Järfälla.**

3 **Optimized transport system in terms of travel time and traffic safety.** [2]

We propose that these goals are organized in a hierarchy, where the first goal is the most important, and the second only applies when it does not conflict with the first. The third goal only applies when it does not conflict with either of goal one or two.

[2] This is explained further in the “goal conflicts” section below.

GOAL 1: ZERO TERRITORIAL TRANSPORT GHG EMISSIONS FROM THE TRANSPORT SYSTEM WITHIN THE MUNICIPAL BOUNDARIES

Järfälla has set an internal goal of becoming climate neutral by 2030, territorially (i.e., in terms of emissions within its geographic boundaries; *Järfälla municipality, 2023a*). In the proposed target visions for 2050, the municipality has set a goal of becoming climate positive (territorially) by that date. Since the transport sector currently produces about 70 percent of the territorial carbon dioxide emissions, *(Järfälla municipality, 2021)* reducing transport emissions is crucial to achieving the municipal climate goals. The environmental plan for Järfälla suggests that a 15 percent decrease in territorial carbon emissions in all sectors per year will be enough, and that the municipality needs to look for ways to compensate for the remainder of the emissions *(Järfälla municipality, 2023a)*. The compensation is outside the scope of transport policy, but the decrease in emissions is not. Because of its high share of emissions, and the efficiency improvements already made in industry and energy production, perhaps the transport sector needs to decrease its emissions at an even higher rate to meet the goals.

Since carbon emissions are not essential to the function of transport itself, we believe it is reasonable to aim for zero territorial carbon emissions from the transport system in the long term.

The method of measuring carbon emissions territorially has been criticized for not taking a holistic perspective on carbon emissions that affect the climate system equally irrespectively of where they are emitted *(Ottelin et al., 2019)*. Alternative measures like life-cycle analysis, carbon footprints and consumption-based accounting take into account not only the emissions produced within the specified geographic boundaries but also those produced elsewhere caused by consumption within the boundary, eliminating side-stepping responsibility by moving production away. Yet, it is a territorial goal that has been established politically within Järfälla, and it is, indeed, an ambitious goal in itself, as well as a first step toward further consumption-based goals.

According to Westin *(2023)*, the key sources of emissions within the transport sector of Järfälla are private automobile trips. Therefore, a lynch-pin of this goal is the reduction of carbon dioxide emissions from private automobiles, either through avoiding trips entirely, shifting trips to other modes of transport, reducing the length of trips or decreasing emissions per distance travelled *(Banister, 2008)*. However, since the goal is zero emissions, the scope also needs to include non-private traffic related to industry, shipping, public transport and public services.

GOAL 2: ENSURE ACCESS TO SUSTAINABLE TRANSPORTATION FOR EVERYONE, EVERYWHERE IN JÄRFÄLLA

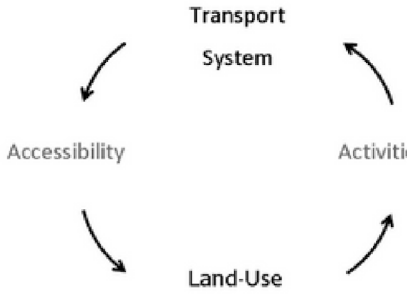
Accessibility as a planning concept entails the number and type of situated opportunities that can be reached within a certain travel time or cost *(Straatemeier & Bertolini, 2020)*. Unequal accessibility, whether physical or financial *(Grisé et al., 2019)*, is an undesired effect of ability variations within the population, as well as varying geographical circumstances and location of previous infrastructure investment. Furthermore, access to the road transport network is reliant on the acquisition of automobiles at a considerable upfront expense. Additionally, the health related effects of motorized transport are usually unevenly distributed, with vulnerable groups disproportionately affected by transport-related air pollution *(Aldred et al., 2021)*. Providing accessibility to everyone regardless of ability or location of residence within järfälla is a matter of justice *(R. Pereira et al., 2016; Shen, 2021)*. Pereira et al. *(2017)* argues that “policies should prioritize vulnerable groups”, namely the elderly, disabled, ethnic minority groups and lower-income families. Providing this equal accessibility using sustainable modes of transportation is necessary to ensure that policies incentivizing shifts toward more sustainable transportation do not aggravate transport injustices.

Due to lack of relevant demographic data specific to the Järfälla population, this section is based on research observations on social justice in the transport literature with as much of our arguements based on Swedish studies and Stockholm surveys. However, it is important to highlight that in order to ensure that modes are just and accessible a continuous or recurrent dialogue with the residents is vital. As argued by Henriksson et al.*(2022)*, accessibility depends on how well differences are recognized in design and distribution, and on the level of participation in decision making.

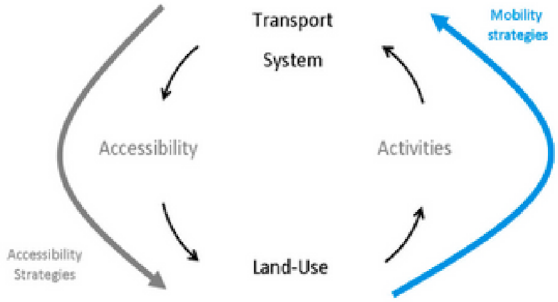
In a study of the general Stockholm region, Ryan et al. *(2023)*show that the freedom of choice when it comes to more sustainable modes of transport, ranges depending on the social group. Mobility challenged groups and lower income groups often emerge as the most vulnerable in terms of options (Cui et al., 2020). Looking at active mobility (walking and cycling), the literature shows that elderly and mobility challenged are the most sensitive to travel time, mode, distance and weather condition factors thus making crosswalk design and sidewalk quality *(Kwon & Akar, 2022)* not just aesthetic but necessary elements of the public space.

Another barrier to using sustainable modes of transport is the perceived or actual unsafety of an area, a station or mode of transport -not referring to accidents here but crime, such as sexual assault or harassment-. A recent case study survey *(Nourani et al., 2020)*, verified that those identifying as women were in fact representing the largest victim group of any type of crime analyzed followed by LGBTIQ+ groups. Besides the obvious mental and/or physical consequences of such experiences across cities and contexts *(Ceccato & Paz, 2017; Gekoski, n.d.)*, such crimes can alter not only the survivor's travel behavior but a whole community's. In the Järfälla area we are aware of two, vulnerable to crime, sites through police reports that are worth exploring through the lens of safety in public space.

We propose to set target levels of accessibility based on the needs of different groups so that Järfälla can ensure that everyone has acceptable levels of connectivity to basic needs. One of the advantages of looking at accessibility is that it can be measured and monitored effectively. In order to have a stable definition, the target levels should take into account the built environment characteristics (density, proximity to open spaces, etc.), the affordability of a mode that adds onto the active mobility capacity and the time needed to reach the respective destination. However, the specific definition of "sufficient" accessibility remains a political decision, and should be negotiated in the goal development process *(Arsénio et al., 2016)*.



Transport and land-use feedback cycle (Giuliano, 2004; Meyer & Miller, 2001; Wegener and Fürst, 1999).



Mobility strategies are dominant while accessibility strategies get less attention (Handy, 2002).

Figures 5a,5b: Diagrams explaining Accessibility and Mobility Strategies Approaches in the Transport and land-use feedback Cycle. Source: *Straatemeier & Bertolini, 2020*

GOAL 3: OPTIMIZED TRANSPORT SYSTEM IN TERMS OF TRAVEL TIME AND TRAFFIC SAFETY

Several of the comprehensive plan strategies are directly related to optimization, and the measures approved politically in the 2019 action plan for the traffic situation in Järfälla *(Järfälla municipality, 2019b)* also suggests that this direction of traffic planning is important to the voters. In addition, this goal serves to keep sight of the fact that the Järfälla voters do not wish to prioritize between the different modes of transport. To some degree, goals number one and two are also optimization goals, but they deal with less easily quantifiable matters. When we discuss optimization in this report, we refer to the former type of (quantitative) optimization.

To clarify this goal, we've identified two separate parameters to optimize for: travel time and traffic safety. The first one, travel times, are traditionally considered a cost to the user and to society, since it is usually "wasted" time that is not desired in itself, but serves the purpose of allowing the user to get to some other activity *(Small, 2012).* However, considering the fact that users generally tolerate around one hour of travel per day, and choose to travel further or more if they are able to travel faster, improvements to travel times in the transport system mainly means greater accessibility to destinations. In public transport research, it is established that lower levels of comfort of certain parts of a trip leads to a higher perceived travel time to the user, effectively lowering the willingness to ride *(Meng et al., 2018*). Presumably, the same behaviour exists for other modes of transport, but in those cases the differences in comfort are not as distinct. Therefore, both actual travel time reductions, and also comfort improvements in the transport system contribute to this parameter.

In terms of traffic safety, the optimization is related to the reduction of bodily harm and deaths caused by traffic. Järfälla's traffic policy inherits the so-called "Vision zero" goal (specifying zero deaths and severe injuries in traffic as a goal; *R. Johansson, 2009*) from the Swedish national transport policy making, especially on its national roads. Fortunately, Järfälla didn't suffer any traffic deaths last year per the above review (Section 2) and severe accidents were down to just seven. This suggests that Järfälla and the National transport administration controlling its motorways has been successful in optimizing for traffic safety so far. We do believe that this will remain important to further reduce the risk for accidents and keep up this result, as well as reducing risk for the more common less severe accidents.

There are pitfalls related to optimization goals. The procedural-rational paradigms of planning that were popular in the 20th century called for a rational optimisation of society *(Taylor, 1998)* and traffic engineering methods have been successfully employing models based on mathematics and economics to make optimal design choices to fulfill certain goals. Such methods have been criticized for taking a too narrow approach to transport planning *(Goulden et al., 2014)* and for uncritically assuming certain goals and obscuring others *(Taylor, 1998)*. These critiques are valid, but alongside a wider scope of comprehensive plan goal achievement and a critical review of the parameters we optimize for, we believe that optimization remains important. While using engineering-like methods like cost-benefit analysis to optimize for these parameters, there is a risk of losing sight of the unquantifiable *(Hickman & Dean, 2018)*. Therefore the municipality regularly needs to zoom out to the strategic level and make sure that its optimisations in one part of the system does not cause detriment elsewhere.

GOAL CONFLICTS

An important purpose of the traffic strategy is to deal with the internal goal conflicts within the traffic planning department of the municipality in a comprehensive way. There are two main types of situations where traffic planners continuously face this type of problem: the first one is what we would like to call the direct goal conflict, where, for instance, improving the quality of one mode of transport has a detrimental effect on some other mode. This problem is especially interesting since it is spatial, and only occurs in particular organizations. The second type is the indirect or budgetary goal conflicts, which are the prioritization of the limited time and resources

Making prioritizations in a comprehensive way, considering all the broader aspects of the traffic system avoids the pitfall of planners losing sight of the bigger picture and the comprehensive plan goals in individual projects and detailed plans. There is also a supportive function for the planner. Being able to know that there is a firm political stance on a matter, makes it much easier for the individual planner to take a stance when such questions come up in a project.

There are, of course, “external” goal conflicts too, like how much money is spent on traffic planning and infrastructure improvements in the municipality, for instance how much land should be allocated to traffic infrastructure and not to parks. It is important to recognize the existence of such goal conflicts, but they do not need to be resolved within the traffic strategy. The reason is that those goal conflicts are dealt with on a higher political level, and are not an issue for the traffic planning department.

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SUGGESTED GOAL HIERARCHY

To clearly deal with the goal conflicts, we suggest that the prioritization of the goals in the traffic strategy by placing the three goals into a hierarchy, where goal one is the most important. Goal two only applies when it is not in opposition to goal one, and goal three when it is not in opposition to either of the others.

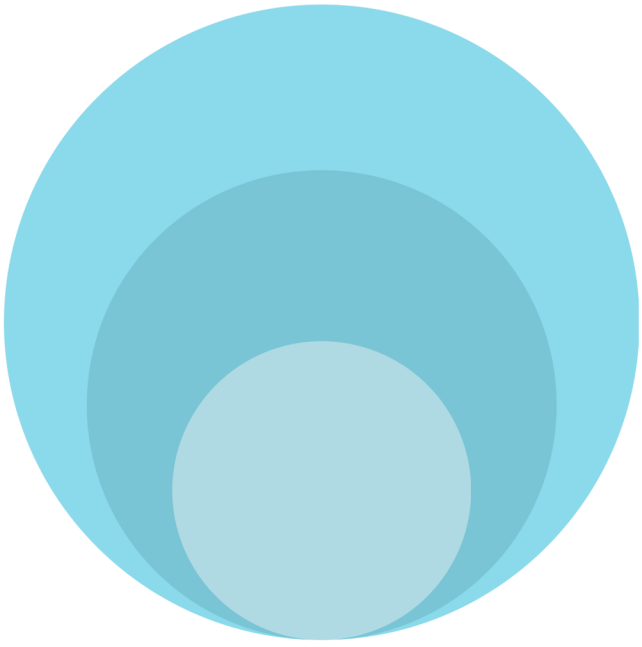
Importantly, what we are proposing isn't necessarily the right prioritization for Järfälla. We have attempted to determine the relative political importance of these different goals based on the target visions of the comprehensive plan and its associated strategies, and have chosen to exclude virtuous things that the transport system could prioritize, but that do not contribute to the comprehensive plan goals. To make the strategy usable, it is essential that the traffic strategy makes a prioritization, and that this prioritization corresponds to the political will of the voters. The order of the prioritization is therefore subject to change as the process of developing the traffic strategy progresses, but some prioritization needs to be made.

In the remainder of this section, we review two of the most prominent direct goal conflicts between the proposed goals, and show how the prioritization would play out in such cases.

Travel time optimisations for car transport can be in conflict with modal shift away from cars. Chakrabarti *(2017)* shows that modal shares are not only dependent on the absolute travel time and comfort of trips using the modes, but also on the relative difference to alternatives. Since modal shift away from cars is a key part of the achievement of goal one, the relative improvement of car transport in comparison to other modes directly counteracts the first goal. The third goal states that Järfälla should optimize the travel times within its transport system, which, among other things, means improvements to car traffic. Since the climate goal has a higher priority, planners using this traffic strategy should choose to not make this decision. Yet, since it is the relative quality that matters, Järfälla can make optimizations of travel time in its car transport system, as long as it is also making travel time improvements of similar magnitude to the sustainable modes of transport. This type of approach is also in line with the municipality's reluctance to prioritize some modes of transport over others.

> *Travel time optimisations for car transport can be in conflict with modal shift away from cars.*
>
> *Chakrabarti, 2017*

Provision of sustainable transport everywhere can be in conflict with the optimization of travel times in the public transport network. As Levinson *(2012)* shows, “horizontal” network topologies (where most public transit routes have similar travel times) means greater dispersion of accessibility throughout the municipality. However, since the density of destinations and residents is uneven throughout the municipality, improvements to some public transit links between high-demand destinations is a much more efficient investment than the equal investment into all links in terms of travel time optimization. The suggested goals and their hierarchy leads to a balance where the municipality should first ensure some baseline of access to public transport for all destinations (goal two). Once this is achieved, the third goal becomes effective, and any further investments should be made toward optimisation of travel times where it is deemed to be most efficient. The very same conflict applies to the provision (and maintenance) of walkways and bike paths.



60 SUGGESTED STRATEGIES TO ACHIEVE THE SUGGESTED GOALS

STRATEGY A: LONG TERM LAND-USE CHANGES AND TRANSPORT NETWORK TOPOLOGY SHIFT

This strategy addresses the organization of the transport network. It builds on network topology, which has already been introduced in section 2, and the concept of transit oriented development (TOD). Järfälla states in their comprehensive plan that the areas around the train stations will develop into a more distinct urban character compared to today *(Järfälla municipality, 2014)*. This puts new demand on infrastructure and how to develop the network topology becomes therefore a central question. Development focused on sites in proximity to stations makes the concept of TOD relevant for the analysis.

TRANSPORT SYSTEMS AND NETWORK TOPOLOGY

Transport networks fills a central role in the urban environment by making large traffic flows possible through and within the city *(Freiria et al., 2015; Perry, 2015)* which firstly, makes it possible for the city to function *(Freiria et al., 2015)* and secondly, spurs economic development *(Ambühl et al., 2023)*. Sreelekha *(2016)* writes that characteristics of a well-connected network are many – and short – links, many intersections and as few dead-ends as possible. The connectivity of the network is how easy a traveler gets from point A to point B.

There are two extremes when characterizing the network topology. The tree-like and grid-like network (Figure 6 below) *(Freiria et al., 2015; Han et al., 2020; Sreelekha et al., 2016)*. According to Han et al. *(2020)*, due to the division of the streetscape into lesser and lesser links, in terms of centrality and size, the tree-like network becomes more hierarchical compared to the grid-type network. The network has a larger number of dead ends and it’s harder to change direction or find alternative routes. At the same time, since the tree-like network separates larger traffic flows from residential areas, this system provides safety and privacy to the citizens, but it also keeps the trunk lines less interrupted, which helps their traffic to flow. The cul-de-sacs system (Figure 6) has a few major trunk lines where the connectivity is good while the system's minor sections are less connected.

Those sections form ‘islands’ between the larger sections with lesser connectivity but offer, on the other hand, some extra privacy *(Han et al., 2020)*. Han et al. *(2020)* also writes that a T-type system (Figure 6) has good connectivity and is similar to the grid-system but since it’s dominated by T-intersections (three-way intersections), this makes the connectivity lesser compared to the grid-system. The T-intersections also keep the trunk lines less interrupted compared to the grid system, making it more suitable for trunkline traffic. The grid-like network is totally dominated by shorter links and X-intersections (four-way intersections). In contrast to the tree-like network, it offers many optional routes and possibilities to change direction of travel and a minimal number of dead ends. This creates a level of accessibility higher than any of the other types. At the same time does it not offer the same opportunities of privacy as in the tree-like – and cul-de-sacs networks. The grid-system’s transport efficiency also becomes lesser than, for example the tree-like network, because of all the X-intersections. It is however suggested that a grid-like pattern has the potential to be used as a tree-like pattern by closing or regulating the traffic in certain streets *(Han et al., 2020).*

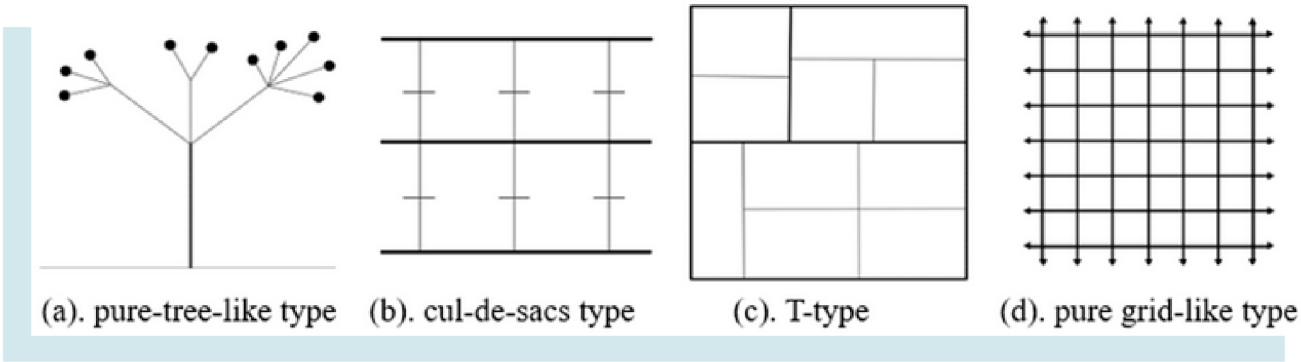


Figure 6: The four network patterns presented in the article, Source: *Han et al., 2020*

By organizing the network around certain transport hubs, higher efficiency and economic development becomes possible *(Rahmati et al., 2023)*. However, traffic flows cause negative effects to environmental and social aspects *(Ambühl et al., 2023).* The forming of hubs causes even larger negative effects, both in the hub itself and throughout the region due to the larger amount of traffic that is generated in the region *(Rahmati et al., 2023)*. Because of this connection, the establishing of transport hubs must be done with caution and take in regard both social – and environmental sustainability. However, Ambül et al. *(2023)* writes that congestion causes economic losses. A lack of transport efficiency risks in other words decreasing economic growth.

TRANSIT ORIENTED DEVELOPMENT

Järfälla municipality *(2014)* as well as Region Stockholm *(2018)* envisions developments of densification in the proximity of public transport. In the literature this is described as Transit oriented development (TOD). This concept was framed in the 1980s *(Ibraeva et al., 2020; Knowles et al., 2020)*. Ibraeva et al. *(2020)* writes however that this approach had, to some extent, already been used in projects in Sweden and Denmark. According to *(Ibraeva et al., 2020; Knowles et al., 2020; Loo et al., 2010; Nasri & Zhang, 2014)* transit oriented development focuses on developing dense and multi-functional urban environments around station areas and equipping those with good access to transit services. The development is pedestrian focused and is, for example, promoted by the multi-functionality, locating potential destinations at walking distance within the neighborhood *(Knowles et al., 2020; Loo et al., 2010; Nasri & Zhang, 2014)*.

To create a successful TOD

One of the intentions with the concept is to reduce car-use, not necessarily by a total replacement but rather by increasing the use of sustainable options through planning *(Ibraeva et al., 2020)*. Studies of TOD indicate a higher use of public transport, walk and bike compared to a more car oriented neighborhood *(Ibraeva et al., 2020; Loo et al., 2010)*. Residents in TOD areas also have lower car use *(Cervero & Arrington, 2008; Nasri & Zhang, 2014)*. Ibraeva et al. *(2020)* write that high levels of walkability, proximity to working-places, transit options and of the regional accessibility and density is said to be of great importance. Dense and mixed-use neighborhoods decrease car use while long distances to jobs and services together with low access in the street network increases it. The success of a TOD is also determined by socio-economic factors, lifestyle and car ownership (Ibraeva et al., 2020). Parking management is described as an important tool for decreasing car use and the success of a TOD *(Cervero & Arrington, 2008; Chatman, 2013; Ibraeva et al., 2020; Knowles et al., 2020; Nasri & Zhang, 2014)*. Knowles et al. *(2020)* writes that transit frequency is essential for successful TOD:s. It is also mentioned that concepts like BRT, ICT-technology, bike-sharing, Mobility as a Service and connected autonomous vehicles could be possible supportive tools. The success of the TOD will also demand a well performed integration between different modes *(Knowles et al., 2020; Loo et al., 2010)*. The street network is recommended to be fine grained *(Knowles et al., 2020; Nasri & Zhang, 2014)* and the distance to the station area is central for achieving the desired accessibility *(Chatman, 2013; Ibraeva et al., 2020; Knowles et al., 2020)*. Ibraeva et al. *(2020)* suggest for example that working places should be located within 500 meters to the station.

Stations that have been in function for some time improves the TODs performance *(Knowles et al., 2020; Loo et al., 2010)*. Nasri & Zhang *(2014)* also points out that long time residents in such an area have a higher degree of transit use. Loo et al. *(2010)* mentions the characteristics of the station as crucial for the success of the development.

A district transformed by transit oriented development easily gentrifies *(Ibraeva et al., 2020; Knowles et al., 2020)*. Measures to include weaker socio-economic groups will therefore be necessary if a more equal development is sought for *(Knowles et al., 2020).* Costs caused by, for example, the multifunctionality and risks regarding peripheral areas and stakeholder acceptance are other challenges according to Ibraeva et al. *(2020)* who emphasize the importance of including residents and other actors in the development but also a political continuity regarding the project. Costs are suggested to be handled by the renting of public land in TOD areas to private actors. Nasri & Zhang *(2014)* writes that traffic might increase in TOD areas which goes in line with the earlier mentioned concept of transport hubs.

CONCLUDING REMARKS FOR THE JÄRFÄLLA CONTEXT

Järfälla municipality *(2014)* suggests a topology characterized by accessibility and no dead ends. Walk, bike and public transport will be promoted and a more fine grained structure will be preferred instead of a more hierarchical one. The emphasis on Jakobsberg and Barkarby as future dense urban centers in an urban environment with open/non hierarchical topology means those areas and the areas between those need to be developed towards a grid like network. A prioritizing of walk, bike and public transport while car traffic efficiency remains intact could mean development of the three former towards a grid like system while the car traffic continues on present links. This approach will require both developing existing bus lines and creating new ones that connect the districts to those locations will be necessary. The comprehensive plan mentions developing bus lines, forming a ring road that both connects some of the neighborhoods and stops at those locations *(Järfälla municipality, 2014)*. This is also recommended by Zhang et al. *(2015)* since it provides better resiliency and transit options. The E18 and the railway creates a barrier to Söderhöjden to the east and to the south. Constructing more bridges over the rail and tunnels below the E18 could be a solution for overcoming those barriers at suitable locations. This will, according to the earlier mentioned transport network literature, result in improved accessibility for walk, bike and public transport which would help the promotion of those modes. Less traffic on the car roads will increase efficiency for a time.

New intersecting walk, bike and bus related traffic resulting from the new grid-like topology and increased numbers of those modes might, though, decrease it and level graded intersections could be an option at some occasions. As Järfälla develops into a regional hub, it will probably concentrate more traffic here which needs to be considered regarding the environmental goals.

Han et al. *(2020)* described the patterns of transport infrastructure as generally leaning more towards a grid-like pattern in urban core-areas and then gradually shifting towards a more tree-like pattern in peripheral districts (Figure 7). If Järfälla intends to develop towards a more urbanized character compared to present, a shift towards a grid like pattern will be a necessary starting point.

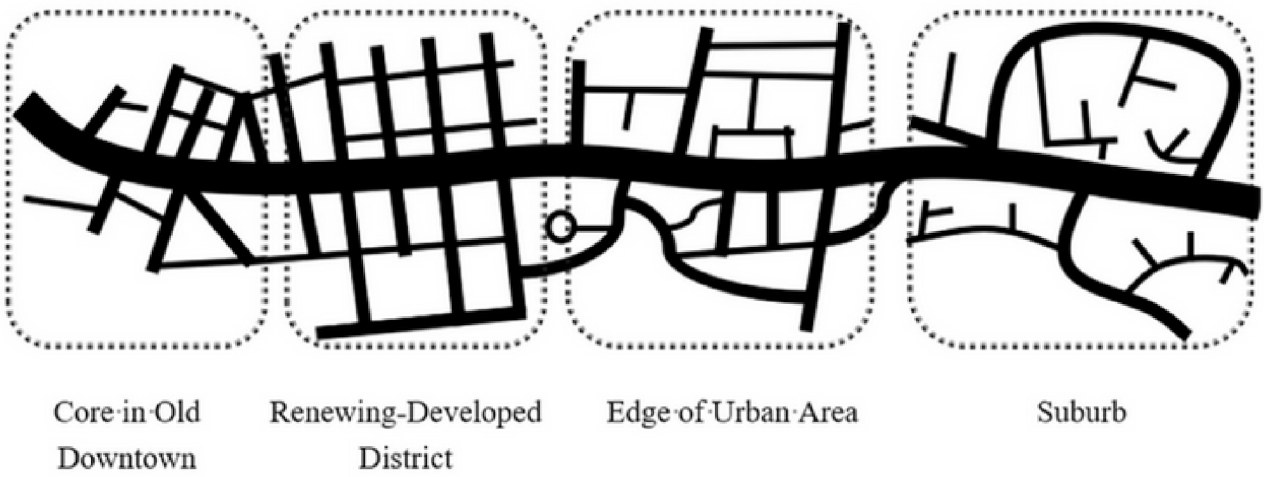


Figure 7: The gradual shifting of street network topology, *Han et al., 2020*

Transit oriented development is currently being implemented in swedish developments such as Roslags-Näsby *(Täby municipality, n.d.-b)* and Täby park *(Täby municipality, n.d.-a)* with dense residential neighborhoods equipped with a variety of functions and options of public transport. Järfälla is also applying this concept to their plans. The municipality of Järfälla intends to develop the areas in proximity to the stations into dense, multi-functional and fine-grained urban environments *(Järfälla municipality, 2014)*. This is what the literature suggests for a successful transit oriented development. In the longer term this will require a shift in concentration of built structures leaning more towards the three train stations in the municipality compared to earlier. Since a key feature of a TOD is good accessibility to stations, especially by walk, this puts a higher emphasis on proximity to the station. This means a higher pressure on land located close to those.

When looking at, for example, Järfällakartan you realize that all train stations to some extent have land in their proximity that could be developed to a much larger extent. Developing those areas will be necessary to achieve a transit oriented development. It will also challenge the road network in proximity to the stations since the TOD concept will require a car traffic that exists on the terms of especially walk but also bike and public transport. This will result in large encroachment on existing functions, values and residential environments. The literature points out the importance of grounding the development within the public and including weaker socio-economic groups. This will be crucial for carrying out transit oriented development. Other necessary measures are; parking management, applying well-considered designs of station areas, and well integrated sustainable transport options. The transport system could, for example, be supported by solutions such as MaaS and BRT.

Improved accessibility and development of different modes should help fulfill the development of MaaS in Järfälla, as suggested in Strategy B, but also a more station focused transport network with higher modal integration. Parking management and Parking Benefit Districts as recommended in Strategy C would help prompting sustainable modes as described by this strategy. A successful TOD gets achieved by a development that is station centered, that integrates modes and makes use of solutions like MaaS which is recommended by Strategy B. Parking management is also considered a supportive tool for a TOD, making Strategy C supporting this strategy also by that aspect.

If the strategy results in higher shares of traveling with modes considered sustainable this will contribute in achieving Goal 1. The challenge will be to tackle possible increases of the total traffic if Järfälla evolves into a regional traffic hub. It will definitely contribute in achieving Goal 2 due to the expansion of sustainable modes and increased accessibility. The TOD do, however, focus on the areas close to the stations which could create an unbalance giving areas in the periphery much lower accessibility compared to areas in the stations proximity. Walk, bike and public transport are less space demanding than car-based transports. This, together with the development of the former and the intended sustaining of the efficiency of the latter suggests that the strategy fulfills Goal 3.

In summary, Strategy A suggests an open/non hierarchical transport network where walk and other sustainable transport modes are promoted and well integrated with each other. Areas between districts should be developed for connecting the districts and areas around the train stations should be developed with mixed functions. All this needs to be grounded among concerned actors.

STRATEGY B: IMPROVEMENTS TO SUSTAINABLE MODES OF TRANSPORT AND INTEGRATION BETWEEN THEM

This strategy, focused on improving sustainable modes of transportation and fostering intermodal integration with a particular emphasis on Mobility as a Service (MaaS), is crucial for shaping a more efficient and sustainable urban landscape. The underlying vision of this strategy is to establish intermodal mobility hubs that aim to provide a seamless travel experience, where various modes of transportation coexist harmoniously. Drawing inspiration from current infrastructure observations, the strategy will be grounded in key principles such as synchronizing public transportation schedules and designing spaces effectively to enhance more intuitive intermodal connections. The objective of this strategy is to enhance the overall quality of urban mobility in Järfälla, leveraging the full potential of the commuter rail line as the backbone of this evolving network.

MOBILITY AS A SERVICE (MAAS)

The Mobility as a Service (MaaS) concept originated in 1996 at the ENTER conference in Innsbruck, Austria, introduced by visionaries Nico Tschanz and Hans-Dieter Zimmermann. They envisioned an "Intelligent Information Assistant" acting as a transportation platform connecting service providers directly to users.*(N. Tschanz et H.-D. Zimmermann, 1996)*. Their forward-thinking idea, conceived before widespread internet access, aimed to empower users to search, combine, and book various routes, including additional services like hotel reservations and travel insurance. Over time, companies like *(BlaBlaCar, 2006; Uber, 2009; UbiGo, 2014)*, have contributed to MaaS evolution globally. In 2014, Sonja Heikkila's thesis at Aalto University laid the groundwork for the Whim application, a notable example of MaaS in Europe. Cerema's research highlights the absence of a universal MaaS definition, suggesting it as a "direction" rather than a strict definition. Commonly, MaaS is described as an integrated system providing information, reservations, purchases, and validation for diverse mobility services through a single user account, simplifying access to collective, shared, or individual transportation within a specific territory. *(J. R. Reyes García, G. Lenz, S. P. Haveman, et G. M. Bonnema, 2019).* Like illustrated by figure XX below, at the heart of this approach, we find transport service providers such as bus, train, or taxi operators making their offerings accessible via the MaaS platform. Concurrently, technology providers develop the necessary tools and systems to ensure interoperability among these various services, thereby guaranteeing an optimal user experience.

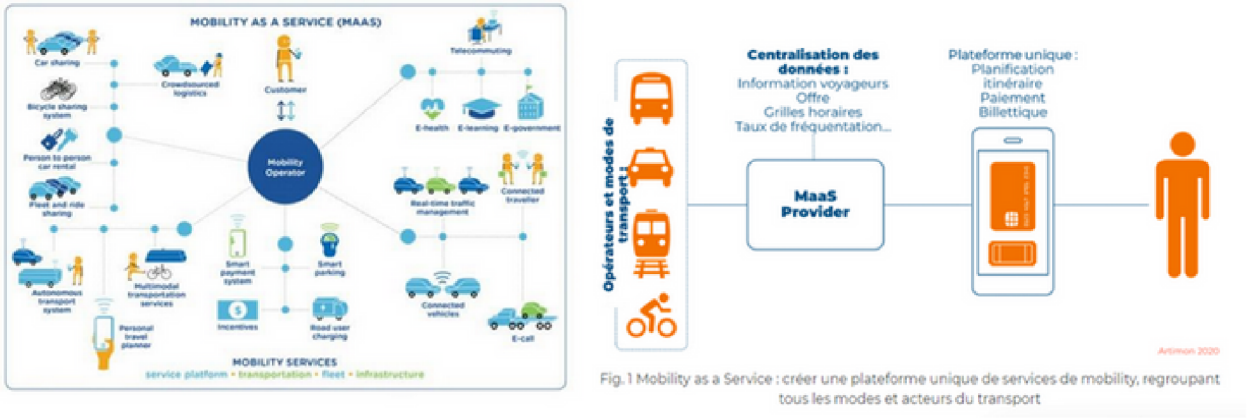


Figure 8: Explanatory diagram of the Mobility as a Service (MaaS) concept. Source: *ARC Advisory Group, 2020*

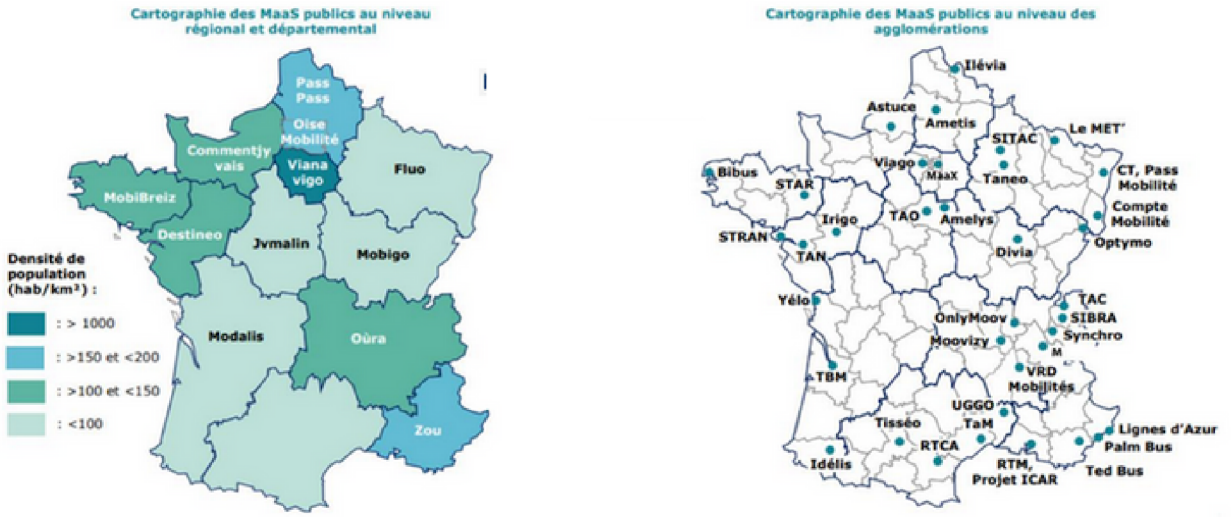
Regulatory and governmental authorities also play a pivotal role by establishing regulatory frameworks and providing guidelines for MaaS development. On their end, data providers collect and analyze crucial mobility information, while end-users, be they individuals or businesses, leverage these services to plan, book, and pay for their journeys. Collectively, these stakeholders collaborate closely to establish a cohesive and integrated mobility ecosystem.

The envisioned ideal of a comprehensive Mobility as a Service (MaaS) platform faces challenges in its realization. Integrating all transportation functionalities and modes is a complex undertaking. The shift from individual car usage to MaaS necessitates reaching a critical mass of users, posing a significant challenge for system operators. While ambitious projects are underway, achieving widespread adoption of the MaaS concept remains a formidable challenge.

POTENTIAL BENEFITS OF MAAS ADOPTION

The adoption of Mobility as a Service (MaaS) offers significant advantages for users, public authorities, and transport operators. MaaS simplifies travel by providing a one-stop-shop for planning, booking, and paying for various transportation modes, encouraging the shift to shared mobility. Public authorities benefit from optimized infrastructure use, reduced congestion, and environmental improvements. For transport operators, MaaS offers diversification opportunities, collaboration, and improved efficiency. Overall, MaaS contributes to efficiency, sustainability, and enhanced quality of life, making it a crucial element in the future of urban mobility.

EXAMPLES OF SUCCESSFUL MAAS IN FRANCE



Maps 9a,9b: maps of publics MaaS in France, Source: *C. Gothberg*

This section explores the state of Mobility as a Service (MaaS) projects in France, encompassing all three scales of implementation. The provided map (Figure 9), based on data from Cerema MaaS Observatory and adapted by the authors, highlights the presence of MaaS at regional levels, particularly beneficial for less densely populated and rural areas facing financial constraints. Challenges persist, especially in sparsely populated regions, requiring a focus on existing transportation axes and integration of various services. The development of regional MaaS is seen as a crucial link between territories, promoting reduced reliance on personal vehicles. SNCF, the French national state-owned railway company, aligning with this trend, is strategically positioned to become a dominant national MaaS service, emphasizing long-distance interurban travel. The Mobility Orientation Law of 2019 in France prioritizes simplifying daily commutes, reducing carbon footprints, and investing in public and digital infrastructure. This legislation mandates the provision of MaaS-related data on a public platform, fostering collaboration between Mobility Organizing Authorities (AOM) and local authorities for sustainable mobility planning and continuous private sector service development.

MAAS AND INTERMODALITY

Establishing intermodal physical platforms in the vicinity of train stations is a strategic approach to enhance the efficiency of urban transportation systems. By situating these platforms around train stations, we create hubs of intermodal mobility that facilitate seamless transitions between various modes of transportation, contributing to the development of a more cohesive and integrated network of movement. These hubs are particularly pivotal within the context of Mobility as a Service (MaaS), where the integration of different transport options is at the core of the value proposition.

Figure 9: Mobility hubs example, Source: *Clemens, 2020*

Within an intermodal mobility hub, one finds stops for public transportation, stations for car-sharing services, bike and scooter-sharing facilities, as well as electric charging stations—crucial elements to provide users with a variety of sustainable transport options. Information desks and digital kiosks play a key role in delivering details about routes, schedules, and available transportation options, facilitating interaction with MaaS platforms. *(Clemens, 2020)*
Comfortable waiting areas, equipped with real-time information panels, aim to enhance the waiting experience for users. Security services, restrooms, assistance services, and dining zones may also be integrated to address the essential needs of travelers. By incorporating digital connectivity, including free Wi-Fi access and digital services, these hubs become convenient access points for MaaS users, fostering integrated intermodal mobility and contributing to the transformation of urban environments toward more sustainable and intelligent transportation solutions.

In the realm of Mobility as a Service (MaaS), the synchronization of public transportation timetables and the thoughtful design of stations and bus stops play a crucial role in fostering seamless intermodal connections. By aligning the schedules of various modes of transport within the MaaS framework, such as buses and trains, and ensuring that the infrastructure design facilitates smooth transitions, we enhance the overall efficiency and convenience of intermodal mobility. This synchronization not only optimizes the planning of multi-modal journeys for users but also contributes to the effectiveness of MaaS platforms, creating a more interconnected and user-friendly urban transportation system. In essence, the coordination of public transport timetables and infrastructure designs represents a pivotal step toward realizing the full potential of both MaaS and intermodal connectivity, ultimately improving the overall mobility experience for urban dwellers.

CONCRETE EXAMPLE OF BARKABY STATION

In the Järfälla region of Sweden, the SL service *(Storstockholms Lokaltrafik)* serves as the central authority for public transportation, managing buses, trains, trams, and ferries. While effective in coordinating various transportation modes, SL does not currently embody a complete Mobility as a Service (MaaS) model as it lacks a unified digital platform integrating public and private services. The existing user experience involves multiple applications, signaling room for improvement. To evolve towards a true MaaS ecosystem, increased collaboration with private stakeholders and the development of a centralized platform encompassing all transportation modes are essential. Initiatives such as collaborating with ridesharing and bike-sharing services, creating a unified digital platform, standardizing data, launching awareness campaigns, and analyzing user needs could transform the region's mobility landscape. A phased expansion approach, starting small and gradually broadening options, would facilitate a smoother transition to a comprehensive MaaS experience in Järfälla. *(Clemens, 2020)*
Around the train stations in Järfälla, the beginnings of a mobility hub have been established, although its coherence and integration are not yet fully realized. Let's take the example of Barkarby station, where observation reveals a spatial organization that lacks cohesion, with all modes of transport seeming to operate independently. Special attention should be given to bus stations, where the fragmented layout could benefit from streamlining through the consolidation of various stops, accompanied by a centralized information board to inform users of bus departures.

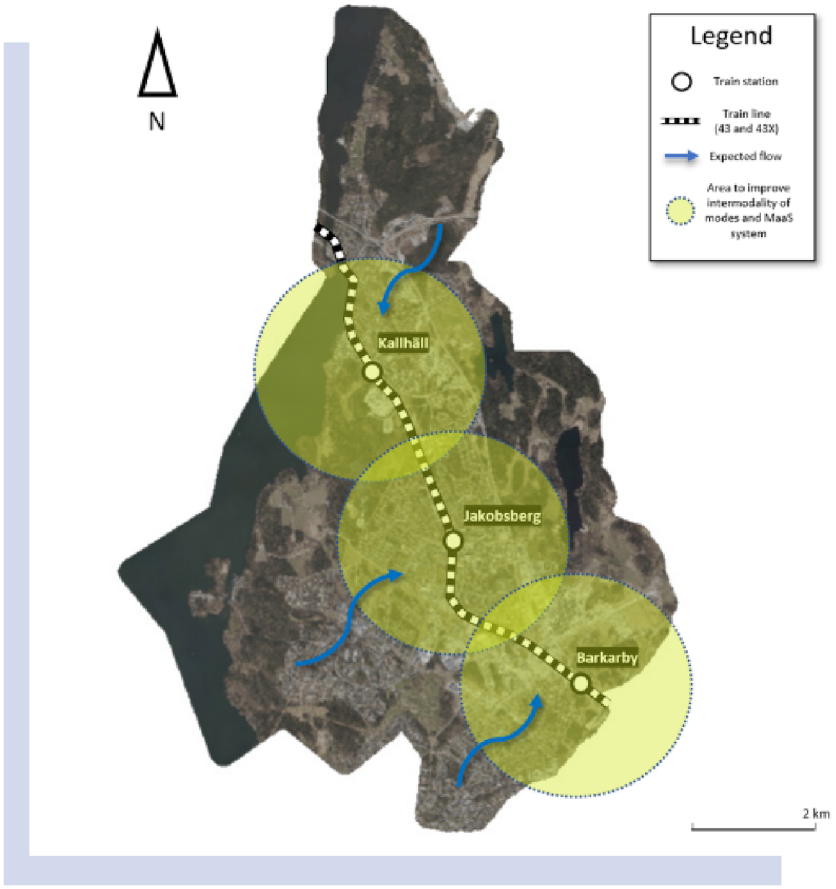
Image 3: Representation of area for each mode, Source: *Google Maps*

A relevant observation also concerns the situation of bicycle parking spaces. The transition between levels creates an imbalance, prompting users to prefer informal parking near the barrier rather than using the more extensive parking facility one level below, indicating a clear preference for immediate proximity to the station. Additionally, the absence of escalators to move between the lower and upper levels poses a challenge, although the presence of an elevator partially compensates for this gap by facilitating access for people with reduced mobility.

Image 4: Photo of the station entrance, *Own*

STRATEGY PROPOSALS

What sparks particular interest is the presence of a major train line (43) traversing the region. Maximizing this commuter train line by making it the backbone of all modes of transport seems to be an ideal strategy to enhance train accessibility and optimize the overall connectivity of Järfälla's mobility network *(CEREMA, n.d.)*.



Map 10: Map illustrating the strategy

Within the framework of this strategy, mobility infrastructures can be enhanced, and we pay special attention to improving conditions for users of active transport modes, with a focus on cycling. In light of the construction recommendations for cycling infrastructures, it is evident that certain roads require improvements to facilitate the safe circulation of cyclists. Below is an example from Fölvägen (Map 10).

Image 5: Example of possible development to improve cycling on Fölvägen Street, Järfälla, Source: *Own & edit, based on CEREMA, 2021*

We advocate for the implementation of measures such as the physical separation of cycling lanes from motorized lanes, whether through colored markings or dedicated borders. Additionally, we recommend the implementation of devices aimed at reducing vehicle speed, such as speed bumps and targeted road restructuring.

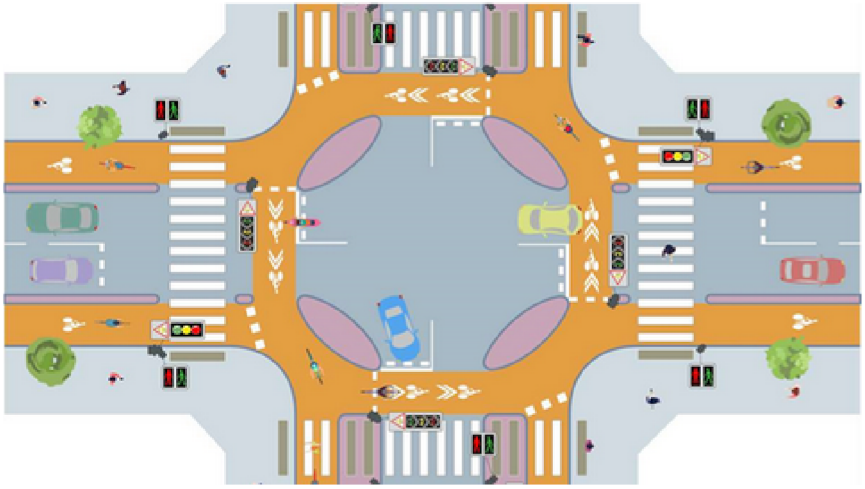


Figure 10: Dutch roundabout from the recommendation of the *CEREMA*

To enhance safety, it is crucial to improve the visibility of motorists towards bicycle users. This can be achieved by incorporating amenities such as roundabouts specifically designed to ensure better interaction between cyclists and motorists, thereby promoting a harmonious coexistence and increased visibility. By adopting these measures, we aim to create an inclusive, secure road environment conducive to the promotion of active transport modes.
In conclusion, the 'MaaS and Intermodality' strategy for the city of Järfälla is poised to make significant strides towards a sustainable and efficient transport ecosystem. ”highlighting the challenge of bringing about the emergence of integrated multimodal systems for the benefit of public policies.” *(CEREMA, n.d.)* By promoting multi-modal transportation options and integrating them seamlessly through MaaS platforms, we are not only paving the way for zero territorial transport GHG emissions but also ensuring equitable access to sustainable transportation solutions for all residents. Furthermore, by optimizing the transport system, we aim to enhance travel time efficiency and bolster traffic safety measures. This strategy underscores our commitment to realizing the core objectives of achieving zero emissions, universal access to sustainable transport, and an optimized transport network within Järfälla's municipal boundaries.

STRATEGY C: MANAGE CAR DRIVING DEMAND USING PARKING MANAGEMENT AND OTHER BEHAVIOR INFLUENCING MEASURES

As a result of the European climate contract, Järfälla has been working on achieving the climate-neutral municipality by 2030 goal. In order to achieve so, currently the CERO method has been used *(Robèrt, n.d.)*. This methodology is based on backasting planning perspective to address the following questions:

1. What targets have been set for the future as regards travel emissions, travel costs, and employee working conditions?
2. Where does the organization stand today in relation to these targets?
3. What target-oriented policies should the organization prioritize in order to move from the present situation to the targets?

In CERO, a thorough survey is conducted to assess the current emissions and expenses associated with all work-related business trips and commuting. The foundation for creating decision-making scenarios lies in statistical modeling and cost-benefit analyses. Järfälla municipality started a collaboration with some large companies to reduce their employee's carbon dioxide emissions from travel to and from work in order to address their climate neutrality.

The emphasis that Järfälla puts on carbon dioxide emissions produced by traveling gives a clue of how much car trips contribute to pollution. As mentioned before, around 70% of the municipality's geographic emission is produced by the transport sector *(Järfälla municipality, 2021)*. In order to achieve the suggested goal 1 "zero territorial greenhouse gas emissions from the transport system within the municipal boundaries", a strategy focused on managing car driving demand is key to shift towards sustainable ways of transportation, and to build a non-car dependent culture. In order to contribute to reach this goal, this strategy provides insights of successful actions that will serve to the municipality as a base to develop a detailed plan. Two main actions are the focus of this strategy, and they are parking management and inducing behavioral changes.

PARKING MANAGEMENT

The primary goal of parking management is to ensure a balance between the available parking spaces and the demand for parking, however, it has been proven that parking measures can influence not only drivers' choices and actions, but the whole function of the transport system *(Simićević et al., 2013)*. Moreover, studies have found the most important factor in reducing car usage is the parking price *(Higgins, 1992)*, for this reason, and for the context of Järfälla and its goals, this strategy highlights parking.

In a more recent study, the results obtained by Simicevic et al. *(2013)* showed that parking prices affect car usage while time limitations when parking determine the type of parking used (on-street or off-street). Furthermore, an important finding for municipalities when implementing this type of measure is knowing that “users with work are more sensitive to parking measures than are other users, so parking measures can be used to manage user categories” *(Simićević et al., 2013, p. 125)*.

Smart and good parking management is important not only because it can help to reduce car usage, but because it can also reduce traffic volume. When studying the 16 cases in 11 international cities, the results showed that approximately 30% of the traffic volume was caused by cars looking for parking *(D. Shoup, 2021)*. For the Järfälla context, this is especially relevant because of the shopping area, meaning that different policies need to be put into place for different types of people namely visitors and residents. The study by Simićević et al. *(2013)* shows that although reducing time limits in zones with already existing limits does not result in a substantial decrease in parking demand, it helps to reduce parking search time. In central areas like Jakobsberg and Viksjö centrum—and assuming an even distribution of parking—reducing time on on-street parking could reduce visitors' search time when looking for parking, meaning less driving time.

Although parking management is less drastic than other restrictive car measures—like no-cars streets and congestion charges—it is still difficult to have support for policies that involve charging something that used to be free *(F. Johansson et al., 2017)*. Parking Benefits Districts (PBDs) is a measure that returns the gains of on-street parking to the area where they were obtained, meaning that the inhabitants are included in the decision-making of where the revenues go. According to F. Johansson et al. *(2017)* this has proven to reduce car dependency by, firstly, increasing the levels of acceptance of controversial measures like pricing, and secondly, by improving alternatives to private cars.

> *users with work are more sensitive to parking measures than are other users, so parking measures can be used to manage user categories*
>
> *Simićević et al., 2013, p. 125*

In the case of the Stockholm municipality, discussion about the implementation of PBD in commercial centers were made but never got included in the parking plan. According to Banister *(2008)*, this measure is a good way to reduce car dependency by softly increasing acceptance of parking charges. However, these types of policies are more common in the USA and "Sweden does not have a tradition of working with this type of participatory planning processes"*(F. Johansson et al., 2017)*. On the contrary, the Scandinavian context shows that in the planning paradigm, the municipality has a stronger role than in the North-American case. By including people in the management of the local budget, residents get involved and accept more measures like pricing on-street parking, which is highly relevant for inhabitants in central areas.

For the second benefit of PBD improving alternatives to private cars, the literature suggests that the combination of push and pull measures is key to provide an efficient package to reduce car traffic *(Banister, 2008; Kuss & Nicholas, 2022; Marshall & Banister, 2000; Piatkowski et al., 2019; Steg, 2003)*. In this sense, it is suggested by F. Johansson et al. *(2017)* that PBD plays a role as a push measure by increasing acceptability. Still, the authors mention that increasing attractiveness to other means of transportation is equally necessary.

PBD then can be a way to extend parking measures outside central areas. Järfälla municipality is already working with parking zones that help to densify areas and reduce parking space in key areas, however, PBD can be a way to explore how to reach less connected by public transport areas, more car-dependent neighborhoods and at the same time, involve inhabitants into participatory planning.

If prices affect car usage, implementing pricing parking in conjunction with PBD could have not only higher leaves of feasibility due to its acceptability, but also of directly impacting the levels of usage around working and housing areas that are highly dependent on cars.

BEHAVIORAL CHANGES

According to Buehler et al. *(2017)*, it is a general trend in countries like Germany, France, Great Britain, Japan, Norway, and even the USA, that younger generations are moving in more sustainable ways, meaning walking, cycling and using public transport more. Successful reductions in car share trips are the result of pull and push measures, however, “a qualitative shift in cultural attitudes and preferences toward less reliance on automobiles” *(Buehler et al., 2017)* has been equally important.

Behaviour is understood as a generative and propulsive capacity brought about through repetition and belonging to body-mind-world assemblages that exceed human individuals as conventionally understood *(Schwanen et al., 2012)*. Behavioral studies related to urban planning face many challenges like the limitations of physical planning when changing habits, meaning that sometimes the built environment is not enough to affect the way humans behave.

Behavioral change is difficult to achieve since habits play a major role when deciding the travel mode *(Gardner, 2009)*, however, they also offer more persistent results in the long term. Based on the distribution of means of transport and the little amount of trips by bike, but also on the area of opportunity that Järfälla represents—as a fast-growing municipality that lacks identity—biking as an identity among the inhabitants is a suggested area to explore.

Urban morphology, especially the proximity to public transport is important in promoting sustainable travel behaviors *(Adolphson, 2022)* and according to Järfälla’s bike plan, work is being done to design and achieve an attractive cycling infrastructure. Moreover, according to Adolphson *(2022)*, attitudes, ideologies, and lifestyles are equally relevant, but how to achieve this is not discussed in the mentioned plan. It is for this reason that when talking about building a biking culture in Järfälla, special emphasis on behavioral changes is needed.

The Netherlands, Denmark and Germany are successful examples of the biking identity construction and, in these countries, not only infrastructure but pro-bike policies and programmes were made *(Pucher & Buehler, 2008)*. Training and education is a key pathway to follow to build a lasting relationship with the biking culture, both for cyclist and non cyclist.

In the mentioned countries, extensive training is part of the school programmes and, by 4th grade, girls and boys have completed such courses. This courses are not only classroom instructions but also ‘on the road lessons’, meaning that from a young age, kids start interiorizing biking as a main option to move around and no only as a leisure activity.

Because education does not end at school, what is learned, discussed and practiced is taken to their homes, forcing the main tutors of the kids to get involve and actively participate in the construction of cycling culture. Moreover, because boys and girls are taught to bike safely, both start biking on equal conditions.

Including cycling courses in schools may be an investment whose benefits will not be visible in the near future, however, there are no arguments terms of education to not do it. Järfälla, a municipality that is still developing its identity and that is welcoming new inhabitants, has the chance to advertise, promote and work with biking until it becomes a habit, not a decision: “we must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against the growing into ways that are likely to be disadvantageous to us, as we should guard against the plague” *(Schwanen et al., 2012, p. 526)*.

Finally, as suggested by Schwanen et al. *(2012)*, behavioral change needs to reach not only users but policy and decision makers, meaning that institutional change needs to happen in Järfälla municipality. In order to create policies in favor of sustainable ways of transportation, internal and institutional behavioural changes are needed, so putting the lens of sustainable and accessible ways of transportation need to be done when making policies.

CONCLUDING REMARKS FOR THE JÄRFÄLLA CONTEXT

The actions included in strategy C are the result of finding which measures are the most effective, suitable and feasible in the Järfälla context. By combining push measures like parking and behavioral change -taking kids as a starting point- have high possibilities to create a synergistic effect in reducing car dependency and achieving goal 1.

Overall, the literature concludes that packages of measures are preferable and more effective than a single policy when trying to reduce car dependency *(Hammadou & Papaix, 2015)*. A US study found that the combination of “carrots and sticks”, meaning expanding public transport, walking, and pedestrian networks, while implementing restrictions or disincentives for car use are most effective to reduce car use and encourage active travel modes *(Piatkowski et al., 2019)*.

In combination with pull measures described in strategies A and B, a comprehensive pathway towards a traffic strategy can be achieved, however, it is important to recognize its difficulties and clashes with other goals. For example Ensuring access to sustainable transportation for everyone, everywhere in Järfälla is goal number two and, although is not the most important goal, introducing -or increasing- pricing might clash with ensuring accessibility.

According to Di Ciommo, *"climate change mitigation and adaptation strategies may significantly affect accessibility levels, especially for vulnerable population groups, such as low income households, single parent households, and persons with travel-related impairments. For instance, the introduction of urban road pricing may have severe consequences for low income persons who depend on a car to travel to work, if no alternative means of travel are being provided" (2016, p. 33)*. Although the strategies are thought to enable those who need driving, to drive, by reducing unnecessary trips by automobile, when facing encounters of accessibility vs reducing gas emissions, this proposal suggests to favour the environment.

GOAL INDICATORS

The goals in the traffic strategy need to be associated with corresponding indicators (similarly to the management literature concept of *"Key performance indicators"*) to allow the municipality to measure if it is achieving its goals and adjust its implementation in response to any failure to do so. Wendle et al. *(2012)* show how indicators help to build support for the strategy by illustrating that it works, and simultaneously serves as a tool for communicating the municipality's efforts to the public.

Within the scope of this project, we've been unable to develop complete indicators for the suggested goals. We do, however, review the most important consideration that Järfälla needs to make as it develops its goals and indicators for the goals iteratively, and discuss what these would mean in relation to the suggested goals.

Quantitative indicators are common in measuring sustainable development and are more simple and efficient to use than qualitative indicators *(Scerri & James, 2010)*. Yet, according to Scerri and James, developing quantitative indicators for qualitative goals risks simplifying or obscuring some parts of the goal.

As the goals are being iteratively developed, therefore, the municipality needs to consider if the goal will be quantitatively measurable as it is defined, or if some set of “proxy variables” that the municipality believes co-varies with the goal achievement should be measured instead.

As the goals are being iteratively developed, therefore, the municipality needs to consider if the goal will be quantitatively measurable as it is defined, or if some set of “proxy variables” that the municipality believes co-varies with the goal achievement should be measured instead.

In theory, almost anything can be measured with a large enough expense. Along with ensuring that the indicators match the goals, therefore, the cost of using the measurement is an important constraint that the municipality needs to take into account as it is defining its indicators. A productive method is therefore to randomly sample some parts of the system and measure its performance. From that, inferences about the system performance as a whole can be made using statistical methods.

To be able to determine whether a goal has been fulfilled or not, the municipality also needs to define target levels of each indicator that should be reached at certain points in time. Measuring the indicators before the implementation of the strategy will give a baseline level to which the amount of improvement required can be relative to. Continuous (e.g., yearly) measurement will then provide the municipality with an indication of whether it is on track to reach its goals. If the municipality compares the relative difference to the previous measurement and puts this in relation to the measures it has taken since, it will also provide an indication of the effects of its measures (so-called ‘urban experimentation’; *Evans, 2016).*

Borrowing from the environmental sciences, the DPSIR typology outlines five different types of environmental indicators that can help suggest what measurements could be used for the goals in the Järfälla traffic strategy *(Malmqvist & Glaumann, 2006)*. We review the different types briefly: **D** for **Driving Force** refers to measurements of the demand for the action that causes the effect (e.g., fossil fuel based transport demand). **P** for **Pressure** refers to measurements of the volume of such actions recorded (e.g., tonnes of GHGs emitted). **S** for **State** refers to measurement of the accumulated state of the affected object or system (e.g., volume of GHGs in the atmosphere). **I** for **Impact** refers to measurement of effects that this state change has on something else (e.g., the amount of change to average temperatures). Finally, **R** for **Responses** refers to measurement of how much resources are spent on counteracting these impacts (e.g., amount of resources spent on climate adaptation).

In terms of the first goal (zero GHG-emission), measuring “Driving Force” type indicators relating to the demand for transport with an extended travel habits survey seems productive. This could cover not only mode choice, but also emission profile of vehicles and amount of kilometers traveled within the Järfälla boundaries, from which territorial emissions would be calculated. The target levels of emission reduction needs to be negotiated as the municipality is defining the goal.

Relating to the second goal (ensuring access to sustainable transport), “State” or “Impact” type of indicators are useful. A state type indicator would measure if sustainable transport of different types is provided and accessible at different origins and destinations within the municipality, based on some standard level of sufficiency negotiated by the municipality in the goal development phase. Preferably this would be done as a statistical sample to get a usable indication with a small expense. A different approach would be an impact type indicator, which could be based on a survey of residents reporting their experiences of coverage and accessibility of the sustainable transport networks.

For the third goal, “State” and “Impact” type indicators can preferably be combined to match the goal as well as possible. State indicators for travel time could include measuring travel times with different modes for randomly sampled trips, collecting data on the average costs and fees of the trips. For the perceived comfort of different parts of trips, impact type indicators asking the users about their experiences and making inferences could be suitable. For traffic safety, gathering data on injuries and casualties from Strada is suitable and would also constitute an impact type indicator.

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NAVIGATING JÄRJEKÄLA