What can be done to improve conditions for micro mobility in urban mixed mode intersections through strategic documents?

Case study Gothenburg

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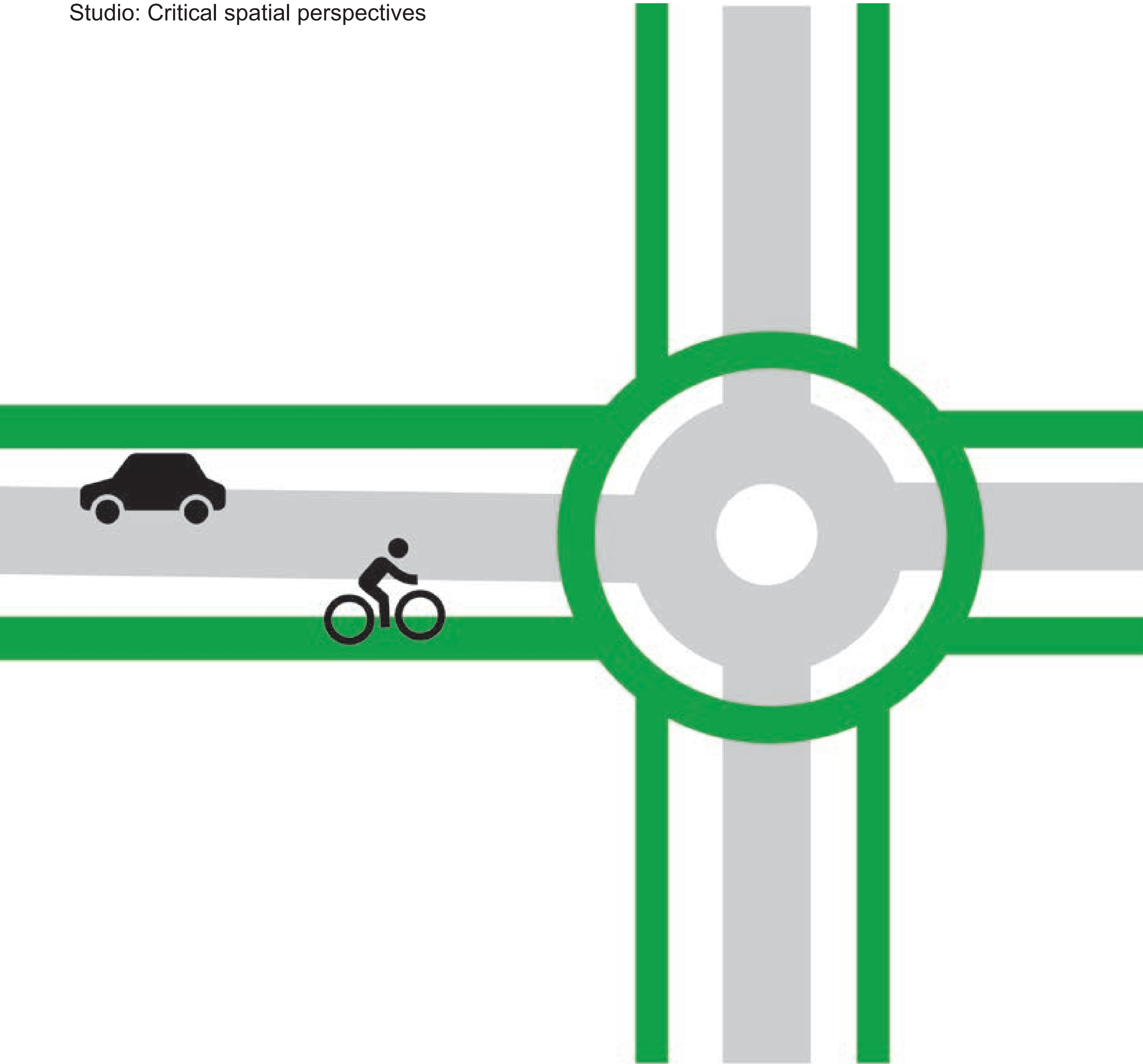

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Student background

I've done my bachelors at Chalmers, and from the start had an interest in urban planning. With time I got more and more interested in traffic planning, and tried to include this in my planning projects. In my master thesis, I wanted to further emphasize this, to be able to strongly show that traffic planning is a familiar topic for me, to be seen in my portfolio and CV.

In my professional career I would like to be able to work with both traffic planning and urban planning at different stages. A possible specialization for me could be working as a bridge between the two fields, which I believe could contribute to better solutions. I've chosen to write my thesis with a private company, AFRY, both for their expertise, and in order to get a potential foothold in my future job market.

Glossary

- **Micro mobility** - Mode of transport that weighs less than 500 kg (Dediu, 2019)
- **Mixed mode** - Different modes of transport, e.g. vehicles, micro mobility, pedestrians
- **Urban** - Built up area
- **Urban intersection** - Intersection that lies in an urban area, and has such a limitation of space that a prioritization has to be made when allocating to different users
- **Strategic documents** - Planning documents regarding land use and infrastructure
- **Planning instances** - Organizations producing strategic documents
- **Modal share** - Percentage of travelers using a particular type of transportation

- **Scale** - Spatial classification of sizes. Magnitude of extent or size of area studied. E.g. region, area and design scale

Design scale - Scale in which design of intersections is made
Area scale - Scale that decides where flows interact, the precise location of networks for different flows. E.g. decisions on where a bicycle path should go, along the river or the highway, are decided in this scale. The area scale sets the requirements for who should be pri oritized in the design scale
Region scale - The region scale encompasses from where clients to an area come from, e.g. labor pool of an area. The regional scale guides type of flow going through an area

Acknowledgments

The report couldn't have been made without the support from my supervisors at AFRY and Chalmers. Joakim Bjerhem and Nils Björling were my main supervisors, but I have also had consultations with many people at AFRY. I want to thank everyone who have I have consulted with, they have without a doubt contributed to a better report!

Multiple diagrams in the report use filled icon figures. These icons were made by *Freepik*, *Kiranshastry*, *Those Icons* and *Google*, from www.flaticon.com

Abstract

The purpose of this report was to investigate how planning instances in the city of Gothenburg, Sweden, could help create better conditions for micro mobility in urban mixed mode intersections. The results are most directly applied to Gothenburg, but the conclusions could be generalized through a context analysis and attributed to other locations as well.

The methodology was to create feedback to strategic documents through a triangulation between context analysis of theory, a case study and strategic documents concerning the case study. The theory included basic traffic safety as well as flow theory, and urban planning theories concerning new urbanism ideas and economical aspects linked to region growth. Among strategic documents included were a regional plan, municipal comprehensive plans, municipal transport strategy, municipal bicycle plan, multi municipal public transport plan, a detailed comprehensive plan and national and municipal dimension standards.

The case study subject was of an urban mixed mode intersection located along Gothenburg's bicycle commuter network, in an area that was transitioning from industrial to mixed land use. The intersection is between Mölndalsvägen, Fredrikdalsgatan and Sankt Sigfridsgatan, with the coordinates 57.683871N, 12.000128E.

The results showed that many structural problems encountered in the case study would have been best solved in other scales, such as of an area or a region. An area scale can be appropriate to dedicate space for transport corridors and decide the priority, between modes of transport, within them. Frequency and type of connection, between transport corridors, can preferably also be solved in an area scale, through placement and design of intersections, stations and parking. If transport corridors and their connection can't handle expected flows, it is suggested that either a budget for grade separation is given, or a limitation of flow type or destinations is created. Guidance for which of these strategies is applicable where, can be given from a region scaled document.

In the case of Gothenburg, working more with area scaled documents, and giving them more power is highly recommended. A stronger infrastructural basis in Gothenburg's comprehensive plan is also suggested, to know where different transport strategies are applicable.

Conclusions for dummies

Short summary of conclusions, and line of argumentation

To physically be located somewhere, there is a requirement of space. When in motion, there is also a need for buffer space to be able to move around safely. This buffer space becomes larger the higher the speed

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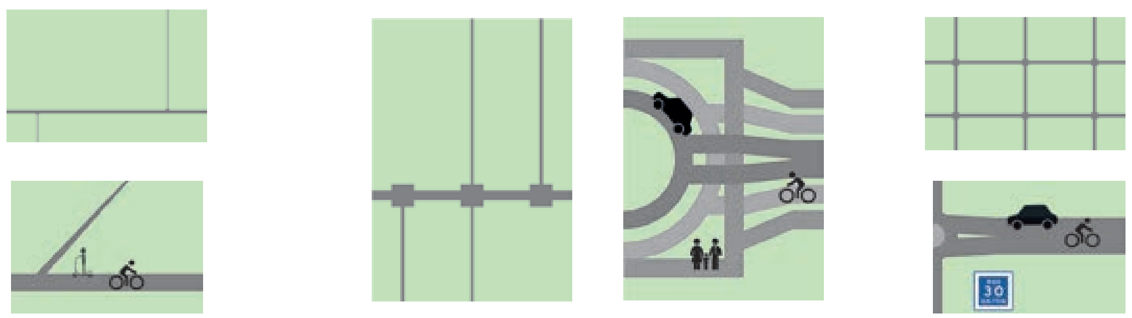
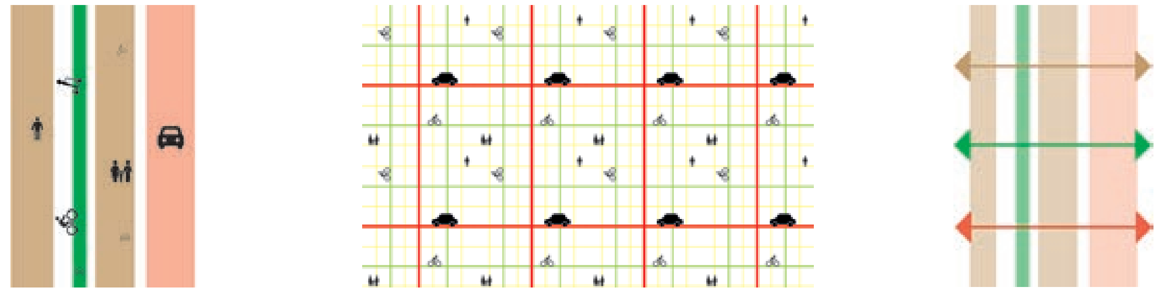
Safe give of way intersections are preferred over signalized intersections for micro mobility.To ensure safe solutions without grade separation, turn types, speed reductions and/or refuge islands can be used



These requirements imply several types of preferential traffic corridors for micro mobility:
a) a relatively narrow corridor, with few intersections and little speed disparity.
b) a broader corridor, especially for intersections, that contains higher speed disparity
c) a medium wide corridor with potentially many intersections, but that has a limit on speed and on the amount of flow. This is especially relevant for secondary and tertiary micro mobility flow

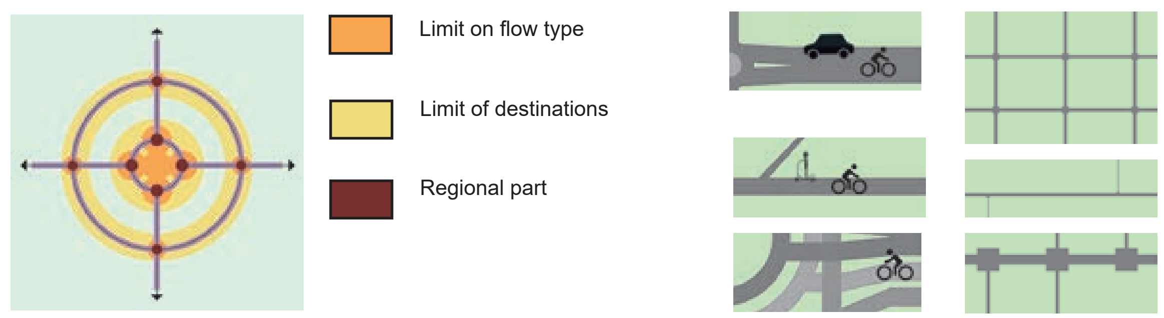
Design scaled documents



To ensure that a desired traffic corridor is created, area scaled strategic documents can be useful. In the area scale, it can be appropriate to decide the size of transport corridors, and use unbundling to direct what modes of transport go where. A relevant question, to be answered in an area scale, is how often the traffic corridors are connected, and how?

To guide the connection between corridors, and determine if they are applicable, design and placement of interchange points are relevant. This had not been done in the investigated case study area, but would be a good thing for the city of Gothenburg to look into. If it's not possible to fit the desired capacity through intersections of an area, even after unbundling, it could become relevant to ask if there is a need to limit certain kinds of flows? Guidance for relevant limitations could come from a region scaled document

Area scaled documents



Regional scaled documents can help determine where/if to limit flow types, and how. From a micro mobility perspective, it would be interesting to either have a limit of flow type, likely vehicles which take up the most space, or destinations, which affects all kinds of flows. Having a budget to mitigate problems of not having limitation is a third option, and could be applicable to a certain degree. In the case study this had not been done, so it is a suggestion for the city/region of Gothenburg to do so. Region scale documents can dictate location of primary, regional roads, which can dictate suitable locations for the different limitation types.

Region scaled documents

Table of content

Introduction

Thesis background

City of Gothenburg has ambitions for bicycle traffic, strategic documents state it through different scales (Göteborg, 2015a; Göteborg & Mölndal, 2016; Göteborg, 2009), while there are also documents that state standards and recommendations for the construction phase (Göteborg, 2015a; Göteborg & Mölndal, 2016; Göteborg, 2009). But the author's personal experience is that it is not reflected from the point of view of a bicyclist in Gothenburg, even in some newly constructed intersections. This is something that people working with bicycle infrastructure in AFRY thought as well, especially in the priority of bicycles in complex intersections. Urban mixed mode intersections have probably some of the most complicated and complex conditions, and if they can be solved in strategic locations, it could open up potential for far reaching infrastructural change throughout a whole area.

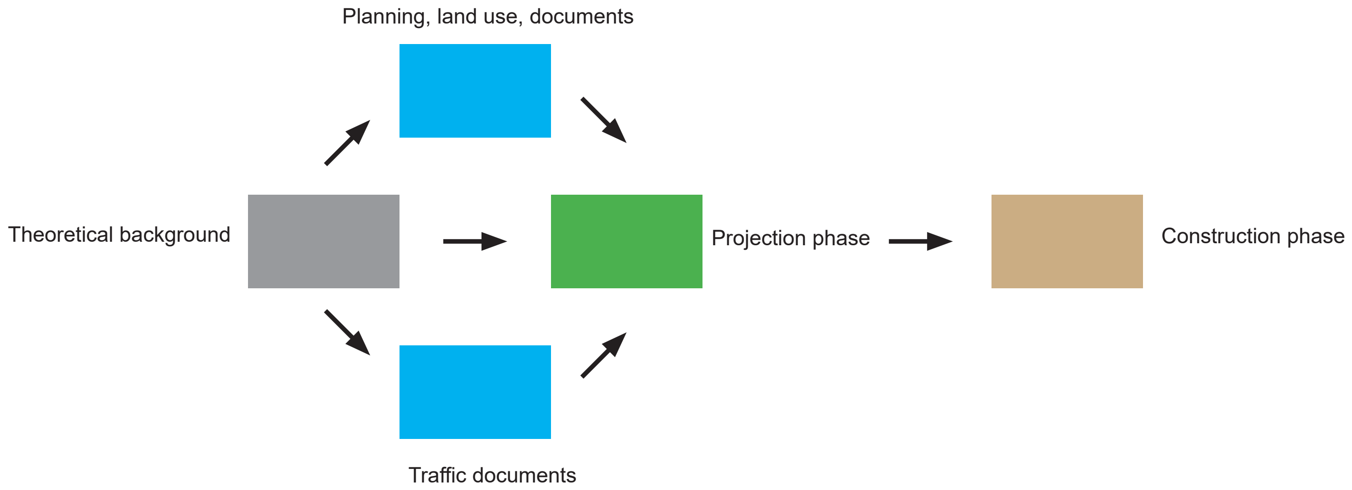
Source: Göteborg & Mölndal, 2016 Source: Göteborg, 2015b Source: Göteborg, 2009 Source: Trafikverket, 2020b Source: Göteborg, 2015a Source: SKL, 2010

Strategic documents stating ambitions, and standards and recommendations for implementation, exist for micro mobility, but problems still occur.(Göteborg, 2015a. Göteborg & Mölndal, 2016.Göteborg, 2009. *SKL, 2010. Göteborg, 2015b. Trafikverket, 2020b*)

Over the last years there has been an increase in the use of scooters, that use the same infrastructure as bicycles. Overall, there exists potential for other smaller, lightweight solutions to have a bigger modal share in the future (Dediu, 2019). The term micro mobility can be used to categorize these smaller modes of transport, and a definition for micro mobility is "*Mode of transport that weighs less than 500 kg*" (Dediu, 2019). In this report it is assumed that micro mobility can use the same infrastructure as bicycles, since they are also a form of micro mobility, and it is assumed a benefit to be able to include more users, and thus a bigger modal share, as it increases the target group.
Therefore the background will use the term bicycle or cycle, since there is more literature on it, while the authors own contribution will use the term micro mobility.

Hypothesis

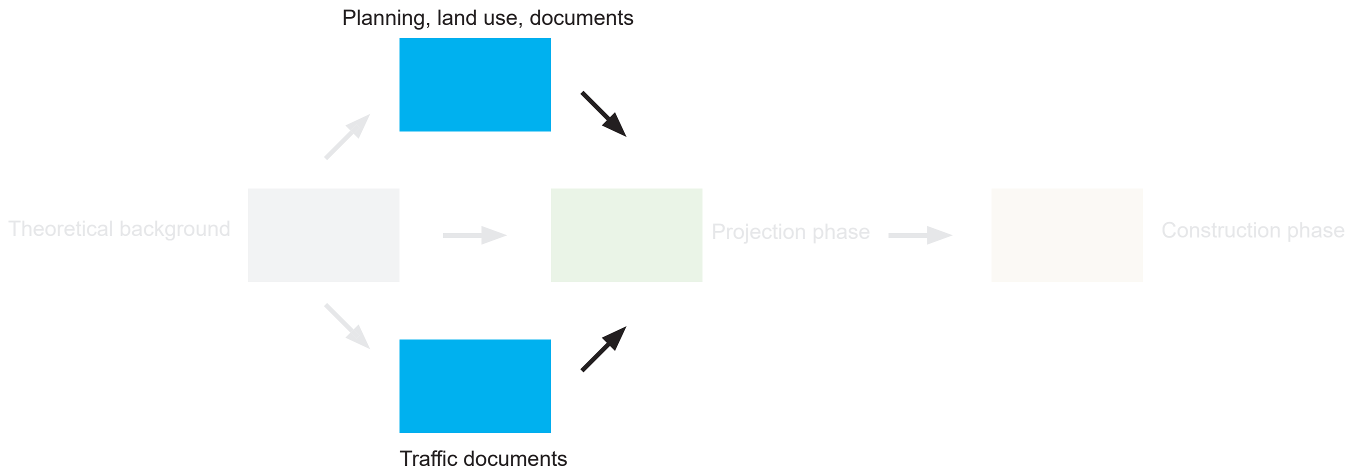
Problems aren't always solved and identified at the right stage. A stronger support from strategic documents can lead to better conditions for micro mobility in urban, mixed mode intersections. To address this it is believed that cross disciplinary feedback would need to be created.



There are many documents for different stages in the planning process. The hypothesis is that some of the problems that occur are not solved in the most appropriate stage. To ensure problems are solved at the right stage, there is a need for cross disciplinary feedback

Research question

What can be done to improve conditions for micro mobility in urban mixed mode intersections in strategic documents?

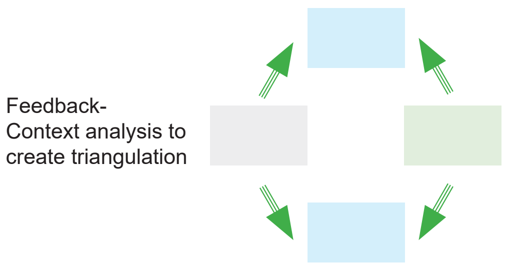


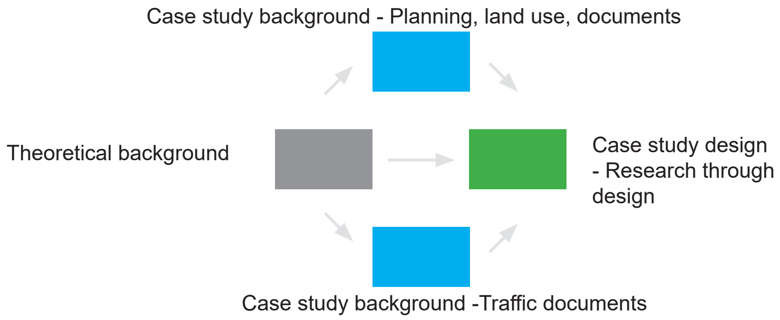
Delimitations

- This report did not thoroughly and properly describe why a region should invest in and prioritize micro mobility. The results of this report could be used as input in formalizing arguments to why it should be done
- The case study was designed to such a degree that the feedback becomes relevant, it is not a finished projected drawing ready for production
- Maintenance was not considered
- The feedback is concerning the city of Gothenburg. To apply the conclusions to other locations a context analysis has to be done

Method

The chosen method was to do a triangulation between literature studies and a case study, through which feedback to strategic documents was made.
The report is divided into four parts; a theoretical background, case study background, case study - design, and the resulting feedback. The feedback will be answering the research question, *What can be done to improve conditions for micro mobility in mixed mode intersections in strategic documents?*

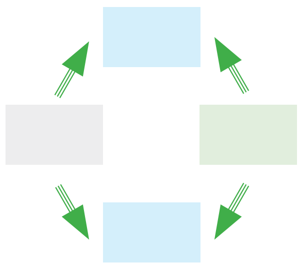




Feedback

Feedback to the strategic documents was created through a triangulation of the theoretical background and case study background + design. This is what answered the research question, *What can be done to improve conditions for micro mobility in mixed mode intersections in strategic documents?*

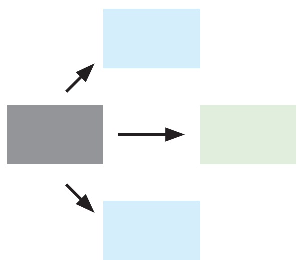
Feedback, made as a triangulation of the context analysis of the strategic documents and case study



Theoretical background

The theoretical background was based on literature studies. It created a base for the concepts used in the case study - design phase and the triangulation in the feedback. This chapter also created a background to different goals of various strategic documents that existed for the site, which were described in the case study background chapter.

Theoretical background through literature studies. Provides a background to the other chapters



Case study background - strategic documents

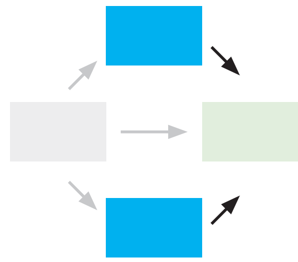
In this chapter the site for the case study was chosen and described. The methodology was literature studies and context analysis.

Criteria for the site of the case study and an initial problem description, from a local stand point, were made through a context analysis.

The conditions of the case study area were later described through summaries of various strategic documents. The strategic documents concerned both traffic and land use planning, in regional, area and design scales. The summaries were based on literature studies of the strategic documents, and acted as a background to the case study - design phase. The authors contribution here was the choice of strategic documents, the choice of what to summarize and to collect summaries of different documents in one location. The feedback chapter, that answered the research question, gave feedback to these summarized strategic documents.

A small analysis of remaining relevant aspects for the case study, that the studied strategic documents didn't cover, was also made. The choice of relevant aspects was based on a context analysis of the theoretical background and strategic documents.

Case study background, base for case study design phase

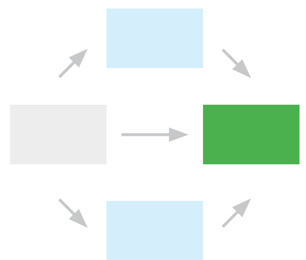


Case study - design phase

This case study design phase had a research through design method, where some basis for the design concepts was described in the theoretical background through literature studies.

It was allowed, by the author, to make changes that go beyond the scale of a normal intersection design, such as the movement of flow or overall transport policy in the area. This later became the basis for the feedback to the strategic documents.

Case study design phase, based on the theoretical and Case study background



Theory

The theoretical background explains some basic concepts of traffic and urban planning, for Sweden.

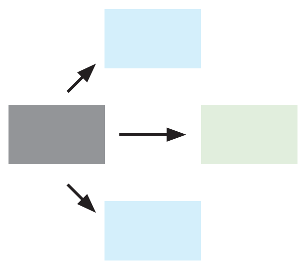
The traffic theory chosen was mainly of elementary principles used in Sweden, extracted from the book *Trafiken i den hållbara staden* (Hyden, 2008).

To strengthen the background of some concepts, Dutch studies (Heinen, Methorst, Schepers, Wegman, 2013); Beleen, 2015), concerning the term unbundling and a comparison of intersection types were also presented.

The urban planning theories were chosen to create a background to goals of the planning documents presented in the Case study background chapter.

The method for the theoretical background was literature studies.

Theoretical background through literature studies. Background to the strategic documents of the case study area, and base for concepts in the design phase



Traffic theory

Traffic safety

There is a history of focus on traffic safety in Sweden. Already in the 60s it was a major planning principle, and in 1968 SCAFT was released, a series of traffic principles for new development that focused on achieving higher traffic safety through speed limitations and traffic separation. As the foremost period of housing development in Swedish history occurred in the 60s, accommodated with large infrastructure investments, SCAFT principles have a significant legacy in Sweden. While the later updates of Swedish traffic principles, TRÅD, TRAST, gradually gave more focus to other aspects in traffic planning, there is a large legacy of infrastructure, in Sweden, built according to these principles (Hyden, 2008).

In 2019 there were still 223 people that died through traffic accidents in Sweden, 137 protected and 86 unprotected road users (Transportstyrelsen, 2020), and the Swedish Transport Administration (Trafikverket) has a *nollvision*, a vision of zero casualties caused by traffic accidents (Trafikverket, 2020a). The vision from the Swedish Transport Administration is that it should be easy to drive safely and correctly, and that no one should be punished by death by making a mistake (Trafikverket, 2020a).

When, where and how do traffic accidents occur?

In 2005 in Sweden, 60% of the accidents occurred during daylight, and 2/3 of the accidents occurred between intersections, as opposed to on intersections. The vast majority of accidents happened at roads with speed limits of 50km/h and over, and only 1% of all serious accidents occurred at speeds of 30km/h and below (Hyden, 2008).

For bicyclists and pedestrians, single -person accidents are underrepresented in these statistics, as bicycle accidents don't get reported, while pedestrian ones aren't qualified as traffic accidents. The most common cause is slippery surfaces, such as ice, followed by different uneven surfaces. It is reported that 60-70% of bicycle accidents in Sweden are single - person affected ones (Hyden, 2008).

Aspects that tend to increase the risk of accidents are higher speeds, increase in vehicles, age of commuters, state of drivers/ commuters and if they are doing something else while driving/ going. The inverse of these aspects, and improvements of road and vehicle design, tend to decrease the risk of accidents (Hyden, 2008).

The connection between speed and accidents is well documented, it has been shown through multiple studies and is considered to be the foremost cause of traffic accidents in Sweden (Hyden, 2008). Reduced speed increases the reaction times of drivers, which makes it more likely that they will react in time and prevent the accident, while also reducing the potential impact of an accident. Speeding is therefore considered a major safety issue, as it is also something that is very common (Hyden, 2008). In 2018 in Sweden, only 45-66% of all motor drivers were keeping the speed limit, depending on if it was a regional (45%) or local road (66%). 40km/h roads fared the worst among local roads, with 53% of drivers being within the speed limit (NTF, 2018).

Speed limit (km/h)	Drivers within speed limit (%)
40	53
50	66
60	80
70	79

Source: NTF, 2018

Because driving a vehicle is a complex behavior, and traversing at high speeds was not something that our bodies were evolved for, there are a lot of socio - psychological aspects that affect driving culture as well. Some of the more important traffic safety related socio - psychological aspects are risk compensation, delegation of responsibility, imitation effect, knock-on effects and migration effects (Hyden, 2008).

Risk compensation is when a traffic behavior changes because of a perceived sense of risk, and can be seen for all modes of transport. If a road is made to a higher safety standard, its users may react by moving on it more carelessly, as it is perceived safe to do so. This can remove some, in certain cases all, of the intended safety increasing effects (Hyden, 2008).

Delegation of responsibility is a behavior where the user may rely too much on a system, and is not adaptive enough when something with the system goes wrong. It doesn't mean that the safety aspect of some systems is non- existent, but rather that it could be smaller than one might have expected it to be. An example of this are signalized stops, where motorists might not react to pedestrians crossing on red, because they assumed that the traffic light was checking this for them (Hyden, 2008).

Imitation effect describes how people tend to imitate other people's traffic behavior, even if it is incorrect. Proffesional drivers, e.g. taxi drivers, often drive above the speed limit, as they might consider that they are more experienced drivers that can handle the higher speeds. Even if that were to be true, they are then ignoring that they can set the pace of the flow, because of the imitation effect, thus increasing the risk for everyone (Hyden, 2008).

Knock-on effects regards when people copy behavior from where it was relevant, to where it isn't. An example of this can be seen when drivers change from a high-speed to low-speed road, and go above the speed limit on the lower speed road. An American study showed that after construction of new freeways, motorists speed tend to increase on all adjacent roads that were up to 20km from it (Hyden, 2008).

A migration effect is when an aspect, positive or negative, moves from one place to another. For instance, this can occur when vehicle traffic is restricted on one road and instead moves to another, or when speed bumps in one place creates a reduction of speed in a whole neighborhood (Hyden, 2008).

Safety enhancing principles

Although each road segment and intersection is a unique case in itself, research conducted by Swedish institutes have led to the formulation of a set of desirable features, as described by Hyden (2008);

1. Low speeds
2. Low speed dispersion - difference in speed between users
3. Clear exposure of unprotected travelers
4. Large exposure of unprotected travelers - large amount of unprotected travelers
5. Decent amount of feeling of unsafety. Note it is the feeling of, not the actual notion of unsafety
6. Low feeling of own right of way - a traveler only has an obligation to give right of way to others, not to recieve it from others
7. Equality and support for proper social behavior

Speed has a great effect on safety, as mentioned many times in previous paragraphs. From a safety perspective, there are therefore many benefits with having *lower speeds* and *dispersion* of it. *Clear exposure of unprotected travelers* means that they should be easy to spot, and that it is clear for them how to move. *Large exposure of unprotected travelers* addresses that unprotected travelers have proven to receive increased safety in greater numbers. The *decent amount of safety* and *low feeling of own right of way,* is meant to address the risk compensation effects and to make travelers alert, while not putting them in danger by doing so. Finally equality and support for proper social behavior regards following the rules and showing respect towards others (Hyden, 2008).

Speed reducing measures

Hyden (2008) mentions that physical speed reducing interventions can be made at strategic points where a transition from a high speed to a low speed environment occurs, such as when entering an urban area. Examples of interventions are side shifts - where roads gets a small turn, narrowing of roadways, smaller roundabouts and elevations (Hyden, 2008).

Noise environment

Hyden (2008) mentions that an aesthetically pleasing and noise free environment is much nicer for pedestrians and bicycles to traverse through, than when it is not. Gehl (2010), behind some urban planning ideas described on page 53, says that bicycles are a welcome support in creating lively, safe, sustainable and healthy cities.

The Swedish transport administration, Trafikverket, has an information page about road noise, where it is said that the noise originates from both vehicle engines and the tires contact with the road surface (Trafikverket, 2017). Generally speaking, heavy vehicles, >3,5 tons, create more noise than light vehicles, <3,5 tons (Trafikverket, 2017). The definition of micro mobility was that they were lighter than 500 kg (Dediu, 2019). At low speeds, around 30 - 50 km/h for lighter vehicles and 50 - 70 km/h for heavier vehicles, engine noise tends to be dominating, while noise from tires tends to dominate at higher speeds. Driving techniques can also affect noise, as sharp and often accelerations creates more noise than when driving calmly with an even speed (Trafikverket, 2017).

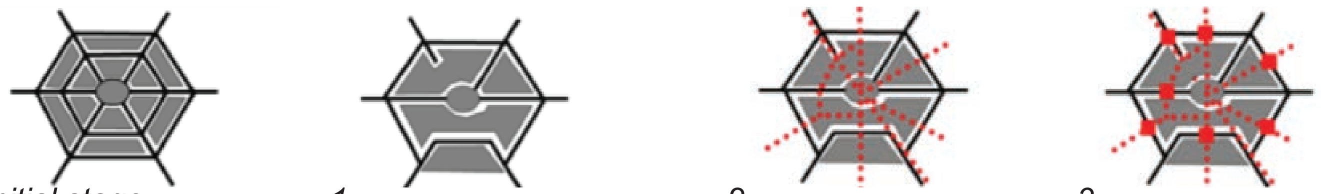
Unbundling vehicular and bicycle traffic

Unbundling is a term that a Dutch study (Heinen, Methorst, Schepers, Wegman, 2013) used to describe the strategy of doing a network-level separation of vehicular and bicycle traffic:

"*Unbundling vehicular traffic and cycle traffic in an urban network is operationalized as the degree to which cyclists use access roads*[a] *and grade-separated intersections to cross distributors*[b]*"* (Heinen, Methorst, Schepers, Wegman, 2013)

The study suggests that unbundling improves cycling safety, and increases the share of cycling in the modal split. It further recommends unbundling vehicular and bicycle traffic in urban networks, through e.g. establishing large traffic-calmed areas with shortcuts and standalone paths for cyclists and pedestrians, and where feasible, grade-separated intersections such as bicycle tunnels.

Example of steps for network unbundling;



Initial stage *1* *2* *3*

1. Concentrate main vehicle flow on a few traffic arteries.
2. Create bicycle network through the inner areas
3. Design safe crossings
Source: Fietsberaad - publicatie 14b, 2011

a. Vehicle road thats run parallel to a higher speed, limited access road
b. Road which acts to move traffic from local roads to main roads

Flow theory

Flow theory is the theoretical background that is used to ensure good accessibility and minimize delays (Hyden, 2008).

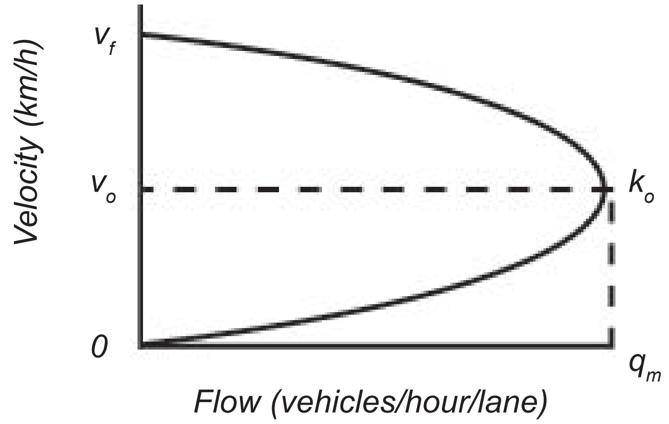
Hyden (2008) mentions several important keywords regarding flow:

- Capacity - which measures the biggest amount of users that can pass a section during a constant time period
- Load factor - current flow/ capacity. Often it is desirable to not let the load factor surpass 0,8
- Delay - the added time it takes to pass an intersection, compared to if it didn't exist
- Free flow - drivers average speed isn't dependent on the interaction with other drivers

In optimal free flow conditions, the following function can be used:

$$q = v*k$$

q = flow (vehicles/hour)
v = velocity (km/h),
k = density (vehicles/km or vehicles per km lane)



Speed limit affects capacity, as a higher speed limit can allow more vehicles to pass during a fixed time interval (assuming it is possible to drive the speed limit). k_o, the capacity limit, generally occurs at relatively low speeds, often around 50km/h (Hyden, 2008).

Broken flow

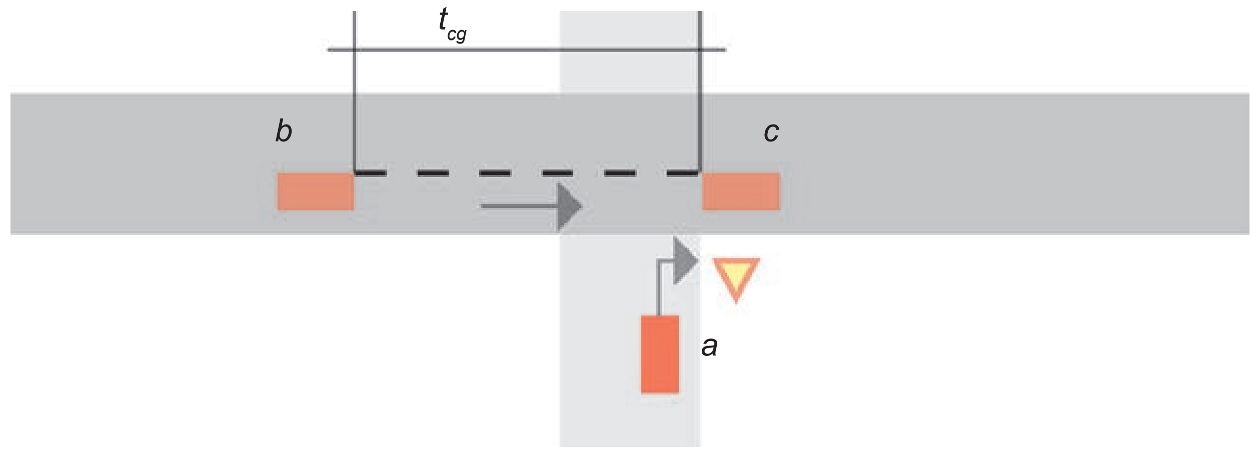
A broken flow occurs when another flow intersects it at grade, e.g. in signalized intersections or when priority signs are put up. The delay caused by this is a common measurement of the quality of an intersection. Another measurement is the likelihood of having to make a full stop, studies have shown that making the stop in itself is perceived as something negative, on top of the actual delay. Also, fuel consumption depends on the amount of accelerations and retardations one makes (Hyden, 2008).

Signal regulated intersections

Signal regulated intersections eliminate conflicts between flows through time separation, and can be used to improve conditions for certain directions. The signals can either be regulated through a time schedule, or by analyzing traffic using detectors. Depending on the goal, a set of phases can be created, with a safety phase, where everybody has red for around 3 seconds, in between them. It can therefore be beneficial to have long phases, in order to minimize the share of safety phases (Hyden, 2008).

Intersections without signals

A guiding aspect in the design of intersections without signals, that often have priority signs, is the critical gap. The critical gap is the smallest time gap that a driver needs to safely exit to another road (Hyden, 2008).



The critical gap, t_{cg}, is in this case the time gap between vehicle b and c, that driver a would need to do a right turn

The critical gap differs depending on the priority of the road, the speed, and the type of turn, (Hyden, 2008). High speeds and left turns for instance lead to higher critical gaps.

Speed limit on prioritized road (km/h)	50	50	70	70	90	90
Priority	*give way*	*stop*	*give way*	*stop*	*give way*	*stop*
t_{cg} Prioritized road, left turn (s)	4,8	4,8	5,7	5,7	6,7	6,7
t_{cg} Secondary road, right turn (s)	5,0	5,7	5,9	6,6	6,9	7,5
t_{cg} Secondary road, straight (s)	5,0	5,8	6,0	6,7	7,0	7,6
t_{cg} Secondary road, left turn (s)	5,3	6,0	6,2	6,9	7,2	7,8

Source: Vagverket, 1995

Comparison of signal and give of way intersections

A Dutch study that compared flows, safety and emissions between signalized intersections and roundabouts, showed several advantages for bicycles in roundabouts (Beelen, 2015).

The study used simulations, video observations and literature studies, and covered various scenarios of flow through an intersection. The signalized options that were studied had characteristics to make them more suited for bicyclists, leading to the assumption that signalized intersections without these characteristics would be less beneficial for bicyclists.

Through simulations, roundabouts were shown to create fewer delays for vehicles than the signalized intersections in all tested scenarios, until the intensity got to around 2500 - 3000 vehicles/ max hour. For bicycles, the simulations showed that roundabouts created fewer delays in all tested scenarios (Beelen, 2015).

Regarding traffic safety, the simulations showed that the tested signalized intersections were safer. But, in reference to other studies of actual statistics which showed the opposite, Beelen (2015) speculated that the simulation method didn't take enough consideration of how the set rules were followed.

Urban planning theories

New Urbanism

The new urbanism charter was written in 1996, and propagates a multitude of ideas that range from the regional to the neighborhood to the block and building scale (CNU, 2020).

The charter says that open spaces in a region should be protected, infill development to be promoted to enable this, and that the region should be supported by a framework of alternatives to car usage, such as public transport, biking and walking.

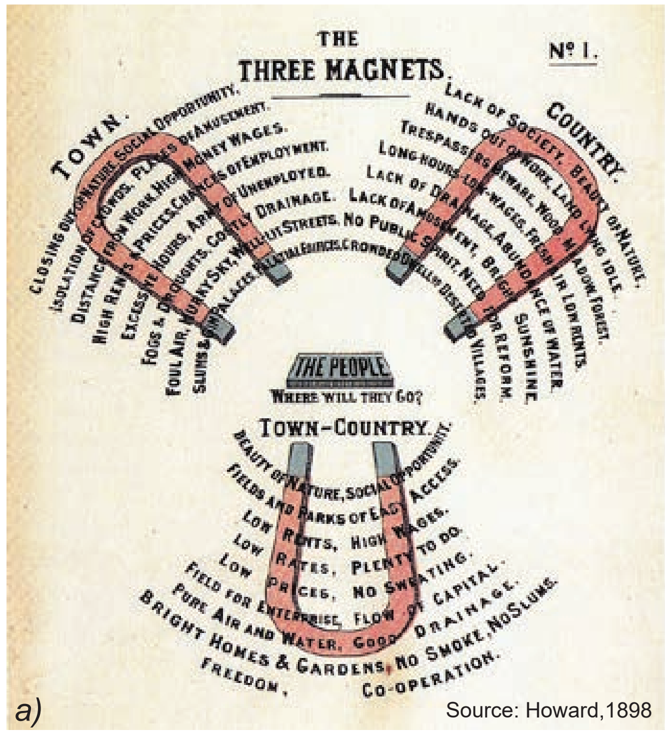
On the neighborhood scale the charter promotes dense, pedestrian friendly mixed use development. Density is supposed to support public transport and enable service of different kind to be available in walking distance.

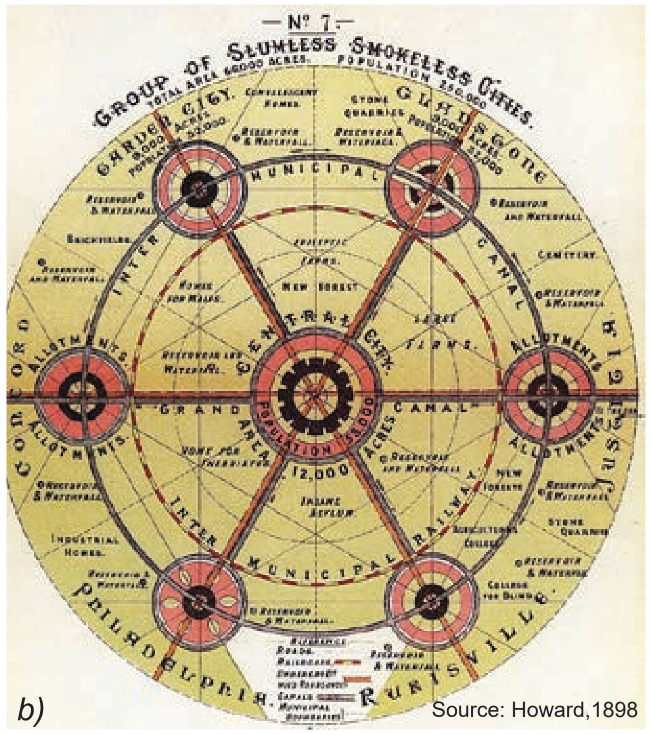
The charter contains both more aspects, and more detailed descriptions of them. If the reader wishes to read them, going to the source, CNU 2020, is recommended.

It could be claimed that certain New Urbanism thoughts are based on theories of Jan Gehl, Jane Jacobs and Ebenezer Howard -Garden city. These theories will be described next.

Garden city

Garden city concept was invented by British reformer Ebenezer Howard in his 1898 book Garden Cities of Tomorrow (Caves, 2005). Howard was looking for a serious, but not too revolutionary, physical and social alternative to nineteenth-century industrial cities, and argued for ‘social cities’ of about 32,000 people. These cities would be located far enough from existing cities for land to be bought at low prices, and have an area of 1,000 acres, surrounded by a 5,000-acre green belt (Caves, 2005). A central illustration in Garden Cities of Tomorrow is Howard’s diagram of a garden city ‘town-country magnet’ pulling people with the force of bright homes and gardens, and ultimately freedom and cooperation away from ‘town magnets’ (Caves, 2005).





a) Howard was looking to create the ‘town country’ magnet, which would have the benefits of city and countryside (Howard,1898)
b) The garden cities would have connections to other cities, including a central one (Howard,1898)

Jan Gehl and Jane jacobs

Jane Jacobs wrote the book *THE DEATH AND LIFE OF GREAT AMERICAN CITIES* , which challenged the planning orthodoxy of her time, such as *Tower in park* and systematic land separation (Caves, 2005). Jacobs (1961) advocated short blocks, high density and mixed use development, in order to create lively and active streets, for more hours of the day. She further claimed that this would create a more interesting cityscape, while the increase of “eyes on” and times when the streets were used would make them feel safer (Jacobs, 1961).

Gehl (2010) has studied and argued to create human - scale places, that are pleasant to bike, walk and stay in. The goal of these human scaled places, is to support and create a vibrant city life (Gehl, 2010).

Gehl says that the human scale is the one that we were evolved to live in, and the one we still prefer today. The human scale leads to exciting, intense and warm cities, and is opposed to the car scale, which Gehl claims dominates cities today. The car scale requires much bigger dimensions, and has acted to damage city life in places around the world (Gehl, 2010).

Gehl mentions 100m, 25m and 7m as important thresholds. 100m is when we start seeing people in motion, 25m is around when we start decoding emotions and facial expressions, and 0-7m is when we can really use all of our senses and exchange more intense feelings. Spaces for humans are usually better when they are a little too small rather than to big. When choosing the type of street, the human dimension should always be considered(Gehl, 2010).

If there is a limited amount of people, concentrating them can be a method to help create city life (Gehl, 2010). A quote that further reflects this:

“something happens because something happens because something happens” (Gehl, 2010, p.64)

500m is an approximate acceptable walking distance for most people, although there exists many variables to this (Gehl, 2010). 500m can be covered in 10 minutes, and it’s a radius than many older city cores have. But this distance can be made longer in pleasant environments, and shorter in others. E.g., if there are many traffic lights that cause long waits, a lot less than 500m can be crossed in the 10 minutes.

Overpasses should only be used as a last resort solution, at grade solutions are usually better. If necessary, ramps are beneficial over stairs as they are more accessible. High density alone isn’t a requisite for good city life, a human scale and pleasant environments are needed as well (Gehl, 2010).

Examples of city parts from Gothenburg that could be claimed to follow Gehl’s ideas. The pictures are of the neighborhoods Vasa and Haga

Economic aspects

Metropolitan size and growth pattern

Glaeser (2011) claims that it is cities that are the engines for economic growth, and have been throughout human history. Larger cities, or today maybe rather regions, also have several competitive advantages over smaller ones. The more people a place has access to in less time, the bigger the market is for a wide array of aspects (Glaeser, 2011). It can become easier to attract new companies, there is a wider array of opportunities on the job market, the underlying service market has a bigger pool of clients, and there are potentially better conditions for specialization and creating new ideas (Glaeser, 2011). Glaeser sees cities as places of economic opportunities, where people can develop wealth and escape poverty, and where people from different backgrounds can meet to create and formulate new ideas (Glaeser, 2011).

There appears to be a limit to how long people are willing to commute, which Marchetti (1994) claims hasn't changed much through the course of time. The main aspect that has changed is the mode of transport, which in turn has affected the size of cities. English (2019) has further reasoned on Marchetti's thoughts, showcasing how cities such as ancient Rome - a walking city, 19th century London - a subway city, 20th century Chicago a train city, and modern metro Atlanta - a highway city, have all grown in the size of their footprint, as a result of technological advancement.

With continuing construction of highways in the US, jobs have become less concentrated within regions. In the top 98 most populated metro areas in the US, almost 50% of all jobs were more than 16km from the main city center, which contributes to lower commute times for suburbanites (Glaeser, 2011).

English (2019) mentions how we today have a much bigger standard for the size of housing, and that the occupancy rate of apartments in older cities simply wouldn't be acceptable in western cities today. The creation of fast modes of transport has enabled "the working class" to afford a much larger space for living than was previously thought possible, and in previous centuries was considered a privilege of the upper class (English, 2019).

Glaeser (2011) uses different US - examples to showcase how restrictive zoning and economy of scale affects the price of housing. An increase in the housing stock, needs to accompany growth in demand for prices to remain stable. Else prices tend to go up, and the population growth gets pushed elsewhere (Glaeser, 2011).

Glaeser claims that restrictive zoning in parts of the US, as a result of the protection of countryside environments and neighborhood characters, has hampered growth. Building standardized units in mass scale might be considered monotonous, but it is what made housing increasingly affordable for Americans during the 20th century (Glaeser, 2011). These aspects is what has driven the major growth of the Sun belt cities, e.g. Phoenix, Atlanta and Houston, relative to more coastal cities in the US (Glaeser, 2011). The Sun belt cities allow growth to happen, that can take advantage of economies of scale. Some have called this for urban sprawl and anti - urban, but this is what has made those cities more affordable (Glaeser, 2011).

Glaeser (2011) does however pose several concerns about this "trend", especially for environmental aspects. The sprawling Sun belt cities have high carbon footprints per capita, compared to coastal cities in the US, as a result of car dependency, long distances and the need for air conditioning in their climates. But Glaeser (2011) also mentions that there is no rule that says that growth must happen in sprawling suburban areas, denser areas have potential to grow with scale effects as well. To combat climate change, Glaeser (2011) says it would be alright beneficial if Americas coastal, denser, cities grew more, as they tended to be have lower carbon emissions per capita than where the growth was pushed instead.

Attracting people

Richard Florida (2002) used the term 'creative class' to describe a socio economical class in a set of creative occupations that help spur growth. This group is said to base their location not only by job opportunities, but also the access to certain life styles. Both street level culture, consisting of vibrant cafe scene, bistro and galleries, and activities where being a participant is in focus, such as running, biking and traveling, is said to be lifestyle aspects that the creative class is looking for (Florida, 2002).

Metropolitan revolution

Bruce Katz and Jennifer Bradley have written the book *The Metropolitan Revolution: How Cities and Metros Are Fixing Our Broken Politics and Fragile Economy* (2013) which further exemplifies Glaesers and Florida's thoughts. Katz & Bradley say that cities, or of economical interest rather metropolitan areas, are not measured by their human structures or routines, but by the ideas that they create. It is exports between metropolitan areas that create revenue, and occupations that work with them have the highest multiplier effects in job creation. The locally focused economy, such as real estate creation, has the most economic activity, but it doesn't have the same impact on growth as selling goods and services to outside the metropolitan area (Katz & Bradley, 2013). Jobs in high-tech have an especially high multiplier effect, and a quote from the book is:

"Businesses that provide local services are important because they are part of what makes a place pleasant to live in: the ability to buy flowers and shoes, coffee and ice cream, legal services and financial advice. But what makes a place prosper is what it offers to people who don't live there" (Katz & Bradley, 2013, p.33)

The modern economy increasingly craves proximity, and a diversified economy and population demand greater choices in where firms and people locate (Katz & Bradley, 2013). Innovation districts, often small enclaves, is where a large part of these mega trends are seen:

"Innovation districts cluster and connect leading-edge anchor institutions and cutting-edge innovative firms with supporting and spin-off companies, business incubators, mixed-use housing, office and retail, and twenty-first-century amenities and transport." (Katz & Bradley, 2013, p.114)

These innovation districts are located in different environments throughout the US, from waterfront and downtown locations to more exurban science parks (Katz & Bradley, 2013).

"Innovation without a dynamic environment for its workforce will not be as successful in attracting and retaining the workforce it needs to succeed" (Katz & Bradley, 2013, p.115)

Summary theories

- Traffic safety is a fundamental part of traffic planning in Sweden (Hyden, 2008)
- Speed has a big impact on traffic safety (Hyden, 2008)
- Unbundling, or network separation, leads to fewer accidents (Heinen, Methorst, Schepers, Wegman, 2013)
- All else equal, safe roundabouts are preferred over signalized intersections for bicycles (Beelen, 2015)
- Bicycles can be part of the solution to create a more vibrant city life (Gehl, 2010)
- Vibrant city life can be important when trying to attract people (Katz & Bradley, 2013)

Case study background

This chapter chooses and describes the case study site. The methodology was literature studies and context analysis.

The site for the Case study was a crossing between Mölndalsvägen, Fredrikdalsgatan and Sankt Sigfridsgatan, in the city of Gothenburg, Sweden. Criteria for the choice of site, and an initial problem descriptions, are explained in the first part of this chapter.

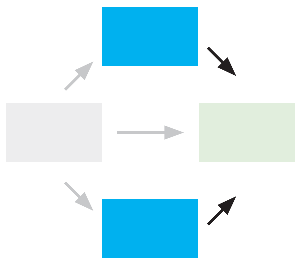
After the introduction to the site, different aspects of the case study area are described through summaries of various strategic documents. The strategic documents concerned both traffic and land use planning, in regional, area and design scales. The summaries were based on literature studies of the strategic documents, and acted as a background to the case study - design phase. The summarized strategic documents were:

regional structure plan (Göteborgsregionens kommunalförbund, 2008), *comprehensive plan of city of Gothenburg* (Göteborg, 2009; Göteborg, 2018), *comprehensive plan of city of Mölndal* (Mölndal, 2020)*, traffic strategy of city of Gothenburg* (Göteborg, 2015b), *Gothenburg's bicycle plan* (Göteborg, 2015a), *Gothenburg's public transport plan* (Västra Götalands regionen, 2018), an article about Gothenburg's logistics demand (Business region Göteborg, 2018), the *detailed comprehensive plan of the valley of Mölndal* (Göteborg & Mölndal, 2016)*,* detail plan proximate to the site (Göteborg, 2016)*,* and a *table with dimensions* extract from different authorities and organizations (SKL, 2010; Trafikverket, 2020b; Göteborg, 2019; Crow, 2016).

The author's contribution here was the choice of strategic documents, the choice of what to summarize and to collect summaries of different documents in one location. The feedback chapter, that answered the research question, gave feedback to these summarized strategic documents.

A short analysis of remaining relevant aspects for the case study, that the studied strategic documents didn't cover, was also done. The choice of relevant aspects was based on a context analysis of the theoretical background and strategic documents.

Case study background, base for case study design phase



This chapter will provide a background to the case study intersection

Case study - choice of site

Motivation for choice of site for the case study, how was the chosen site representative in answering the research question *What can be done to improve conditions for micro mobility in urban mixed mode intersections through strategic documents?*

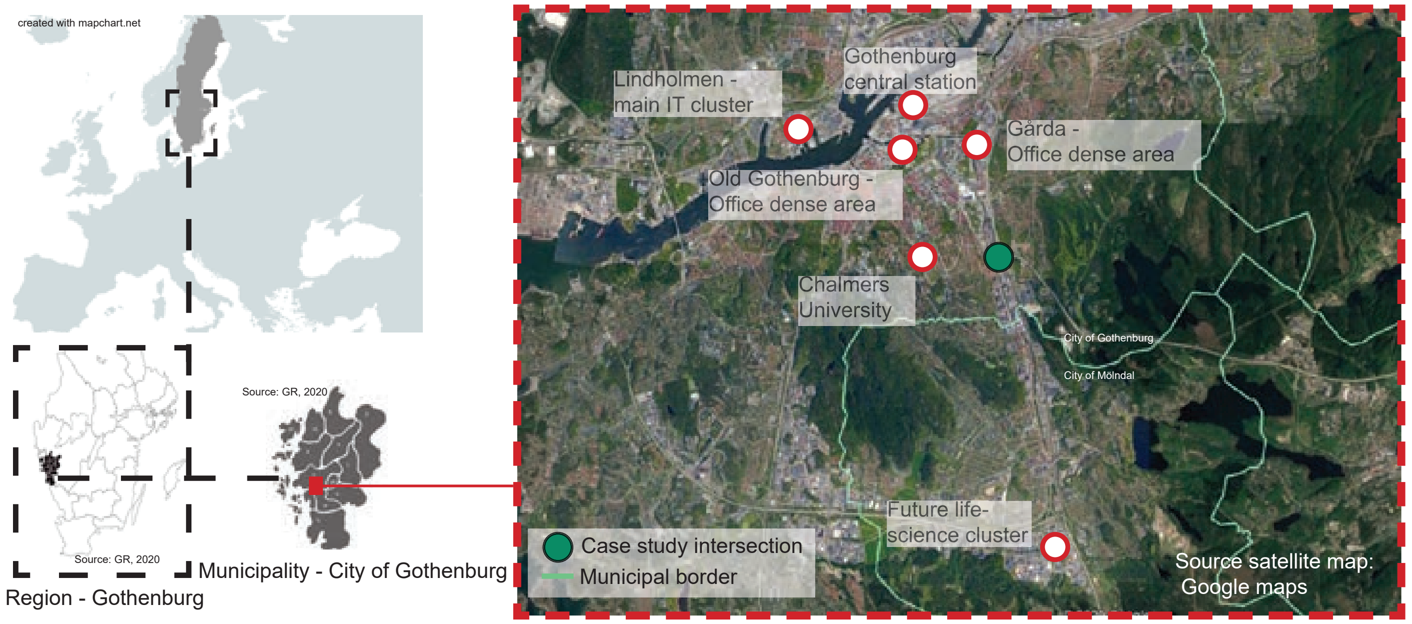
Picture of the case study intersection. It is a signalized intersection, containing tram tracks, bicycle paths, car roads and sidewalks, and is bounded by properties and the Stream of Mölndal. The intersection lies along Gothenburg's bicycle commuter network, and the area is undergoing a transition from industrial to mixed use development

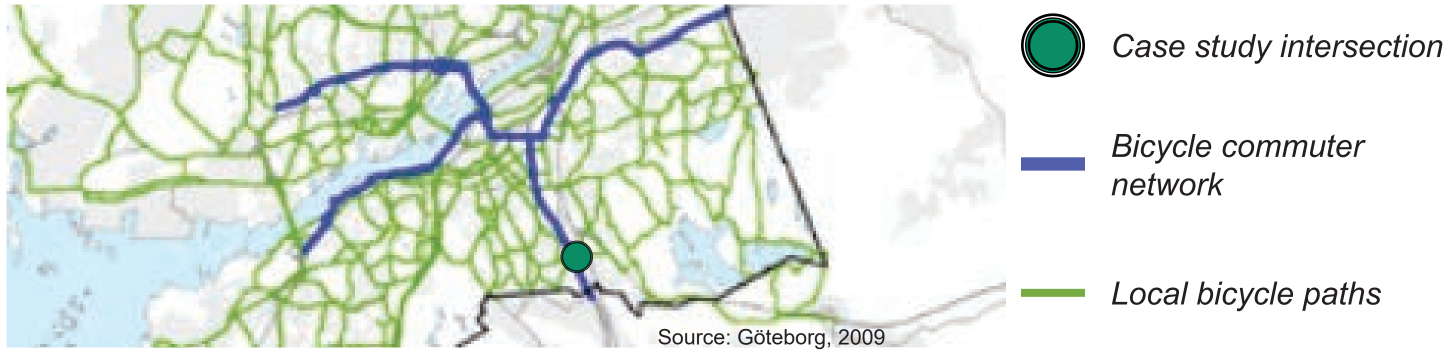
Where?

The case study intersection is a crossing between Mölndalsvägen, Fredrikdalsgatan and Sankt Sigfridsgatan, in the city of Gothenburg, Sweden. The coordinates are 57.683871 N, 12.000128 E.

The intersection is located along Gothenburg's bicycle commuter network, in an area that is going through a transition from industrial to mixed use development *(Göteborg & Mölndal, 2016).* The area lies in the municipality City of Gothenburg, but is also in proximity to the municipality of Mölndal.

City of Gothenburg is one of thirteen municipalities that form the Gothenburg region. The case study lies in the most accesible part of the region, the core, that is vital for the region's job creation and continuing growth potential (Göteborg, 2009).





The case study intersection lies along Gothenburg's commuter bicycle network. The chapter Case study background has further description of site characteristics

Why?

The case study intersection lies along the important commuter bicycle network, while also being a mixed mode intersection in an urban environment. The area is also undergoing a transition, affected by interests of different authorities, further increasing the complexity.

The intersection accommodates trams, vehicles, micro mobility and pedestrians, which makes it a mixed mode intersection. As there is a limited amount of space, which sets restrictions on the kind of solutions that can be done, and the intersection is located in an urban area, it fits the definition of an urban intersection. As this could be considered the most complicated and complex intersection along Mölndalsvägen, in some sense it sets the traffic conditions for the entire area. If this location would be improved, potential to do further improvements throughout the area would be created.

The area was going through a transition, for which a FÖP - Fördjupad översikts plan (Göteborg & Mölndal, 2016), translated to detailed comprehensive plan or master plan, was created. Planning documents, such as Gothenburg's comprehensive plan and the local FÖP suggests a transition from industrial to mixed use development in the area. But there are also roads of regional and national importance in the area, controlled by different transportation authorities (Göteborg, 2009). Further, the FÖP for the area was created by two different municipalities, Mölndal and Gothenburg (Göteborg & Mölndal, 2016), making the site even more complex.

Making a FÖP wasn't always the case in Gothenburg, but there are ambitions to do more of them (Göteborg, 2009). Gothenburg has planned many transitional areas, many of which lie close to major transportation corridors (Göteborg, 2009). As the case study area also lies in proximity to major transportation corridors, it could be seen as a representative example of the change of transportation solution that these kind of areas would need, and something that could be quite useful in the continuation of the development of the city.

The city of Gothenburg hadn't asked the author to redesign this intersection. It was rather considered that the goals set of various strategic documents of Gothenburg implied change (Göteborg, 2015a. Göteborg & Mölndal, 2016.Göteborg, 2009. *SKL, 2010. Göteborg, 2015b. Trafikverket, 2020b*) - that hadn't been realized nor planned for.

On a more theoretical note, the case study intersection could be seen as an example of an unbundling of different modes of traffic, where the main corridors for vehicle and micro mobility traffic had been separated. Mölndalsvägen, along which the intersection is located, used to be the main traffic corridor for vehicles going south, but has since 1980 been replaced by the motorway E6. At the time of writing, Mölndalsvägen was still the main corridor for micro mobility, but not vehicles, how should this kind of road be designed?

Taking account of these aspects combined, it was considered that this site was representative of urban intersections that have gone through an unbundling of traffic. Solving this site could show the potential that these kind of roads have for other modes of travel than cars.

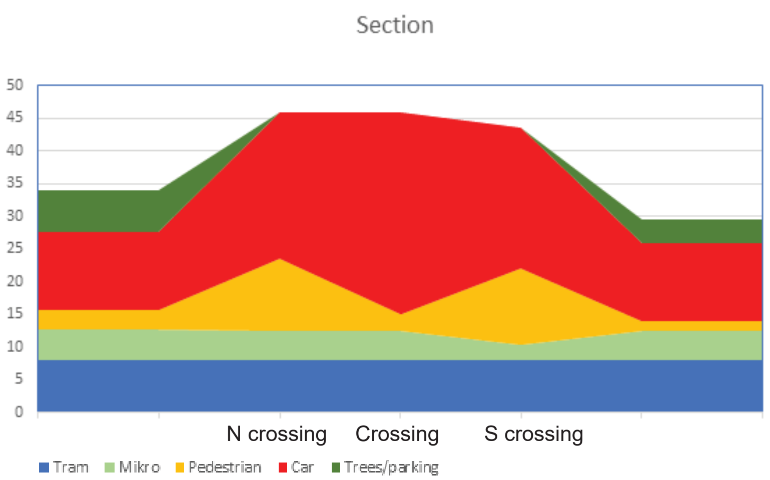
Problems to solve

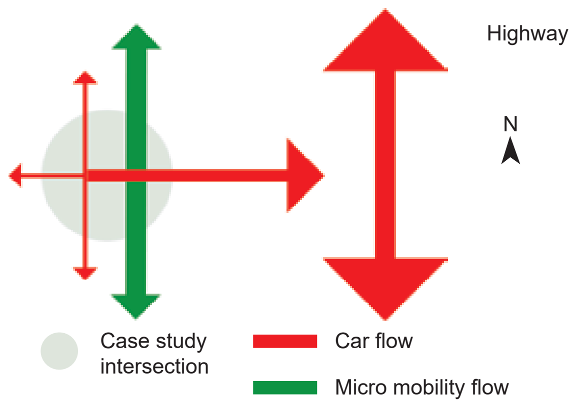
This page will show problems for micro mobility, and pedestrians, at site. The problems are defined from a local stand-point, but it will later also be explored how regional conditions contribute to them. The method for defining the problems has been observation.

Considerations for bicyclists at the intersection had been made, such as the separated bicycle path and painted red field, but a more thorough view also show several problems, such as waiting space

Observed problems:

- Long waiting times, especially for main flow of micro mobility
- Unclear flow patterns for micro mobility
- Lack of space for micro mobility, both before intersection, but also in refuge islands
- Uneven surfaces

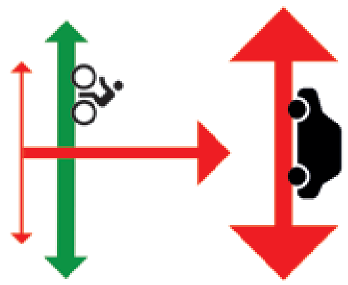




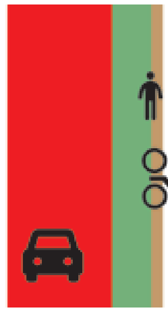
Width of the road Mölndalsvägen for different modes of transport before and after the crossing. The road got wider in the crossing, to provide space while waiting for signals, but more so for cars

Main flows of cars and bicycles. While bicycles want to go north, the biggest vehicle flow turns east, across the bicycle path, to the highway. The signals were designed for the red car flow, which can explain why they seemed "unfair" to the green bicycle flow

These problems can be grouped into in three main categories; flow, space and surfaces, which could be solved at different scales, while still being intertwined.
The flow pattern depends on the flows that go into the intersection, and the priority within the flows (Hyden, 2008). The amount of space given depends on the property that has been allocated for it, while the division of space is based on the flow pattern and priority, which set the need for the amount of lanes and need for refuge islands (Hyden, 2008). Surfaces can later be placed on the different allotted spaces (Hyden, 2008).



a)



b)

c)

The problems can be grouped in three main categories:

a) Flow - the flow pattern that the signals create was unfavorable towards micro mobility, as it was optimized to get vehicles to their primary road, the highway. Since it was the commuter bicycle network that passed through the case study intersection, the waiting times that the prioritization of flow created was seen as highly problematic. It was not uncommon to have 45s -60s ≤ waiting time for micro mobility.
b) Lack of space - there was not enough space in the intersection for micro mobility, especially as it was shared with pedestrians
c) Surfaces - the surfaces in the intersection, and the roads leading to it, weren't always as even as would have been desired for micro mobility

The case study design offered a solution to the flow and space problems, with the assumption that micro mobility is prioritized in the intersection. Surfaces need a certain amount of space, for which dimensions were suggested, but are later dependent on maintenance. The case study, and the report itself, did not investigate maintenance or construction principles in - depth.

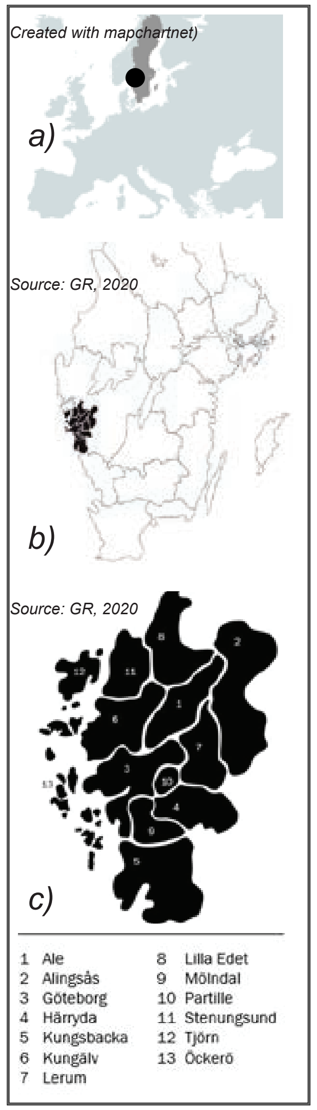
Since flow was affected by the roads leading to the intersection, which are regional factors, it was allowed to zoom out to other scales and do changes necessary to make micro mobility prioritized. These suggested changes, presented in the case study chapter, formed the basis for the strategic document feedback, which answered the research question

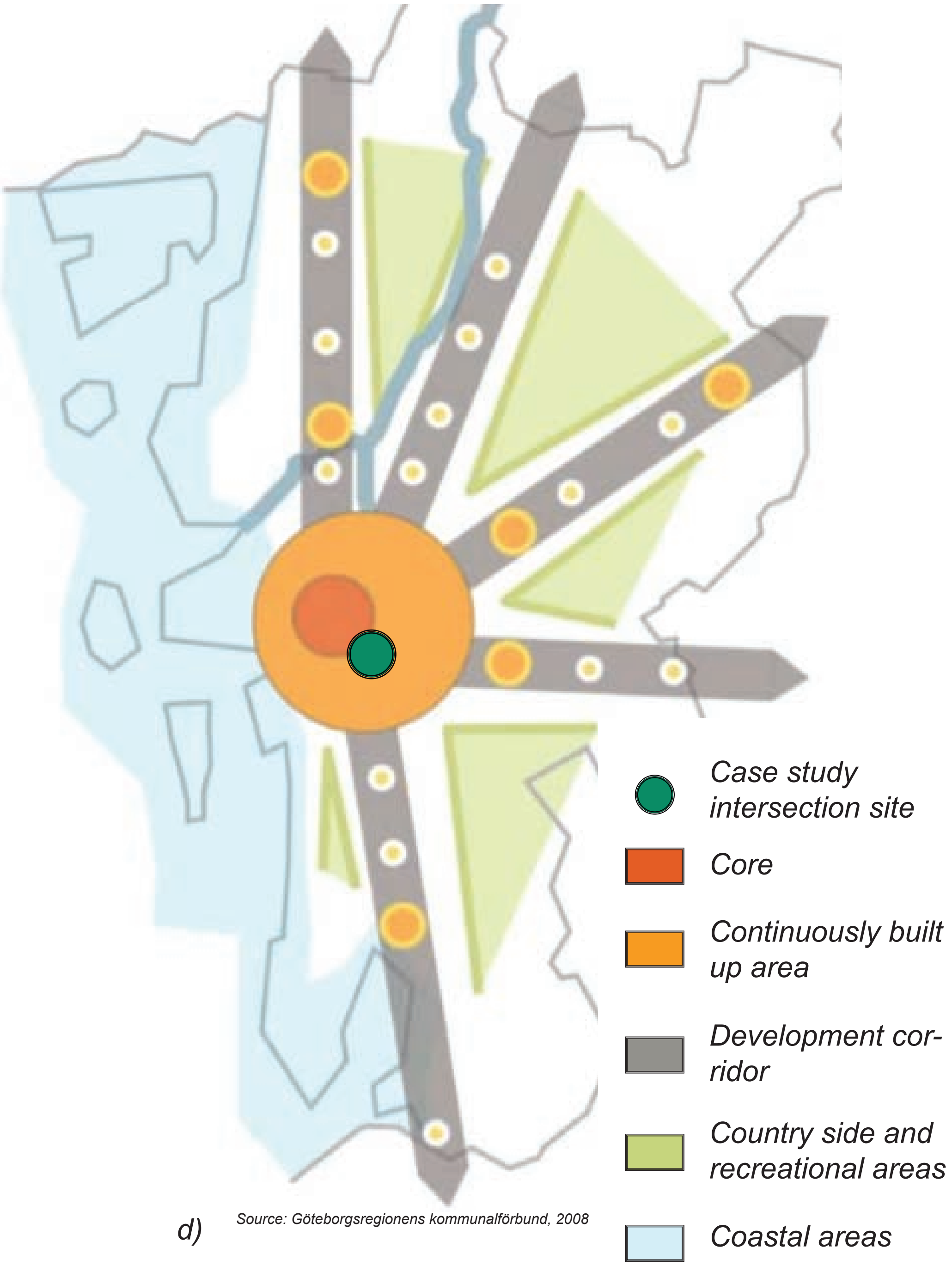
"What can be done to improve conditions for micro mobility in mixed mode intersections in strategic documents? "

Region

Regional structure plan

The Gothenburg region consists of 13 municipalities, and had as of 2019 just over 1 million inhabitants (SCB, 2020.02.20). The Gothenburg Region organization has composed a document formulating strategies and goals (*Göteborgsregionens kommunalförbund, 2013*) and a structure plan (*Göteborgsregionens kommunalförbund, 2008*). Their considerations to traffic and urban planning will be presented next.





d)

a) Gothenburg regions location in Europe (created with mapchart.net)
b) Gothenburg regions location in Sweden
c) 13 municipalities of Gothenburg region
d) Gothenburg Regions structure plan (Göteborgsregionens kommunalförbund, 2008)

Region - Goals

The goal is to create “The good life” in the Gothenburg region. A strong industry and sustainable growth that provides continued well - being, the good life, for everyone *(Göteborgsregionens kommunalförbund, 2013).*

Region - Strategies

“The good life” will be developed through the following strategies *(Göteborgsregionens kommunalförbund, 2013)*:

- Stimulating a continuing population growth and taking advantage of the benefits that a larger region can create
- Strengthening the qualities that make people want to live in and visit the region
- Creating a strong and sustainable regional structure that builds on the areas opportunities
- Developing a sustainable transportation system with attractive public transport

The population increase should be at least 10 000 inhabitants/year in the region, for which strategies to attract and retain people are used. Urban environments are designed to offer good living and attractive meeting places. The structure should follow the structure map, with a strong regional core, Gothenburg, and clear development strips with several smaller centers in between. Development should be concentrated to the core, the local centers and the development strips to ensure that energy efficient structures are created *(Göteborgsregionens kommunalförbund, 2013).*

By 2030, the core will gain 45 000 inhabitants and 60 000 jobs by the year 2030, while the rest of the region will gain 135 000 inhabitants and 50 000 jobs *(Göteborgsregionens kommunalförbund, 2013).*

The regional transport corridors should have good capacity, and support the regional structure. 40% of trips should be done by public transport by the year 2025. The transport system overall should support an increase in the size of the region, so that more municipalities can become part of the region. An integrated transport strategy for the region should be created to address this *(Göteborgsregionens kommunalförbund, 2013).*

Region - Structure

A document that describes the comprehensive structure of the region has been made, which the different municipalities have agreed to follow *(Göteborgsregionens kommunalförbund, 2008)*. The structure map is shown on page 28 - to the left, and its legend will be described next:

The core consists of the central parts of Gothenburg, and is the engine of the region. The core has high accessibility from the region, and has a special function as a meeting place. Higher education institutions are placed here, and there is a big variety commercially *(Göteborgsregionens kommunalförbund, 2008)*

The continuously built up area can gain from infill development to increase access to services, and preferably this development is located close to public transport nodes. Surrounding nature can also be saved if development is placed on “abandoned” land *(Göteborgsregionens kommunalförbund, 2008)*.

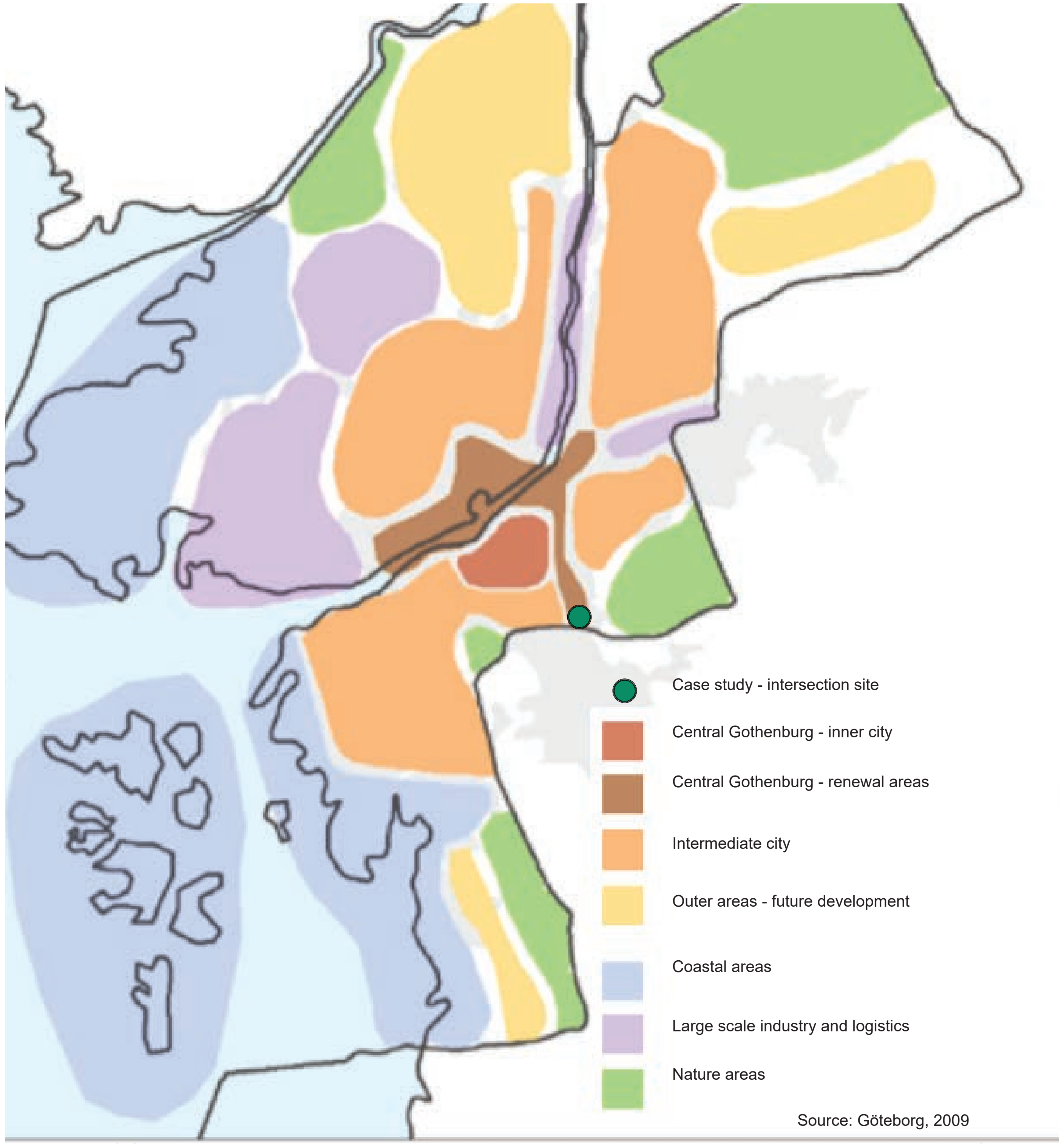
In the development corridor housing should be built with access to public transport. If it’s possible to bike/walk to stations they can be built within 1km of the major stations. Labor intensive work places or services that have a large catchment area are also placed in proximity to main stations *(Göteborgsregionens kommunalförbund, 2008)*.

The coastal areas should get better public transport access, while the Country side and recreational areas shouldn’t be over exploited *(Göteborgsregionens kommunalförbund, 2008)*.

City

Comprehensive plan Gothenburg

The city of Gothenburg is a municipality, which in Sweden is required to have an up to date comprehensive plan. The comprehensive plan is supposed to show long term visions of land usage (Göteborg, 2009). Both the 2009 comprehensive plan, which the following presented transport strategy is based on, and the upcoming, work in progress, comprehensive plan will be presented here.



Source: Göteborg, 2009

The city of Gothenburg comprehensive plan calls the area the case study intersection is in for 'central Gothenburg - renewal areas' . The plan says that this kind of area should, among other factors, have high regional accessibility through public transport, prioritize public transport, bicyclists and pedestrians, and have an overall high density (Göteborg, 2009). Note that the case study is close to the border of another municipality, Mölndal

The 2009 comprehensive plan was based on the regional plan, and mentions shared goals, such as enabling 'the good life' and having high accessibility to the region. The projected growth is said to be concentrated in the core and transportation nodes, in order to enable less resource intensive travel. It is mentioned that streets and places should enable meetings, and that the spaces should be planned for the way people move on foot and bike. Overall bicycle infrastructure, for different scales, is described needed and a commuting bicycle network is said to contain the most important paths. It is also mentioned that the harbor of Gothenburg is of regional importance, and that it should have continued regional accessibility (Göteborg, 2009). Next comes a description of the different area types.

Central Gothenburg - inner city is said to be the region's and the city's main destination. It should be developed and strengthened as a place for shopping, work, living and leisure. Good regional accessibility should be created, and pedestrians, bicyclists and public transport should be prioritized. The built form should be characterized by high densities and mixed use.

Central Gothenburg - renewal areas should be built with mix - use development, and house much of the expected population increase. Good regional accessibility should be created, and pedestrians, bicyclists and public transport should be prioritized.

Intermediate city contains various kinds of built up areas in the municipality. Dense development along public transport nodes should be striven for, and in appropriate locations housing and non - disturbing commercial spaces should be mixed. The opportunities to bike and walk within the intermediate city, and to Central Gothenburg should be improved.

Outer areas - future development is a land reserve that can be used in the long run, but only after big investment in public transport and other infrastructure has been made.

Large scale industry and logistics should have high accessibility through roads and railway. No housing should be placed here.

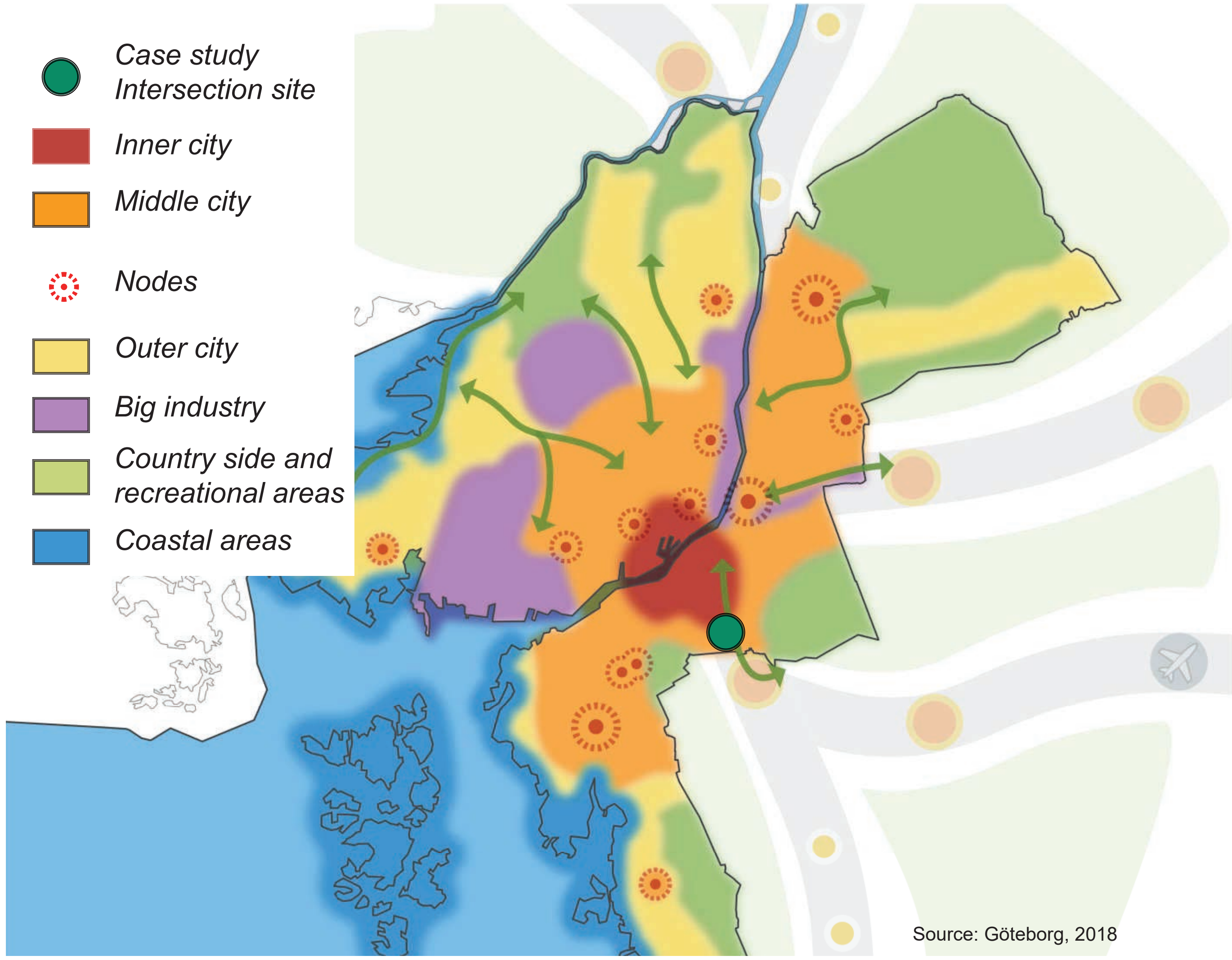
Coastal areas has a large focus on recreational areas, development that occurs here should be in connection to public transport.

The nature areas consist of countryside and recreational areas.

A new comprehensive plan is also in the process, which Gothenburg's traffic strategy has not yet been related to. The new comprehensive plan has goals to create a structure that connects different areas and its inhabitants, and that it should be easy to commute between work, home, recreation and leisure (Göteborg, 2018). The city's mixed population and diverse business community creates and receives impulses from the whole world (Göteborg, 2018).

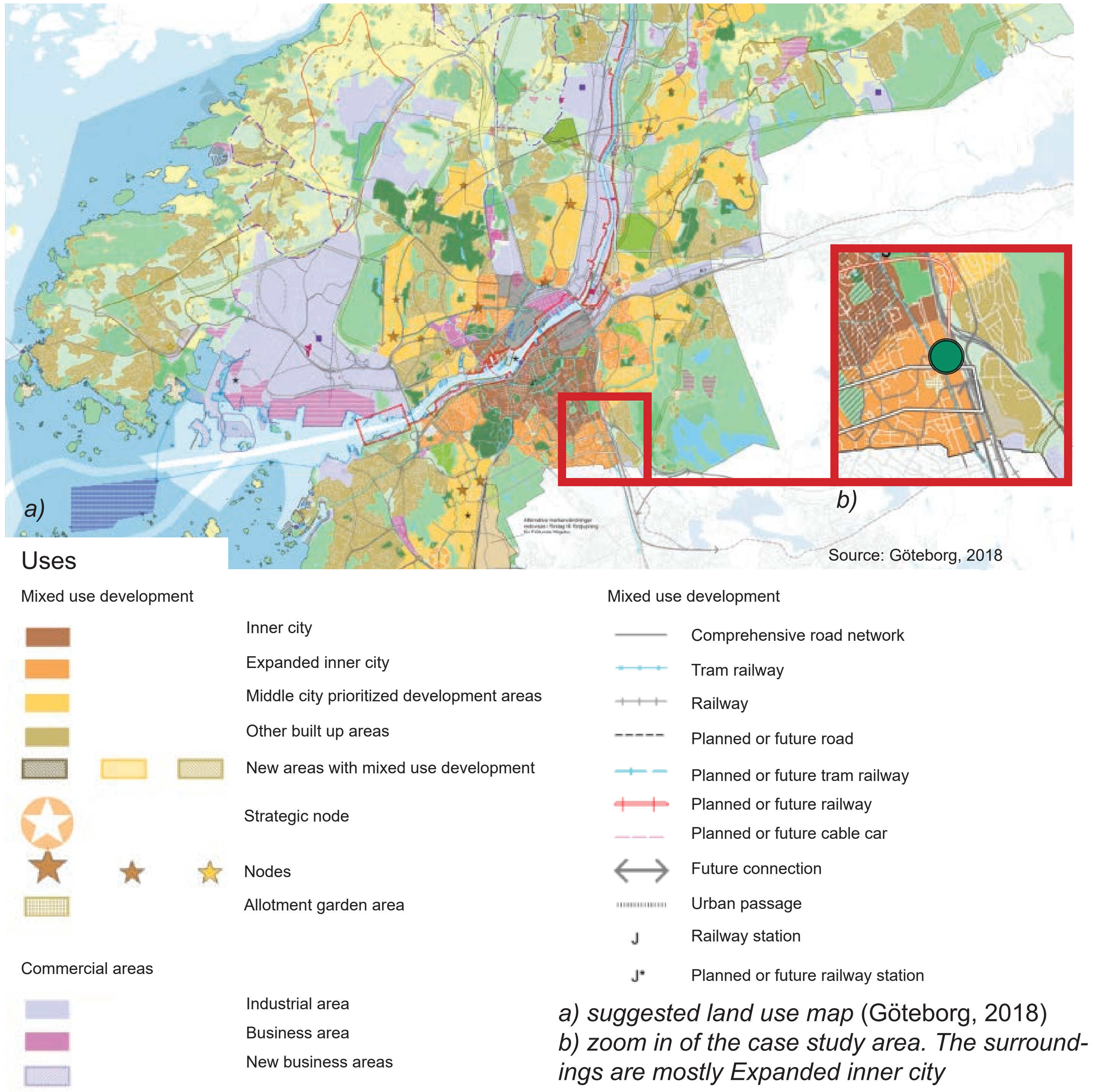
The plan says Gothenburg works as an engine for the entire region, and that a strong core is a condition for the entire region to continue developing. Especially in the central parts of Gothenburg, there is a challenge to create regional accessibility while protecting local qualities of life (Göteborg, 2018). A dense city creates conditions for a space effective and high capacity public transport system, which hasn't been possible in today's comparably sparsely populated Gothenburg (Göteborg, 2018). Regionally, the train should work as the backbone for the commuter journeys into Gothenburg (Göteborg, 2018). With today's system of investments in infrastructure there is a risk for a significant delay to meet demand (Göteborg, 2018).

Strategies include developing main nodes, as Gothenburg should be going towards a more multiple core structure, where services, culture and workplaces should be placed in more locations than today's center. These main nodes have the potential to receive a higher density of people, housing and work places (Göteborg, 2018). The higher densities can be used to increase qualities and make more use of resources, but it requires understanding and knowledge of how everyday life gets affected (Göteborg, 2018).



New strategy map. The zones have fairly similar explanations as the old one, but an addition are the nodes

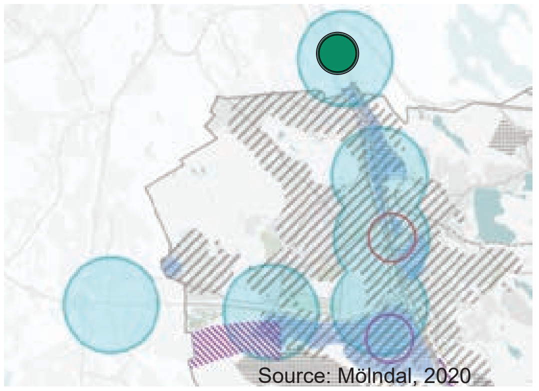
The case study area is still in the Expanded inner city, but its border has been shifted outwards , shown on the map on the next page. The expanded inner city and nodes have a common explanation, where it says that these areas are attractive for office development, and that the direction of these areas is to have an increase of housing and offices to provide an increased clientele for local businesses. This area is close to the inner city, and has many similar characteristics with it (Göteborg, 2018). As in the previous plan, it is says that infrastructure investment should go towards public transport, bicyclist and pedestrians (Göteborg, 2018).



a) suggested land use map (Göteborg, 2018)
b) zoom in of the case study area. The surroundings are mostly Expanded inner city

Comprehensive plan Mölndal

The municipality of Mölndal lies south of Gothenburg, is part of the Gothenburg region, and took part in the development of the detailed comprehensive plan for the case study area, presented on page 42 - 45. Presented below is a map from Mölndal's upcoming comprehensive plan:

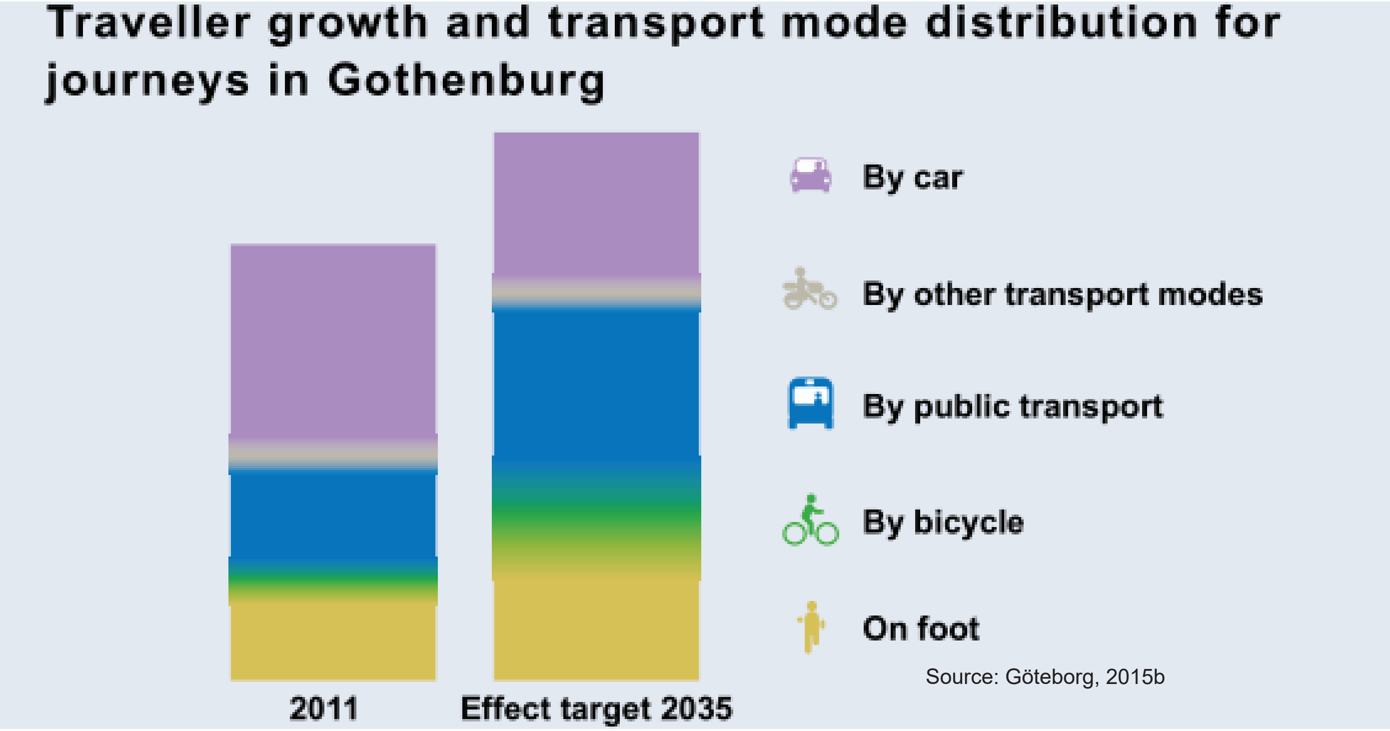


Case study Intersection site
Housing development
Metro bus stations
Densification areas

Placement of metro bus stations, traffic concept that will be described on upcoming pages, and densification areas. Overall the land use types in Mölndal are fairly similar to those of Gothenburg

Transport strategy

The transport strategy of Gothenburg, *Gothenburg 2035 transport strategy for a close-knit city*, is guiding how the transportation network should develop to handle the challenges that the city is facing the upcoming 20 years (Göteborg, 2015b). The strategy elaborates the transport elements in Gothenburg's comprehensive plan, and its underlying premise is:
"planning should be target-led rather than prognosis-based" (Göteborg, 2015b, p.12).



Modal share, percentage of journeys of each mode of transport, targets in Gothenburg's transport strategy plan. While public transport has the biggest growth target, bicycle usage is also targeted to have a large increase, especially percentage wise (Göteborg, 2015b)

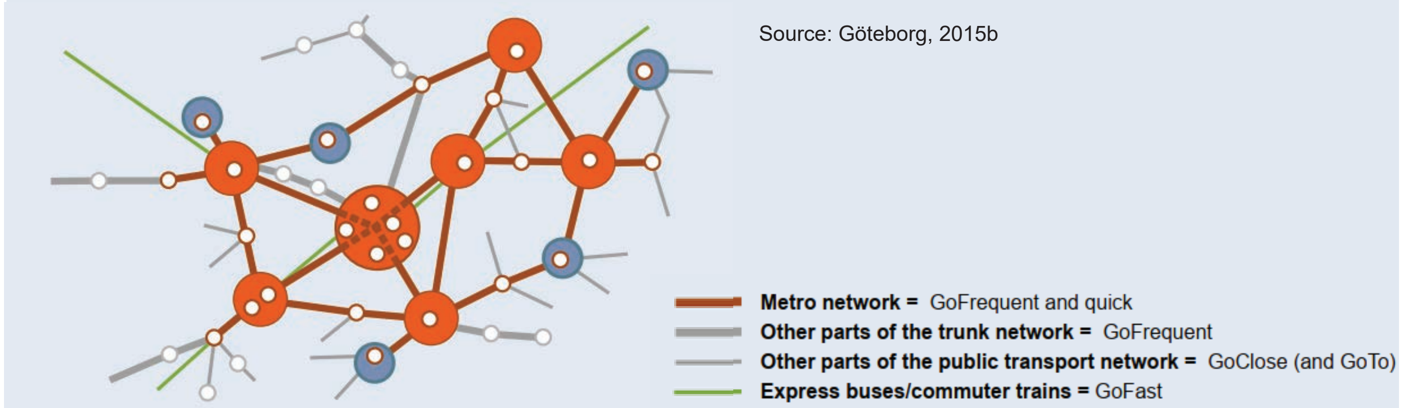
The document says that the inhabitants of Gothenburg should be able, and want, to use walking, biking and public transport as their main mode of transport. Three focus areas are brought up; travel, urban space and transport of goods. *Travel* encompasses that the regional center should be easily accessible for all modes of transport (Göteborg, 2015b), while *urban space* targets how to contribute to:

"more attractive city environments where people want to live, work, shop, study and meet "(Göteborg, 2015b, p.5).

The strategy assumes that the amount of journeys in the city will increase with time, as the population grows. This should be in journeys that aren't made by car, e.g. by bicycle, walk or public transport (Göteborg, 2015b). Further, there is an aim is to create a city structure that is based on key cores/nodes that are interconnected:

"A structure based on the city's cores makes it possible to offer rapid,reliable, high-capacity public transport and a high-quality cycling network that is easily accessible from anywhere in the city. At the same time, the structure supports the development of designated nodes into areas of a dense, mixed-use character" (Göteborg, 2015b, p.6).

Urban environments should be designed for pedestrians, and space should be distributed to create conditions for attractive, lively and safe environments. A balance between pedestrians, bicyclists and public transport has to be created where they meet, and it will differ depending on location (Göteborg, 2015b).



Node based structure that the traffic strategy proposes (Göteborg, 2015b)

The strategy outlines that :

"cycling is a separate transport mode that requires its own structure" (Göteborg, 2015b, p.33) and that "bicycles and pedestrians should be separated as well" (Göteborg, 2015b, p.33).

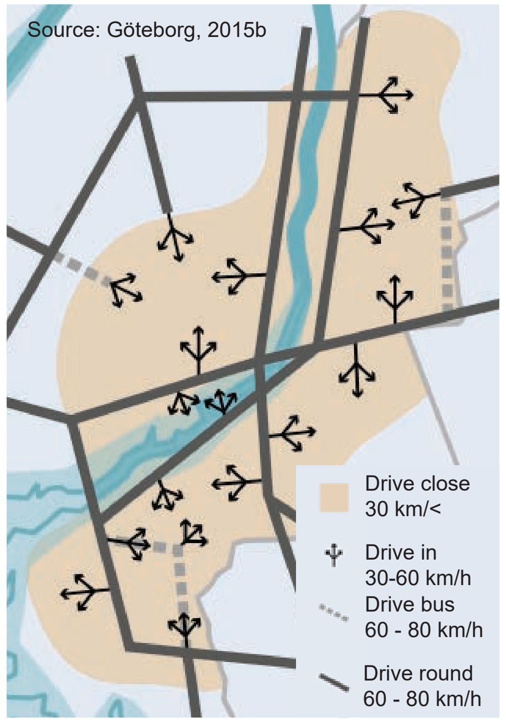
In areas where bicycle and motor vehicle traffic have to be mixed or intersect, the strategy says bicycle traffic is given priority and speeds adapted to bicycle speeds (Göteborg, 2015b).
It further takes note that it is important that bicycle travel is perceived as simple, safe and quick, and that

"a commuter bicycle network is therefore needed to connect the city's cores and key destinations. This commuter bicycle network will offer very good ease of passage, with few or no conflicts with other road users*"* (Göteborg, 2015b, p.33)

The traffic strategy also points out that:

"the needs and conditions of cyclists will always be considered in city renewal, density measures, conversions and new construction" (Göteborg, 2015b, p.33).

A bicycle plan, which will be described on upcoming pages, was based on this transport strategy.



Car and bus speed principles in the city (Göteborg, 2015b)

Regarding cars, the strategy says that:

"The car will continue to be an important means of transport in an easily accessible regional center, even if not the most common" (Göteborg, 2015b, P.38)

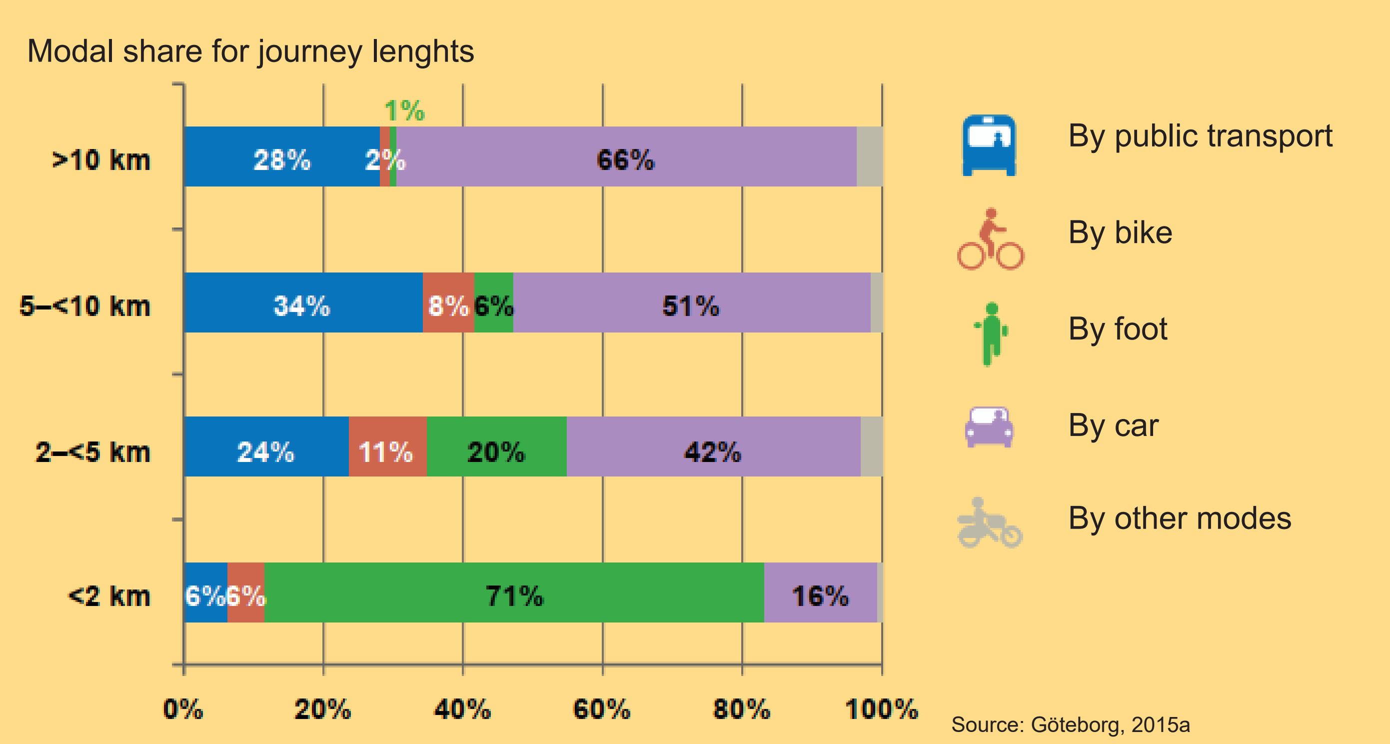
"There are many areas where it isn't economically viable to offer good public transport, or where distances are too great to cycle or walk, or where the car provides functions the alternatives do not. The car as transport mode is necessary for many service industries and for those with special needs, regardless of where in the city they are" (Göteborg, 2015b, P.40)

"margin for larger road investments will be small. This means that the continued ease of passage of car traffic is based on the entire increase in travel, at a minimum occurring in other transport modes such as walking, cycling and public transport" (Göteborg, 2015b, P.38).

For transport of goods there is a separate strategy which emphasizes high accessibility (Göteborg, 2015b).

Bicycle plan

The bicycle plan of Gothenburg is a concretisation of the transport strategy. It describes how Gothenburg should become an attractive city for bicycling by the year 2025, with the goal of increasing bicycle journeys three fold, from the year 2015. To achieve this, the role of the bicycle in the transportation system needs to be strengthened, and to a higher degree be considered a mode of transport of its own. The plan covers aspects from network development to maintenance (Göteborg, 2015a).



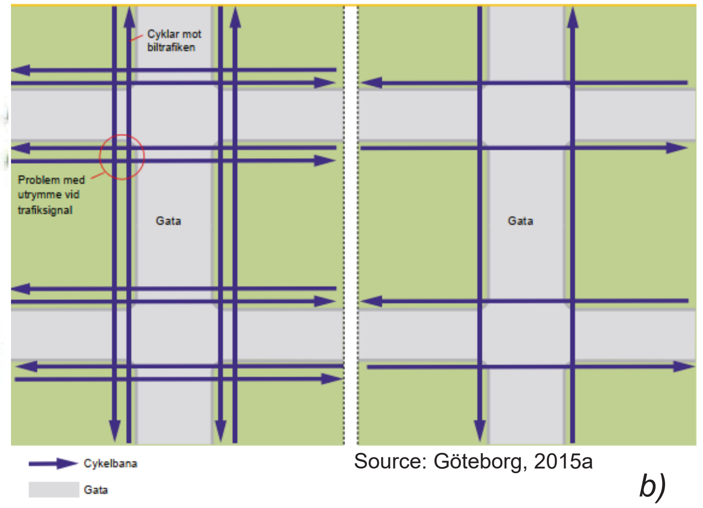
Modal share at different distances. There lies great potential in bicycle traffic for journeys <10km. If 10% of car trips <10km would be done by bicycle, the modal share of bicycling would increase 50% (Göteborg, 2015a)

The bicycle plan points out that bicycles need an infrastructure of their own, with a clearer separation from pedestrians. The goal is to make it fast, simple and safe to commute by bicycle, for which a commuting network should be developed. The measurements and criteria for the commuting network would not only work to ensure journeys at higher average speeds, but also make it easier to orient oneself and increase the capacity of the whole network (Göteborg, 2015a).

The plan emphasizes the benefits of one way bicycle paths on each side of the road, especially in the inner city. One way paths are said to create better conditions in order to both solve intersections and provide adequate dimensions for bicycles. There are however cases where two way paths are better, such as stretches that have few turns (Göteborg, 2015a).

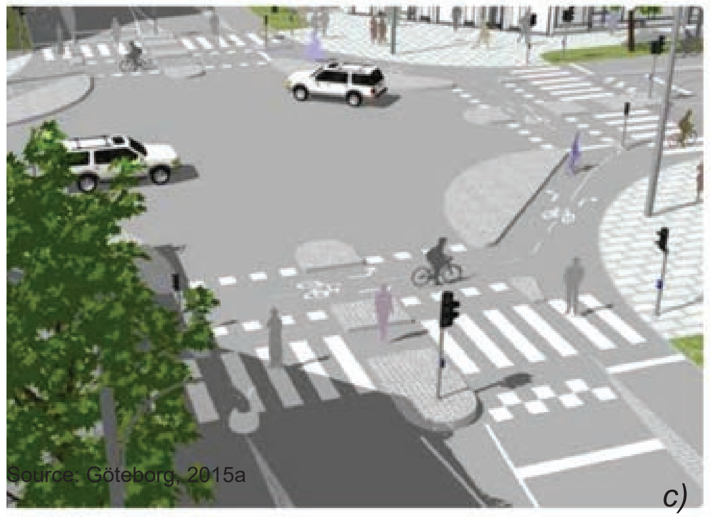
A clear separation from pedestrians is striven for, and the plan takes note of many different aspects, through different scales, to take in consideration (Göteborg, 2015a). Different recommended dimensions from the plan will be described on page 39.

a)



b)

a) Principle of separation of bicyclists and pedestrians, which works for both one way and two way paths (Göteborg, 2015a)
b) Principle of the simplified effects of one way streets, which the plan sees as preferential in the intercity (Göteborg, 2015a)

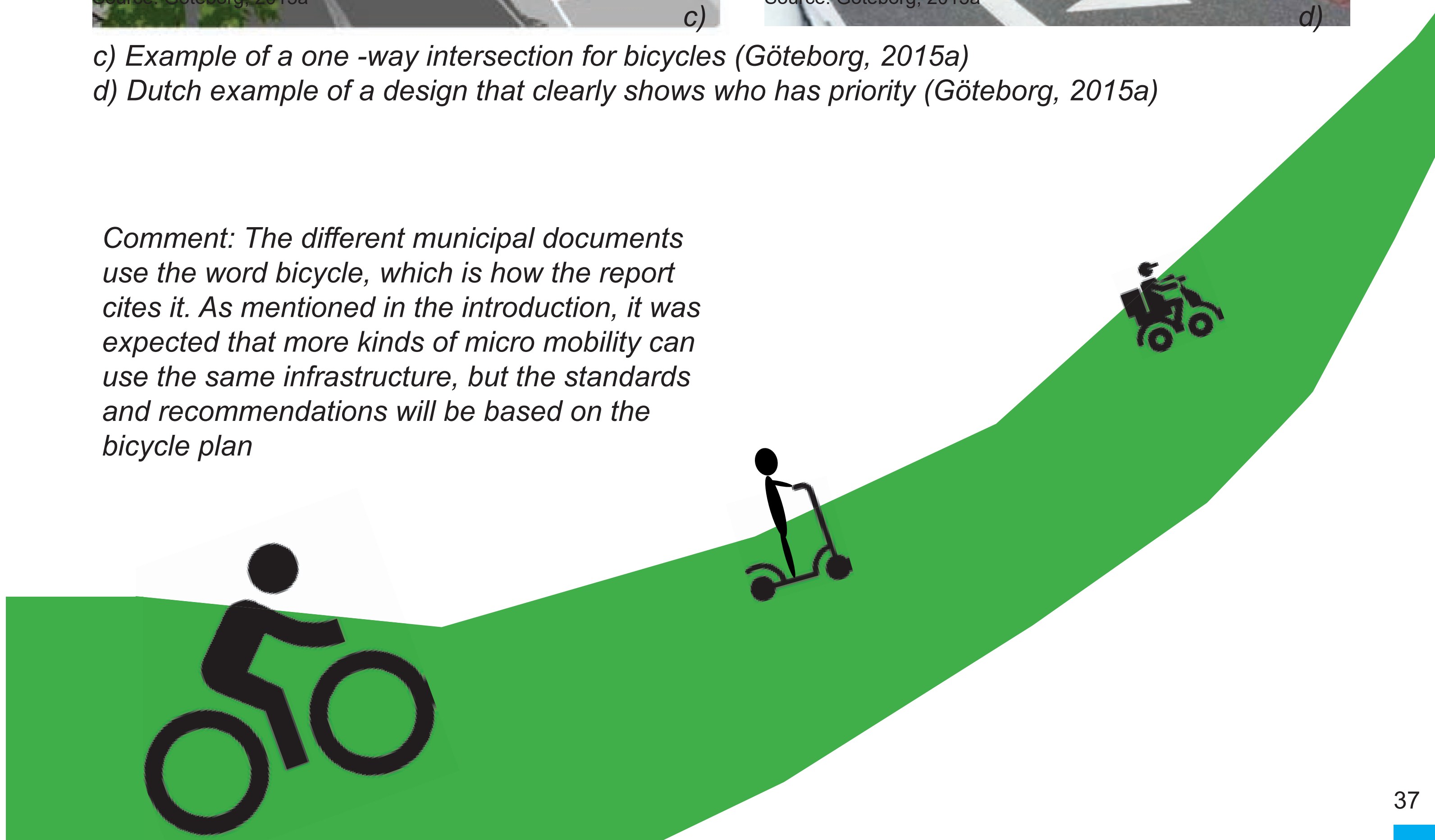


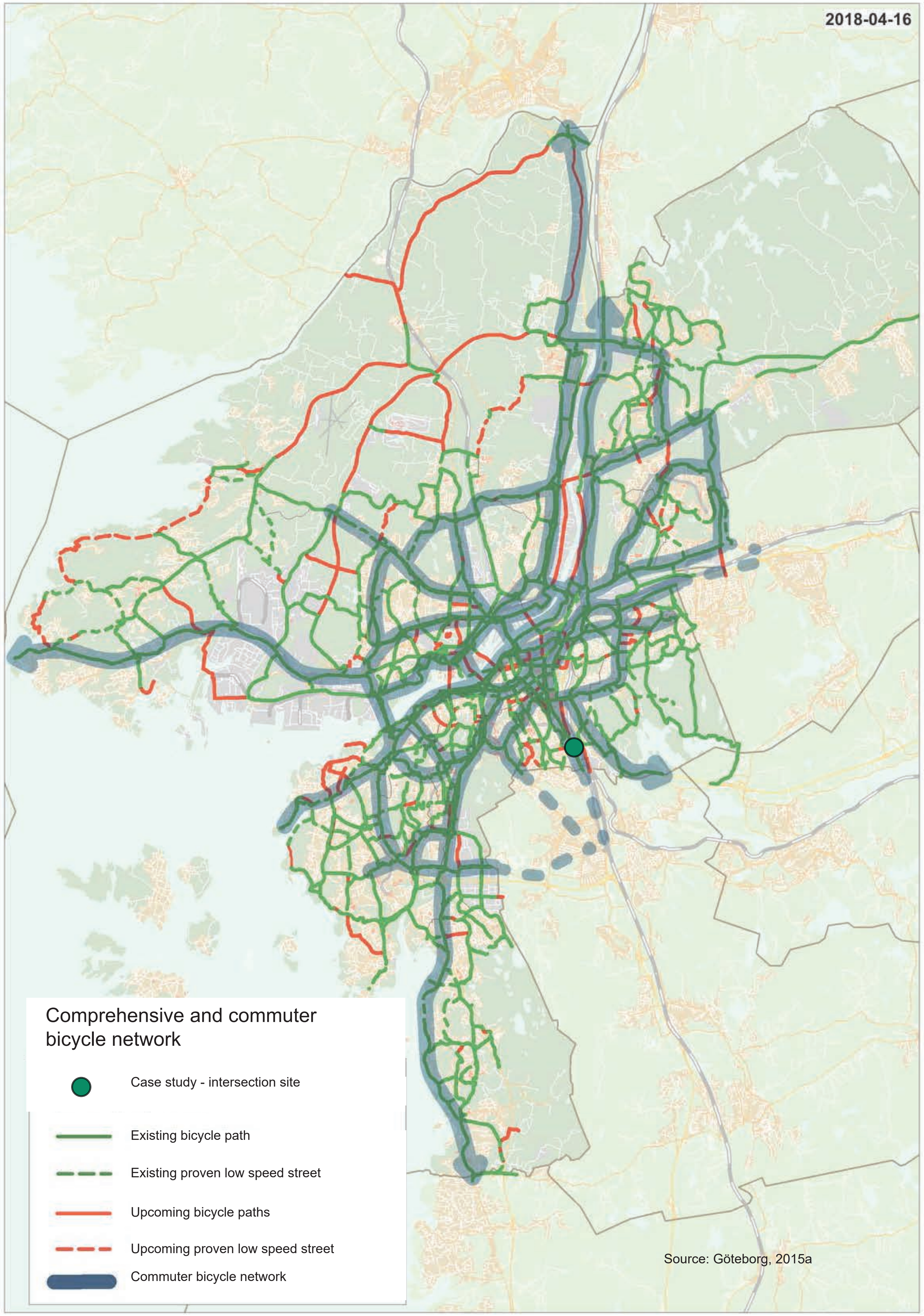
c)

d)

c) Example of a one -way intersection for bicycles (Göteborg, 2015a)
d) Dutch example of a design that clearly shows who has priority (Göteborg, 2015a)

Comment: The different municipal documents use the word bicycle, which is how the report cites it. As mentioned in the introduction, it was expected that more kinds of micro mobility can use the same infrastructure, but the standards and recommendations will be based on the bicycle plan





Dimensions

On this page required or recommended dimensions from different sources are listed. GCM is a Swedish national support document for pedestrians and bicyclists (SKL, 2010), VGU are Swedish national demands and recommendations (Trafikverket, 2020b), the Gothenburg standard is from the city's 'teknisk handbok' which contains the different standards that are used in the projection and construction phase in the city (Göteborg, 2019), and Crow Fietsbeerad is a Dutch research center for bicycling policy (Crow, 2016). Crow was presented because Gothenburg's bicycle plan showed many examples from the Netherlands as inspirations for good solutions (Göteborg, 2015a) .

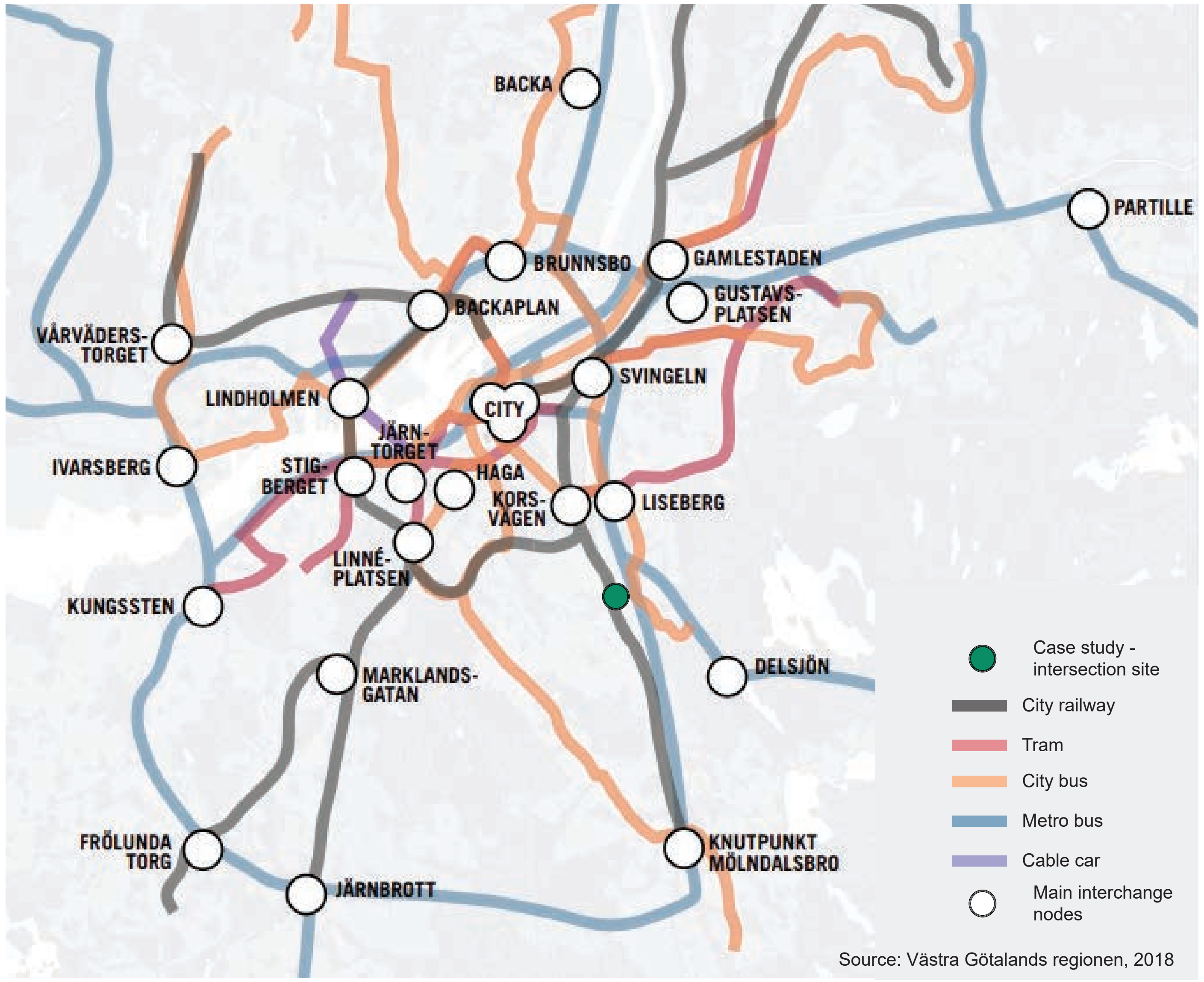
Source Dimension (m)	Gothenburg bicycle plan[1]	GCM[2]	VGU krav[3]	Gothenburg standard[4]	Crow[5]
Bicycle commuter path	3,0[a] . 2,4[b]. 2,0[c]	n/a	n/a	3,0[f] . 2,4[b]. 2,0[c]	3
Bicycle commuter path[bd]	4,8[a] . 3,6[b]. 3,0[c]	n/a	n/a	4,8[f] . 3,6[b]. 3,0[c]	4
Bicycle path	2,4[a] . 2,0[b]. 1,6[c]	2,0[d]. 1,6[e]	1,2	2,4[a] . 2,0[b]. 1,6[c]	3,5-4,0[n]. 2,5-3,0[g]. 2,0[k i].
Bicycle path[bd]	4,8[a] . 3,6[b]. 2,4[c]	2,5[d]. 2,25[e]	1,8	4,8[a] . 3,6[b]. 2,4[c]	4,5[j]. 3,5-4,0[h]. 2,5-3,0[i]. 2,5[k]
Separation bicycle -pedestrian	different material[7 lv] 0,5<separation strip[7 hv]	~0,3	n/a	0,1[l] 0,25 - 0,3[hs] 0,5 - 1[hg]	0,5<
Separation bicycle path - vehicle (if parking allowed)	n/a	n/a	0,3 ≤ 0,8 ≤ [bd] (1≤)	0,5 ≤ (0,8 ≤)	0,35< (0,5)
Protection strip bicycles[6]	n/a	n/a	0,6	0,5	0,5
Bicycle + pedestrian path	n/a	4[d]. 3[e]	<2,5	4,8. 3,0[lv]	2,4<
pedestrian path	n/a		<2	4[hv]. 2,5 - 3[mv]. 2[lv]	1<
Vehicle lane	n/a	n/a	3-4	3,5	n/a
Refuge island - slotting not allowed	n/a		<2	2	2,5<
Refuge island - slotting allowed	n/a	4<	n/a	n/a	?

1. Göteborg, 2015a. **2.** SKL, 2010. **3.** Trafikverket, 2020b. **4.** Göteborg, 2019 . **5.** Crow, 2016 **6.** Strip where no obstacles are allowed to be placed. **7.** Depending on pedestrian flow

a. 1500< bicyclists/max h. **b.** 501-1500 bicyclists/max h **c.** bicyclists/max h<500. **d.** 200< bicyclists/max h. **e.** bicyclists/max h<200. **f.** 1000< bicyclists/max h. **g.**150-750 bicyclists/max h **h.** 150-350 bicyclists/max h. **i.** 50-150 bicyclists/max h. **j.** 350< bicyclists/max h. **k.** 0-50 bicyclists/max h. **bd.** bi-directional. **l.** low standard, stone. **hs.** high standard, stone. **hg.** high standard, grass. **lv.** low volumes. **mv.** medium volumes. **hv.** high volumes. **n.** 750< bicyclists/max h.

Public transport

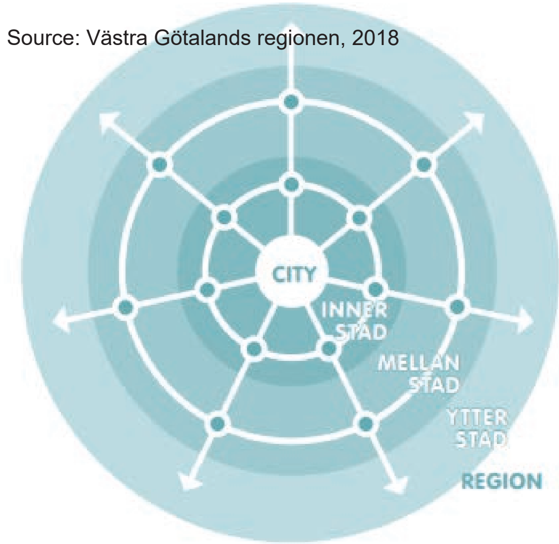
Målbild koll 2035 is a document that describes how public transport in the continuous urbanization of Gothenburg, Mölndal and Partille should develop until 2035, in order to attract and handle a substantial increase in users (Västra Götalands regionen, 2018). Quick connections, relieving central Gothenburg and clear traffic concepts with their own characteristics are the strategies to achieve this (Västra Götalands regionen, 2018).



Main public transport corridors and interchange nodes. The corridors contain different types of public transport, that each has its own characterstics (Västra Götalands regionen, 2018).

As seen in the map above, in proximity to the case study intersection a city railway, city bus and metro bus passes. The city railway will be a transformation of the current tram line, and will connect important nodes. It will have a big capacity, have its own space lanes, grade separate intersections and fewer stations than the current tram network *(Västra Götalands regionen, 2018).* The city bus will connect nodes, have its own lanes and have a similar function to today's trams. The metro bus will have fewer stops than the city bus, and only stop at the major nodes. It will have its own corridor mainly along highways *(Västra Götalands regionen, 2018).*

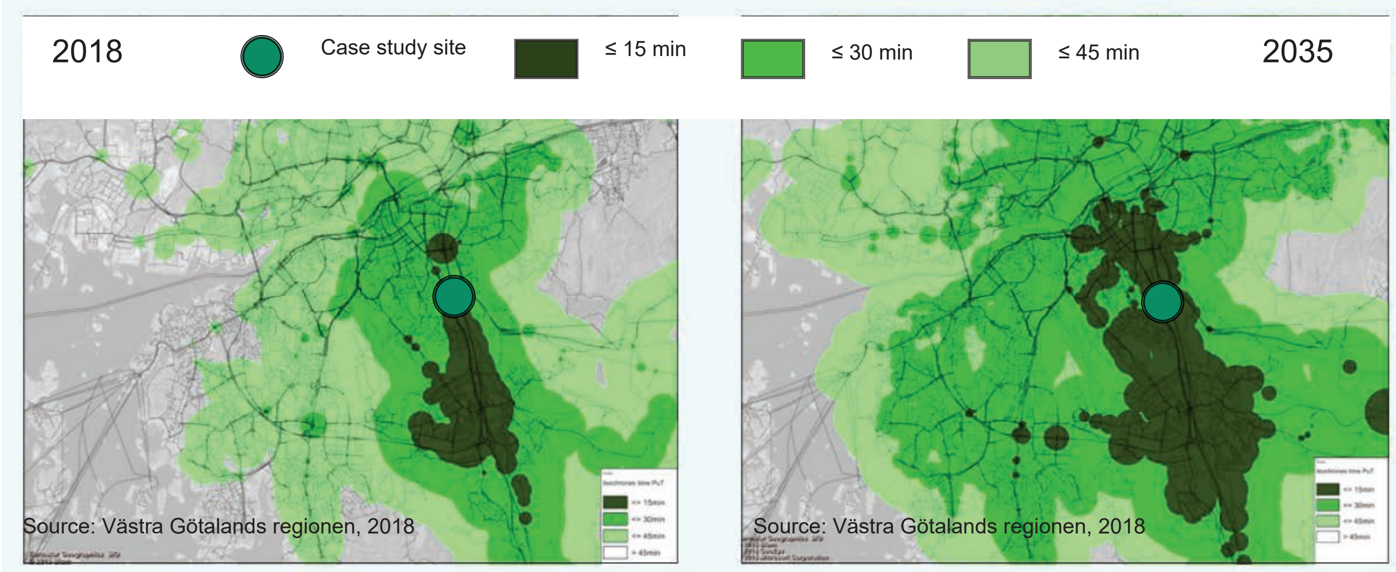
Since public transport creates big concentrations of people, it is also mentioned that it can strongly contribute to create lively urban life. Pedestrians should have priority around all nodes, and the accessibility for bicyclists should be high *(Västra Götalands regionen, 2018).*



a)

b)

a) Concept of traffic corridors and main nodes (Västra Götalands regionen, 2018)
b) Illustration of the metro bus, which will connect the nodes (Västra Götalands regionen, 2018)



Travel times 2018 and the targeted travel times 2035 for Mölndalsbro, which lies 3,5 km south of the case study intersection, based on the suggested improvements in the document

Region/city - logistics demand

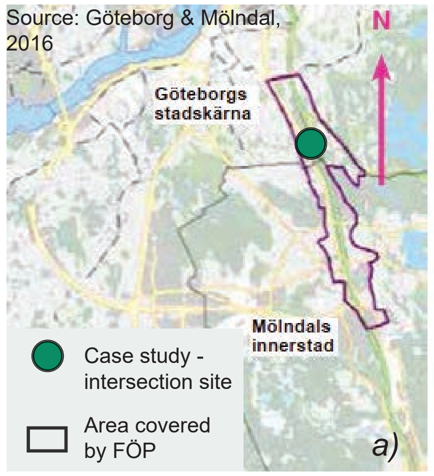
A report from Business region Göteborg (2018) said that Gothenburg is a very important location logistically in Scandinavia. Gothenburg has access to Scandinavia's biggest port and second largest airport, and the demand for industrial sites is expected to be large the upcoming years.

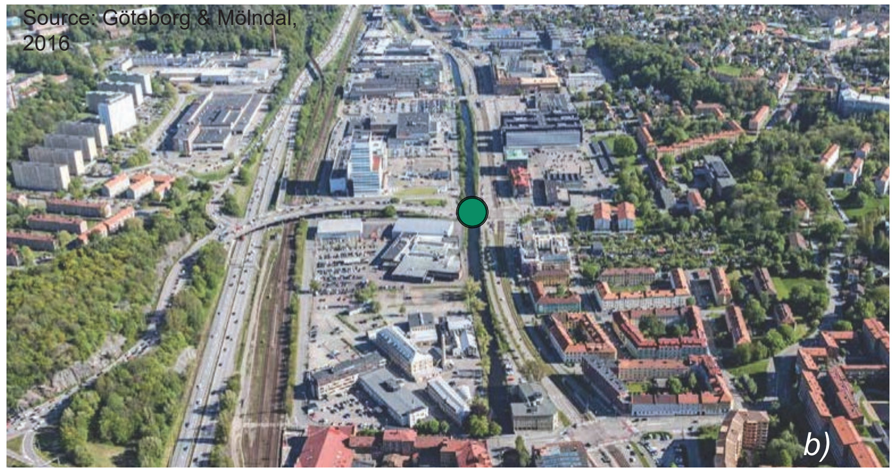
The supply of land should be viewed from a regional perspective, as there lies greater potential to find supply for land that way. However, the regional structure plan didn't take account of industrial land (Business region Göteborg, 2018).

Since large urban developments are expected to happen through conversion of industrial areas, it is expected to further increase demand for logistical sites. Since current plans don't take proper account of this, it could lead to development placed in locations further from the harbor. This would in turn lead to logistical traffic needing to travel longer distances (Business region Göteborg, 2018).

Area
Detailed comprehensive plan

A detailed comprehensive plan, or FÖP in Swedish, has been created for the valley of Mölndal, where the case study is located. As the valley is located in two different municipalities, Gothenburg and Mölndal, the detailed comprehensive plan is a joint collaboration between them to create common strategies. The plan covers strategies for traffic, green areas and cultural sites, but isn't enforced by law, meaning it acts more as recommendations for detailed plans (Göteborg & Mölndal, 2016), which is the next step in the Swedish planning process.





a) The area that the detailed comprehensive plan addresses (Göteborg & Mölndal, 2016)
b) The area is believed to be transforming from industrial to mix -used (Göteborg & Mölndal, 2016)

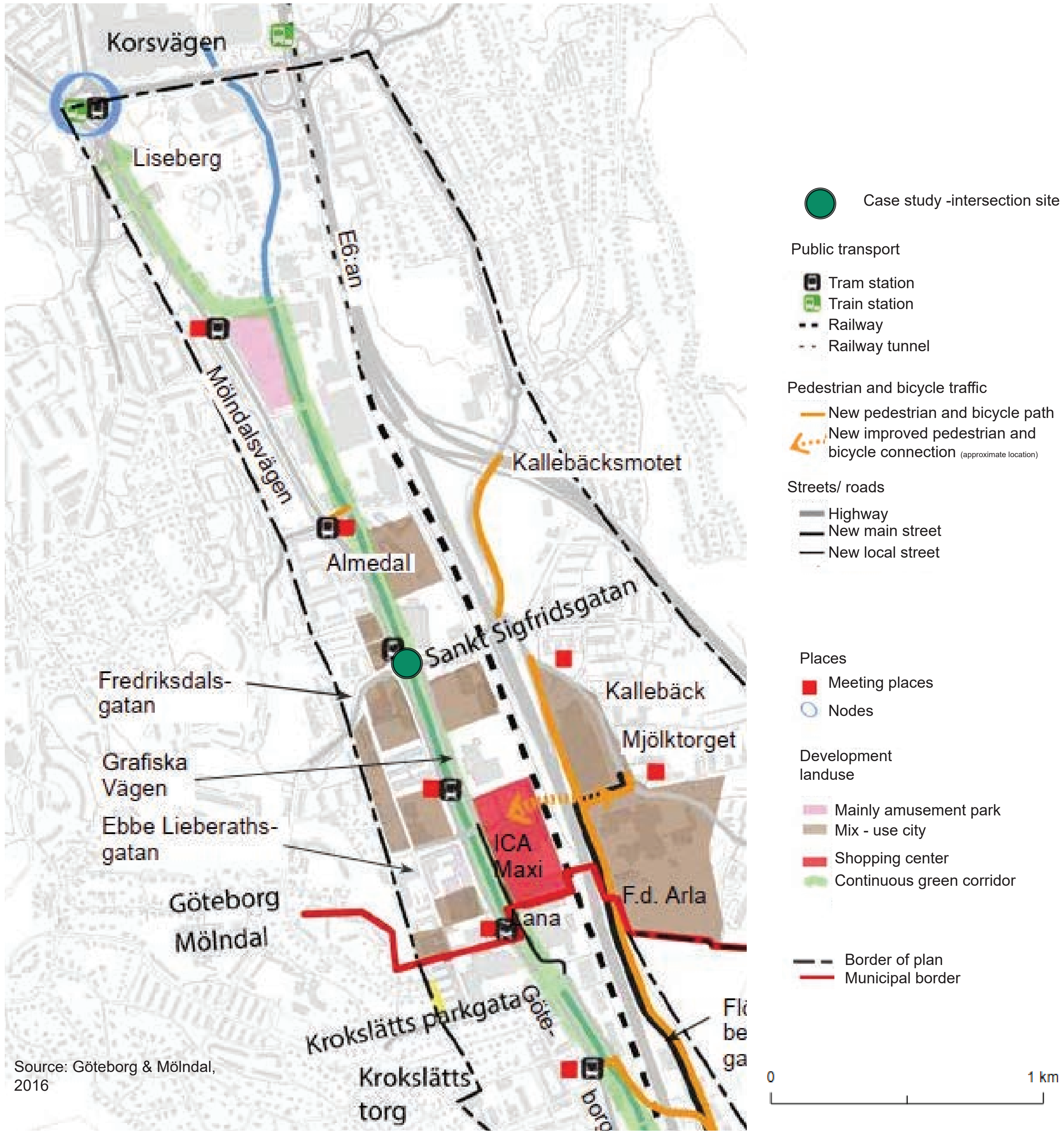
The FÖP (Göteborg & Mölndal, 2016) says that the background of the need of a plan for the area is that demand for industrial sites has decreased, while demand for a denser environment of housing, offices and service has increased. It is believed that at least 7 500-8 500 new houses, 220 000m^2 – 320 000 m^2 of new commercial space and 5 500–8 000 new office spaces could be built in the area *(*Göteborg & Mölndal, 2016).

Some general recommendations from the FÖP (Göteborg & Mölndal, 2016) are:

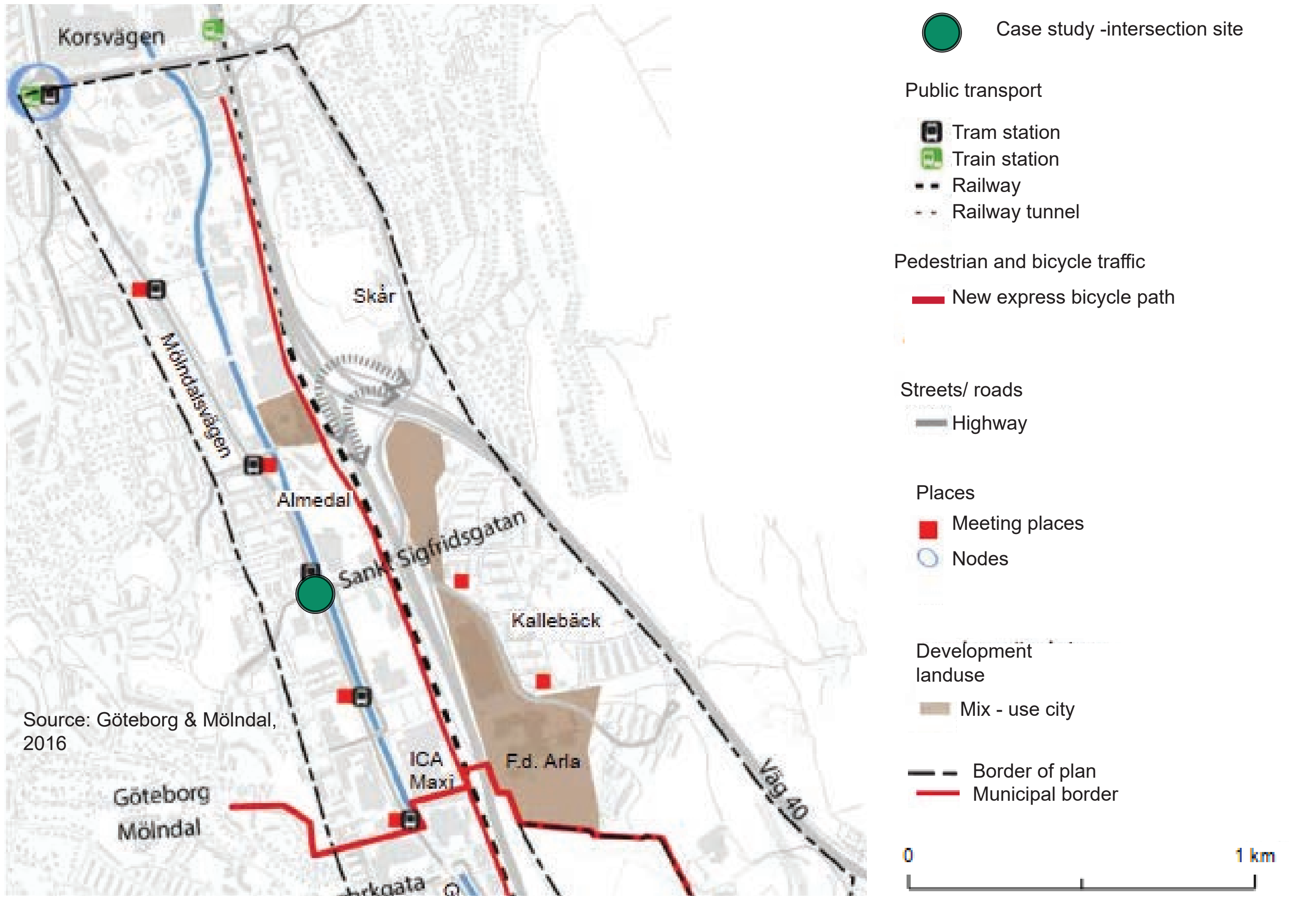
- Planning for dense mixed -used development, especially near public transport nodes
- Bottom floors along main streets should be 'active', with service or cultural activities towards the street
- Buildings along main streets should be placed adjacent to the street, or the land between the building and streets should be public
- 'Barrier' (author assuming against noise) in the shape of offices and parking houses should be built in land adjacent to the railway and motorway E6.
- Housing should be designed to ensure a good air and sound environment

Further, there are also recommendations more specific to traffic (Göteborg & Mölndal, 2016):

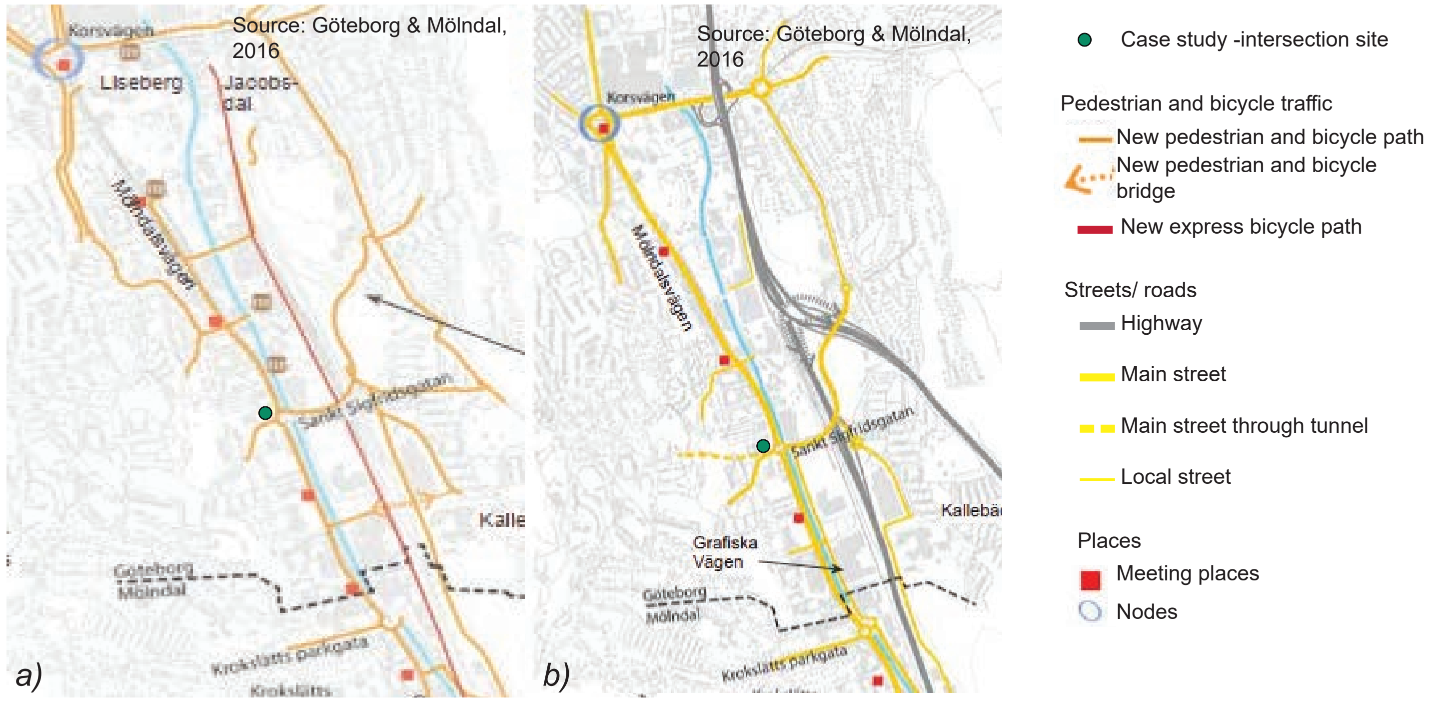
- Pedestrian, bicycle and public transport should be prioritized
- Pedestrian and bicycle connection should be improved across the traffic corridor containing the railway and E6 motorway
- Mölndalsvägen, along which the intersection is located, should be transformed into an 'urban street', with sidewalks, bike paths and landscaping
- Sidewalks and bicycle paths along local streets should be widened and improved
- Street parking is allowed for visitors, while other parking should be located on private land. Open parking lots should be avoided as land use should be focused on housing and green areas
- The railway should be expanded
- Public transport should be built according to the document 'målbild 2035 för kollektivtrafikens stomnät i Göteborg, Mölndal och Partille'
- A safety zone of at least 30m between construction and the railway should be kept
- fast commuting bicycle path should be created along the railway tracks



Land use development - short term, 5-7 years (Göteborg & Mölndal, 2016). It is during this time most construction close to the case study intersection should be done, especially noted is the new bridge across the highway



Land use development - medium long term, 10-12 years (Göteborg & Mölndal, 2016). It is during this time a suggested express bicycle path along the highway is suggested to be built

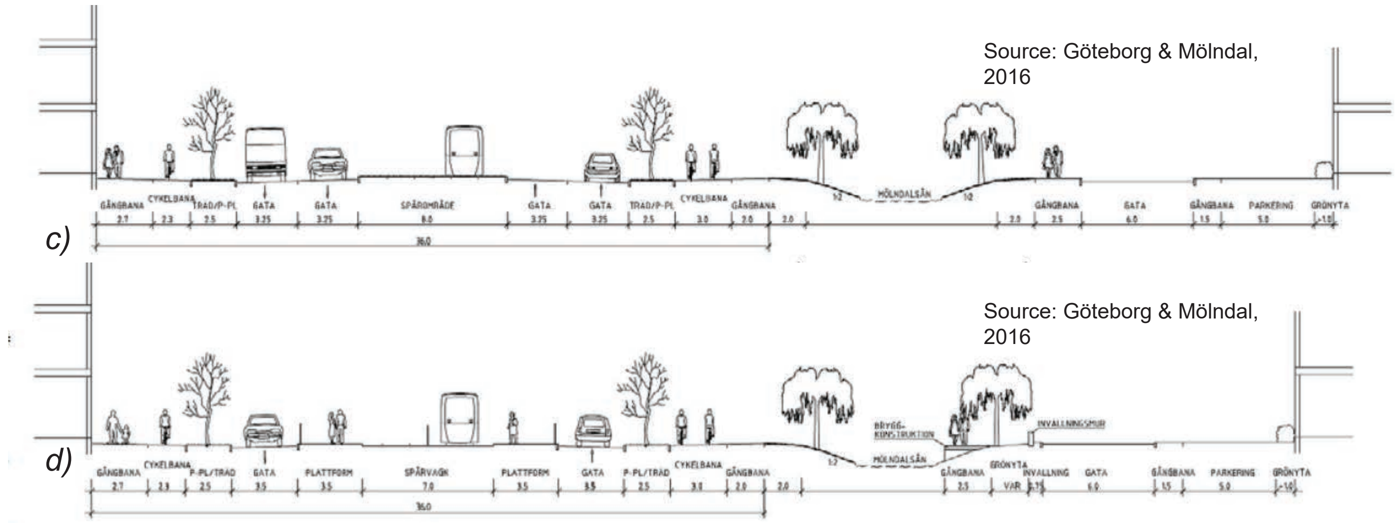


a) Future pedestrian and bicycle network map. A new bridge is planned across the motorway and railway (Göteborg & Mölndal, 2016)
b) Future road structure (Göteborg & Mölndal, 2016). It appears a roundabout has been added to the case study intersection, and other intersections along Mölndalsvägen, but it isn't mentioned anywhere else

A condition for the suggested plan to go ahead is that the car traffic in the area doesn't significantly increase, which also means that the amount of parking spaces shouldn't increase too much. Co-usage of parking and certain car free neighborhoods is one strategy to accomplish this, while also a change from commercial to residential parking generally creates fewer vehicle movements (Göteborg & Mölndal, 2016). The increase in movements should be added through pedestrian, bicycle and public transport.

Mölndalsvägen, one of the roads crossing the case study intersection, is said to have already gone through the previously suggested transformation. Until 1980 it carried the main vehicle flow going north -south, Denmark to Norway, which nowadays goes along the highway E6. Mölndalsvägen nowadays has 2 car lanes, with trams in the middle. Where possible, a bus lane could be added to the road section (Göteborg & Mölndal, 2016).

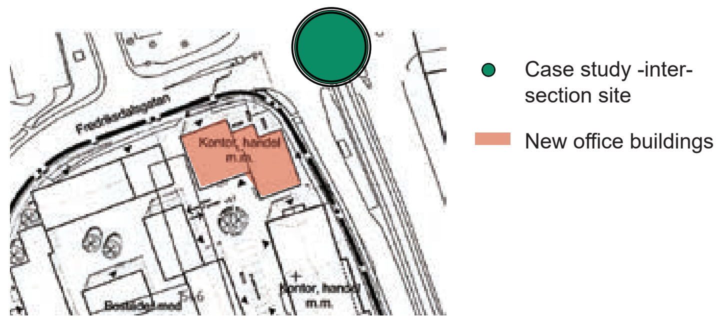
Park - like environments should be created where possible along the Stream of Mölndal, which named the valley. Bridges across the stream are also suggested, as are bridges across the major traffic corridor. Most relevant for the case study is a proposed bridge 450m south of the case study intersection.



c) Suggested section along Mölndalsvägen with a separate pedestrian path along the stream (Göteborg & Mölndal, 2016)
d) Suggested section along Mölndalsvägen next to station. In narrow places a bridge can be built over the stream (Göteborg & Mölndal, 2016)

Detailed plan

Swedish municipalities can use detailed plans to regulate land usage (Boverket, 2014). The previously described FÖP gives recomendations for detailed plans. A relatively new detailed plan, from 2016, of residential quarters in proximity to the case study has been reviewed, and the relevant parts for the later design phase is here presented.

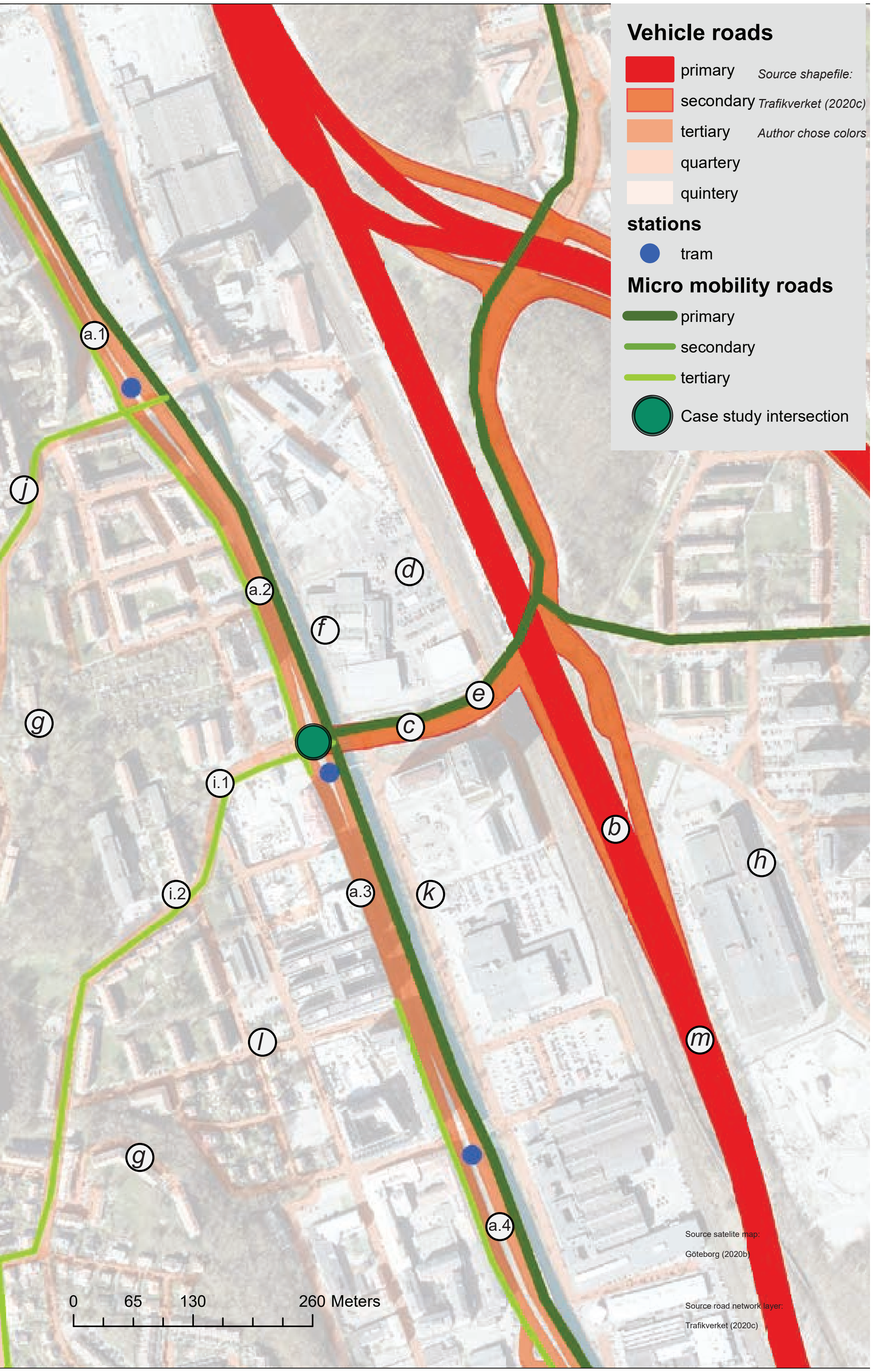


Source: Göteborg, 2016

Adjacent to the case study intersection, rights for an office tower with multiple entrances, demands of having commercial space in corner locations and upwards 16 floors has been given through the detailed plan (Göteborg, 2016). As of june 2020, construction of this building has not yet started

Further site analysis

The strategic documents have already described many parts of the local conditions. Relevant details that weren't mentioned will be presented next. This includes dimensions of the site, through both section and plan, and the character that the area gets from a local point of view.



a Mölndalsvägen: Road along which the commuter bicycle path went on one side. Only small additions are needed to create it on the other side as well

1. 4 100 (cars/day, 2017)[1]
2. 11 200 (cars/day, 2017)[1]
3. 13 500 (cars/day, 2017)[1]
4. 14 200 (cars/day, 2017)[1]

b Traffic corridor: Highway + railway

c Sankt sigfridsgatan: Leads across and to highways

22 400 (cars/day, 2016)[1]

d Skårsled: Old main road, now local road for industrial area

e Existing viaduct that goes over traffic corridor and Skårsled

f Stream of Mölndal: Goes along Mölndalsvägen

g Krokslätt: Residential area

h Kallebäck: Residential area

i Fredrikdalsgatan: One of Krokslätts main streets

1. 8 600 (cars/day, 2014)[1]
2. 5 100 (cars/day, 2014)[1]

j Framnäsgatan: One of Krokslätts main streets

2 800 (cars/day, 2014)[1]

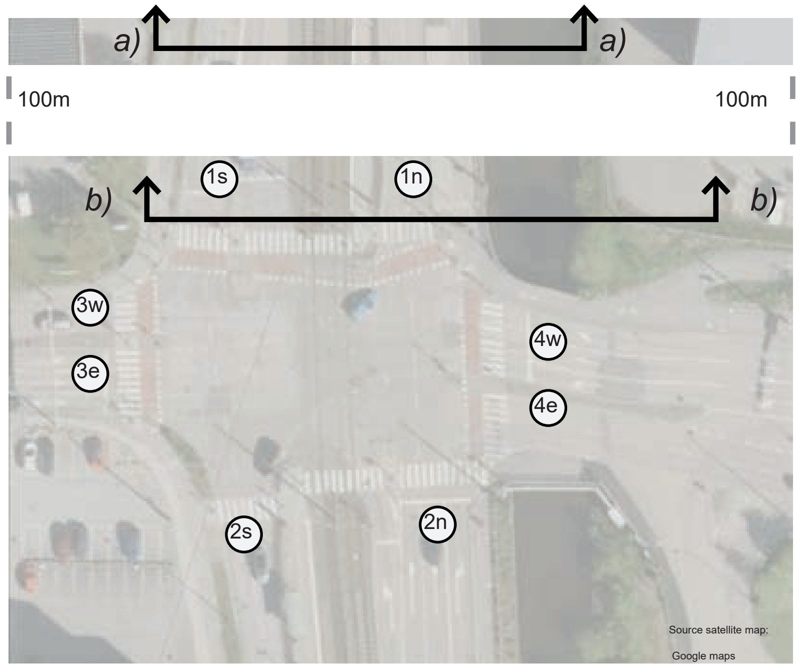
k Grafiska vägen: Local street with entry before/after case intersection

l Falkenbergsgatan: Local street, but important for pedestrians

m Location of future pedestrian bridge

1. City of Gothenburg - trafikfmängder, 2020a.

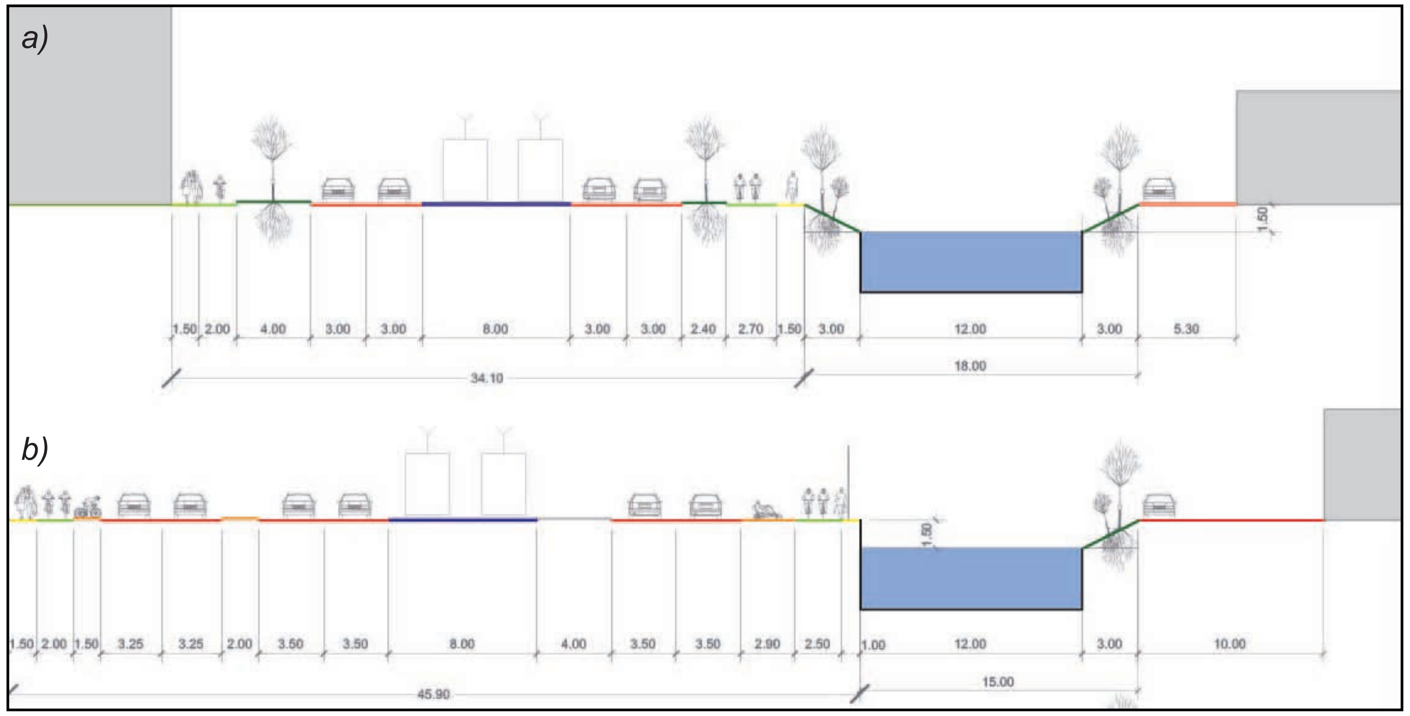
Intersection



Vehicle traffic volumes

1. Going north: 580 / Going south: 490
2. Going north: 940 / Going south: 420
3. Going west: 330 / Going east: 460
4. Going west: 830 / Going east: 1390

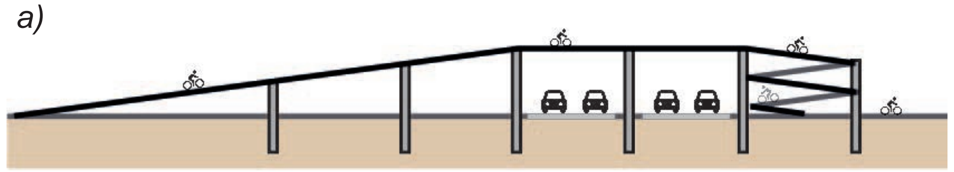
Max hour vehicle traffic, data from 2016 and 2014 (City of Gothenburg - trafikfmängder, 2020a). Total 2 720 cars/max hour, which is below the 3 000 cars/max hour limit that Beelen (2015) mentioned roundabouts had an advantage over signalized intersections for vehicle delays



a) Section in between crossings. The dimensions weren't constant along the road, this is rather a snapshot that gives an approximate understanding. That the section varied so much was perhaps not that reflected in the FÖP
b) Section next to intersection. The road got wider here, especially for vehicles. Note that there are more car lanes on one side than the other. This is to give space before signals, and it becomes inverse south of the intersection. The section next to the intersection is probably what would have been most informative to have from the FÖP, as the space required in between crossings is a result of this

- Micro mobility zone
- Pedestrian zone
- Refuge island
- Station
- Car lane
- Tram lane
- Landscape - grass/tree row
- Stream of Mölndal

a)

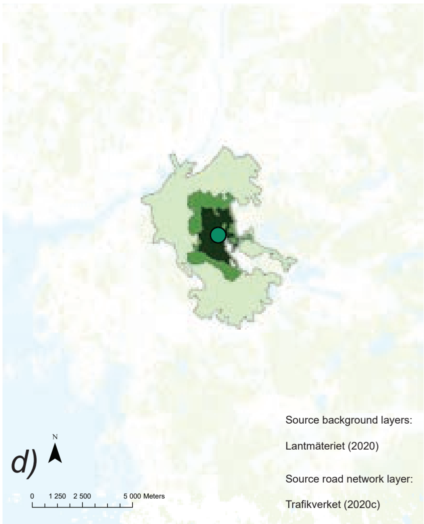


b)

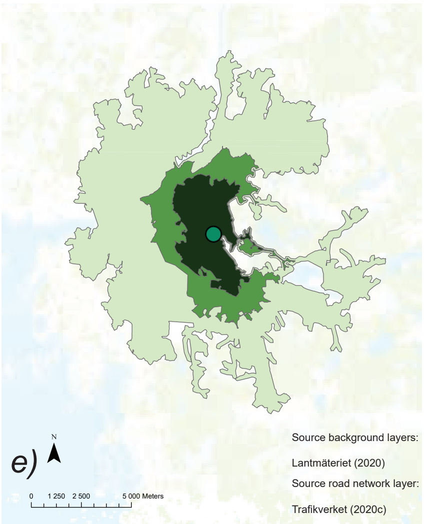
a) To create an overpass for bicyclists a rather long ramp would have to be built, and for it to be properly placed a clear guidance from sort of comprehensive plan would be needed. In the case study area, one of these overpasses was suggested south of the case study intersection (Göteborg & Mölndal, 2016), over the highway E6. Similar overpasses at the case study intersection are deemed unnecessary, since their desired effect would only be achieved if they were placed across all intersections along Mölndalsvägen, and there quite a few of them. The FÖP had a suggestion to have a commuter bicycle path along the traffic corridor of the E6, which would have needed these kind of overpasses. For that solution to happen, a clearer more detailed guidance from the FÖP would have been needed

b) Going under the bridge that passes the stream would require a smaller height difference and thus less inclination, but it wasn't considered possible to create this with current conventional solu-

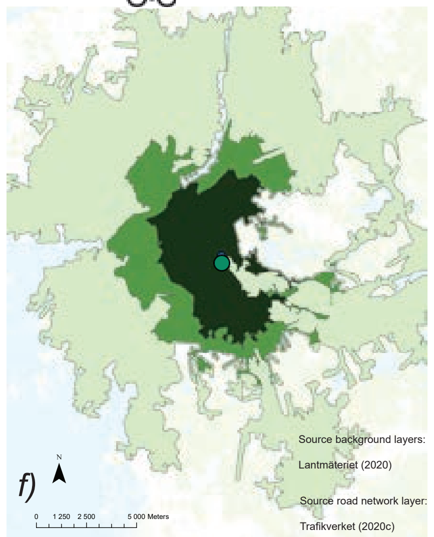
10km/h



20km/h



30km/h

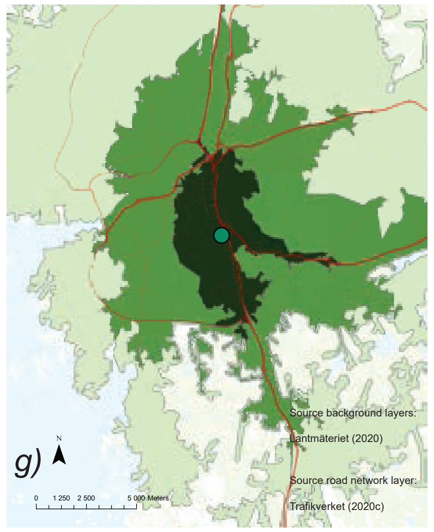


Case study site

Travel times: ≤ 10 min

≤ 15 min ≤ 30 min

Speed limits + 5min



d) How far from the site micro mobility could reach with an average speed of 10km/h. Probable that this is the speed the network is currently designed for

e) How far from the site micro mobility could reach with an average speed of 20km/h. Probable that this is what a commuter network standard would enable

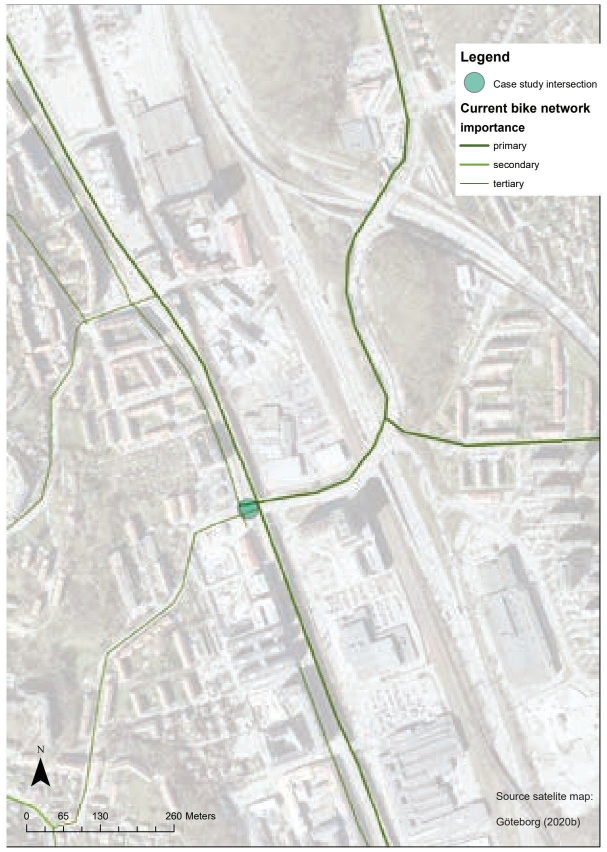
f) How far from the site micro mobility could reach with an average speed of 30km/h. If the commuter network would get a really high standard, this could be imagined, for some users

g) How far vehicles could reach by following speed limits + 5 min. The case study location is close to the highway network, shown in red, and through it has high regional accessibility

A speculation is that the site is attractive for office locations because of its high regional accessibility through the vehicle network, combined with access to land to develop while still being somehow integrated to the micro mobility and public transport network. Upgrade in micro mobility and public transport network is probably needed for the modal share targets of the city to be accomplished.

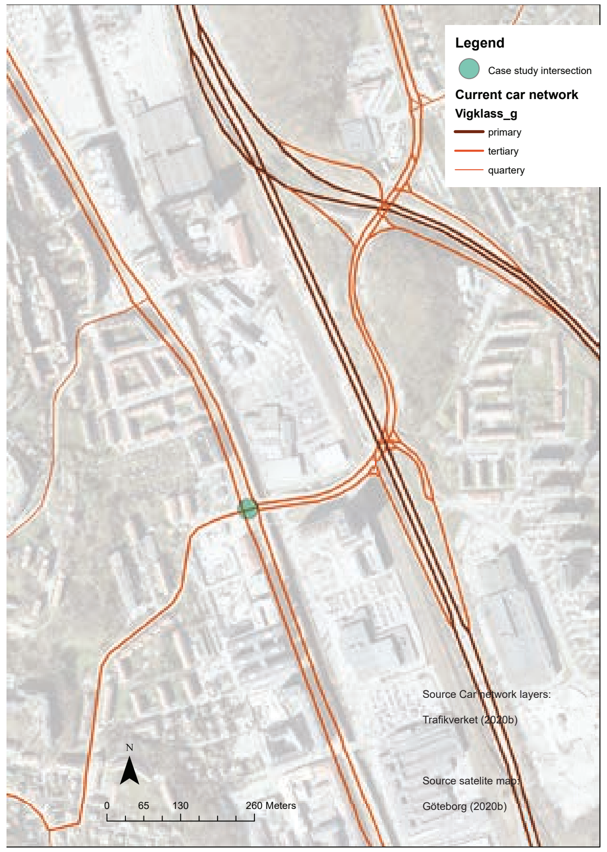
Infrastructure area short term - 2020

Present infrastructure, based on public GIS layers (Trafikverket, 2020c), and author analysis where needed.



a) Micro mobility - road importance

b) Pedestrian - road importance



c) Vehicle - road importance

a) The case study intersection was an important part of the micro mobility network, having two primary roads meeting here. Since Mölndalsvägen is at the bottom of the valley, naturally much of the micro mobility flow goes there. Based on bicycle network maps

b) There are three stations in the area, quite closely placed, while the overall network east of Mölndalsvägen - west of the traffic corridor is rather scattered. Stations based on Gothenburg's GIS layers, importance was decided by author looking at how integrated and to what the roads lead

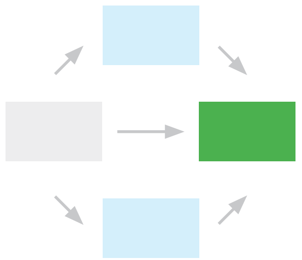
c) Unbundling in the area has already been started, as the primary vehicle roads are the highways, while Mölndalsvägen, which used to be the main road, is considered a tertiary road

Case study - design phase

Design of an urban mixed mode intersection for micro mobility, located at the crossing of Mölndalsvägen and Sankt sigfridsgatan in Gothenburg, Sweden.

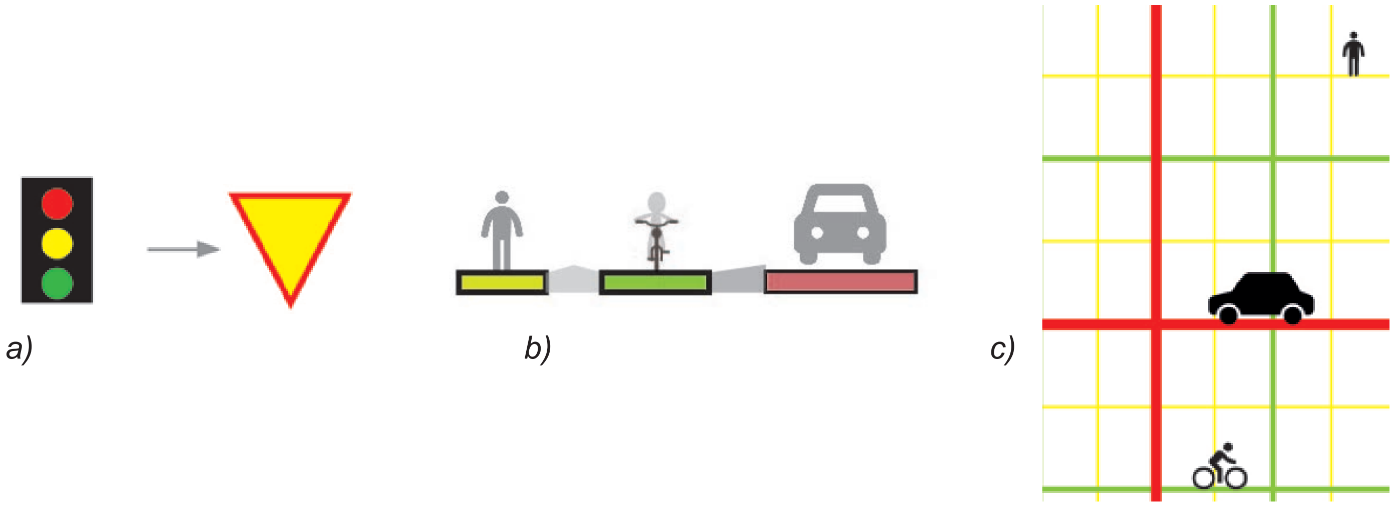
The intersection was designed so that micro mobility would be prioritized, but other modes of transport that were previously going through the intersection would still have an alternative. In order to prioritize micro mobility, measures through different scales were taken. These measures exemplified how earlier parts of the planning process affect solutions in later stages.

Case study, with base in the theoretical and Case study background



Concepts

The concepts were the strategies that were used during the design process. Three main concept categories, *providing enough space for all modes of transport*, *use give of way* and to *unbundle flows,* were created to make it easier to explain the concepts step by step. The following pages will present the different concept categories, and the strategies that they contain, more in detail.



The three main concept categories:
a) Using give of way
b) Providing enough space for all modes of transport
c) Unbundling flows.

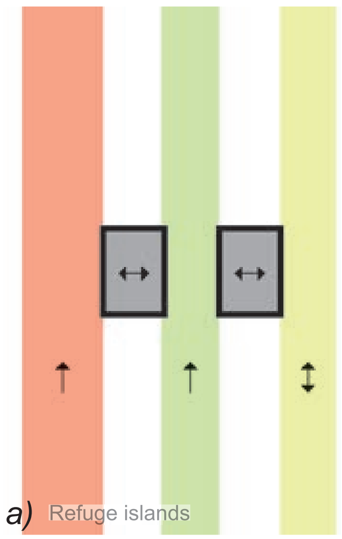
These categories were created to make it more comprehendable for the reader, but ultimately they all affect each other

Using give of way 

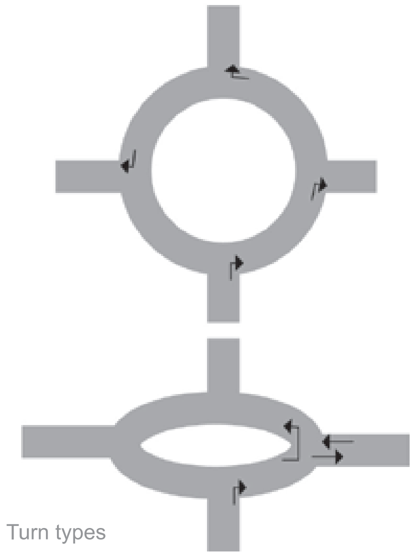
Using give of way, rather than signals, seemed to be suggested by some of the safety enhancing principles in the theoretical background chapter. Example of these principles are *decent amount of feeling of unsafety* and *low feeling of own right of way* (Hyden, 2008). Using priority signs, rather than signals, also removes some delegation of responsibility and can help mitigate risk compensation. Roundabouts, which is a give of way intersection, instead of signals, has been shown to often be safer for micro mobility (Beelen, 2015).

It has been shown that roundabouts cause smaller delays for micro mobility than signalized intersections with micro mobility enhancing principles (Beelen, 2015). It can be assumed that the difference in delays becomes even bigger if the enhancing principles wouldn't had been applied, such as in the case study intersection. For minimizing vehicle delay it has also been shown that roundabouts are preferable over (micro mobility enhanced) signalized intersections for most cases, until it gets to high vehicle volumes, around 3 000 vehicles/hour (Beelen, 2015).

Another common occurring notion in the theoretical background was the effect of speed on safety, and that the critical gap, which depends on speed and direction, is an important aspect in the design of un - signalized intersections. Many of the strategies in this concept category therefore deal with contributing to a shorter critical gap, in order to increase safety and decrease delays, thus improving flow as well. As speed affects the critical gap, coping with migration, knock on and imitation effects becomes relevant as well, as is risk compensation.



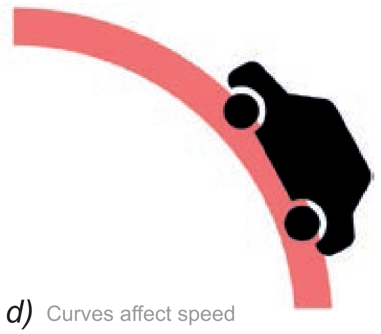
a) Refuge islands



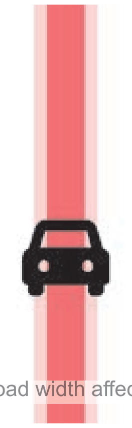
b) Turn types

c) Speed

a) Using refuge islands can help shorten the critical gap, as they enable passing one flow at a time. This strategy can be used for both vehicles, micro mobility and pedestrians, but it is important that this space has sufficient width, which is why the Proving enough space for all modes of transport category was created
b) Using designs that create right turns, with few left turns, reduces the critical gap
c) Avoiding too high speeds decreases the critical gap, making it easier and safer to pass in an intersection. To emphasis, micro mobility rarely reaches high speeds of > 30 km/h, this particular strategy is foremost implemented on vehicles



d) Curves affect speed



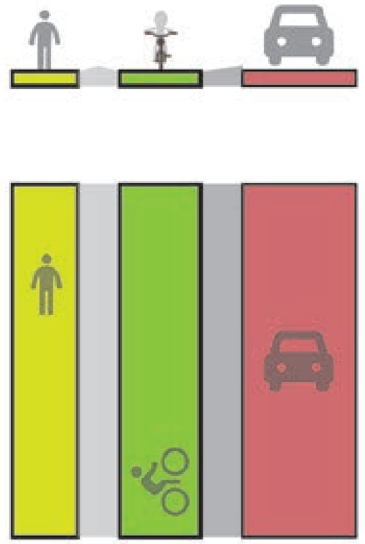
Road width affects speed

e) Bumps affect speed

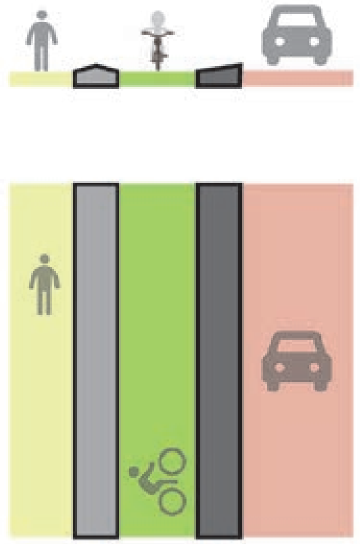
d) The planar design of road can be used as a tool to mitigate migration effects of higher speeds. Road width and curves probably affect the perceived appropriate speed on roads, and could be used to ensure users follow the targeted speed limit (Hyden, 2008)
e) The section design of roads could also be used as a tool to mitigate migration effects of higher speeds (Hyden, 2008)

Providing sufficient space for all modes of transport

Providing sufficient space for all modes of transport, it was meant that different modes of transport should have enough space to traverse safely, in accordance with pre-designated road speed. Road speed designation could be given by more comprehensive documents, or in this case study also by other concept categories. Not giving enough space can lead to a bigger exposure to speed dispersion, which makes roads more accident prone (Hyden, 2008) and can affect flow. Too much of certain types of spaces can lead to risk compensation and higher speeds than desired. This can lead to a longer critical gap, as explained in the previous concept category.

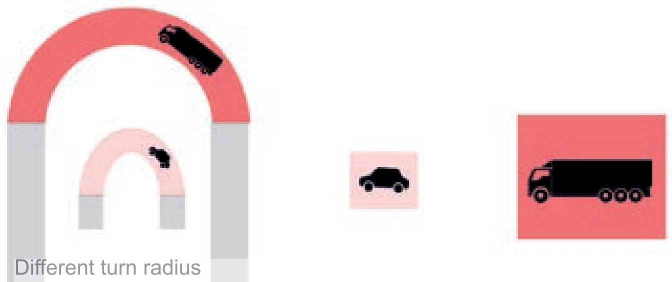


a) Sufficient space

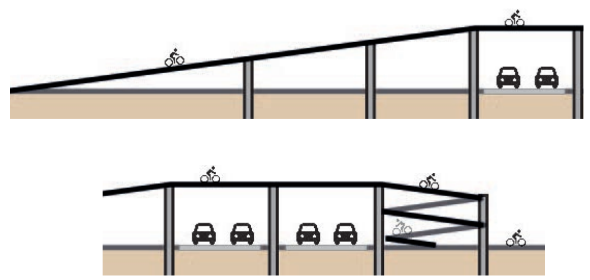


b) Separating space

a) Different modes should have sufficient space in their traversing fields, to be both able and encouraged to travel safely at the designated speed within the targeted max capacity. The importance of a road for the different modes affects what this speed is, but it was important that this was applied to all modes. Otherwise it was believed modes will start using each others fields, which is both not safe if the speed dispersion is high and can affect their fields designated capacity. Noteworthy is that for vehicles this field can also become too wide, as it can lead to speeding because of risk compensation, so there should be sufficient space for vehicles, not more. Other modes don't have the same ability to accelerate as much, so it wasn't considered as big of an issue
b) If the speed dispersion is high it is important that the different modes are separated, and a separation strip can be an important tool to make sure this separation is clear and followed. The dimension table (p 39) contained measurements to be followed, and it was important that this separation could be comprehended by different groups, preferably both visibly and tactilely. Noteworthy is the potential to use this space as a tool to balance the width of the traversing field. The traversing field can be designed to accommodate the proposed speed, while the separation field can be used for passage in the seldom cases that the road needs to be wider, but at lower speeds. Examples of this are larger trucks or a big group of people, preferably a comprehensive document can dictate how seldom these cases will/should be



c) Different turn radius

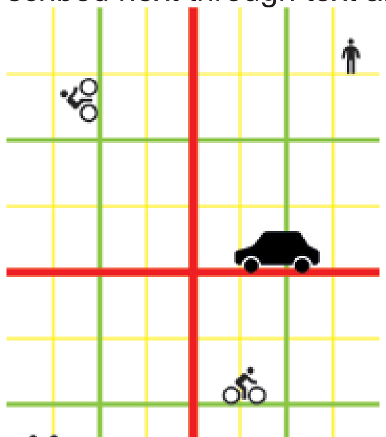


d) Grade separation

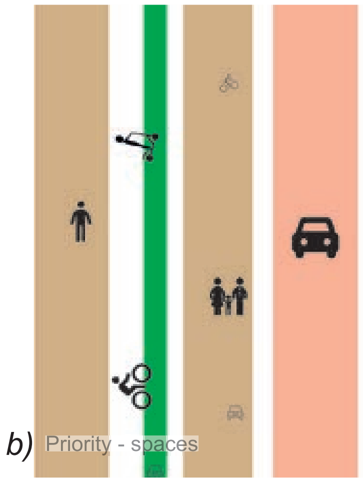
c) Consideration was given to the turn radius of different sized vehicles. This didn't mean that all types of vehicles needed to be able to turn in every intersection, flow of different sized vehicles could be separated. But it should have been possible, in a clear manner, to pass through for differently sized vehicles
d) Grade separated solutions, which can be used to remove conflicts points and simplify intersections to the point that give of way can be used, require ramps. Ramps could be up - bridge, down - tunnel, and both straight and zig zaged, but either way need space. This was mentioned as a consideration for the next concept category, unbundling flows

Unbundling flows

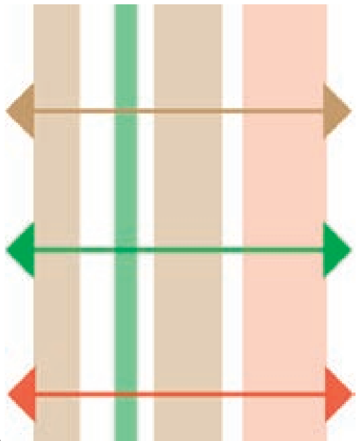
Unbundling is a term used to describe the strategy of doing a network-level separation between vehicular and bicycle traffic in the theoretical background. Unbundling was proven to lead to safer roads (Heinen, Methorst, Schepers, Wegman, 2013), presumably because the speed dispersion becomes lower (Hyden, 2008). Here the concept was applied to pedestrians as well, and the speed of transport modes decided the structure of the unbundling of flows. This is further described next through text and diagrams.



a) Unbundling



b) Priority - spaces



c) Connecting prioritized spaces

a) Unbundling is here a term used to describe the strategy of doing a network-level separation of pedestrians, vehicles and micro mobility. The structure of the network is based on speed, which dictates distance sensibility and space usage
b) Within a transport modes main network, it has priority, shown through the design of the space. This doesn't mean other mode's could never use each others network, as it in many cases can be possible to adapt to the other priority
c) A problematic issue is the connection and crossing of networks. Next page therefore shows strategies for placement of intersections

As modes of transport that have high speeds require more space, and modes that require less space are slower, as shown in the dimensions table in the Case study background (Trafikverket, 2020b), it is assumed they have different optimal structures.

With the assumption that faster modes of transport are less sensitive to distance because of their velocity, but more sensitive to a lack of space (Trafikverket, 2020b), it is arguably preferable for their network to have longer more indirect main routes with fewer intersections. This given a high capacity and safe road design has been given for their indirect route.

Micro mobility have slower speeds than vehicles, but go faster than pedestrians, meaning they require their own space. Gothenburg's bicycle plan (Göteborg, 2015a) mentions this many times, and it can also be explained with the theory that lower speed dispersion leads to fewer safer roads (Hyden, 2008). Since micro mobility are more sensitive to indirect routes than vehicles, because of their lower speed, they could arguably benefit from having more space in the most direct routes, from which regional vehicle flow can be redirected from.

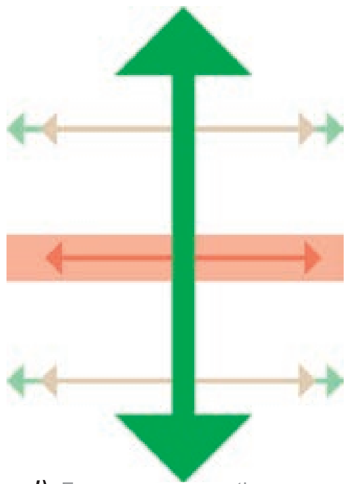
The different optimal structures, coupled with the increased safety (Heinen, Methorst, Schepers, Wegman, 2013), is the argument to use unbundling as a concept.

As speed causes road noise (Trafikverket, 2017), which micro mobility and pedestrians are more sensitive to (Hyden, 2008), and the added space can create an unhuman scale (Gehl, 2010), there also exist arguments to separate pedestrians and micro mobility from main vehicle flow on top of the safety and capacity issues.

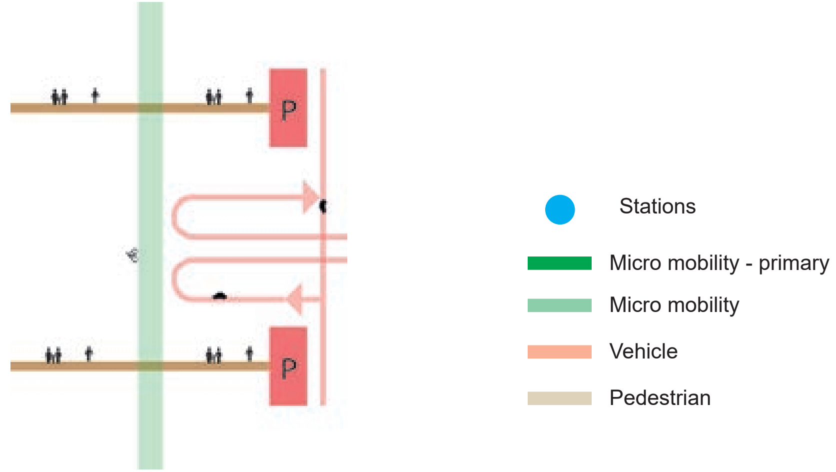
Pedestrians are overall the most sensitive to factors such as noise, distance and scale of environment, as mentioned in the theories of Jan Gehl (2010). They have different optimal conditions than micro mobility, but given each mode of transport has been given enough initial space, pedestrians are also not as disturbed by micro mobility as by vehicles, as micro mobility is smaller and quieter (Gehl, 2010). As mentioned in the k2020 public transport plan document (Västra Götalands regionen, 2018), stations can contribute to urban life as they concentrate pedestrians.

Where pedestrians are concentrated could be seen as the most important place to prioritize them, in both street and intersection, and thus the location of stations becomes part of the unbundling strategy as well.

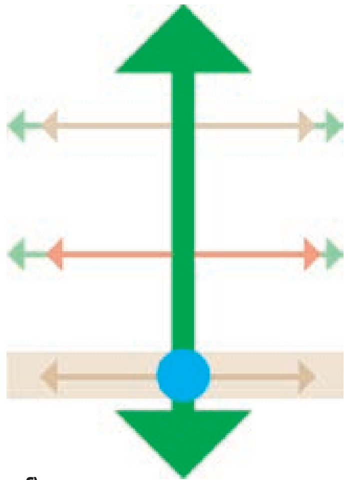
A problem that occurs when the unbundling concept is used is that intersections can become more complicated, as different modes of transport can have different main flows. The unbundling concept category therefore handles strategies of the placement of intersections, described further down on this page.



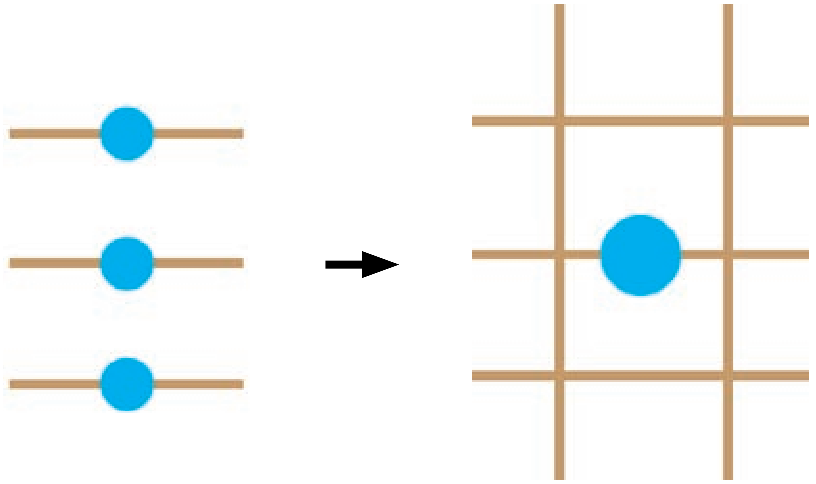
d) Frequency connections



e) Parking placement



f) Station placement -connections



g) Many stations - unconnected network

Few stations - connected network

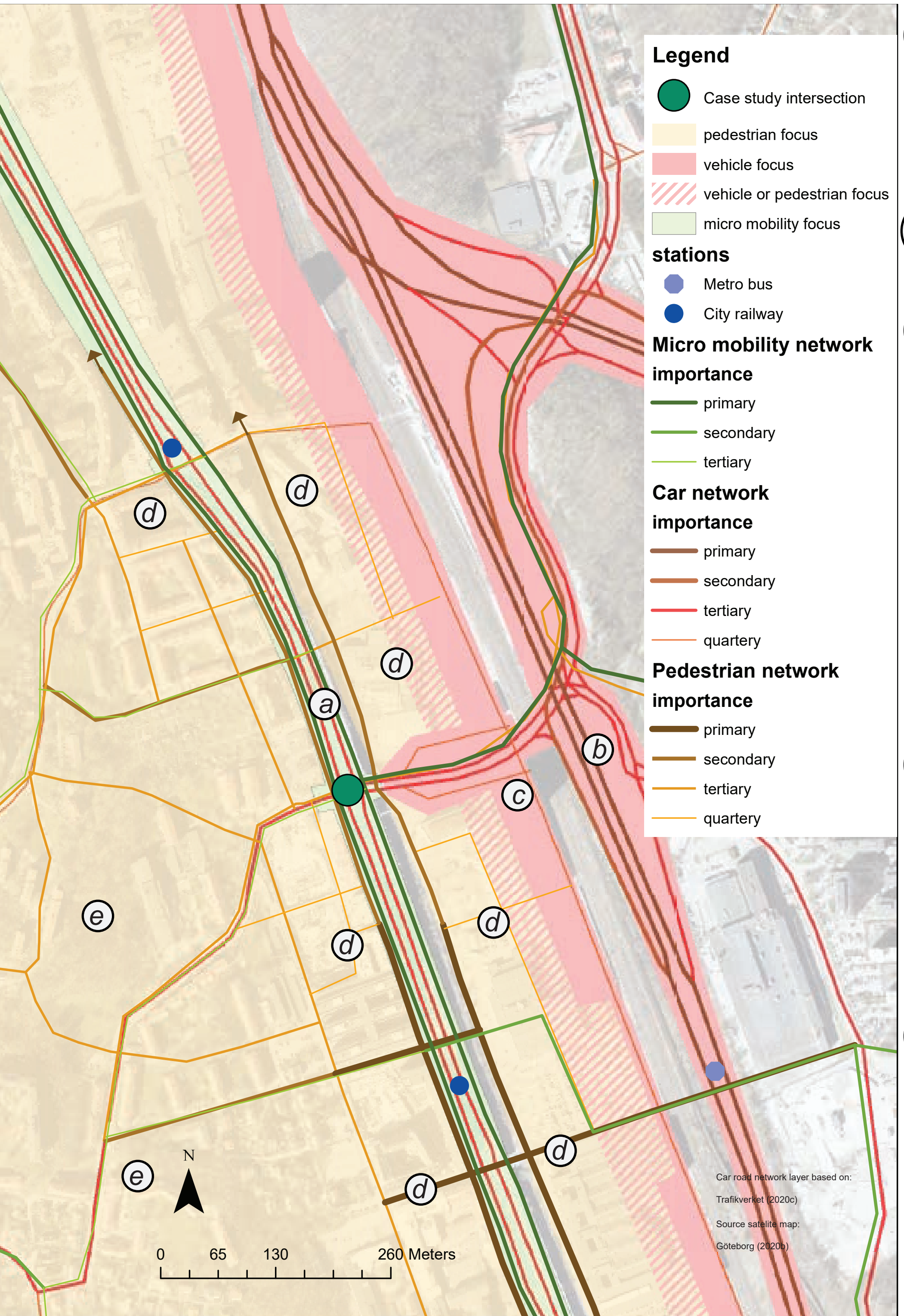
d) Vehicles take up more space, which can make it more difficult to design preferable intersections, as per other concept categories, but are also less distance sensitive. As such, one strategy is to allow micro mobility and pedestrians cross prioritized roads more often than vehicles
e) Following strategy d), if there are many destination points in proximity, diverting vehicle flow from even crossing a network corridor (wide green field), and making them use smaller and simpler pedestrian crossings can also be beneficial. Location of parking spaces is a vital part for this kind of strategy to work

f) Stations, blue circle, can create big concentrations of pedestrians that require plenty of space if prioritized. If the public transport corridor is shared with other modes of transport, it can be beneficial to place stations away from mixed mode intersections to not make the intersections further complex. Potentially this could also create more space for the stations
g) Having fewer stations is also something k2020 desired for the tram going through the case study intersection, in order to create a faster tram lane. For this to work it is important that pedestrians have a proper local network. Gehl (2010) mentioned that 500m is a distance most accept walking, but that this distance significantly reduces if the network is incomplete or requires many stops

Long term - suggested solution

Transportation land use focus

Map which shows what transport priorities different spaces can have, based on context analysis's of the documents described in the Case study background chapters, together with the short term map. The strength of the local area is its accessibility through different modes of transport, and it is thus probably a good location for offices. Further west, marked e, is an area that was believed not in need of, nor currently not having, high vehicle capacity. The case study intersection becomes some sort of transition point between different transportation zones, which should be reflected in the design of the case study intersection. Having a design for, likely, the most challenging point in the area, provides clarity for what can and cannot be done in the rest of the area, which was the reason this site was chosen for the case study.



a — Primary corridor for micro mobility, that is also used by other modes of transport. Micro mobility is prioritized here, and other flows must adapt to this. The city railway, for which it is also a primary corridor, has same main flow direction as micro mobility, so it isn't considered problematic

b — Primary corridor for vehicles. Great consideration is given where it meets other primary corridors

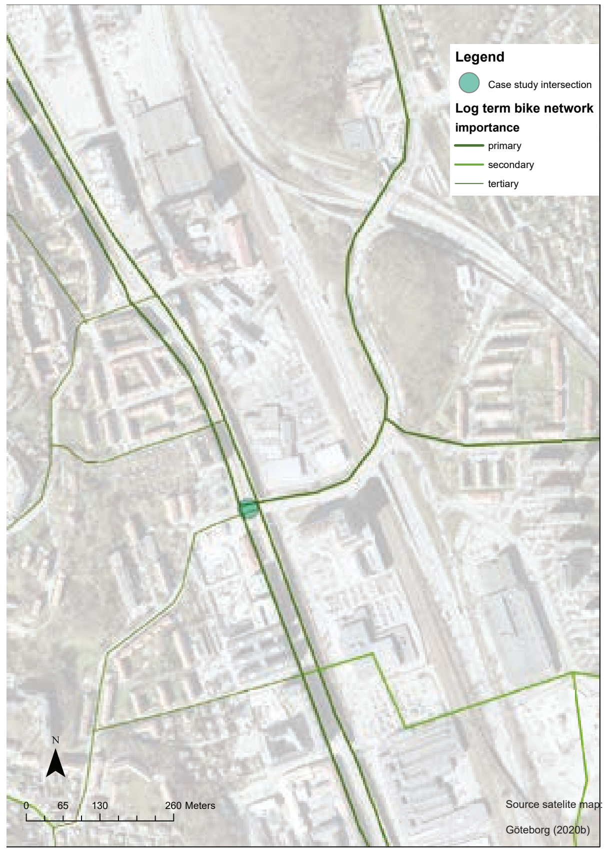
c — Most noise exposed part of the area, which is believed to be an appropriate place for local vehicle flow and parking. A local, quarterly, road for vehicles should be created to reach here, and there seems to exist potential to largely grade separate this road from other flows by using the viaduct. Depending on how many destination points are created, and what modal share targets are made, both of which affect the amount of vehicles, this part will have different solutions. What is important is that these vehicular solutions don't create conflicts with other modes of travel, and spatially it is believed these conditions have been created

d — Pedestrian focused areas, here it can be most appropriate to apply Gehls (2010) theories. The proximity to fast public transport, and primary micro mobility and vehicle corridors creates regional access to these areas, potentially making it a very attractive office location

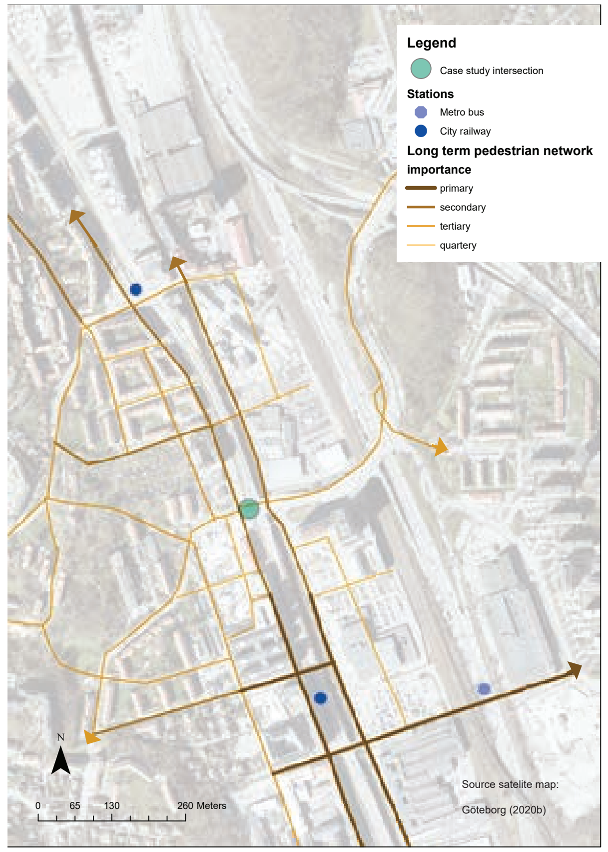
e — Areas that have less destination points, and also fewer primary flows. Connections for different modes are created, but because of the proximity to office locations and clusters through other modes than vehicular, creating high vehicular capacity isn't a priority.

Infrastructure area long term - 2030

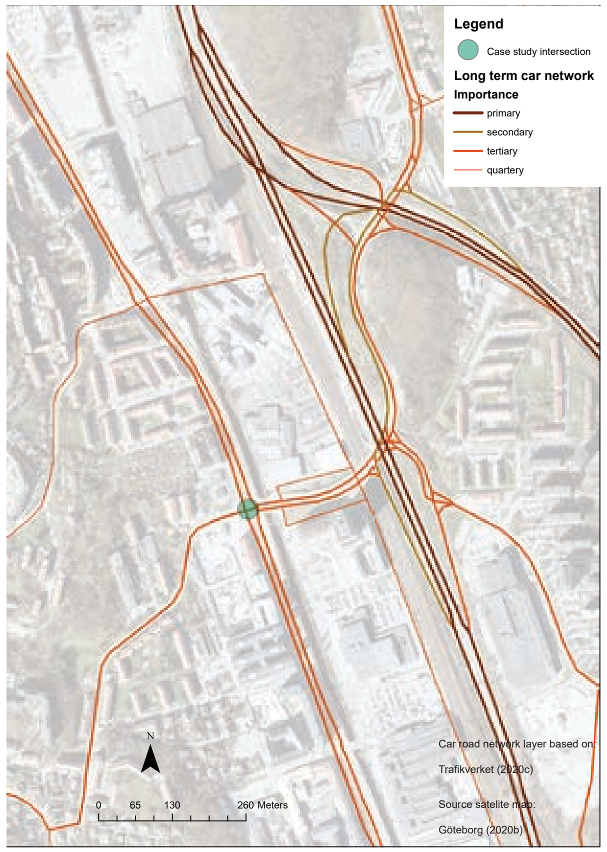
How the infrastructure in the area could be developed in the coming years. The base was existing strategic documents, but this level of detail - comprehensible for different modes, was never presented in the strategic documents.



a) Micro mobility - road importance



b) Pedestrian - road importance



c) Vehicle - road importance

a) The new bridges to Kallebäck, as mentioned in the FÖP, will divert part of the micro mobility flow, but overall the case study intersection will continue being important. The overall flow to and through the area is expected to increase as well. Importance was decided by author looking where roads lead

b) Fewer tram stations and a metro bus station, making the public transport faster, is coupled with an improved pedestrian network, making it easier and more pleasant to walk locally. The placement of stations is currently not mentioned in strategic documents, as is most of the new network parts, so those are the authors suggestion

c) Importance has been adjusted by the author, and the design will follow this change. Note that importance was changed only upwards, but it was considered the current tertiary network was over prioritized. Crucially, east of the case study intersection new connections have been created to reach the suggested vehicular focused land use area. These additions were believed to greatly reduce vehicle flow from the case study intersection

Long term street solution

In the long term, a roundabout where micro mobility is prioritized is envisioned. It gives good conditions for micro mobility, while also enabling large vehicles to do large turns after exiting the highway. Pedestrians are given much more space on one side of the stream, and have been directed away from the intersection. In order to make this solution plausible, several area additions were made, which wouldn't be far fetched if working with in an area scaled document such as the FÖP.

For vehicles, turns before the roundabout were added, which can be used to reach the vehicle focused land use areas, described on the previous pages. This could offload a large amount of rush hour traffic, as there are plenty of offices that could take advantage of this addition. Main vehicle flow going into the case study intersection is believed to be the south - east direction. However, the biggest bottleneck for vehicles will probably still be the entry to the highways from the area, which wasn't a part of the scope of the design. Several speed reducing measures have also been suggested, including speed bumps going into the roundabout, and small turns.

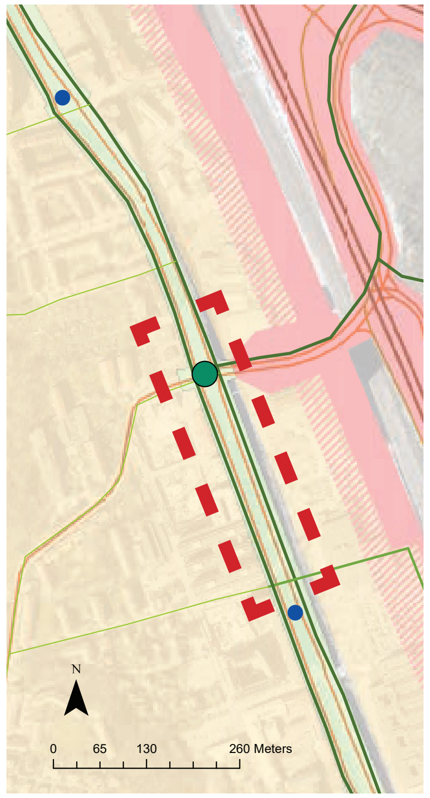
The tram station has been moved further south, as this will give a connection to the newly added pedestrian bridge, and it is around there that pedestrians are prioritized. In this area there are two crossings of Mölndalsvägen, quite closely placed, which can also be used to exit from either side of the station. Noteworthy is that the added exit from the station significantly affects bottlenecks of pedestrians and how accessible the station is. Along Mölndalsvägen, noise exposure will probably be reduced because of the reduction of speed, and pedestrians are clearly separated from micro mobility here, with a wide, often >2m, separation strip. If the speed dispersion is small there is no need for a separation, and micro mobility is allowed to use the space of pedestrians, but on the conditions of pedestrians. The biggest concentration of pedestrians will probably be a pulsating flow next to the station, while the wide pedestrian zone on the eastern side of the stream can be expected to have the biggest non pulsating flow of pedestrians, as the conditions to create quite pleasant environments exist there. Shops and services have the best conditions along the eastern side of the stream, and next to the station, locations where there often is space for e.g. outdoor seating areas and short term parking for deliveries.

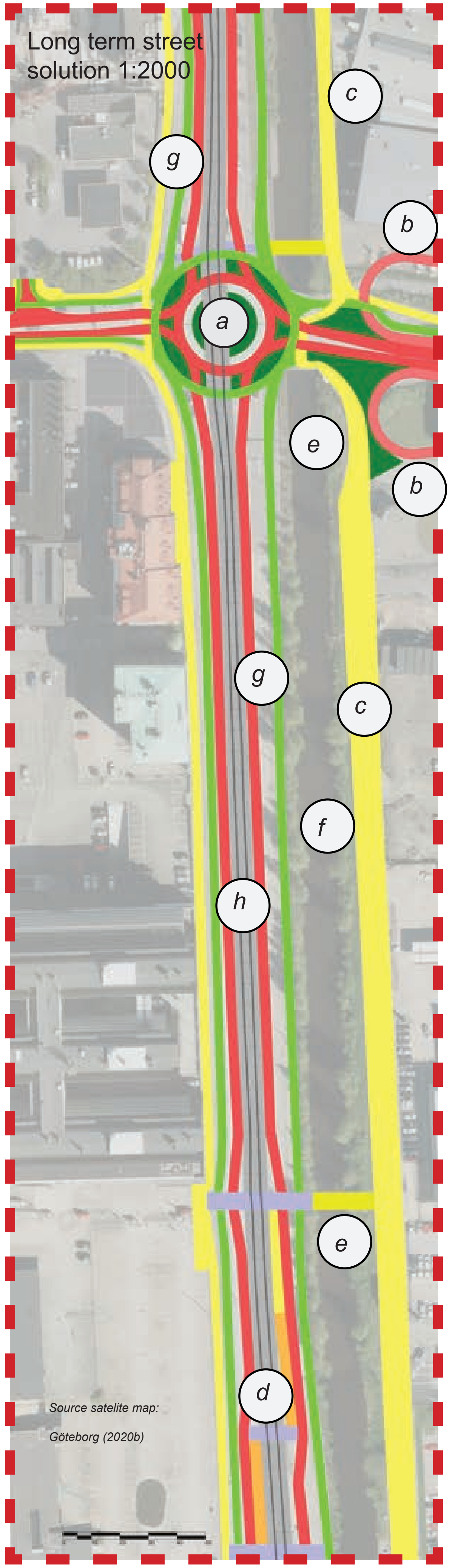
Micro mobility has received a much improved intersection, that uses priority and has critical gaps that fit well the speeds of micro mobility. This example shows one way paths along Mölndalsvägen, which depends on this being created along the entire road. Given the conditions that this solution has created for Mölndalsvägen it is probably quite plausible to create this, but even if not, there is enough space to create bidirectional paths. If lightweight bridges were to be built over the stream next to intersections, a bidirectional path on the east side could even be made to the highest level of commuter standard. What is most important in the intersection is that space for refuge islands is given. If space for refuge islands has been given, conditions for both one and bidirectional paths have been improved.

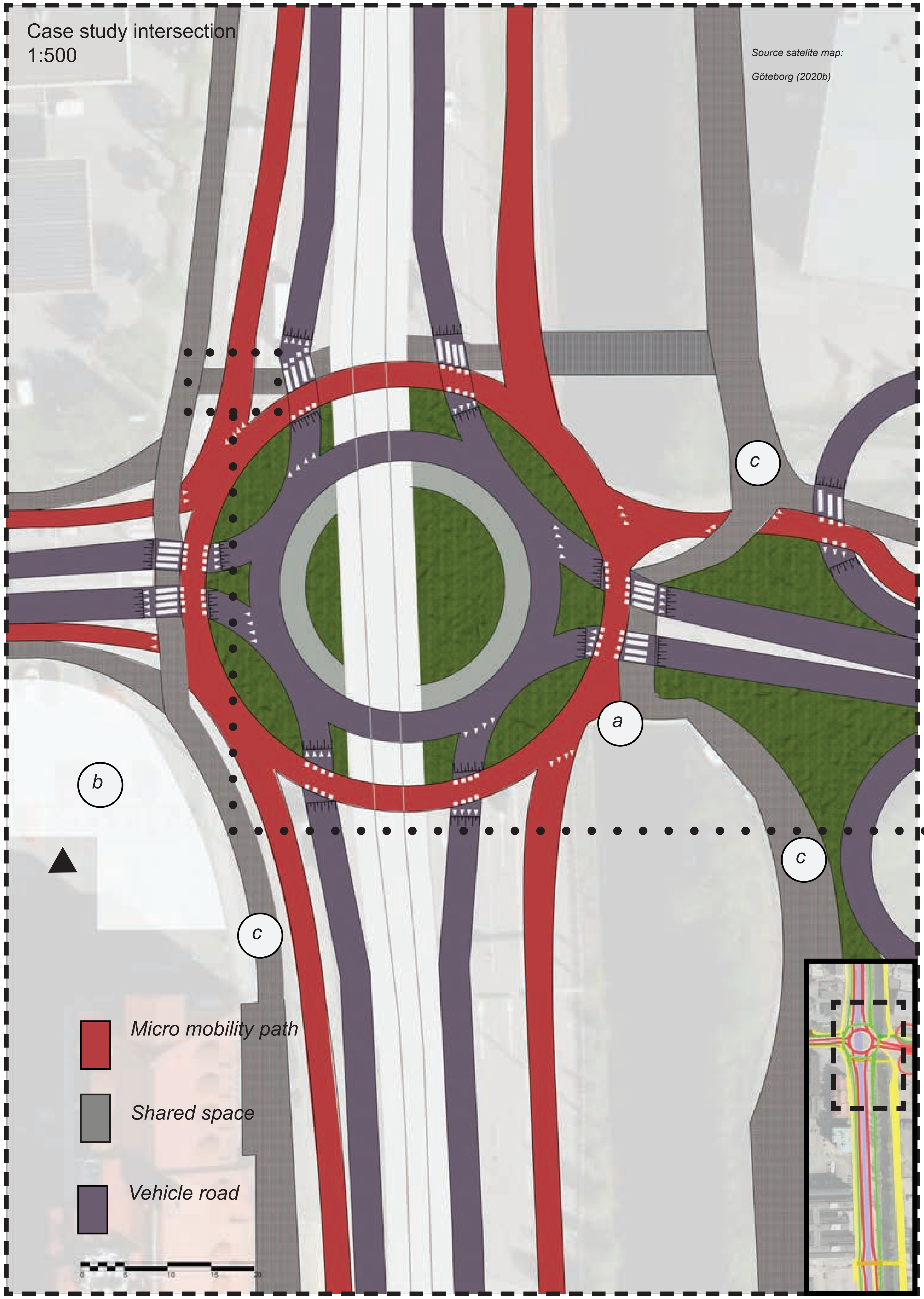
Micro mobility has been clearly separated from other modes along the commuter path and where speed dispersion is high. Where speed dispersion is lower, micro mobility can share space with other modes. Micro mobility could definitely use the shared space on the east side of the stream, and probably also use the pedestrian "shared space" along Mölndalsvägen, given they move slow enough. While improvements have definitely been done in favor of micro mobility in this solution, perhaps the biggest change from existing strategic documents is what happens to other modes of transport. When everything isn't mixed and put together in one place, it seems to be a lot easier to create good solutions. Vehicle flow has been redirected, pedestrians have been given more space, the focus of human scaled environments has shifted away fror Mölndalsvägen and the number of stations has been reduced and relocated. It could be argued that overall conditions for all modes of transport have actually been improved in the area, which makes the case for this type of solution stronger. But for this unbundling of flow to happen, which the author would argue very much played a big part of this solution, consideration to all modes of transport has to be given, and therefore area scaled documents play a big role in creating good intersections for micro mobility.

- *a* The case study intersection is now a roundabout, where micro mobility is prioritized. Micro mobility flow is one directional, but there technically exists space to create bidirectional designs
- *b* Vehicles, whose destination is local, have the option of exiting before the roundabout. This is expected to significantly reduce the vehicle flow in the case study intersection
- *c* Shared space zone, where traversing is done on the conditions of pedestrians
- *d* Public transport station. Exit from two sides to reduce congestion and increase accessibility
- *e* New bridges and crossings. These can be used by micro mobility and pedestrian and give both better conditions to create one directional micro mobility paths, and to integrate the different sides of the stream
- *f* Stream of Mölndal
- *g* In multiple locations there has been separating strips wide enough to accommodate vegetation and possibly trees. Not a main aspect of this report, but since it is another value added to the area, it further shows the benefit of area scaled documents to work with intersections
- *h* If the public transport lane could have more uses than accommodating trams, it would help make the case study design suggestion further credible. Examples of other uses are that buses and emergency vehicles could go there, or that the space could be used during road repairs.
If rail tracks wouldn't need to be accounted for, it would also give more flexibility for the road design. Currently there is excess space on the east side, and lack of space on the west side

Micro mobility
Vehicle
Pedestrian speed zone, micro mobility is allowed
Crossing
Public transport
Station







Long term intersection solution

More detailed views of the suggested solutions. Priority between micro mobility works like in a common roundabout for vehicles, with give of way when entering. The ambition was to provide enough space to create refuge islands for different modes of travel, and to stack up space where it could help create a better flow for the prioritized micro mobility. It is these additions, for pedestrians and micro mobility, that were missing in Gothenburg's technical handbook example drawing of roundabouts, and also what increased the size of the roundabout. If less space for the intersections would be given, vehicles are among the last to get affected, as they typically have the innner most spaces. It is rather pedestrians and micro mobility that would suffer from not providing enough space in traffic corridors. This is a message that could be emphasized more in Gothenburg's strategic documents; wider traffic corridors can, all else equal, be very beneficial for creating better conditions for micro mobility, especially if there is a big speed dispersion.

a Priority in between micro mobility works like in a normal roundabout

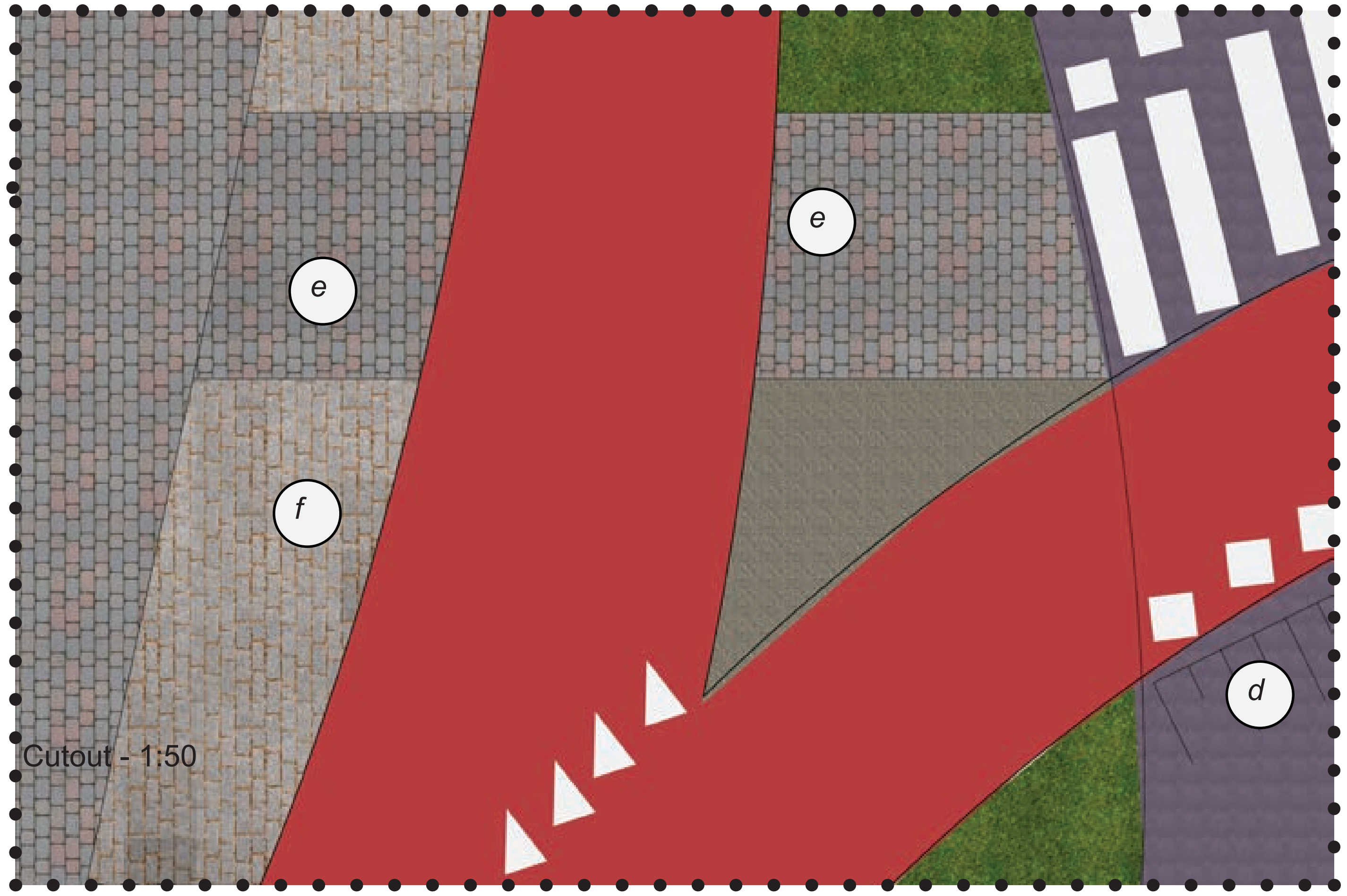
b It is suggested the permit for the building site is adjusted, if not removed, so that construction doesn't block access for pedestrians. The FÖP suggests building adjacent to the street, so this is a critique towards the existing plan. The FÖP should protect primary infrastructure, not the least infrastructure of pedestrians and micro mobility, which were supposed to be a major mode of transport in the area

c Micro mobility is allowed to use this space, but on the conditions of pedestrians. Clear signage of this is needed, it could even be sentenced on the sign "micro mobility allowed to be here, but on the conditions of pedestrians. If using faster speeds please use the micro mobility path". Since pedestrians have been given a generous amount of space, it is believed there wont be a problem handling a few micro mobility users

d Heightened passage that creates a speed bump for vehicles

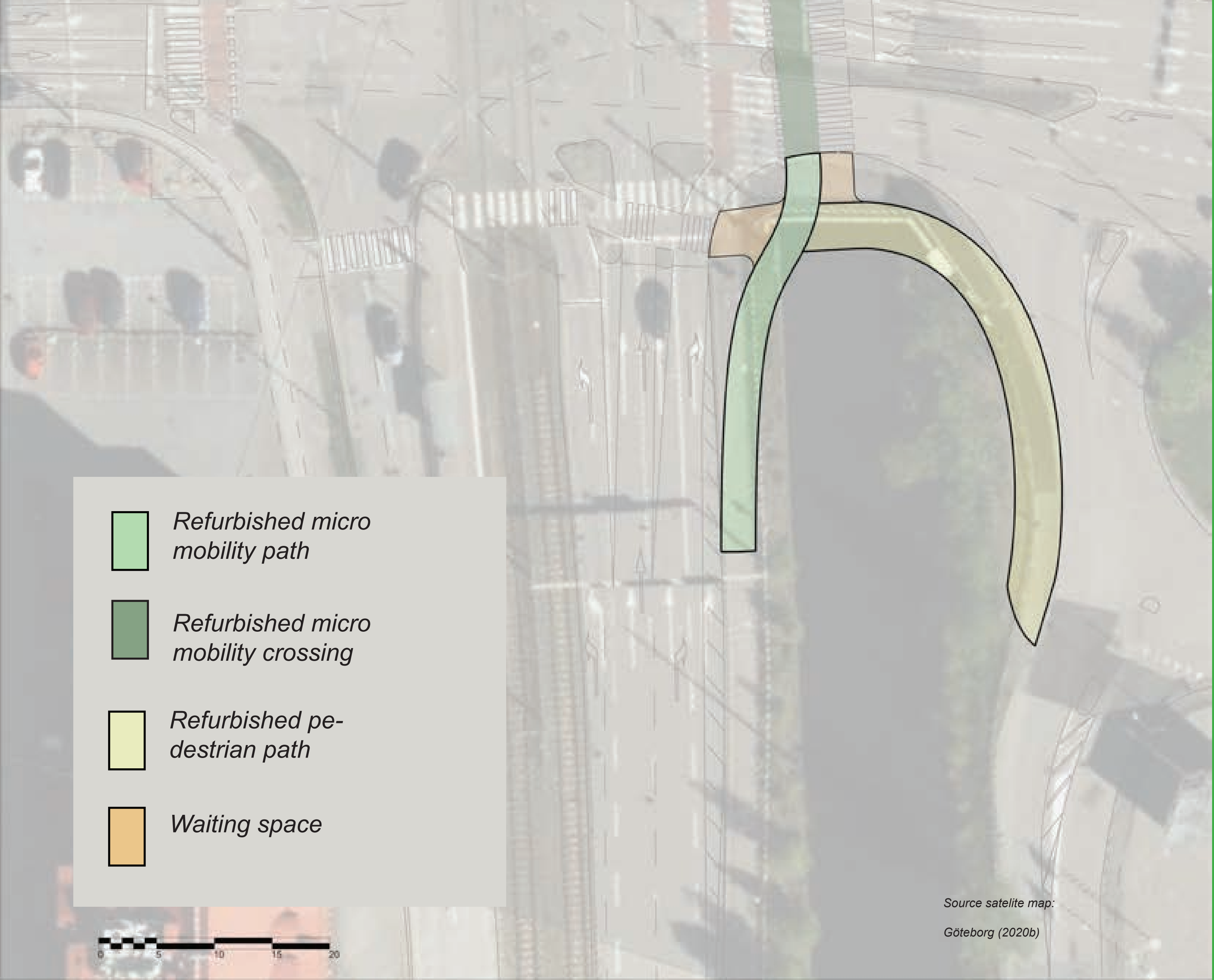
e The dimensions for refuge islands between pedestrian, micro mobility and vehicle parts in the entry of a roundabout was not clearly shown in the roundabout example drawing Gothenburg's technical handbook, but probably should as it is an important part of a good design. 2m ≤, dimension recommended for refuge islands, was used here

f Further study of separating space between pedestrians and micro mobility, from Gothenburg's guidelines, would be desired. It was suggested that a strip 0,5m ≤ would be used and that it could consist of grass, but also that grass surfaces should be at least 2m wide. The report suggests an uneven hard surface, which can be both a tactile and visual separation, but also act like some sort of shoulder. If micro mobility wants to stop, or if a wider pedestrian part is briefly used, it can be done over this space. The same could be said if micro mobility wants to go the other directions and goes to the pedestrian path, they can use this space to bypass pedestrians. Standard solutions of this type would have been desirable, and a minimum width for them



Short term solution

The short term solution is assuming structural change of flow can't be done, and a comparison of this solution with the long term one is in some sense an illustration of what the difference support from strategic documents further up the scale can do. The short term solution mainly uses the concept of providing sufficient space for all modes of transport, and an attempt to accomplish this is done through building light weight bridges over the stream. The bridges can create more space on the currently most important, for micro mobility, east side of the intersection. In the suggestion, sufficient space has been provided for micro mobility, but the problem of standing on red light for a long time wasn't solved.
Also, this solution wouldn't be as easy to standardize as the long term solution. There is likely something to take hold of on, such as the stream in this case, in most complex locations. But, doing this is time consuming, thus taking resources, without fully solving the problem.



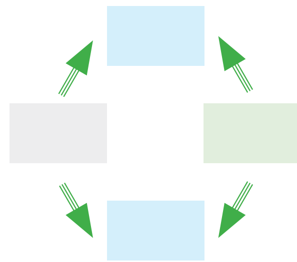
Source satelite map: Göteborg (2020b)

Feedback

This chapter will contain feedback in regard to Gothenburg's strategic documents, based on a triangulation of a context analysis of the theoretical background and the case study. This is the chapter that answers the research question, *What can be done to improve conditions for micro mobility in mixed mode intersections through strategic documents?*

The feedback written here was most applicable to the city of Gothenburg, but probably many of the general notes could be applied elsewhere, if a context analysis is made

Feedback, based on a context analysis of the strategic documents, the case study and the theoretical background



Design scaled documents

Design scaled documents refers to requirements and advice given to the design phase, e.g. required dimensions. These documents can differ between localities, so this particular feedback becomes rather specific to Gothenburg. There are many documents that can be used, and this report didn't present their whole content, rather their most relevant parts for the case study. Supporting documents that had been investigated included VGU (Trafikverket, 2020b), GCM (SKL, 2010) and Gothenburg's technical handbook (Göteborg, 2015a).

The general feedback is that design scaled documents can be used to help support a standardization of solutions. As discussed further on page 66, there can exist different preferable solution types, which is something that could be reflected in design scaled documents. In the case of Gothenburg, what was perhaps missing was perhaps example solutions on the interaction of different modes of transport, further explained next:

Separation pedestrian - micro mobility

Clearer solutions from Gothenburg's technical handbook, and cohesion with VGU, on the separation of pedestrians from bicyclists would be desirable. The dimensions are given, but it was a bit unclear in the design process of the case study to decide how they would be used, especially the variant of 0,5m< separation. This report didn't investigate in full how the separation should look like, the message is rather that somebody should investigate this. Perhaps several solutions dependent on the volumes of micro mobility and pedestrians?

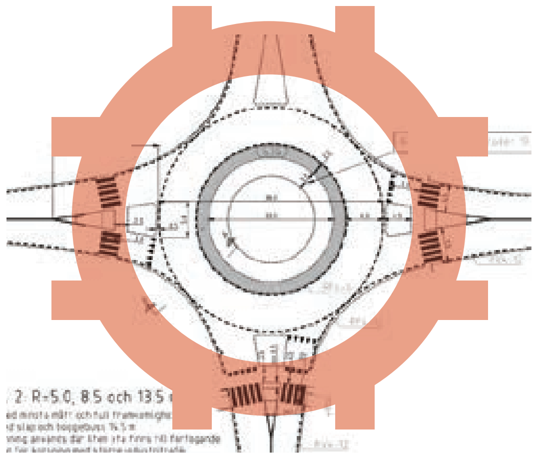
Pre- intersection space, refuge island - dimensions

How much space should be given directly after the passage? A comparison of the refuge island dimension between Swedish document and CROW shows a difference in required dimensions. Perhaps the Swedish required dimensions could be seen as the bare minimum, while CROW shows more optimal solutions?

Roundabout - dimensions

There existed many dimensions for vehicles, and dimensions for bicycle and pedestrian passages. What would have been helpful is a complete and ready example of several roundabout types with exact dimensions. Otherwise there exists many possibilities for 'mistakes' to be made, especially in the border line between different criteria. What angle for turns is acceptable, what refuge island width is striven for, how are pedestrians and micro mobility separated?

These questions could be solved in example roundabouts. Doing these examples would ensure a quality check when designing roundabouts. The design should achieve the suggested or equivalent quality. Another benefit of examples is that they would create a tool for area scaled documents, as they make it possible to see where different intersection solutions can fit, given micro mobility has been given consideration.



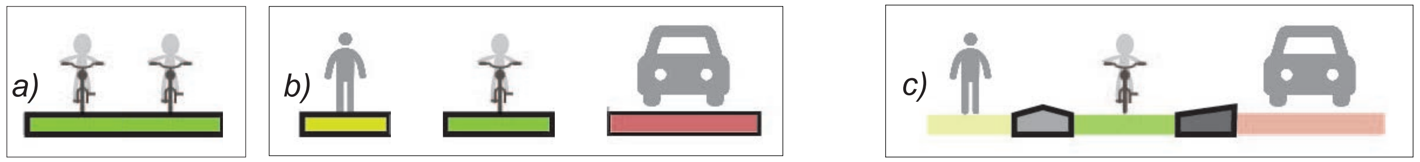
Dimensions for the whole red area would have been beneficial. In this drawing, solution pre- intersection space and refuge island dimensions could also be presented. Optimally several roundabout solutions are shown, to ensure a standardization of solutions

Image based on Göteborg, 2019

Area scaled documents

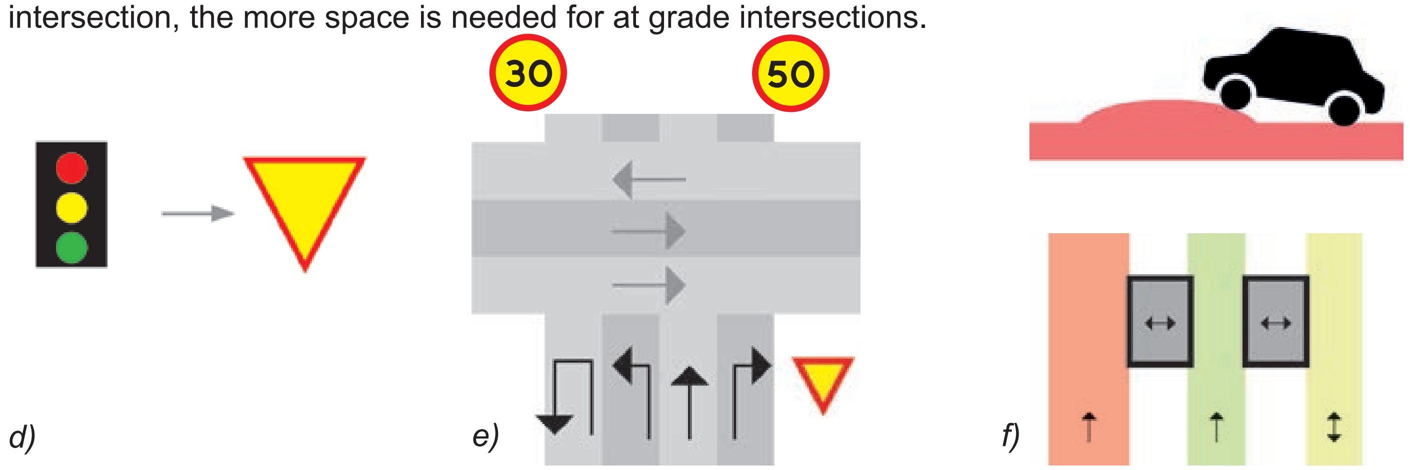
Summary of what was learnt

Providing enough space for the expected users to physically fit in a traffic corridor might almost be considered some sort of axiom. There also appears to be a need to have a separating space in between users that is dependent on speed, such as reflected in the required dimensions of different road space by the Swedish transport administration (Trafikverket, 2020b). This separating space needs to be larger the higher the speed of users, and if there is a speed dispersion (Trafikverket, 2020b). Micro ability users going at 30km/h needs more space in between them than pedestrians going at 0 (sitting/standing still) or 5km/h. In sum it can be said that for safe roads, higher and larger dispersion of speed leads to a need for a broader traffic corridor.



a) There should be enough space to physically fit on a street + buffer space to the side and other users
b) The buffer space needs to be wider the higher the speeds are, which can result in differently wide corridors for the same amount of users
c) If the speed dispersion is high than its safer to give different modes different spaces, with a separation field in between. The higher and larger dispersion, the wider the traffic corridor

For micro mobility, give of way intersections rather than signals are preferable to reduce both accidents and delays (Beelen, 2015). In these kind of intersections the critical gap becomes relevant, which is dependent on speed and how much flow needs to be passed. Refuge islands and additional lanes can reduce the critical gap and increase how much flow can pass per critical gap. This results in that, all else equal, road segments with intersections need more space than road segments without intersections. The higher the speed disparity and amounts of flows going into an intersection, the more space is needed for at grade intersections.



d) For micro mobility give of way are preferable over signals
e) Speed, amount of flow and type of turn affect the critical gap
f) Speed reducing measures and refuge islands can be used to lower the critical cap, while amount of lanes/fields affect how many users can pass per gap. Hence, where lowering speed isn't an option, or where the speed disparity is high, having more space to work with is beneficial in order to create safe solutions, with good flow

With this in context, it could be said that good primary micro mobility infrastructure corridors can either:

- have few intersections, be relatively narrow and not shared with other modes
- or have more intersections and/or be shared with other modes, in which case the transport corridors - space needed to fit infrastructure, needs to be broader

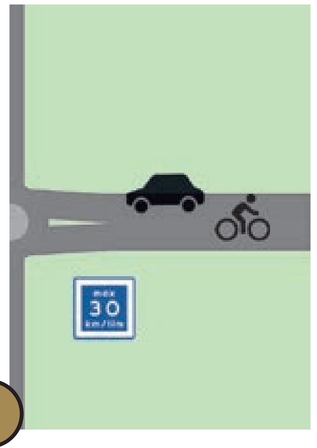
What would have been desired?

What would have been desired from area scaled documents is conditions for one of the following traffic corridor types:

a)

b)

c)

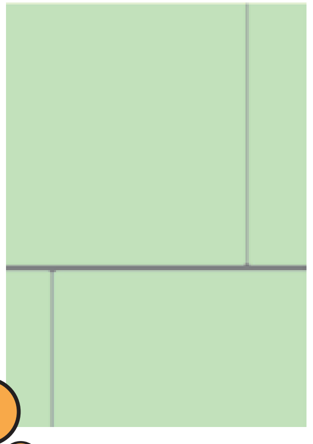


a) Relatively narrow traffic corridor with few intersections, that isn't shared with other modes. This solution is suitable for the primary network, and doesn't require much space because refuge islands and merging lanes are not needed

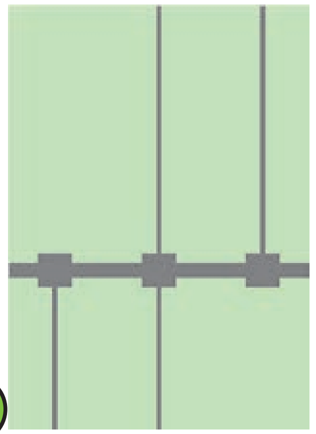
b) Broader traffic corridor, that handles several modes of transport, which could also work for the primary micro mobility network. The more intersections for all modes of transport, the broader this corridor would need to be. The case study was an example of this type of solution, and from a delay and accessibility perspective, this kind of solution could probably be beneficial for pedestrians as well. However, having a human scale proportion for streets for this solution is not always possible. In the case study, 40m could easily be used for a road section, a dimension that increased near the intersection, well above the 25m limit that Gehl (2010) mentioned. If there would be a higher vehicle and/or pedestrian flow in the case study, the space required for good multi modal solutions would increase further. There also exists a limit on the speed disparity until these kinds of solutions become unsafe, reflected in the definition standard of a highway in Sweden (Trafikverket, 2020b)

c) Smaller roads, that have a limitation on speed and flow. This solution could work for at least the secondary micro mobility network, and can be seen as something in-between diagram a) and b). If the main direction of micro mobilities main is clearly prioritized it could also work for the primary network, but it is not unlikely that this prioritization would steer back towards solution a) and b)

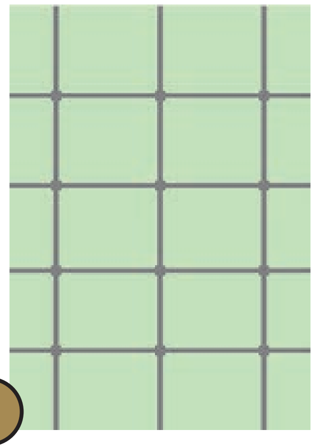
a)



b)



c)



a) Can be fitted in a relatively narrow corridor. 4,8m would be enough for the primary network of micro mobility in accordance with Gothenburg's bicycle plan. From a planning perspective, the difficulty probably lies in finding the continuous conditions for such a corridor

b) Requires a broader corridor, especially near intersections. From a planning perspective, the difficulty probably lies in always finding enough space for such a corridor, especially in urban environments

c) Relatively narrow corridor with many intersections could be used. From a planning perspective, the difficulty probably lies in limiting flow and speed disparity through such a corridor

Reflection traffic corridors

In order for diagram a) to work there should be few obstructions. It can therefore be placed in a scarcely built environment, such as a field, along a barrier (e.g. a river or highway), or be grade separated in itself. Since micro mobility also need to reach their end destinations, it is important not to neglect secondary and tertiary roads when attempting diagram a).

Diagram b) has the weakness of becoming a rather broad corridor, but in places where space is not a big restriction, or if the corridor doesn't receive high amount of vehicle flow, it can probably be a preferable solution.

Diagram c) doesn't have big speed disparity, for which restriction of speed and flows are needed, but it could however handle a high frequency of intersections. If flows with higher speeds are considered important, they should be placed away from here, while large vehicle flows on this type of road can be undesirable for noise reasons (many accelerations and retardations would probably be needed). For the primary micro mobility network a speed of 30km/h was said to be desirable (Göteborg, 2015), but the desirable speed for this solution depends on the kind of importance the road has for different modes of transport.

In the FÖP for the case study area, solution a) was suggested along the railway track, but hasn't been materialized. A clearer action plan would be needed to create it, but overall there actually existed several barriers for this solution to happen. It is neither in the area of the case study, or likely many other urban locations, easy to find uninterrupted corridors, so detailed studies and protection from documents further up the scale are probably needed if this kind of solution is suggested. A context analysis of the strategic documents would suggest grade separated solutions are expensive, since they seem to be beneficial but aren't always used. This could be explained with the difficulty in creating standardized solutions for grade separation in urban environments, that would give scale effects that can reduce costs. E.g. parametric tools could have potential in creating scale effects, but it is beyond the scope of this report to explore this. The message is rather that the planning process should take consideration in if it encourages innovation.

A different reflection is if alternative a) or b) was more preferable in the case study area to begin with. The solution for the case study intersection was done according to the characteristics of b). In addition to having the standards of a commuter bicycle network, that solution also provided better access to local destinations for micro mobility, in a quieter and probably more interesting environment than solution a) along the railway tracks would create. If also considering pedestrians, which the FÖP (Göteborg & Mölndal, 2016) and comprehensive plan (Göteborg, 2009) definitely did, the case study solution also gave the benefit of reduced speeds and thus noise, while also providing more space for pedestrians. This could be an example of what Gehl (2010) meant by that bicycles are a welcome support in creating lively, safe, sustainable and healthy cities.

Another aspect in the case study area, was the big addition of office space (Göteborg & Mölndal, 2016). Glaeser (2011) mentioned, offices benefit from having access to a large pool of workers, and since a large part of Gothenburg's region population doesn't live in the municipality (SCB, 2019), it could be expected that offices would want high regional accessibility. The new comprehensive plan (Göteborg, 2019) pointed out that the case study area, for which the FÖP was made, didn't necessarily have regional accessibility, but could see an addition of offices. The author believes this creates unclarity, especially as there is high regional accessibility through the motorized network. This is probably a fundamental problem for the entire FÖP, and something the comprehensive plan, a regionally scaled document, could probably have given better guidance in. More on how regionally scaled documents can support micro mobility solutions can be read in the region part (p 71). By assuming low vehicle dependence, but creating environments that probably promote vehicle journeys, it becomes unclear what transport strategy is applicable. This was the reason vehicle roads and station placement was shown in the case study, to better argue for lower traffic volumes along Mölndalsvägen, so that micro mobility could have enough space for good solutions.

Examples of how it shouldn't be

d)

e)

f)

d) It is not safe with a big speed disparity. Both the speed limit and the design of a street can contribute to this

e) Especially the primary network should be able to do speeds around 30km/h, and in this example the sidewalk doesn't fit that speed. This solution could be acceptable for the tertiary network, if the sidewalk was slightly bigger. But for the primary network, a change to either a), b) would be needed

f) Letting the primary micro mobility network go through slow walking pedestrians zones is not desirable as it doesn't meet the speed criteria. For the tertiary and lower network, to reach end destinations, it could be acceptable

The authors judgment is that the knowledge of what to do or not to do, existed throughout the planning process for the case study. What occurred in the case study area was rather an unfinished product of an unbundling strategy, a strategy that involves multiple modes of transport, and is therefore most properly decided at a stage where control of different modes can be made. The above mentioned examples could happen because of spillover effects of not working out the unbundling strategy for all modes. Not creating alternative for vehicles, in important network parts for them, can make it more difficult to transfer space from micro mobility to vehicles in existing traffic corridors. Creating urban environments that best fit a change in modal share in their corridors, without a reflection in the design and priority of corridors, hampers the potential of the change. That diagram b) and c) contained mix - mode traffic shouldn't be confused with them necessarily handling primary traffic of different modes. Not providing enough space for pedestrians can make them use the micro mobility lane instead, and take away the benefit of the created micro mobility lane. Different problems are best solved in different scales, the area scale shouldn't be forgotten, as by just working in it, opportunities to solve problems show up. Next will come examples of how an area scale strategic document can handle these aspects.

What can area scaled strategic documents do to support better conditions for micro mobility?

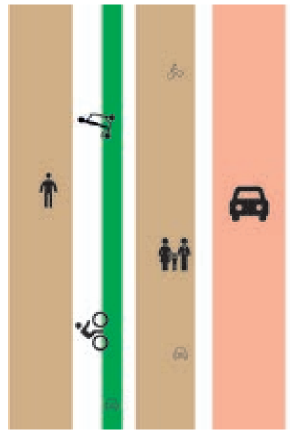
An area scaled document could be used to create the different transport corridors, and distribute and prioritize traffic among them, including for micro mobility. Tools include the size of corridors - land could be acquitted to increase and create them, unbundling the flows among the corridors and deciding prioritization for intersections. If there is a lack of space, limitation of flow or flow type is needed. The regional scale documents can give guidance in what it is most appropriate for an area.

Limit flow type or destinations

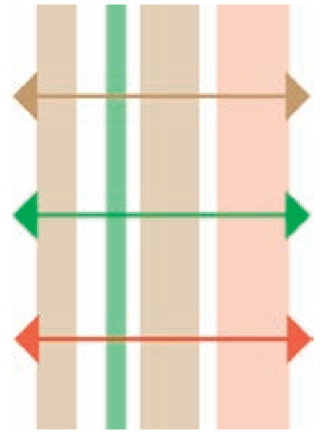
It has so far been observed that different built environments can support different transport solutions, and that space could become a limitation. To limit what type of flow enters an area, the modal share, or the amount of destinations, which is what generates traffic, could thus be tools to ensure that there exists good conditions for micro mobility in an area. The report suggests a clear guidance from regional strategic documents in determining where these tools can be used, as it is in that scale that most of the primary transportation network is set.

Unbundling and traffic corridor

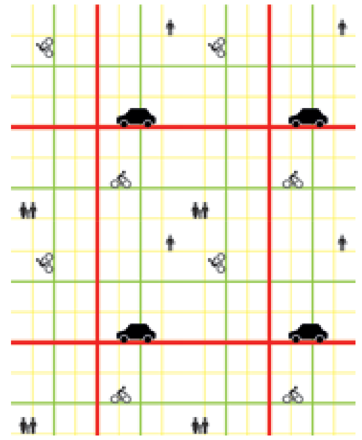
a)



b)



c)



a) The area scale can be used to decide the size and location of transport corridors and zones, and the priority within them. The most prioritized flows have ideally been identified in a more regional scale, here the task is more to find where to place it. For high speed flows the required dimensions are probably so demanding that it can be restricting moving it, but there are still likely many other flows to work with.

To have in consideration is if the corridors with assigned priorities can have positive or negative effects on each other. For instance noise can have a negative effect on the travel experience of micro mobility and pedestrians

b) Another aspect is how often, if at all, the different corridors need to be connected. Vehicles need more space for their corridors, but can also travel at higher speeds, while the opposite can be said of pedestrians.

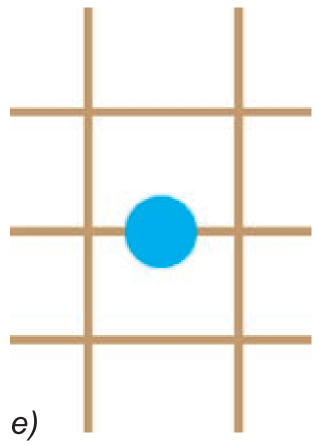
Designing these connections - intersections, is therefore of interest, as they showcase the priority. Location of inter modal change, stations and parking, can be a useful tool as well.

c) Unbundling can be used to redistribute flows to where the best conditions to solving them exists. Investing in vehicle infrastructure can in this principle contribute to improved conditions for micro mobility.

It is important that the respective priorities are respected. If not, there is a risk that different authorities loose trust in the whole strategy, which could be counterproductive. If vehicle road investments doesn't lead to better micro mobility infrastructure, it is not unlikely these investments will loose supporters. This principle could be applied to more modes of transport, and highlights the need of strategic multi disciplinary documents and plans to tackle these questions

d)

e)



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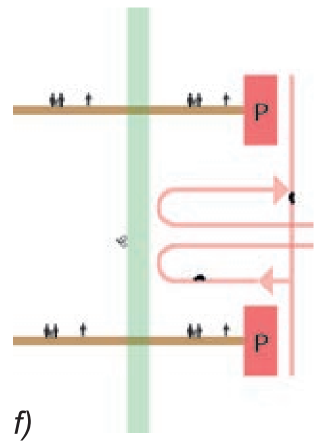


d) Intersection design should come from an area scaled document. It provides dimensions needed for traffic corridors, while also showcasing the priority. If the flows don't fit in the corridors, either a reduction of flows or new corridors could be created

e) Stations, which can be seen as an inter modal change, can be placed in the area scaled document. This gives an idea where pedestrians need to be most prioritized, and can create a more efficient public transit system - thus affecting modal share

f) Parking is another inter modal change. Its location can also be appropriate at an area scale, and can affect where different flows go

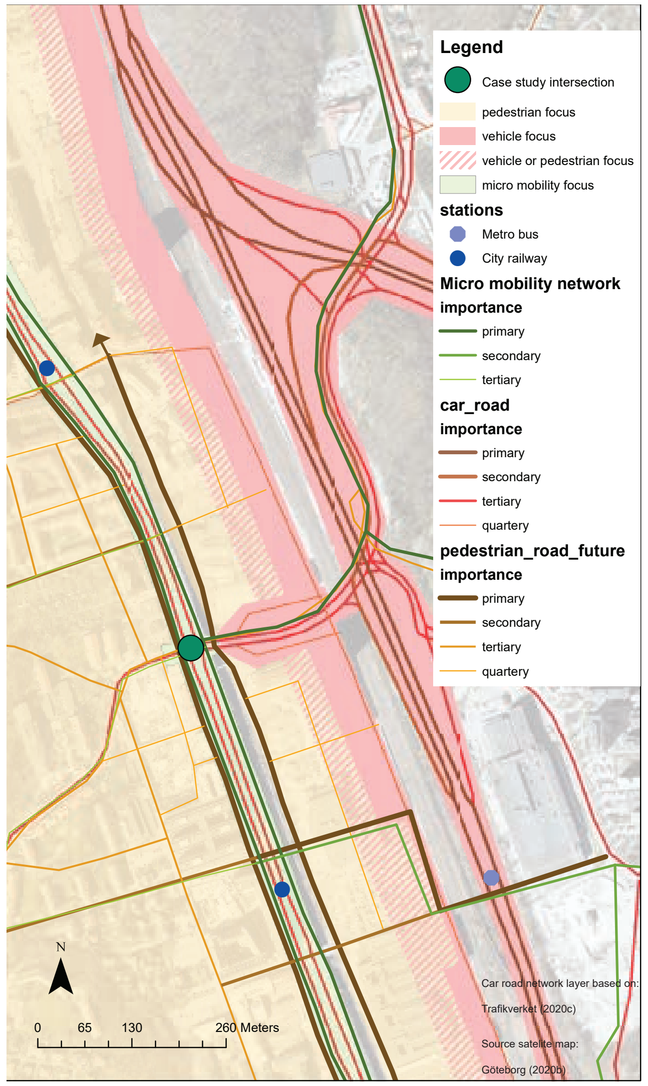
Example - case study

The land use map in the case study followed these principles. A new traffic corridor was created for vehicles, while unbundling was used to distribute flows along the different traffic corridors. Within the corridors there was a prioritization, and micro mobility got prioritized in one of them. Micro mobility and pedestrians have a higher frequency of intersections than vehicles, but intersections without vehicles also take up less space, which makes it easier to place them.

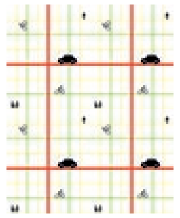
Station location was also decided in the case study, and thus implied were pedestrians should be prioritized.

Parking was placed to guide away vehicles from complicated intersections, and make people walk the final distance - through simpler pedestrian intersections.

The case study intersection is an example of intersection design that should be done at an area level, as it showcases the transportation ideas and prioritization of the entire area. By solving one of the most complicated points, the solution sets the conditions for the rest of the streets throughout the whole area.

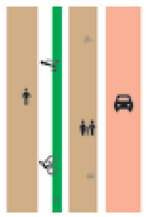


Prioritization and spreading of flows where made in the case study, which improved the conditions to create good micro mobility infrastructure

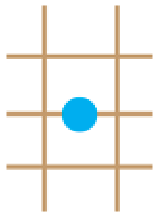


Unbundling was used to distribute flows in area

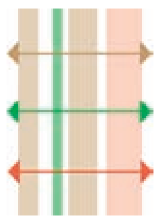
Intersection design that shows cases the priorities was done



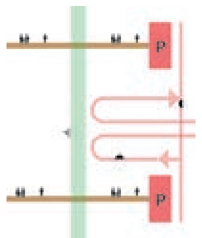
Transportation priorities were made



Station placement was decided



Consideration to frequency of intersections was made



Vehicle land use focus implied location for parking. Vehicle owners can walk the final part of their journey through simpler pedestrian intersections

Region

Summary of what was learnt

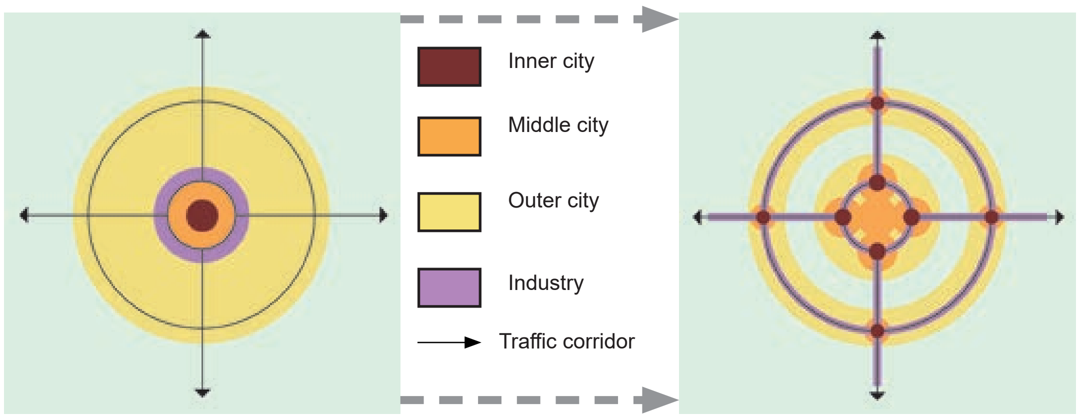
It wasn't clear what transport strategy should be applied in the case study area, or what modal share target was applicable there. The old comprehensive plan said the area would have strong regional accessibility (Göteborg, 2009), the new one doesn't (Göteborg, 2019). The new one does however state that offices will be placed in this kind of area (Göteborg, 2019), as did the FÖP (Göteborg & Mölndal, 2016). The transport strategy of Gothenburg seemed very focused on the 'inner city', which the case study area wasn't. The public transport plan mentioned a faster tram line and a metro bus which will pass close to the area (Västra Götalands regionen, 2018), but it didn't say where the stations would be. The case study area had high accessibility for micro mobility, and also for vehicles, but the transport strategy put a great focus on public transport as an important mode of transport (Göteborg, 2011), while the new comprehensive plan had walking as an increasingly large modal share (Göteborg, 2019).

Both theoretical and Case study background mentioned that different built environments appear to be in demand (Glaeser, 2011; Katz & Bradley, 2013; Göteborg, 2019; Göteborg & Mölndal, 2016; Business region Göteborg, 2018), and needed for regions to thrive (Katz & Bradley, 2013; Göteborg, 2019; 2016; Business region Göteborg, 2018). Gothenburg's comprehensive plan mentioned brown field development and densification as the tools for providing added supply of real estate (Göteborg, 2019).

In the area scaled feedback it was said that different built environments can have different optimal transport solutions, and it was therefore asked for a clearer guidance from regional strategic documents in determining the type of development of areas, based on infrastructure conditions. Since it is in this scale that primary flows are decided, it seemed in the area scale feedback that the regional scale would be most appropriate to address this issue.

What would have been desired?

In the case study a stronger connection between traffic and land use documents would have been beneficial, which could have guidance from regional plans. Each land use type should have had an own transportation plan, as they have different needs, and location of land uses would preferably be based on the transportation network. A context analysis of the theoretical background (Katz & Bradley, 2013) suggests that this differentiation is not only possible, but also preferable. With this in mind, it is believed it would have been easier to achieve the set regional goals in the more detailed stages. The following diagram illustrates the principal change that more transport oriented land use development would create:



A different, more transport connected, definition for city parts would create better conditions at later stages. Crucially for the case study area is that certain central parts wouldn't need regional connections, while others would. This will be described more in detail on the next page.

Limit of flow types

Given Gehl's (2010) ideas of human scale, and that it is difficult to properly fit certain flows in limited amount of space without doing potentially expensive grade separation, it is suggested that a built environment that doesn't have criteria for high regional accessibility, but has limitations on vehicle accessibility is created.

If there are limitations on vehicle accessibility, this type of area will probably have better conditions, than else, to support higher densities. Micro mobility could presumably have a high modal share in these kind of areas, and proper infrastructure to address this can fit because of the limit of certain flow types.

The location for these environments could be decided by a time distance to the regional parts using different modes of transport, such as walking and using micro mobility. Noted, that it isn't suggested that only old built environments can be built with this transport solutions, new ones could be created as well.

Comprehensive plans can think of exact definitions and what activities can be fitted here, but from the theoretical background it appears that this kind of environment can be used to create quality of life attributes which at least part of the creative class has demand for. While there will be work places located here, it is probably not the prime office locations in the region.

Limit of destinations

These built environments, which have potential to contain some of the ideas of the garden city, appear to be in demand. Fitting transport corridors, including for micro mobility, shouldn't be problem here since land prices are presumably cheaper, and because a limitation of destination creates a limitation of flows. This environment should have a different transport strategy and modal share target, than other city parts.

Limit of destinations - less strict pollution limit

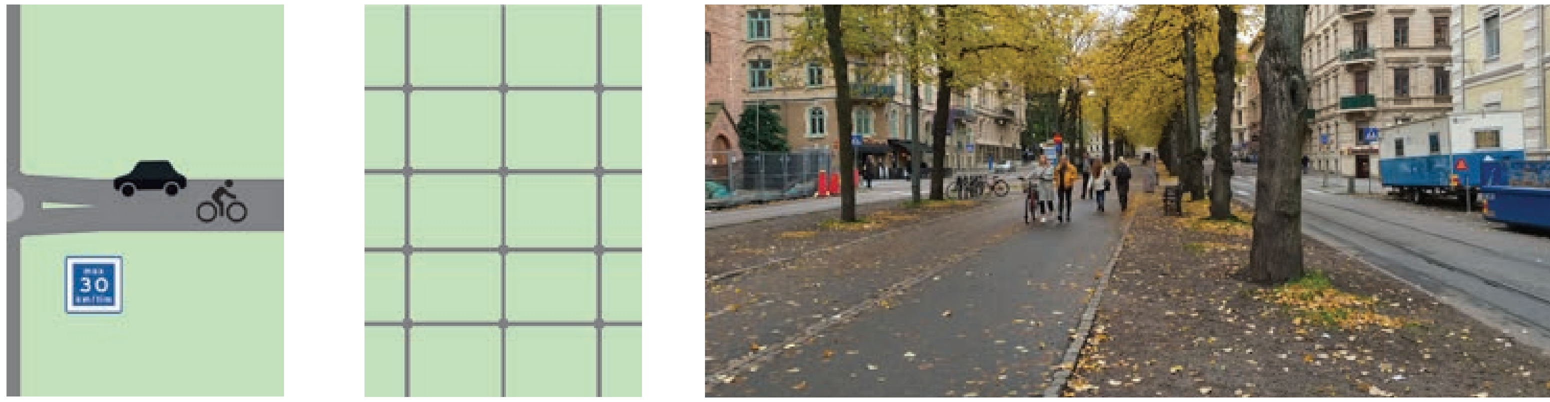
Here there is also a limit on destinations and not flow, but noise, and other types of pollution, could perhaps be slightly less regulated. Exposure to pollution can make these areas unfit for housing, but likely attractive for certain industries, as these areas are naturally placed near large traffic corridors, which creates high regional accessibility. What was important for the case study is that enough of this type of environment should be created in order to create liquidity in the transformation of city parts.

Regional

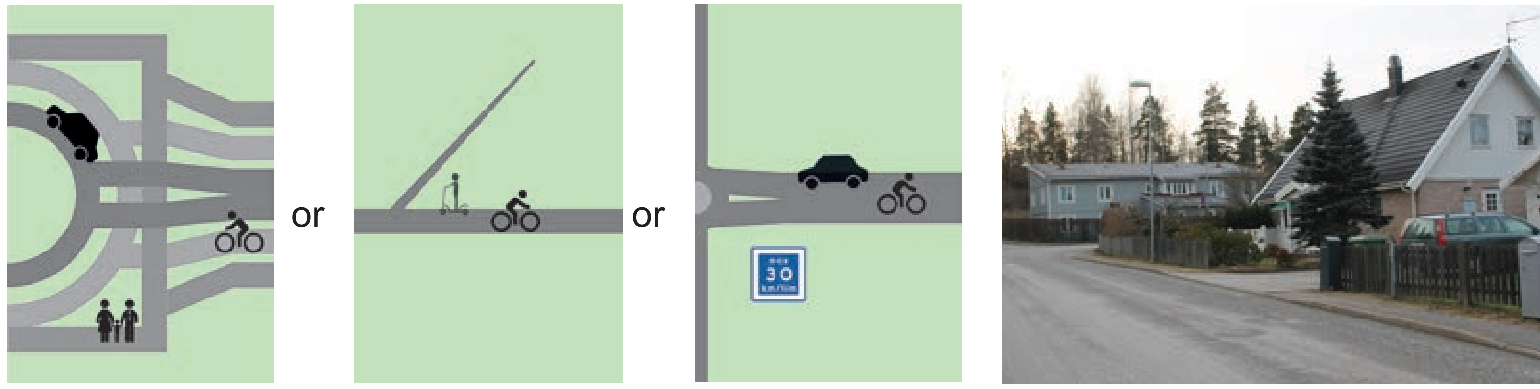
These environments should have the highest region accessibilities, and have high accessibility from both the limit on flow type and limit of destination areas. Likely, this is where creative offices want to be located, as it will be accessible to a large labor pool, that can live in different city parts.

This could potentially be the most difficult environment to create, as it is where people from areas with different transport strategies meet. Because of the complexity, there can lie great importance in saying where this type of area shouldn't be. Assuming this is where offices want to be located, great consideration of where this type of conditions are created, and what modes of transport create the regional accessibility is needed. Another way to frame this is that comprehensive plans shouldn't say that large amounts of labor intensive offices will be created in other city parts, as it can become difficult to create good transport solutions for that, not the least for micro mobility.

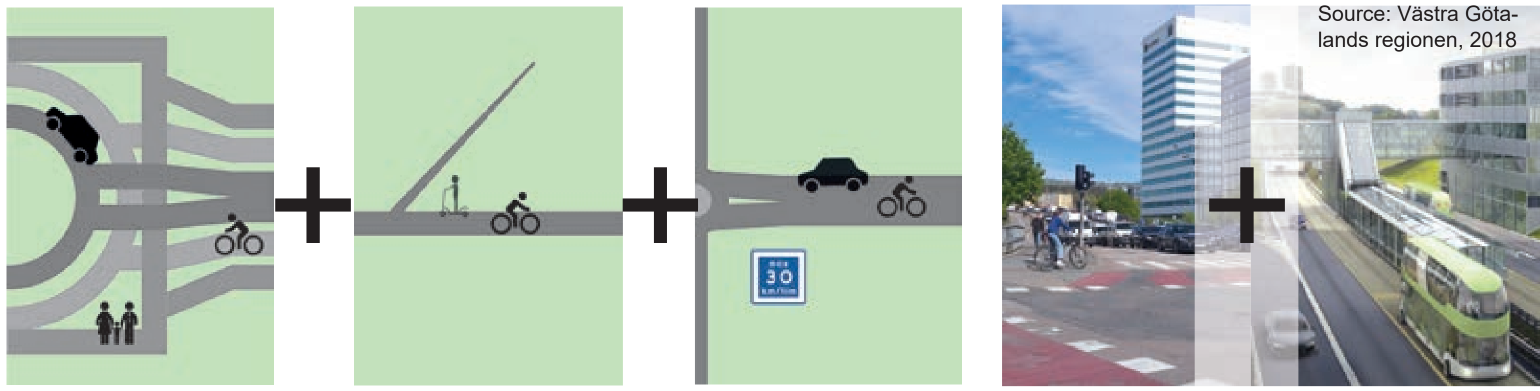
Ideally, here is where innovation districts are located. If they aren't, it should be asked why. In some sense it is believed the case study area is becoming this kind of area, and therefore the case study solution presents an example of a traffic solution for these kind of environments, while showcasing the problems created by not pointing out where this type of area is.



The limit of flow type areas can handle high frequancy of intersections, and could, from a transport perspective, potentially have high densities

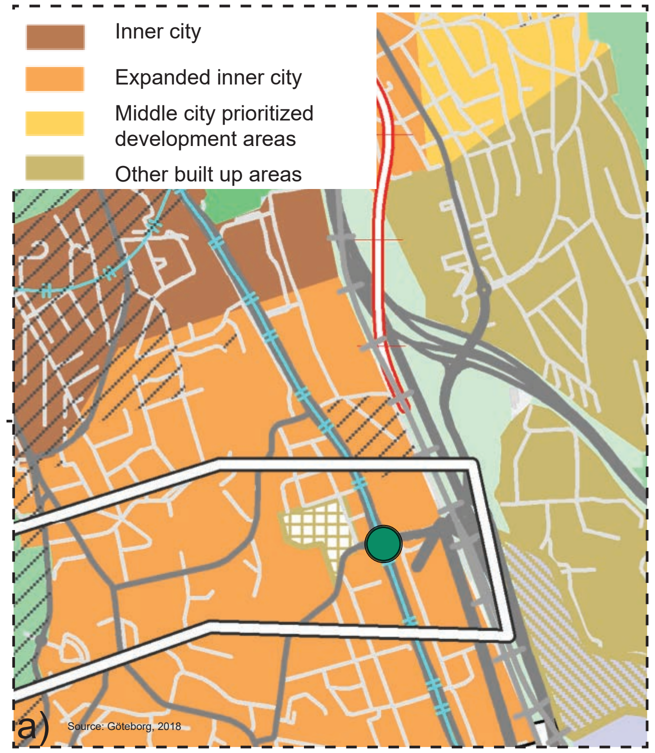


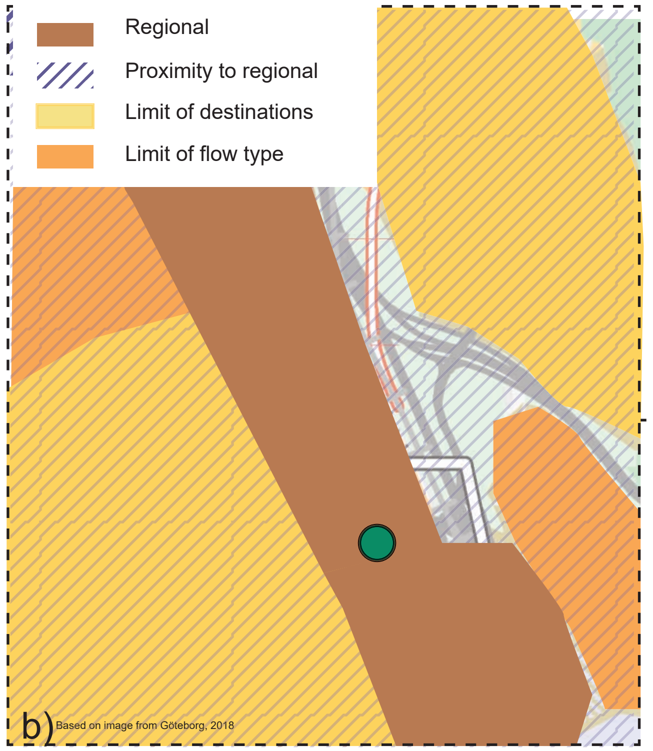
The limit of destination type areas can presumably have space for wide traffic corridors, while potentially having the possibility of fitting traffic mode separated roads. What is typically called industrial and suburban areas could be placed here



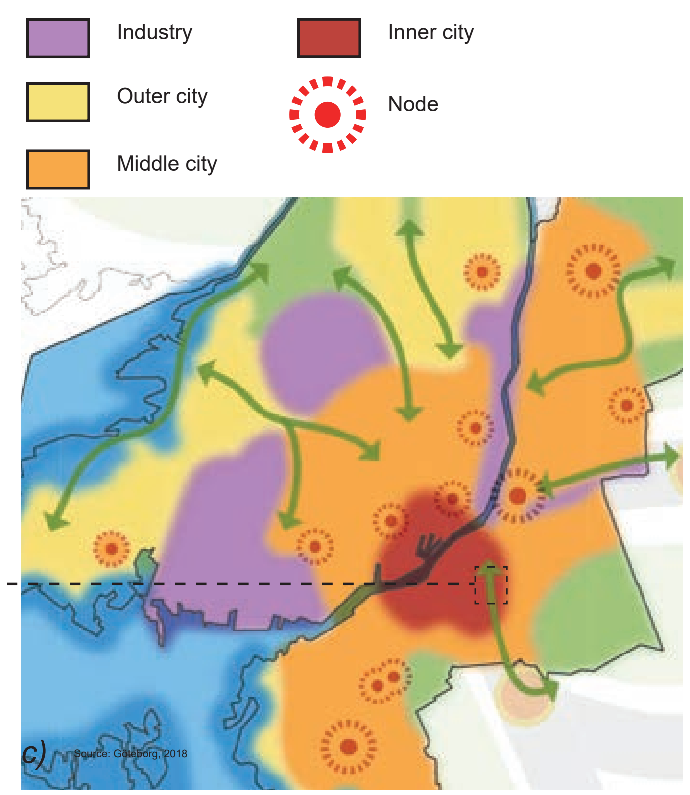
Source: Västra Göta-lands regionen, 2018

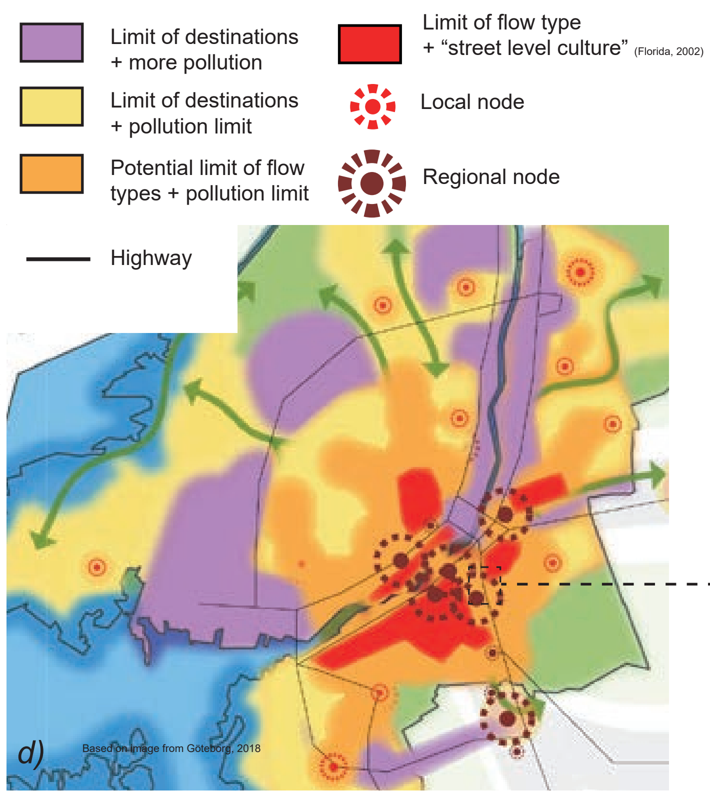
Regional land types are presumably the most difficult create, and are probably in need of some sort of grade separation



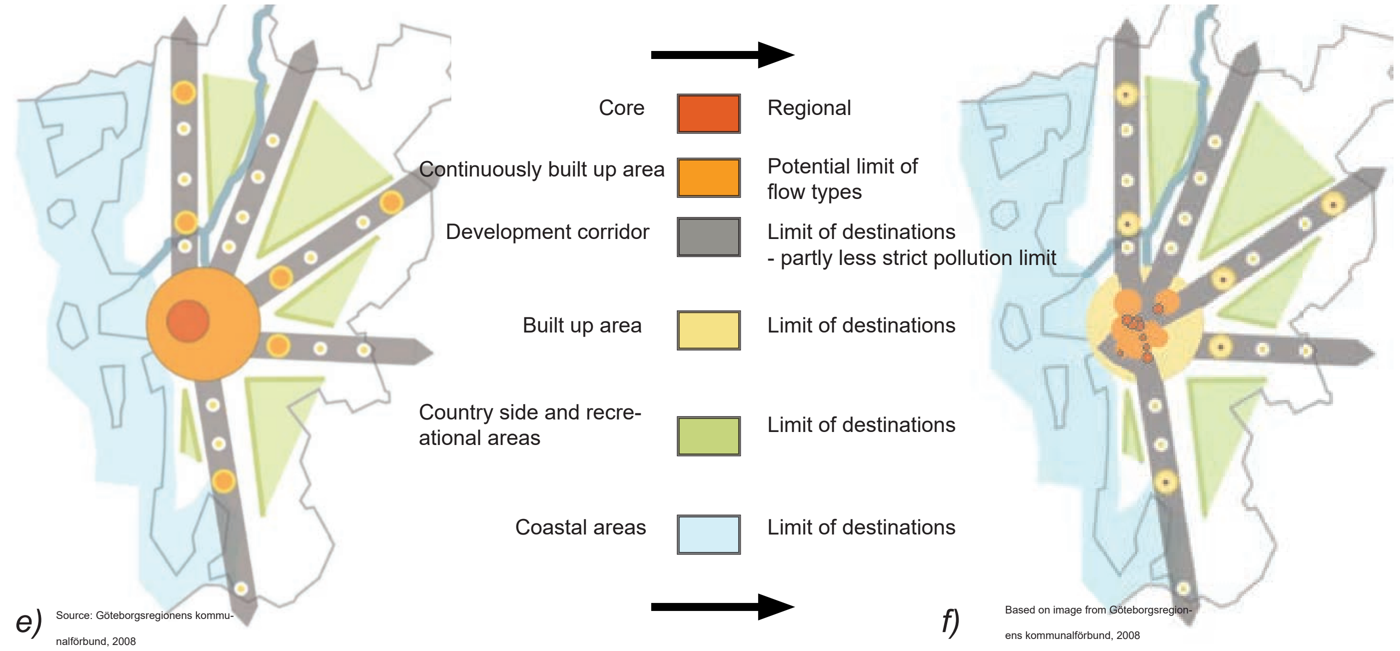


a) Zoom in of the new comprehensive plan (Göteborg, 2018) near the case study area. The different colors don't seem based on transportation accessibility
b) How a more transport based zoning for the area would have looked, dependent on access to different modes of transport





c) 2018 comprehensive strategy map for City of Gothenburg
d) Very rough sketch of how the suggested changes could be applied directly to the existing strategy map. Note that there isn't one land use concentrated only to the inner city, they are, and could be further, placed throughout the region. New industrial locations are needed for a liquid processes of urban renewal to occur, for which the municipality has excellent land reserves for, while some industrial areas should possibly not be transformed



e) Current regional structure plan (Göteborgsregionens kommunalförbund, 2008), that places big emphasis on the central core
f) Suggested change to a more multi nodal structure

The case study area isn't currently a regional area, even though its usage and growth potential suggests so. What is desired is hence a slight rethinking of the comprehensive land use strategy that is more transport based. Areas that have growth potential for offices should probably be part of the regional category, while other areas perhaps don't need to be. Layout of primary network and GIS network analysis could be good tools in determining what land use fits best where. Giving supply of all demanded areas is asked for, to create liquidity in their transformation, and to better argue for the different transport strategies. It becomes easier to argue for dense environments with less regional accessibility if there are also created areas with high regional accessibility and areas that are less dense. A regional perspective is probably the best one to decide area character, as mentioned several times in the *Case study background*, contribution from different municipalities was desired to meet land demand. In the end, the market decides what is desirable, but a comprehensive plan can create potential for areas that have different transportation conditions.

What can region scaled strategic documents do to support better conditions for micro mobility?

The report suggests that regional land use plans have a strong infrastructural base, and that there is a transport strategy, where micro mobility is included, for all different kind of land uses. It is important that regional plans become applicable for all areas, as otherwise there is a risk they become both less trustworthy, and used. Strong collaboration between transport and land use plans, and great consideration of what is and isn't best decided at this scale, could be used to increase the credibility of these plans.

An indication of what is best solved in the regional scale is what was previously mentioned desired. It was desired to know where primary transport corridors go, as they are regional, and the same could be said of other cross - regional dependent infrastructure. It was also desired to give guidance to area scaled documents if they should limit flow type or concentration of destinations. Aspects that weren't mentioned in *What would have been desired* give an indication of what shouldn't be solved in the regional scale, but of course a context analysis is needed to determine this for different regions and their specific conditions.

Ensuring that enough supply of all land use type areas is given is also important, both to give liquidity in the transformation of areas, and to ensure that the regional plans become applicable everywhere.

Reflection of feedback

The feedback written here was most applicable to City of Gothenburg, but probably many of the general notes could be applied elsewhere as well. That give of way intersections are preferable for micro mobility, or that different traffic corridors types require different amount of space, is not unique to Gothenburg. Neither is the notion that unbundling can be used as a tool, that an area scaled plan can be useful to solve certain problems, or that having different traffic strategies for different parts of a region is beneficial.

What is unique to Gothenburg are the exact dimensions and standards, the precise definitions or combination of problems needed to be solved, and the current tools/departments that can be used to address these problems. The feedback in this report has done several suggestions to the combination of problems that are specific to the city, or rather region, of Gothenburg. However, if a context analysis is done, the reasoning behind these suggestions could also be applied elsewhere.

Some of the feedback in this chapter relates to the gap in between planning documents, which could be explained by that they could be written by different actors. In the case of City of Gothenburg, there was both a municipal planning and traffic department, so if the assumption that *land use depends on infrastructure is held*, the question of what department holds what responsibility arises? The complexity of the matter could be further complex if different authorities deal with planning and traffic in different scales, e.g. if there is a special authority dealing with only national roads.

Overall, a hypothesis is that having different authorities and actors can lead to tasks becoming complex, not the least if they have to go through different types of bureaucracies. Bureaucratic issues could potentially be in the way of solutions happening even after common goals have been set. It should be kept in mind that the bureaucracy was likely put in place for a reason, and that it could be a tool to ensure standards are kept and that different considerations are taken into account for. With this being said it doesn't mean that there isn't room for improvement in the process.

There could exist misalignment of goals between authorities, and as seen in the feedback of this report, it is not possible to build everything everywhere. When there exist misalignments of interests, there arises a need for a tools to determine what to prioritize. Region and area scaled should optimally work with these tools, which could be easier said than done, as existing structures aren't necessarily divided by 'optimal' region and area scales.

A speculation is that there exists a scare of deciding too much in an out zoomed scale, as it could be difficult to come to an agreement and potentially lead to inflexibility in later stages. There probably does exist many regulations that shouldn't be decided in a zoomed out scale, something that should be held in consideration when working with region and area scaled documents. But that doesn't mean that nothing is best solved in that scale. Working with transport corridors, unbundling and area transport strategies is a clear example of this, it is likely very difficult, if not impossible, to solve it properly in more detailed stages.

The case study design showed that investments in new infrastructure gave potential to use existing infrastructure differently. That is, when doing fill in development, or densification, there could still be a need for new infrastructure. This new infrastructure could be used to kick start a process where existing structures are used more efficient. Having this in consideration, perhaps it could be valuable when using new urbanism ideas to have a smaller scare of investing in new car infrastructure, and instead have a bigger focus of where these investments should happen, and how conditions of other modes of transport could be improved in the process?

For City of Gothenburg to apply the feedback, their land use and transportation plans would both need to be clearer connected, and support a more diversified set of land use types. Misalignments of goals, bureaucracy and delegation of responsibility could be in the way for this, but if this would be done, a stronger base to create coherent solutions would be created.

Another feedback to City of Gothenburg was that the usage of area scaled documents should both increase, and have a clearer implementation plan. Once again there is a question of who should be in charge of this, Gothenburg's traffic or planning department? What is the easiest/most efficient thing to do, to make the traffic department more land use based, the planning department more traffic based, or integrating the departments all together? It is beyond the scope of this report to answer what would be most efficient, as there could exist a hurdle of bureaucratic/administrative issues affecting the answer. What this report rather has done is implying what should be done in some sort of area and region scaled document.

In order for City of Gothenburg to further improve their bicycle network, likely area scaled documents for all parts of the city would need to be made and implemented. Unless there is an increase in funding, these changes will probably take many years to implement.

Even if City of Gothenburg would apply all the suggested feedback, there is still the question of funding. The funding of strategic documents was beyond the scope of this report, but it is likely an important aspect to take in consideration. Since land use depends on access to transportation networks, it could be reflected in the financial instruments used to fund infrastructure. Having a stronger connection between traffic and land use documents therefore also has a role in ensuring that resources are used efficiently.

Conclusions - feedback

Many structural problems encountered in the case study would have been best solved in other scales, such as of an area or a region, although design scaled documents have a roll in exemplifying preferable solutions.

An area scale can be appropriate to dedicate space for transport corridors and decide the priority, between modes of transport, within them. Frequency and type of connection, between transport corridors, can preferably also be solved in an area scale, through placement and design of intersections, stations and parking.

If transport corridors and their connection can't handle expected flows, it is suggested that either a budget for grade separation is given, or a limitation of flow type or destinations is created. Guidance for which of these strategies is applicable where, can be given from a region scaled document.

In the case of Gothenburg, working more with area scaled documents, and giving them more power is highly recommended. A stronger infrastructural basis in Gothenburg's comprehensive plan is also suggested, to know where different transport strategies are applicable.

Questions for further research are:

- Definitions of land use types for strategic documents. From a transportation perspective, distance from cores and guidance if there should be a limit of flow types or destinations could be beneficial to include in the definitions
- Standardized safe intersection designs for micro mobility, the standardization could be different for different locations.
- What targets should be used in target led infrastructure planning?

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