SAFETY FIRST!

Planning for traffic safe bicycle paths to schools

Åsa Karlsson
Master's Thesis at Chalmers School of Architecture
Master's Program Design for Sustainable Development
Department of Architecture and Civil Engineering
Chalmers University of Technology
Gothenburg, Sweden, 2017

SAFETY FIRST!

Planning for traffic safe bicycle paths to schools

Åsa Karlsson
Master's Thesis at Chalmers School of Architecture
Department of Architecture and Civil Engineering
Master's Program Design for Sustainable Development

Chalmers University of Technology
412 96 Gothenburg
Tel: +46 (0) 31-772 10 00
Examiner: Meta Berghauser Pont
Supervisor: Henrik Markhede

CHALMERS
UNIVERSITY OF TECHNOLOGY

Abstract

The increase motorized vehicle traffic in cities has made many streets unsafe for children which has led to a decreased independent movability for them. Many parents are anxious and do not let their children cycle or walk by themselves in the traffic system. As a result, the number of children cycling on their own to school has decreased since the 1970s and is still decreasing.

The purpose of this thesis is to explore how spatial analysis and inventories can be combined and used as tools when planning improvements in traffic safety for children. Spatial analysis and inventories have been carried out for three primary school sites in Gothenburg to study the local surrounding street network. This has allowed traffic safety aspects to be included in the analysis.

The result show how a combination of spatial analysis and inventories can give a better understanding in studying traffic safety for cycling children. The spatial analysis showed the most important and frequently used streets in children's movement pattern when travelling to school in the neighborhood. A combination of this analysis and the traffic safety analysis made during the inventories made it possible to find out which streets are most relevant to improve in terms of traffic safety. Based on the analysis results, design proposals were created to show examples of designs with safe and accessible bicycle paths suitable for children.

The conclusion is that spatial analysis and inventories in combination are efficient for finding the most important streets and to identify the traffic safety weaknesses within the street network. The combination of the quantitative spatial analysis and the qualitative inventories give a broader and more in-depth analysis than if relying on one method only.

Acknowledgement

I want to thank my tutor Henrik Markhede and my examiner Meta Berghauser Pont for all the valuable input and help with the spatial analysis. I also want to my external tutor Tobias Nordström for input regarding bicycle planning. Thank you all that have supported me during the semester and Annika Larsson for proofreading my thesis. Finally, I also want to thank my parents that once taught me how to cycle.

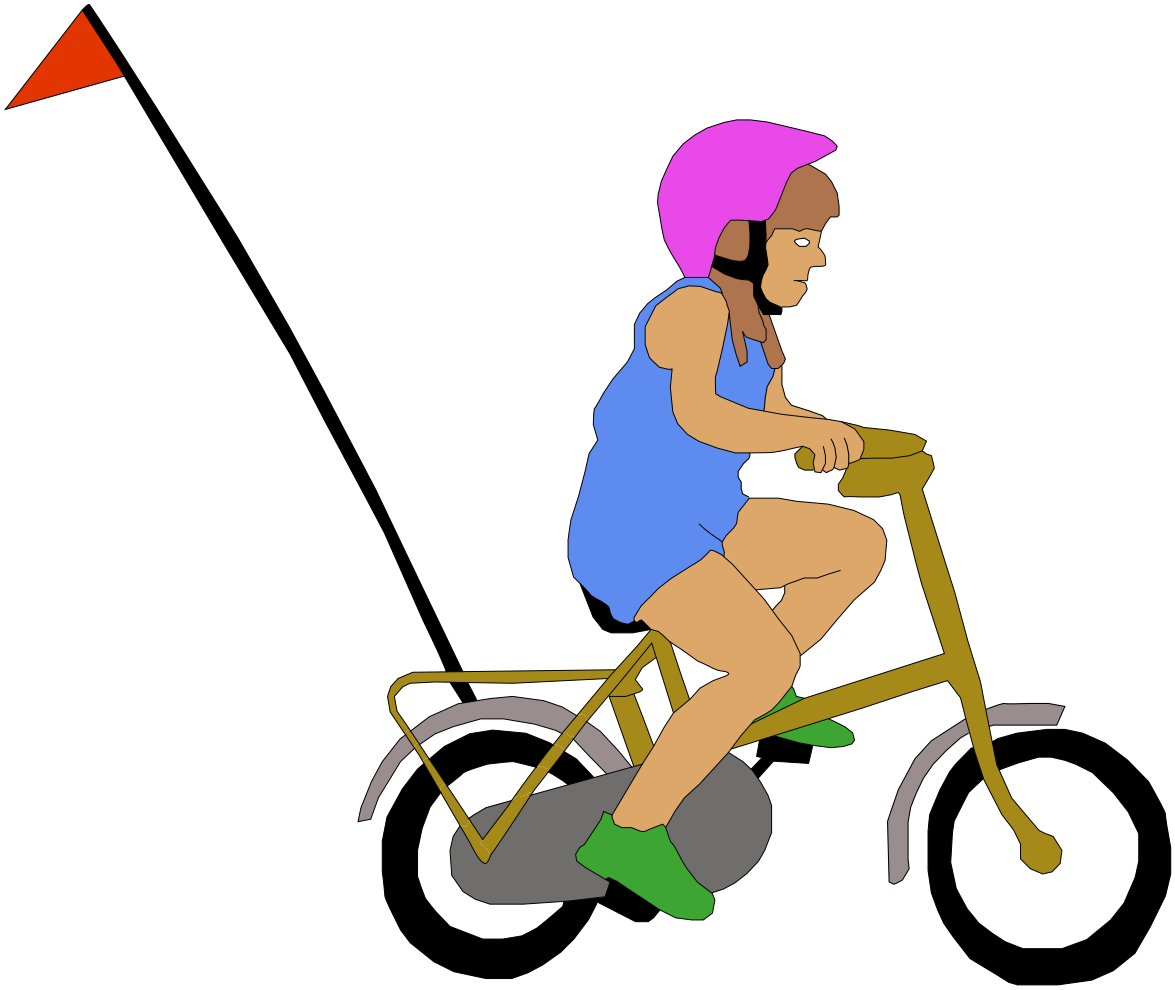


Table of contents

Part 1- Introduction

Problem Formulation

Today an increase in vehicle traffic causes several different problems in urban areas. For example it contributes to problems and issues such as global warming, air pollution and traffic congestion. Another problem that is closely connected to the increasing number of cars is children's reduced access to move independently in the traffic system. The risk injured in traffic when walking or cycling is higher for children than for adults (Johansson 2008:3). Children do not have the same preconditions as adults and therefore are more vulnerable. This means that they require special traffic safety treatment in order to be able to independently use the traffic system in a safe way.
All roads and bicycle paths do not meet the traffic safety standard to match children's needs. This limits children's movements. Therefore if only one part of the bicycle network is unsafe this will make the whole network inaccessible to children. Researchers have pointed out that children younger than 12 years old, in general, are considered traffic immature (SOU, 2012:169). In the long term limited ability to move leads to decreased physical and social health for children (Gummesson, 2007:47). The number of children killed on our roads has decreased in recent decades. However the reason for this development depends, according to several research projects, in very large part on the reduced independent mobility for children. Hence the decrease is due to children being less exposed to traffic rather than the traffic situation having become safer (Faskunger 2008B:21, Björklid 1992:7).

When studying children's possibilities to cycle by themselves to school, it is easy to see a correlation between the decreasing number of children that cycle and the increasing motorized traffic. The number of children cycling to school and other activities has decreased as the motorized traffic has increased. In the 1970s more than 90% of all children walked or cycled to and from school, in the 1990s this figure was around 77% and in 2006 it had decreased even further, down to around 58% (Faskunger, 2008:22,32). In Gothenburg, approximately around 33% of all children are driven to school by their parents. One of the reasons cited by parents for driving the children is the convenience of bringing the children in the car and then leave them at school before continuing to work. Nor the youngest children attending primary school are not traffic mature which means that their parents probably want to follow them to school, in most cases, if the way is traffic unsafe. That makes it even more comfortable bringing the children in the car. It is also more common that younger children (6-8 years) are driven to school. Another common reason is that parents experience the route to school traffic unsafe and therefore choose to drive their children (Göteborg, 2013:3,11, Broo et al. 2006:33, Trafikverket 2012:5). The increased amount of motorized traffic, in the city in general, and parents driving their children to school, in particular, are two of the reasons explaining why less children cycle to school today. When more parents drive their children to school it causes more traffic around the school and that, in turn, leads to even more parents driving their children, which creates a vicious circle. Many parents do not let their children cycle themselves because of the traffic situation around the school (Faskunger 2008:17, Faskunger, 2007:85-86, Gummesson, 2007:16).

To break the circle off fewer children cycling and more children being driven to school the parent's and their transportational behaviour also need to be studied. If the parents do not cycle to work it is more likely that the children do not cycle. Changing parents' movement behaviour, will also directly affect children's movement patterns. Even if parents take the car to work it would still have positive affects for their children if they first cycle or walked with them to school and then drive themselves to work. If more parents choose to walk or cycle with their children to school the area around the schools will also become more traffic safe.

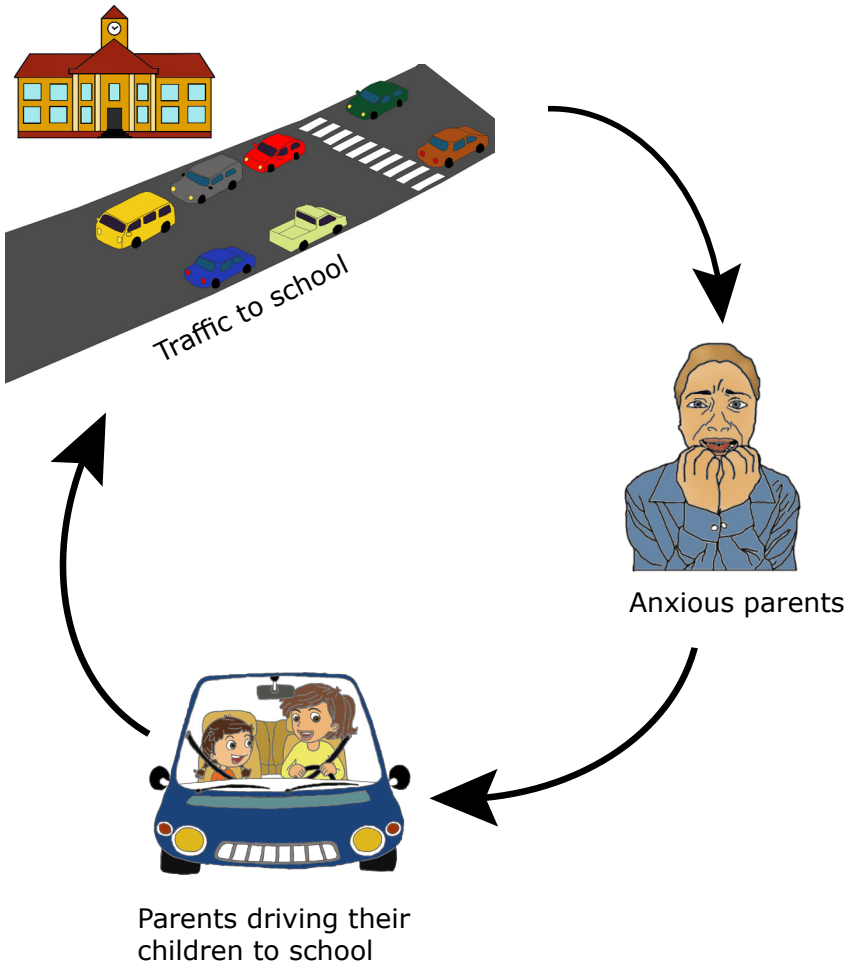


Diagram showing transportation circle

In order to change parents' behaviour it is important to make cycling accessible, comfortable and easy. This is something that is possible to change with spatial planning and physical design.

In order to increase the number of children cycling to school regularly, is bicycle planning need to be given more attention and children's needs have to be taken into account and focused on. One problem within the bicycle planning field is that there is still insufficient knowledge about how to create good and traffic safe bicycle networks and consequently increase the number of children cycling. To get a better understanding of bicycle planning, infrastructure planning and how the urban form affects it, it is necessary to do more research that is specifically focusing on cycling within the field. To some extent there is even a need for new methods and tools to be developed for making analysis and creating good bicycle networks (Hochmair 2009:1, Spolander 2006:11, Raford et al., 2005:527).

Purpose

The purpose of this master's thesis is to explore how spatial analysis and inventories can be used in combination when planning improvements in traffic safety for children. The purpose is further to combine this analysis and find out which streets are the most relevant to improve in terms of traffic safety. The results from the analysis will finally be tried out and exemplified in design principles.

Research questions

How can a combination of spatial analysis and inventories be used to find the most relevant streets to improve in terms of traffic safety? Based on Case Study in part 3.

What design principles can be used for improving traffic safety for schools in Gothenburg? Based on Research and Field overview in part 2.

Method

Introduction

In this thesis three different methods will be used. These are spatial analysis, inventories and observations. The methods are a mix of qualitative and quantitative ones. Three different methods are chosen to get a broader result.

Case study research

The research strategy used in this thesis is case study. Case study means that the thesis will focus on one or a few specific phenomena in order to do a more in-depth study of these specific themes. Different methods can then be used to study different perspectives and aspects of the chosen phenomenon. The characteristic of a case study is that it is only focused on one single research part. In a case study a general problem is studied through a specific situation or site. In this thesis, the specific focus will be to study children's possibilities of cycling safely to school. This will be done using the three different methods. Three primary schools in Gothenburg will be studied. The schools are Nordhemsskolan, Hjällboskolan and Hovåsskolan. The advantages of only studying 3 schools are that the study can be more in-depth. The results of this project can later be used to study the situation for other schools in Gothenburg or other similar cities. The result can not automatically be applied to other schools and streets connected to these schools as every school has its own unique location. This means that the road conditions of the school differ for each specific school site. The fact that the study and the analysis is unique to some extent is something that the researcher has to be aware of when making conclusions of the study (Denscombe 2009:59-62,65,68). The result of this thesis will be divided into two parts. The first part is a quantitative analysis result where the process of using spatial analysis when planning

for traffic safety for children is studied and developed. The second part is a qualitative analysis where this will be tried out in practise when creating design principles.

The focus of this thesis will be Gothenburg. Gothenburg is an interesting and relevant city to study because the municipality of Gothenburg works hard to transform the city into a more bicycle friendly city where a large proportion of daily transports is done by bicycle. In a number of different documents about bicycle planning in Gothenburg children's accessibility to a safe bicycle network is raised as one of the focus areas (Göteborg, 2012:96, Göteborg, 2015:9,39). Nevertheless, none of the documents have studied or specifically focused on children's accessibility to traffic safe roads to school.

Gothenburg municipality has also worked a lot with children's perspective for a number of years which makes a study that combines bicycle planning and planning based on children's needs interesting. The traffic situation has, when it comes to traffic safety and security in recent years, been considerably improved in Gothenburg and the city is a model for other cities. However, it is still relevant to study the traffic security for children and create design principles for how it could be improved since the work with traffic safety is still going on and will do until traffic deaths and injuries have been eliminated. (Göteborg, 2009:3, Göteborg, 2011:30).

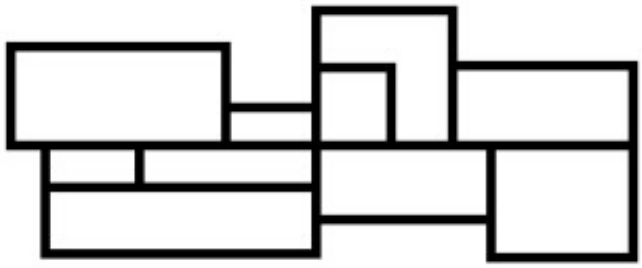
Spatial analysis

Spatial analysis is a generic term, within the spatial morphology field, encompassing different kinds of analyses. Spatial morphologies study the interaction between physical structures within the city area. They can be studies of density, block size and street patterns from many different aspects. Spatial analysis is a quantitative method where you can gather a lot of information about the urban form, how streets correlate with each other and how it correlates with different functions within the city. It is the complexity of the physical urban form that is studied. It is a wide concept. For the purposes of this thesis spatial analysis is analysis made within the urban morphology field. However, spatial analysis is also a theoretical model of human space, studying how spaces are structured, how they work and how they are understood (Hillier, 1996:27,70-71). These methods are used for analyzing and describing relations between buildings, areas between the buildings and the connection between buildings and functions. In this case spaces are seen as voids, for instance streets, squares, fields and parks (Klarqvist, 1993:1). Spatial analysis is made in a GIS-program, in this thesis Mapinfo has been used, where data is calculated in different ways. The data can be combined in different ways to make a different kind of analyses. In order to map and discover large scale patterns, like movements, within and through a city, spatial analysis can be used. It is possible to analyse large areas since the calculations are done with a computer. Within the spatial analysis field space syntax and place syntax are two different kinds of analysis which can be used both separately or in combination (Ståhle, 2005:147-148). In this thesis both space syntax and place syntax analysis will be used.

Space syntax theory and method were developed by the British researcher Bill Hillier, Julienne Hanson and their colleagues at The Bartlett University College London in the 1970s. Space syntax includes several different techniques and theories for analysing spatial configurations within urban areas. This means that it is possible to do many different analyses by using space syntax. The aim of space syntax is to describe how people move and use public spaces within urban areas. What makes it different from other spatial analysis methods is that within space syntax, the spaces in between are studied rather than the spaces themselves. It is not the actual roads and their functions that are studied, but the relations between the road elements. It is the sight lines, and how far you can see on a street, that are studied and not the street in itself. The most likely travel routes between two different areas can be captured, studied and analyzed (Hillier, 2005:484-485). The sight lines are based on nodes and the crossings between the sight lines are the links in the system. This means that the positions are reversed compared to other spatial analysis. The aim of reversing the positions is studying movement between different spaces to be studied rather than the distance between spaces (Hillier, 1996:65-72).

To explain the concept of space syntax Hillier and Vaughan (2007:213-214) have constructed a sketch showing a small street pattern consisting of a main street, a crossing street, side streets and some backstreets.

If we suppose that the target points within the street pattern are evenly



Source:Hillier and Vaughan 2007

distributed we can almost assume, just by looking at the street pattern, that the main street will be the most frequently used when people move to different target points within the street pattern. Intuitively one can also assume that more people will move along the central part of the main street, since that part is closer to other parts, than at the edges of the main road, and that less people will move along the backstreets. The main street is thus the most accessible and integrated street. How the movements to and through the street pattern are distributed is not a result of psychology, but rather of the construction of the street pattern and how it is put together. Every trip ends with a destination and on the way, we will pass a series of spaces. Locations that are located "nearer" to other locations within a specific radius will be more probable as destinations since they are more accessible. It might

not be clear which these locations are. This is what space syntax analysis measures and studies, especially for networks more extensive and complex than this simple example.

It is the number of, "steps", angular changes between two specific sites that is studied in a basic space syntax analysis. The number of "steps" needed between site A and site B describes how well these two spaces are integrated. Out from the sight lines a so called axial map is created and is used as the basis for the analysis (Hillier, 1996:65-72). From the axial map the different analyses calculate the most likely route between two sites. Space syntax is however the configurative system of space and how it is generally used by people. It is the relationship between the spatial configuration and the spatial behavior that is studied in the analysis (Koch, 2004:46). Studies have shown that the relationship between the road elements tend to illustrate how people move in the city. Analyses made using space syntax correspond with the observed flows of people quite well. It has been shown that 60-80% of the difference between a busy street and an empty street can be related to the structure of the street pattern (Hillier, 2005:484-485).

Place syntax tool (PST) is an extension tool developed by Lars Marcus, Alexander Ståhle and their colleagues at the architecture department at KTH in Stockholm in the 2000s. It is a GIS application and with this tool it is possible to calculate and include destination points like the attraction accessibility and attraction distance from one point to another. This can for instance be an analysis capturing the most frequently used streets between an address to a school. These analyses can be done if GIS data such as location of schools, shops or where people live is included in the analysis. This analysis will be a combination of space syntax and place syntax. The place syntax analysis means that a distribution of location points is included in the betweenness analysis which gives a street that is integrated and have many location points a higher value in the analysis than an equally integrated street that has less location points. When more aspects are included in the analysis the results will be more exact as standard space syntax analysis only takes into account street patterns and how different axial lines are connected. (Ståhle, 2005:147). By combining space syntax with place syntax different location points can be included in the analysis and the analysis will also show the accessibility of certain attractions, in the network, and not just the accessibility of different public spaces (Marcus, 2006:4-5). The possibility of combining space syntax data such as axial lines with GIS data makes the place syntax tool unique. It also adds another perspective to the spatial analysis (Ståhle, 2005:147).

Spatial analysis as a design method

To be able to carry out traffic safety analysis within the field of urban morphology the method has to be developed. Spatial analysis cannot answer questions about traffic safety in itself. Since the different parameters of traffic safety are not captured by the space syntax and/or place syntax analysis these parameters need to be registered manually to be included in a spatial analysis. The parameters included are, for example, speed limitations and the presence of separate bicycle paths. In order to do an analysis where traffic safety is included a definition and categorization of what traffic safety is and a definition for each street have to be established. This is possible to do by including material from inventories in the process which means that more data regarding traffic is included in the analysis. The traffic safety is then analysed based on the criteria set. The point of developing this analysis method is to try out an alternative method for planning for traffic safe bicycle networks.

The analysis will be used to study the traffic safety for routes to schools in Gothenburg, both on an overall level and on a detailed scale level. The analysis will be used to assess how safe or unsafe it is for children to cycle to school. Several different kinds of spatial analyses studying different aspects will be done to get as broad a picture as possible of what streets are the most integrated ones and what streets are the more problematic ones. The existing situation will be studied, as well as the potentials and what effects streets can have for the improvement of the bicycle network. This analysis will be done both on a local scale and on a global scale for the whole bicycle network in Gothenburg. It is relevant to do place syntax analysis as the schools and their location within the street network is the focus and therefore it is interesting to include the location of the schools in the analysis. As GIS data over the population is available for the municipality it is also possible to study where most children live and how that differs between areas. This information makes it possible to analyse which road is most likely to be used by the largest number of children will pass on their way to school.

It is interesting to do this kind of analysis within the field of urban planning as spatial analysis makes it possible to combine large amounts of data and statistics . It is possible to combine a lot of different types of data. For example, traffic safety can be combined with information on the flow of children and basic space syntax analyses showing the streets that are the most integrated and the betweenness in the network. It is the combination of different parameters that is the interesting aspect of spatial analysis. It is possible to handle large amounts of data in the analysis since calculations are done with the help of a computer. The same analysis would be hard to do manually. A possible disadvantage of using GIS data is the risk of the data being inadequate and therefore not producing appropriate results. GIS data can also be expensive to produce (Ståhle, 2005:133-134).

The purpose of this method is to exemplify how to study traffic safety by combining the use of spatial analysis and inventories. The combination of two

different methods, quantitative and qualitative can give a better understanding of how to create a physical plan for traffic safe bicycle paths for children. The analysis will show where to invest and where there is potential for the biggest changes for as many children as possible. The intention is to then see how this analysis best can be used for improving traffic safety and accessibility for children to safe cycling in the traffic system to school.

Tornberg (2012:21) states that it is unusual to combine qualitative and quantitative methods within the transportation research field. The reason for this is a lack of theoretical models that make it possible to combine these two approaches. As a result, many research studies choose to just focus on one approach. Still there are some researchers trying to combine the qualitative and quantitative approaches to broaden the picture and include more perspectives. However, the benefit of using both approaches is that it gives a broader base for conclusions. One explanation for most bicycle studies mainly being based on qualitative methods, such as cyclists' experiences may be the lack of developed quantitative methods. At the moment only a few studies have looked at the correlation between urban morphology and cycle flows (Raford et.al, 2005:527). A study made by Manum and Voisin (2010:7) states that spatial analysis in combination with qualitative aspects gives a broader result and a better understanding of people’s travel behavior than just using qualitative methods.

The quantitative part, in this thesis, will be used for the overall perspective and the fixed structures, such as street patterns, the address points where children live and the location of schools. The qualitative part will focus on more detailed aspects, such as the look and feel of a specific crossing, the vegetation and other aspects of the studied school sites. The results of the qualitative and the quantitative parts will then be compared to broaden the perspective and get a more diverse analysis. While the quantitative aspects of the spatial analysis give the criteria for the systematic measurements and the values of the analysis, the qualitative aspects give criteria focused on feelings and behaviour and help to value and interpret different results from the analysis. The conclusion from the analysis will be the basis for the final design principles.

Observation

Observations will be made in the direct connection with the three schools selected. During the observations, the number of children cycling, walking and driven to school in the morning was studied and counted. The exact numbers will not be possible to obtain and study since the schools have several entrances and all children do not start school at the same time. It will not be possible to observe all children, but the observations will provide an overview and an understanding of the current travel situation of the schools. The number of bicycles parked at the school will also be counted. The observation will make it possible to estimate how many children cycle to school. Observation will be used as a complement to the quantitative spatial analysis to get a better overview and understanding of the existing situation.

Inventory

The inventories will be done in the same areas as the observations. Inventory refers to data gathering, which in this case is information about traffic safety. The collected data will then be processed and analysed. For the inventory, a specific inventory checklist will be created where all the parameters to be studied are included. Inventory is an uncomplicated way for the researcher to gather information needed to make an analysis and reach project goals. A traditional inventory is based on direct observations made by the researcher. The purpose of the inventory is to obtain information and an understanding about the site first hand. It is the only way of getting information about the look and feel of the site. An inventory checklist helps the researcher to structure the inventory and study the same things on the different inventory locations (Denscombe, 2009:151,271). Only the streets will be studied during the inventories. Some of the parameters from the checklist will not be possible to gather through the inventories, but that information can be gathered from GIS data and the information from the municipality.

Inventory checklist

Cycling along a road, considered meeting traffic safety standards for a 6-year old if:

1. <30km/h and not more than 4000 transports/day (ÅDT) (Yearly day traffic)

2. >50km/h with a separate bicycle path

3. <50km/h physical distance between the road and the bicycle path

Crossing over a road (Speed limit), considered meeting traffic safety standard for a 6-years old if:

4. <30km/h in mixed traffic, acceptable lighting

5. 30-50km/h with a separate bicycle path, acceptable lighting, speed bumps (or similar)

6. <50km/h there is a flyover and no shortcut close by

Crossing over a road (traffic situation), considered meeting traffic safety standard for a 6-years old if:

7. There are not more than 4000 transports/day (ÅDT) (Yearly day traffic)

8. Not more than 2 traffic lanes/ both directions

9. The cross over is clear and there are places for waiting on each side

10. Children and vehicle are clearly visible to each other

Other risk factors, ***Not*** considered meeting traffic safety standard for a 6-years old if: traffic safety if:

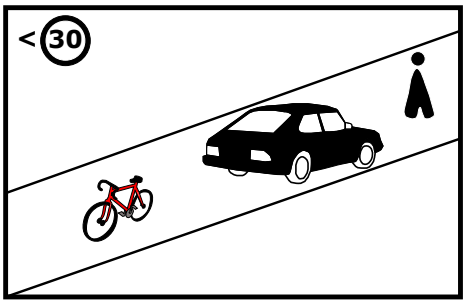
11. If the situation (for some reason) requires extra attention from the driver and less focus can be directed to cyclists and pedestrians. Example: roads with a lot of traffic, roads with many information signs,

12. Places where children can be interested in something in the surrounding.

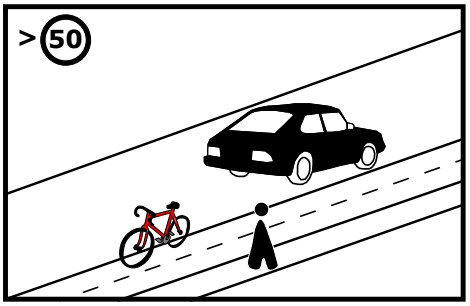
Example: playgrounds, creeks, plashes, other things that invites for play
The result from the inventories will be included in the spatial analysis and then studied through computer based analysis. The material will also be analysed qualitatively. In order to include and capture the safety aspects in the spatial analysis it is necessary to gather the material through inventories. For the qualitative analysis, the roads around the schools will be assessed based on the impression of how they look and feel.

Inventory and observations have been picked as methods to complement the quantitative spatial analysis method. They also allow a qualitative study of the of the site in reality and in detail. Using a combination of qualitative and quantitative methods will allow getting a broader picture and finding where there are problems within the street network and then zoom in and in more detail and qualitatively study that specific sites (Denscombe, 2009:271).

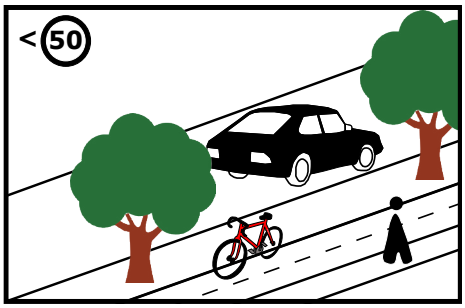
Traffic safety standard, considered meeting traffic safety if:



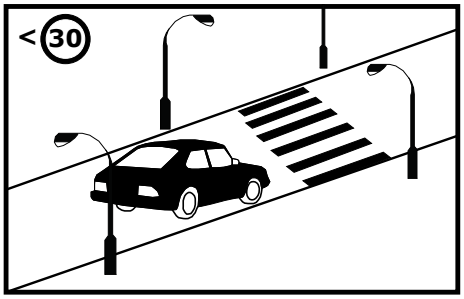
1 <30km/h, mixed traffic



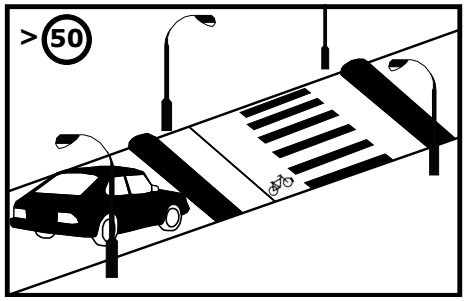
2 >50km/h, separate bicycle path



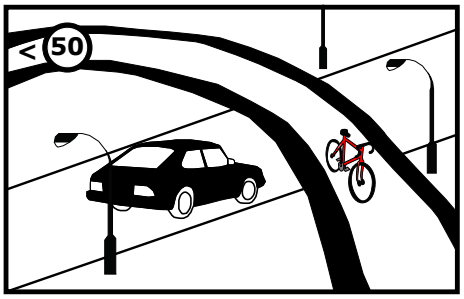
3 <50km/h, physical distance between the road and the bicycle path



4 <30km/h in mixed traffic, acceptable lighting

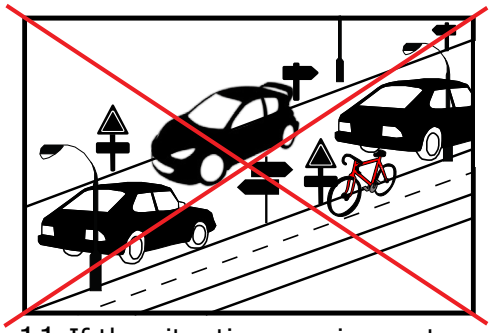


5 >50km/h with a separate bicycle path, acceptable lighting, speed bumps (or similar)

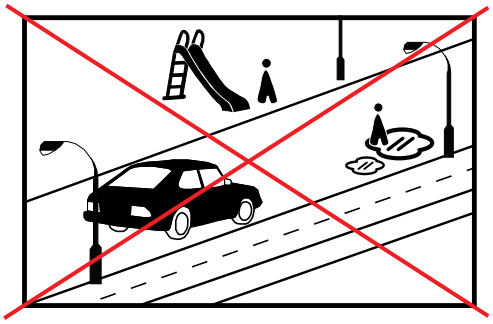


6 <50km/h there is a flyover or tunnel

Other risk factors, *Not* considered meeting traffic safety standard if:



11 If the situation requires extra attention from the driver and less focus can be directed to cyclists and pedestrians.



12 Places where children can be interested in something in the surrounding. Example: playgrounds, creeks or plashes.

Delimitations

The thesis will only focus on traffic safe bicycle paths to schools for primary school students aged 6-15. This age group will also be the definition of a child in this thesis. In the overall analysis, all primary schools in Gothenburg will be studied, both public and private. In the detailed analysis only three chosen public primary schools will be studied.

However, all schools in Gothenburg will be studied, on a general level, through the spatial analysis. The design principles will nevertheless be based on the analysis done for the studied school areas. The design principles will work as examples of how improvements can be done and how these improvements further can affect children's accessibility to safe bicycle paths to schools in general.

The real catchment-area for the schools will not be taken into account. The catchment areas for the schools studied might be different from the studied area of 1km. Children living in the areas might also go to schools other than the studied, but this will not be considered in this thesis.

Furthermore, existing and ongoing plans to connect the bicycle network made by the municipality will not be taken into consideration. The thesis will not discuss how to proceed in order to influence children's attitude to bicycles and cycling and economical aspects will not be considered. There will be no focus or discussion on how to define traffic safety for children, instead already known definitions will be used. Only the physical differences between the three school sites will be studied and compared and no other aspects like socio economic differences or the number of children living in the areas will be taken into account.

Part 2- Research and field overview

Introduction

The following chapter presents an overview of perspectives on cycling as a means of transport and children's access to the city as presented by research, authorities and municipal documents. To explain what the analysis is based on it is relevant to summarise the theories and research that have been studied. Research about bicycle history gives an overview of how we have looked upon cycling in a historical perspective. Children's access and relationship to individual streets and the city as a whole is also studied to get a better understanding of today's problems. Children's physical access to the surrounding environment and society is a popular research subject and many studies within this field have been made. It is a broad field and it is possible to study children's accessibility in many different ways. Since the focus of this thesis is children's possibilities to cycle to school the starting point is to study children's existing access to the street network and how bicycling affects children, both physically and mentally. These parameters will be the base for the case study in the project. The theoretical starting points and the research that is the base for the case study are described below.

Bicycle history

The bicycle was invented in several steps and in different places at the same time. The first patent for a bicycle was registered in 1818. This bicycle did not look like the modern bicycle, it had no pedals or chain (Johansson

et al., 2016:8). In the late 19th century the bicycle was mostly seen as entertainment for wealthy people and not really as a means of transportation. However, this view changed in the early 20th century and bicycles were then seen as a way of travelling for everyone. Sweden had a large number of cyclists and in 1936 one out of three trips were made by bicycle. During World War II the bicycle was still a common means of transportation partly because of the limited supply of gasoline. After the war the number of cars rapidly increased and as a result the number of bicycle trips decreased (SOU, 2012: 79-80). In the 1960s car use became widespread in Sweden. As a consequence, streets became dangerous and unpleasant for cyclists and pedestrians to use (Jägerhök et. al, 2011:9). Ever since then cycling has decreased in favour of cars. The number of cyclists in Stockholm decreased from 35% in 1939 to 0,8% in 1970 (Gullberg et. al, 2007). It is still hard to tell if the total number of cyclists nationally has increased in the last years as there has not been a national survey about people's travel habits since 2005/2006 (SOU, 2012: 79-80). However, some surveys state that the number of cyclists has increased in the last few years. For instance, Jägerhök et al. (2011) claim that the number of everyday cyclists in Stockholm has increased by 80% since the beginning of the 21st century (Jägerhök et. al, 2011:9). In 2008, approximately 10% of all transports in Sweden were made by bicycle, but there is no data to give an overview of the changes over time on a national level.

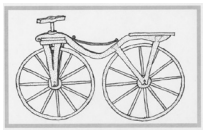
Bicycle today

Nowadays bicycles are seen as one of the solutions available for decreasing traffic congestion in cities as well as decreasing air pollution and emissions caused by vehicle traffic. There are political visions and goals for bicycles that deal with the positive aspects of an increased number of cyclists. A national goal has been set which wants to increase the number of cyclists, especially on trips shorter than 5km (SOU, 2012: 117,127, Faskunger,2008:11,25). There has been an increased interest and focus on bicycles and the development of the bicycle infrastructure in the last few years. Cycling is now an important part of general traffic planning and a lot of attention is given to different bicycle documents and research projects. The questions are often focused on making the bicycle infrastructure more accessible, safer and more comfortable. The increasing interest is closely connected with the increased focus on climate change and the question about how bicycles can replace cars in many situations to create a more sustainable future (SOU, 2012: 147-148, Faskunger, 2008:11).

Bicycle history timeline

Cycling makes a real impact in Sweden. The new car roads make it more comfortable and secure to cycle. The streets in Stockholm consist of 70% cyclists.

Cars take over the streets. The economic situation is better and cars are seen as the future. Bicycles are not needed.



First patent for bicycle, a so called Draisine or velocipede. The bicycle has no pedals or chain.

The safety bicycle is developed. A modern bicycle with 2 wheels the same size and a chain.

Sweden is the country in Europe with the highest number of cars relative to population.

1818 — 1870s — 1885 — 1920 — 1930s — 1939-1945 — After 1945 — 1950s — 1952

The high-wheel bicycle is invented.

The first children's bicycles are produced

The peak for bicycles in Sweden. Gasoline was rationed during the war which limited car traffic and public transport. 90 % of all vehicles in Malmo are bicycles.

Traffic injures increase and the number of people killed in traffic doubles during this period.

Stockholm city begins to build bicycle paths, yet only 1 % of the inhabitants of Stockholm cycle. This period is the lowest point for cycling in Sweden.

A turning point for bicycles. Politician and urban planner start giving space to cyclists.

Electrical bicycles, with a speed up to 25km/h starts getting popular.

By law children up to 15 years old must wear a bicycle helmet when cycling.

1960s — 1970s — 1971 — 1980s — 1990s — 2000s — 2000-2007 — 2005 — 2015

The development of traffic separated roads (SCAFT) for different types of vehicles causes a decrease in the number of traffic casualties.

400 children are killed in traffic accidents.

Politicians start talking about health and environmental benefits of cycling.

In Gothenburg 6 cyclists are killed in traffic.

7% of all transportation in Gothenburg are made by bicycle

(Johansson et. al, 2016:12, Everett C. 2016:10-20, Naturskyddsföreningens cykelnätverk, Göteborg 2009C:23, Göteborg 2015:45)

Children's rights

It is both important and interesting to focus on a child's perspective when planning for bicycle paths. Since children do not have the same preconditions as adults, they need some extra safety measures when it comes to traffic planning. This is one of the reasons for focusing on children's needs (SOU, 2012:169). Nevertheless, children are part of society and according to the UN: s convention for children's rights (UNCRC), which Sweden has signed, children's best interests should be kept in mind when developing society. UNCRC was founded in 1989 and is a special convention for children under 18 years old focusing on human rights of children. On an overall level, it means that children's civil, cultural, economic, social and political rights should be ensured. In other words, the convention states that society should be developed so that children can be safe and have their rights to the city. In particular, articles 3 and 12 are connected to urban planning. Article 3 is about planning according to the best interests of children and it considering these when making decisions. Article 12 is about showing respect for the views of children and giving them the right to state their opinions (UNICEF, 2014). The UNCRC is one reason why it is important to include children's perspective when planning for future cities. It also means that it is relevant to include children within the planning process. When including children in the process they can state their opinions and tell the planner what they need and how they view things. Without doing this it can be hard for planners to picture children's needs.

Accessibility to the traffic system

A study of six Swedish cities (Alingsås, Säffle, Helsingborg, Trelleborg, Luleå and Umeå) showed that around half of children do not have a traffic safe route to school. For children walking and cycling the number was even lower. In Alingsås, which was the most secure and traffic safe city, just over 30% of all children had a secure and traffic safe route to school. The worst situation could be found in Säffle where only 2,7% of all children had access to a secure and safe route to school (Faskunger, 2008B:26, Faskunger, 2010:23). Even though the study only focused on six different cities it still gives an overview of the traffic situation for children living in Sweden. A large number of children do not have a traffic safe route to school. These numbers can differ a lot between different areas within the same municipality. The traffic situation of an area is affected by the kind of building typology, how close to the city centre the area is and how large the catchment-area for the schools are. A study made in 1985 showed that children's independent mobility varies according to the kind of area they live in. 95% of children between the ages of 7 and 9 living in traffic-separated areas were allowed to walk by themselves to school. In an area consisting of single-family houses, the same number was around 80% and in an inner-city area the figure was only about 50% (Trafikverket, 2013:12). These different kinds of areas are the same types of areas studied in this thesis. This does not mean that the figures from the study exactly describe the situation.

Physical activities

Children's independent mobility, in general, has decreased in the last decades. A project that studied children's possibilities to walk or cycle independently to school or other destinations such as playgrounds, parks, stores or libraries done in the 80s showed that almost all children between 7 and 9 years old were allowed to walk or cycle independently. When this study was repeated 20 years later, the proportion was two-thirds. In 2012, the study was done once again and by then the figures had decreased even more down to less than half of all children. The reason for the decline is partly car traffic, parents' worries and the lack of traffic safe bicycle and pedestrian paths (Boverket, 2015:20). In a survey about children's traffic safety made by Vägverket (Swedish transport administration), 45% of parents stated that they experience their children's route for walking and/or cycling to school as traffic unsafe (Broo et al., 2006:15).

Children walking or cycling to school

Children drived to school

Sources:
Faskunger J. (2008)
Trafikverket (2012)

This means that children do have a more limited space in which to play and it also means that children are not able to discover and experience their surroundings by themselves. When children have to play in a smaller area they become more sedentary which in turn contributes to negative physical and phycological impacts. Less freedom for children to easily move around by themselves and smaller areas for playing leads, in the long term, to a decreased social and physical health for children (Gummesson, 2007:47). For instance, children that are less physically active are at greater risk of suffering from obesity and psychological illnesses (Pucher & Buehler, 2012:235).

Being physically active when travelling to different destinations including school is therefore an important part of children's physical activities. Research has shown that regular walks or cycling to school gives several positive effects for children's health. For instance, they tend to become less aggressive, unfriendly and anxious. Children that are active when travelling to school also tend to improve concentration and tend to engage in more physical play before class when arriving to school in the morning (Faskunger 2007:101-102). These things are important for a child's development. Children need physical activities to develop (Björklid, 1992:9). When children cycle together with other children they socialize and play at the same time. It is therefore very important that children have a direct and safe route to school without barriers. If the route is not direct enough it is likely that the children take a short cut which is more insecure (Gummesson 2007:47). Traffic priorities are crucial for children as is their access to the surrounding area. Urban areas where motorized traffic is prioritized become barriers to children's everyday movements. In Gothenburg, the number of children getting injured in traffic has decreased by 34% between 2000 and 2007 (Göteborg, 2009B:128). However, traffic accidents are still the most common reason why children are injured and killed. 60 % of fatal accidents involving children aged up to 15 years old are traffic related. For children aged 15-18 the figure is approximately 50 %. Motorised vehicles are often involved in injuries and deaths in this age group which makes the number too high. Most accidents that involve children are single accidents that involve cycling or driving a moped (Göteborg, 2009C:17).

School reform

One reason explaining why more children are driven to school today might be Friskolereformen (Private school reform) from 1992, which means that school selection is free. It is possible for children to go to another school than the one they live closest to. The distance to the school can then be longer than before (Nationalencyklopedin, 2017) However, 68% of all children living in bigger cities, like Gothenburg, still live less then 2km from their school (Bro et al., 2006:13). This is a distance it is possible to cycle.

Future travel habits

If children are used to being driven to school, it is not that likely that they will start cycling to school when they are mature enough to do so. This is because up to 90 % of a person's movement pattern is constructed before the age of 13. This means that it is crucial to get children to cycle early in life if the aim is to get them to cycle when they get older as well (Vägverket, 2004:1). If society wants to increase the number of cyclists in the future it is important to create a cycle friendly environment for children so they are getting used to cycle, among other things (Trafikverket, 2015:12).

Institution documents

Several different institutes have pointed to the importance of improving the accessibility for children to cycle and walk by themselves within the traffic system. One example is a study made by Nationella Folkhälsokommittén (the national Public Health Committee) in 1999, which suggested six different proposals for physical activities. The first proposal is making the route to school traffic secure so children can walk or cycle there themselves (Faskunger, 2008:32-33).

The Swedish parliament revised the transport policy goals in 2009, in which they stressed the importance of safety, accessibility, sustainability and health. In the bill Goals for future travel and transport (prop.2008/09:93) the Swedish government stresses the importance of these issues as well. In both cases high priority was given to traffic safety for children and overall increased access for non-motorized traffic. Children should have access to the transport system and it should be safe for them. When planning for infrastructure children's behaviour and understanding of the surrounding environment should be considered. One of the improvements pointed out as being especially important by the government was creating safer school roads. Trafikverket (The Swedish Transport Administration), working with developing Swedish roads and the transport system, stresses the importance of planning for and adapting the transport system to make it suitable for children's capacities and abilities and not vice versa, i.e. making children adapt to motorized traffic and the existing traffic conditions (Björklid et. al, 2013:13).

Statens väg- och transportforskningsinstitiut (The government road and transport research institute) was tasked by the government to study why children cycle less. The commission is also to study what different organizations and areas can promote a safe and increased cycling for children. The study should be done in November 2017 at the latest. Since the government wants to promote an increase in safe cycling it is important to increase the possibilities for children to cycle. The number of children (7-14 years) cycling on an everyday basis has decreased from 24% in the 1990s to 15% in 2014. There is a need for more knowledge about the reasons why cycling is decreasing among children, something that is not clear at the moment (Regeringen, 2016:1).

Bicycle and sustainability

It is easy to see a connection between bicycles and sustainable development. Bicycles and children cycling to school can be connected to all three different aspects of sustainable development: the ecological, economic and social aspects. There are several reasons why cycling as a means of transport is in focus within many different areas todays. There are also several advantages which is why researchers, politicians and urban planners recommend investing in bicycle planning. Cycling as a means of transport at promotes equality as almost everyone can cycle and for children especially, cycling is often the only way of transporting themselves. Research has shown that more bicycle paths lead to more people cycling. This also applies for children: a more traffic safe bicycle network around schools leads to more children cycling (Faskunger, 2008:17,29). In Gothenburg's bicycle programme, it is stated that more cyclists are good for the individual, the city and for society as a whole. Since bicycles do not cause emissions, particles or noise interference a higher number of cyclists around schools has many positive aspects (Göteborg, 2015:17). A safe bicycle network, where children can cycle themselves, also creates access for children to develop and become independent. It is important for their development that children have spaces to play (Björklid, 1992:3).

The more children that cycle or walk to school, the fewer cars will be driven around school in the mornings and afternoons when children are on their way to and from school. This means that there will be less emissions from the motorized traffic around the children which is good both for the ecological and social sustainability. It improves ecological sustainability as decreasing carbon dioxide and other emissions caused by motorized traffic is good for the environment. From a social perspective, less emissions are good for children’s health, since children are extra sensitive to air pollution caused by motorized traffic (Björklid,1992:1).

There is also a more indirect economic aspect. Our travel behavior is formed when we are children and if children cycle to school it is more likely that they continue to cycle, even when they are adults. An active population is good for the national economy (Vägverket, 2004:1, Rose, 2014:1). An area with few cars around schools and safe routes to school for children make the area attractive for families with children, as parents in general want to live in areas that are safe for their children.

Gothenburg bicycle documents

Gothenburg is the second largest city in Sweden with 556 640 inhabitants (2016). The city is located in the south west part of Sweden, on the west coast (Göteborg, 2016).

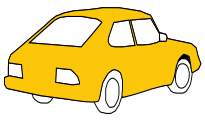
To create a more sustainable city the municipality of Gothenburg has a clear goal, which is increasing the number of bicycle transports in the city. The

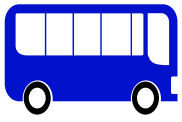
vision is that the inhabitants think of Gothenburg as a bicycle friendly city and the goal is that the number of bicycle trips, in 2025, will be three times as large as in 2011. The goal is that it should be easy, fast and safe to cycle in Gothenburg. Since 2011 the proportion of bicycle trips has increased from 6 to 7%. This is still a low proportion, compared to for example Malmö, where bicycle trips represent approximately 25 % of all trips (Göteborg, 2015:9).

However, the bicycle network in the municipality has been expanded from 110km, in 1999, to 470km, in 2012. Up until 2015 bicycle planning in the municipality was based on the bicycle programme from 1999 and in that programme the main focus was traffic security. As a consequence of this, other qualities have been paid less attention, such as the directness and the comfort in the network. This has, in turn, meant that the number of cyclist has not increased as much as hoped. Nevertheless, from a children's perspective the investments in traffic security are still very important (Göteborg, 2015:23-24).

The programme also brings up the importance of including children's perspective when planning for bicycles. Creating separated bicycle paths is the main way of making cycling for children accessible. In places where children have to cycle in mixed traffic the speed limit should set to maximum of 30km/h. The crossings should also be secure so the speed will not exceed the speed regulation. When improving the local bicycle network the programme states that the bicycle network should be planned and built so that it is safe enough for children 10-12 years to cycle by themselves to school and other areas (Göteborg, 2015:39,41).

Transport to school in Gothenburg 2013
It can be combination of transports.


Car 33%


Public transport 19%


Walk 60%


Cycle 19%

Source: Göteborg (2013)

Building typologies

Majorna/Linné

The area of Linné, which is a part of the city district of Majorna/Linné is located in the city centre, just outside the moat and Majorna is an area west of Linné around 3km from the city centre. The building typology in Linné is block structure and the street pattern also follows that form. Even if the block where Nordhemsskolan is the highest point of one of the blocks, the street pattern is the same still. In some places, there are stairs in order to make the pattern work in the terrain. The location of the school on the top of the hill shows that the school had a high status in the area when it was built in 1912-1917. The block structure of the area was built from city plans made in 1866 and 1877 and most of the buildings are from around the same time. Most of the streets are of city street character with mixed traffic. One characteristic of the area is that there are mixed functions such as offices, restaurants, shops and residential houses. There are not a lot of green areas except Slottskogen in the south part of the area (Caldenby et.al., 2006:130,140-142). The terrain is very hilly. The car ownership is 235 cars/1000 inhabitants (Gothenburg average is 285/1000 inhabitants) (Göteborg, 2014).

Askim/Frölunda/Högsbo

Hovås is a part of the city district Askim/Frölunda/Högsbo. The district consists of different kinds of areas with different building typologies. Hovåsskolan is located in a part of the district which mainly consists of detached houses and it is this building typology that will be described here. The majority of the buildings in the area are detached houses with a designated parking space next to the house. The area expanded in the post war era as car ownership increased. This means that cars are allowed on almost all streets in the area. In a suburb like Hovås which is located relatively far from the city centre, car dependency is high which results in a high car ownership. (Caldenby et.al., 2006:164. The car ownership is 329 cars/1000 inhabitants (Gothenburg average is 285/1000 inhabitants) (Göteborg, 2014).

Angered

Hjällbo which is a part of the city district Angered was built during the one million home programme between 1965-1974. The area was designed according to the ideas of funktionalismen, the Swedish version of modernism. The ideas of modernism were a reaction to the traditional city that is narrow and with tight streets. The goal during this period was to create modern areas with health and light, where air and sun were in focus. Angered was built on unexploited land. New methods made it possible to build on sites where it had been to problematic and expensive to build earlier (Johansson et al. 1997:23, Berglund et al. 2004:8-10). The modernism areas are often traffic separated and often a car road is going around the area at the outskirts with the rest of the area car free. The street network is planned according to the SCAFT

principles which means that vehicle traffic is separated from pedestrians and cyclists (Rådberg 1988:242-243). The areas were designed to fit families' requests which means that children often were in focus. There are also many big green spaces and the areas are dominated by multi storage buildings. The area of Hjällbo was the first part of Angered to be built (Caldenby et.al., 2006:236-242). The car ownership is 250 cars/1000 inhabitants (Gothenburg average is 285/1000 inhabitants) (Göteborg, 2014).

Traffic safety

Traffic safety can be defined as low risk of personal body injury in the traffic system (Trafikverket, 2008:63). There is a difference between safety and security. Safety is the perceived sense of security whereas security is the actual traffic status. Traffic safety is, for instance, how safe you feel around traffic. Traffic security is a statistical measure of, for example, the distance you can except to cycle without being injured. These two different kinds of safety are of course connected to and affected by each other. Traffic safety affects whether a person will feel safe enough to cycle or not, while traffic security will affect a person's feeling of safety. The focus in this thesis will be to increase traffic safety by improving the actual traffic security (Oslo, 2015:35).

Since children do not have the same ability to read traffic situations their preconditions for moving safely in the traffic system are not as good as adults' ones. Researchers often state that children younger than 12 years old are, in general, considered traffic immature (statens offentliga utredningar, 2012:169). Children's sight and hearing are not fully developed which impairs their ability to assess traffic situations. Also, children are not able to focus on several different things at the same time. This means that they can only focus on cycling, and do have to concentrate on that to be able to manage. Therefore, they cannot focus on the traffic at the same time. For children up to 10 years old, a cycling tour is also very much seen as a time for playing and they do not see the cycling as a transportation (Björklid, 1992:12).

What is considered traffic safety for children is not fixed but has changed over time. To be able to discuss and study the topic it has to be defined somehow. There is neither not a national standard that regulates the traffic safety standard. In this thesis, the definition of traffic safety for children will be based on various sources to get as specific and clear definition as possible. Children constitute a very diverse group since all persons aged between 0-18 are counted as children in Sweden. Even if, in this thesis, the age group studied is only between 6-15, this is still a wide range. Since the age group is so wide the children will be at different maturity levels which means they have different possibilities to travel in the traffic system as well. It is therefore very hard to make one definition of traffic safety that fits all age groups. In order to include the whole age group the definition has been based on the youngest and least traffic mature. If the traffic system is safe enough for them, it is safe for the older children as well. Nevertheless, this makes the criteria for what can be considered traffic safety unnecessarily strict for some age

groups. Thus, a traffic safe route to school means that a child's unpredictable behaviour should not result in death (Midtland 1995:20-22). How to define traffic safety can of course also be discussed, but the focus in this thesis is not defining traffic safety for children, but rather how traffic safety criteria can be used in analysis and when creating design principles.

Nevertheless, there is some basic knowledge when it comes to traffic safety, which applies regardless of age. One example is that most people survive if a car travelling at 30km/h hit them and that most people are killed if the car is travelling at 50km/h or more. This means that the speed limit needs to be set to 30km/h in order for cyclists and pedestrian to survive a collision, regardless of age (Trafikverket, 2015:6,10). A speed bump halves the risk that a child will get hit by a motorized vehicle. Roads with a higher speed limit than 20-30 km/h for motorized vehicles are therefore usually considered traffic barriers for children aged 6-12. For adults, the corresponding speed is a speed limit higher than 50km/h. It is the speed limit, and not the amount of traffic, that determines if a road is unsafe and therefore a traffic barrier (Faskunger 2010:22,31).

The criteria for traffic safety will mainly be taken from Oslo sykkelstrategi (Oslo bicycle strategy), GCM-handboken (pedestrian, bicycle and moped handbook), the TVISS method (Tillgänglighetsvillkor i svenska städer) (accessibility conditions in Swedish cities) and TransportØkonomisk institutt (Institute of transport economics). These documents will be presented individually below.

TVISS-method

TVISS is a GIS based method developed by Mats Reneland (2000). It is used to study and describe the traffic accessibility in cities. With this method, it is possible to study different parameters to assess accessibility. Different groups have different preconditions for having access to the transport system. With this method, the possibility of access for different groups can be studied separately, as different parameters can be included in the analysis, such as traffic safety. Different parameters for traffic safety can be assigned to different types of analyses depending on the demands of the different groups. In this case children have higher demands on traffic safety than adults which can be considered in the analysis (Reneland 2003:8). In this thesis, the TVISS- method will only be used as an inspiration for defining traffic safety and what can be considered traffic safety. The method will therefore not be utilized fully.

GCM-handboken

GCM-handboken is a publication published by Sveriges kommuner och landsting, SKL (The Swedish Association of Local Authorities and Regions, SALAR) and Trafikverket (the Swedish Transport administration). The purpose of the handbook is to collect information on pedestrians, cyclists and moped

users to support the planning and maintenance of walking and bicycle paths. The handbook contains recommendations and best practise in designing the infrastructure in a traffic safe way. The belief is that the book will work as an inspiration for improving and developing walking and bicycle paths that fit all travellers. In the handbook, there are also some examples of definitions of traffic safety (SKL, 2010:3).

Oslo sykkelstrategi

Oslo bicycle strategy is a bicycle plan created by among others the consultant company Space scape on behalf of the city of Oslo. In the strategy traffic safety is defined and divided into three sections; high, sufficient and low traffic safety. There is also a definition especially adapted to children. During the working process, spatial analysis has been used to study and show what the existing traffic safety situation looks like (Oslo, 2015:35-40, 48-50). The use of spatial analysis for studying traffic safety makes this document especially relevant for this thesis.

TransportØkonomisk institutt

TransportØkonomisk institutt is a Norwegian centre for transport research. It has published a report where children's conditions to travel safely in the traffic system is studied. In the report, there is also a checklist of different risk factors for children aged six, that can be identified while they are travelling along and crossing a road. The checklist is based on fact and research regarding six-year-old children's conditions to walk safely or cycle to school by themselves (Midtland 1995:35-39). Parts of this checklist will be used to map and evaluate traffic safety when doing the inventories.
Based on the perspectives on traffic safety from these four documents the definition of traffic safety for children aged 6-15 can be made. The criteria and focus during the inventories will be based on the definition.

Vision Zero

Vision Zero is a Swedish vision for road traffic safety established in 1995. The aim is to achieve a road traffic system where no one will be killed or seriously injured. The vision is an attitude towards life, but also a strategy for designing safe roads. The road traffic system should be adapted to humans and the design should be made with this in mind. Vision Zero has a holistic perspective on safety in the transport system and that perspective is also characteristic of the vision. This perspective has resulted in closer collaboration between different actors within the road and traffic field, such as system designers and urban planners. It is still too early to assess the effects of Vision Zero to date. The work of changing the infrastructure and the view of it takes a long time. However, the number of people killed in traffic has decreased in recent years, even if traffic has increased. Another obvious result is that Vision Zero has changed how we look upon, relate to and plan for traffic in Sweden (Trafikverket, 2015:2,5,8,15). The safety philosophy makes it reasonable to

limit the speed to 30km/h on streets where cars and children are assigned to the same space (SKL, 2008:16). One of the goals of the vision is about children and their travelling to school and it reads: "The number of children in urban and rural areas who can travel safely to school shall increase every year to 2017" (Vägverket, 2008B:59). The importance of a long-term transport system that is sustainable and allows for an increasing amount of bicycle traffic within urban areas is also stressed. However, this can lead to an increased number of injured people which is not compatible with the goal of a decreasing number of injured people. To discourage this traffic and roads have to be adapted to fit cyclists needs, through for instance lower speed limits and separate paths for cyclists (Faskunger, 2008:31).

Bicycle planning and design manuals

When studying different bicycle planning and design manuals it quickly becomes apparent that they all deal with the same two main problems; space and speed. In a lot of streets, it can be difficult to make space for separate bicycle paths and/or lines since there is a lack of space within areas already developed. The speed limit for motorized vehicle traffic is also essential for the access and traffic safety for cyclists. It is based on these two problems almost all design solutions are constructed. Since these problems are essential for cyclists they are also the most important ones to work with. A lower speed and more space for cyclists is often a part of the solution. When it comes to the design for children's needs space and speed are extra important aspects (Andersen 2012:10-18, French et al., 2014:10-20, København, 2013:6-13).

The bicycle guide Healthy and Bicycle-Friendly School Roads - Guide with ideas for healthy and active transport (2012) is a Danish design manual focusing on how to get children to cycle to school. The manual shows the connection between physical improvements and a changed behavior. It describes examples from Denmark where physical improvements and campaign activities have led to changed behavior with more children cycling to school. One example is the municipality of Odense, where the work of increasing the number of children cycling to school has been ongoing since the 1980s. The proportion of children cycling or walking to school in Odense is around 80% (a Danish average is 45%). One of the many projects completed during this period is called "living roads". This was a project where both physical improvements and attitude campaigns were focused on. The project included reducing the speed limit to 30km/h in two residential areas and doing a number of physical improvements. At the same time, several campaign activities were connected to the improvements to create a sense of importance for the physical changes and the speed reduction. There are no specific results or evaluation presented in the guide, but still this kind of project shows how physical and mental aspects can be worked on in connection with each other (Andersen, 2012: 9,12).

The physical solutions aimed at making more children cycle to school focus on various aspects such as speed reduction, cycle path design, intersections

and parking spaces. The traffic behavior and attitudes to cycling are also raised as important aspects. It is useful to work with a combination of physical improvements and different promotions focusing on how to get more children cycle to school.

One example of a physical change that can improve the traffic safe for cyclists is construction of blue lanes. Blue lanes can be painted in intersections to clearly show drivers that it is a space for cyclists. It also makes it easier for cyclist to navigate where to cycle. A blue lane improves traffic safety and reduces the number of injury accidents involving cyclists by 30-40%. There should only be one blue lane within each intersection, as having more instead increases the number of accidents (Andersen, 2012:16).

Example showing a blue line in an intersection in Copenhagen. Photo by Keith Hauser

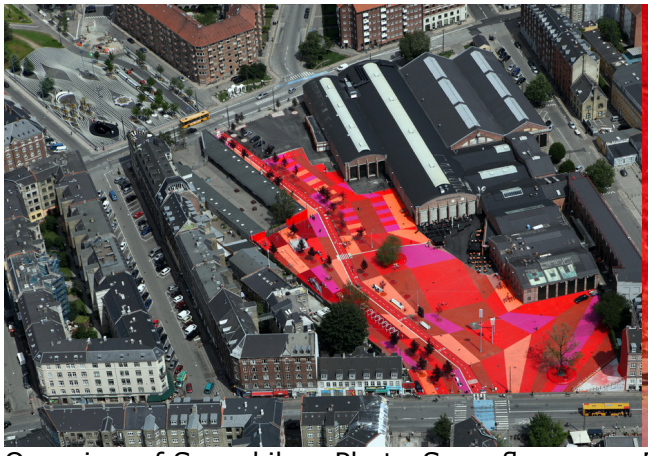
Another improvement presented in the guide creating raised surfaces in intersections. The crossing will then just be a continued and uninterrupted part of the bicycle path. The raised surface will be a plateau bump which means that motorized vehicles have to slow down and give way to cyclists and pedestrians. Several studies that have looked at the role of crossings state that these kinds of crossings generally result in 20% fewer cycling accidents and 40% fewer pedestrian accidents. This kind of design improves traffic safety which benefits child cyclists and pedestrians (Andersen, 2012:17).

Example showing a raised intersection. Illustration: NACTO:2017

Reference projects

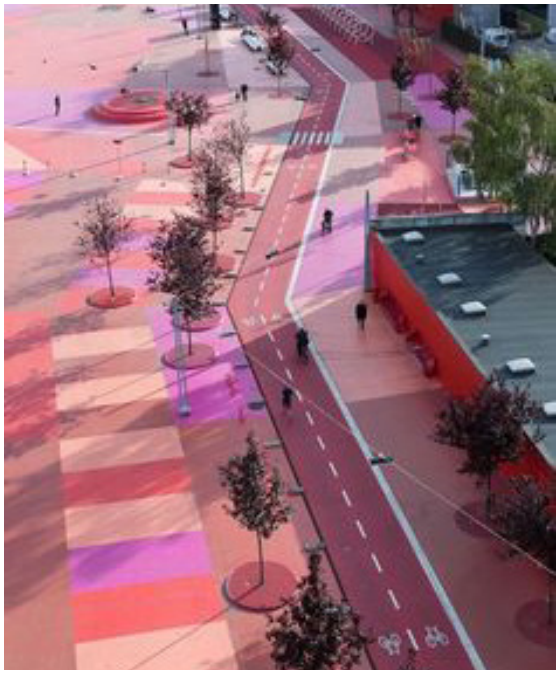
Superkilen

Superkilen is a one kilometre long park in Copenhagen. Through the whole park there is a bicycle path. The park area is divided into three different parts: the 'red square', the 'green park' and the 'black market'. Every part has their own playful character and design. The hope is that the park will support a diversity of local inhabitants. The design of the park includes objects and symbols from countries all over the world (Denmark.dk, visitcopenhagen). The design of the park is very playful and it shows that a bicycle path also can be designed in a playful way and that is why it is included as a reference project within this thesis.



Overview of Superkilen. Photo:Superflex

Bicycle stand in the park.
Photo:Torben Eskerod



Overview of Superkilen. Photo: Iwan Baan

The red bicycle path going through the park. Photo:Superflex

Bicycle promotions

There are several examples of bicycle promotions aimed at getting more children to cycle to school (Trafikkalendern, på egna ben, Odense, 2003:40). A lot of the discussion around cycling is about the attitudes towards cycling and a lot of the work is focusing on how to get more people, both adults and children, to cycle on an everyday basis. The projects are about teaching children about traffic, transportation and sustainable development but there are also challenges where classes compete to be the class cycling and walking the most to school. In Gothenburg, there is a project called på egna ben (approximate translation to: on my own) where children in school years 4-6 (ages 10-12) can participate in a challenge which is about transport to school by cycling, walking or by public transport. The project has been organized by the traffic office at the municipality since 2006. This project wants to introduce children to the idea of traveling to school in a more active way and as a result decrease the problem of sedentary children. The challenge is organised five weeks every year and the classes collect points when they travel to school in an active way. During the competition, the children also learn more about the environment, health and traffic security (påegnaben.se). These kinds of projects show that there is a great interest in trying to get children to cycle more. To succeed, it is also important that streets are traffic safe, so it will be safe for children to cycle to school.

Problem statement

There is a lot of documents discussing the problem that many children are sedentary and not cycle and/or walk to school to the same extent anymore. But often it is just the problem that is described and few ideas and concrete examples on how to change the trend is presented. Several documents state, however that one solution can be to promote active transports to school in order to get children more active. The focus is then mainly on how to change the attitude to cycling and how to increase the willingness to cycle or walk to school. Seldom there are arguments or solutions on what impact physical improvements has. This create a need for more concrete design principles on how to change the physical environment. This is something that this thesis contributes to. There is also a lack of documents discussing different methods on how to study and analyse the problem from a physical perspective. In this thesis, an alternative method on how to analyse the existing street network is presented. This method can be used to find out where there are problems in the network today and where to make the most strategic improvements. The combination of a quantitative method (spatial analysis) and a qualitative method (inventories) is what this thesis is adding to the field. It is important to develop methods that can be used when analysing the physical structure on specific sites

Part 3- Case Study

In this chapter, the result and analysis from the case study, including inventories, spatial analysis and observations will be presented. In the first part of the chapter, the school sites and the reason to study these specific school is explained and then the result from the inventories, spatial analysis and observations follows. In the end of each heading a short conclusion describes the most important and relevant result from the analyse.
Inventories

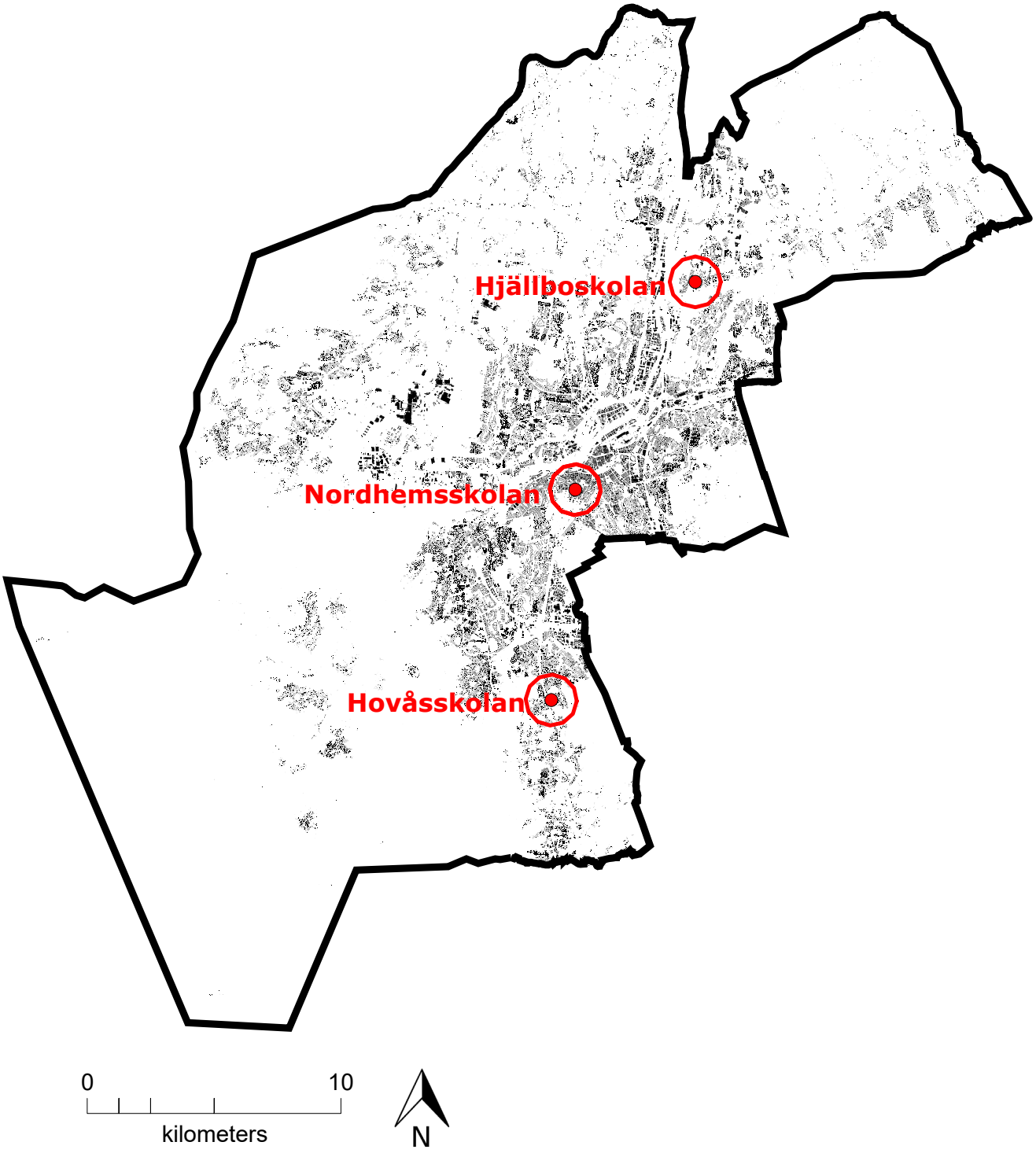
Three school sites in three different city districts in Gothenburg municipality have be chosen for a more in-depth study and analysis. The sites including the schools and the network approximately 1km around the schools will be studied. The schools are Nordhemsskolan in the city district of Majorna/Linné, Hjällboskolan in Angered and Hovåsskolan in Askim/Frölunda/Högsbo.
These schools have been chosen based on results from a study made in 2013 by the municipality where parents of children aged 6-12 were asked how their children travelled to school. The results showing the number of children being driven to school were split over city districts. The schools which were studied in this thesis were chosen based on the proportion of children being driven to school. The districts chosen are Askim/Frolunda/Hogsbo (highest proportion, 48 %), Majorna/Linne (lowest proportion, 8 %) and Angered (mid range, 33 %) (Göteborg, 2013:8).

There are several schools in each district. The schools studied should be schools run by the municipality where all classes from F-9 are represented.

They should also be ordinary schools with no specific educational form or schools for children with special needs. The schools that were finally chosen are representative of each district. The three schools are also located in different kinds of areas dating from various times and with different building typologies. This makes the surrounding networks different for the three schools and that allows for more relevant and interesting comparisons in the final analysis. Hjällboskolan, the school in Angered, is a school with only classes 4-9. This school is selected anyway as there is no school with all classes from F-9 in the part of Angered what has the typical one million programme building typology.

All three inventories have been done based on the same inventory schedule.

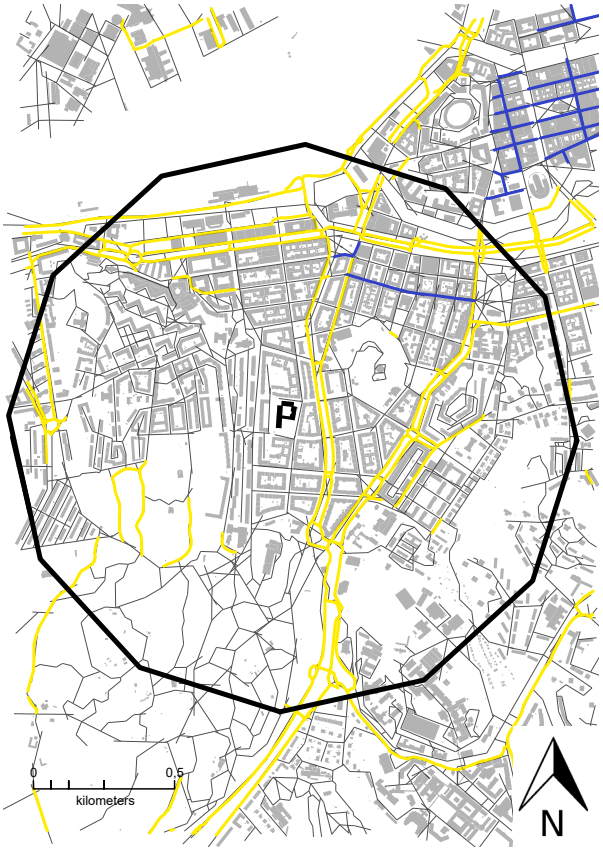
The location of the three school sites



Nordhemsskolan

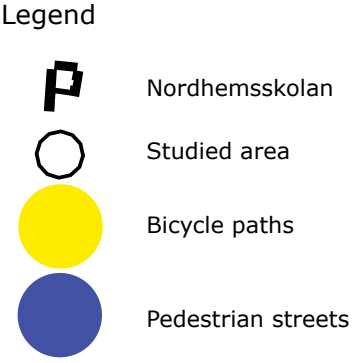
Norhemsskolan is located in Linné in the central part of Gothenburg. The inventory was done on 3/4 at 12:40-14:30. There are approximately 750 children attending the school (Goteborg.se).

There are several schools within the area which means that children living closer to another school probably do not go to Nordhemsskolan. There are four other schools run by the municipality and four private schools within the area. Nordhemsskolan is however the only municipality school for school years 7-9 (13-15 years old).



There are not many streets with separate bicycle paths and almost all streets have a speed limit at of 50km/h which makes them traffic unsafe based on the checklist. Many of the streets are so called city streets which means that they are narrow with car parking on one or both sides and sidewalks on both sides, next to the buildings. This means that cyclists, on most streets, have to cycle in mixed traffic.

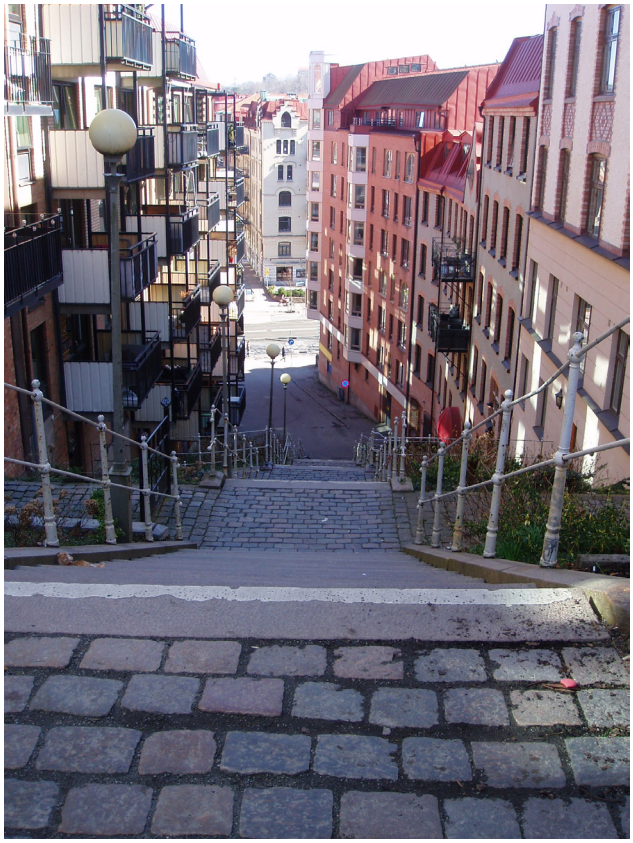
Nordhemsskolan is located on a hill which makes it quite hard to cycle there, both because there are stairs in several places and because it is hard to cycle up a steep hill. For instance, the closest connection to the west of the school is a stair leading down to the western part of the area. The terrain in the whole area is quite hilly, especially the west part. These conditions make it less likely that children cycle to school. However, even if the children do not cycle to school, there is still a need for improving the bikeability for children living in the area, so they can cycle to other places.



The general impression of the site is that since this school is located in the central part of Gothenburg the street network is busy and not very child friendly. There are, however separate bicycle paths along the main streets in the area, like Linnégatan och Övre Husargatan. In the area of Slottsskogen vehicle traffic is not allowed which makes it traffic safe for children, but this area is more of a recreation area and not really a transport route for children going to Nordhemsskolan.

The street outside the school

The hill at Nordhemsgatan



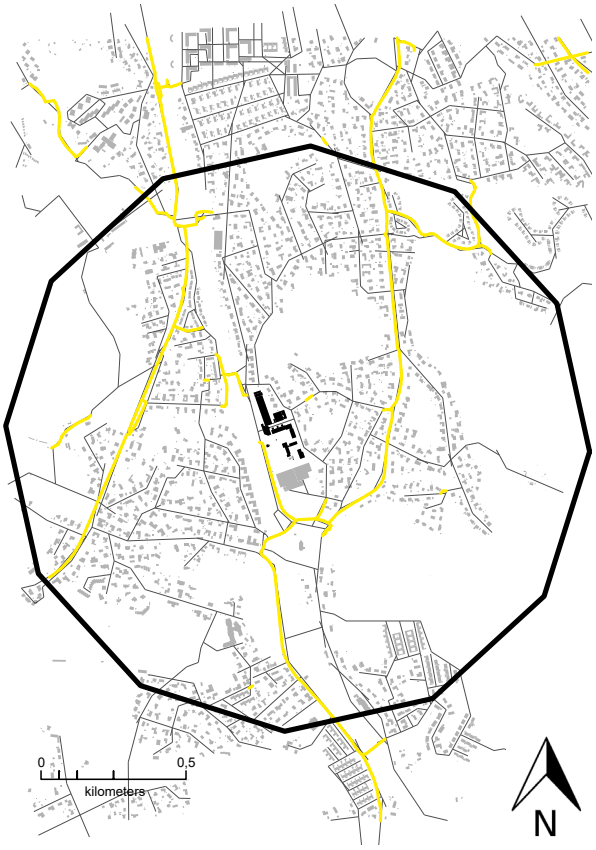
One of the stairs leading up to the school

An example of an ordinary street in the area with small sidewalks on each side and no bicycle path

Hovåsskolan

Hovåsskolan is located in Askim which is approximately 14 km from central Gothenburg.The inventory was done on 4/4 at 16:15-17:30. There are approximately 730 children attending the school (Goteborg.se). Hovåsskolan is the only school within the area.

The area is a typical Swedish suburb with detached houses which means that it is possible to drive and park the car just next to the house in almost all places. This means that motorized traffic is allowed on most streets. Most of the streets are very narrow, with a speed limit of 50km/ and there is no separate path for either pedestrians or cyclists which makes them traffic unsafe for children. There is also poor visibility on many streets due to several different aspects, such as that narrow streets, hilly terrain, curved streets and high hedges.



The big road, Säröleden, divides the area into two parts. In two places within the area of the inventory, it is possible to cross the road by tunnel. The remaining two crossings have traffic lights. On a big road such as this it is not traffic safe to cross the street if there is no flyover or tunnel.

There is a high-speed bicycle path in the west part. Several commuter cyclists passed me when I walked along the path during the inventory. Otherwise there are almost no separate bicycle paths or sidewalks in the area. Of the bicycle paths that do exist, many are shortcuts between the houses connecting different streets and parts with each other. The streets closest to the school have many speed bumps.

The general impression of the site is that it is quite calm and that not many cars drive on the smaller local streets. Where there is traffic, the average speed sees relatively high. Some of the streets are probably quite traffic safe for children to cycle on in mixed traffic, but since the speed limit is set to 50km/h they are still classified as traffic unsafe based on the inventory checklist. Säröleden is a very busy road and here cars drive fast since the speed limit is 70km/h. There are no places to walk or cycle along that road.

The street outside the school

Säröleden, the big road dividing the area

Main bicycle path in the area

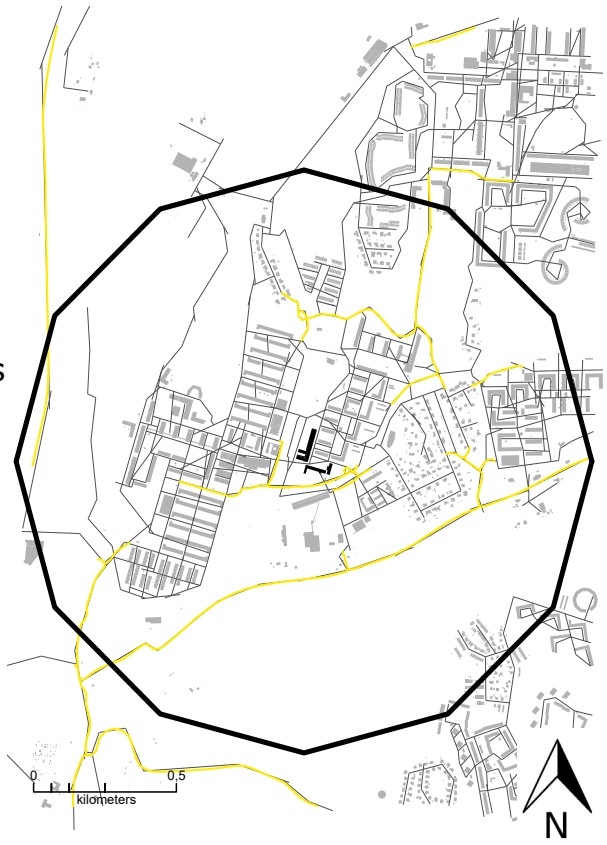
An example of an ordinary local street in the area

Hjällboskolan

Hjällboskolan is located in Angered and more specifically in the area Hjällbo which is a suburb around 9km from Gothenburg city centre.
The inventory was done on 5/4 at 8:10-9:30. There are approximately 350 children attending the school (Goteborg.se).There are two other schools within the area: one for years F-6 (6-12 years old) and one for years F-3 (6-9 years old).

The area is very traffic separated with cars being allowed along the edges of certain blocks and the spaces between the buildings being almost exclusively for cyclists and pedestrians. This means that there are many traffic safe paths within the area. Almost all multi storage buildings are connected to a traffic safe bicycle path. It is obvious that this area is planned and built based on other values and ideas than the other two areas.

Gråbovägen, which is quite a wide and busy road, divides the area. There are, however, four tunnels where it is possible to cross this road in a safe way.
There are some streets where there are detached houses and there the speed limitat is 30km/h which also makes it more traffic safe. This is true only for some streets, the other streets where there are houses have a speed limit of 50km/h.



The general impression from the inventory is that it is very easy to walk and cycle around without crossing streets with cars. The terrain is quite flat except the northern parts of the area which are hilly. There are many tunnels for pedestrians and cyclist in the whole area.

Conclusion inventories

There are some impressions that are common for all the inventories and one of these is that a lot of the streets are traffic unsafe only because the speed limit is 50km/h. The speed limit is a central part when talking about traffic safety. However, some of the streets with that speed limit seem to be traffic safe since there are quiet local streets leading to houses without much traffic.

The street outside the school

One of the local villa streets

A pedestrian and bicycle path in the area

An example of an ordinary pedestrian and bicycle path in the area

Spatial analysis

In order to make the spatial analysis a lot of different types of GIS-data and specific data created for space syntax have been used.

Segment map. The segment map is designed to capture all streets and paths pedestrians can walk along. Since this thesis is focusing on cyclists all stairs located within the chosen school areas have been removed, but not for the rest of the map. This is because it is too time consuming to remove stairs on all sites in all of Gothenburg.

Address points. This data shows the locations for all the addresses in Gothenburg. This data makes it possible to analyse where children's home addresses are included in the analysis.

Population children age 0-18. This data is a grid that shows the approximate location for where all children lives in Gothenburg. The data does not exist for all locations in the municipality. Sites show up where it seems no one lives. Still the data exist for the chosen school sites so the data is enough for analysis in this project.

Base areas. Base areas are smaller areas covering the whole municipality. The size of the different areas vary. These areas have been used to gather all address points and all children living within each base area. This has made it possible to divide the children, using an average, for every address points within the base area.

Primary schools. Data for the location of all primary schools has been used in order to include their locations within the analysis.

In this thesis four main spatial analyses have been done in order to see what streets are the most important ones in children's movement patterns. The analysis has been done at a municipal level and then the ranges in the analysis have been customized to fit and best show a result for each one of the three school sites. Since the school sites are located in different parts of the city the ranges have to be adapted to each site in order to get a result that can give useful information about the existing situation. There is no point in doing an analysis that shows a result with only one colour. The most important streets (shown in red) mean the streets that have the highest value in the analysis. What streets get the highest values differs depending on what has been studied in the analysis. Common in all the analyses is that streets getting a high value are streets with high potential for being used by children on their way to school. The black dots shown in the maps are schools. Below each analysis is described in detail.

Attraction distance 1000m

This analysis shows the distance of each street segment to the nearest school with a maximum of 1000m. The streets nearest to a school are shown in red and the streets furthest away are shown in blue. Streets further away than 1000 meters are shown in grey. It can be several schools in the same area and all schools are included in the analysis. This means that not just the chosen schools are studied in the analysis. The streets closest to the schools are the streets that potentially will be used most by children on their way to school as they encircle the school.

Attraction reach 1 step

This analysis shows the distribution of the number of children in Gothenburg based on their home address.[1] The street segments where most children live are shown in red; the streets with the least number of children in blue. The streets with a high number of children are potentially the most used ones by children on their way to school. This is just because along these streets the most children lives. If these streets are traffic unsafe it means that more children have a traffic unsafe way than if a street where not as many children living are traffic unsafe.

Betweenness 1000m

This analysis shows what streets segments are located within a 1 km radius of the shortest route when moving through the city. The street segments that are passed most frequently get the highest value and can be seen as being essential for this through movement. These streets are shown in red; the least through movement is shown in blue. The red lines are the most frequently used and therefore get the highest value. These streets are most likely to be used by many children when walking or cycling to school, but also to other activities after school.

Importance

This analysis is a combination of all the three analyses described above. In this analysis, the results from each analysis have been merged into one common analysis. In order to combine the results from the different analyses, the values from each analysis are normalized (on a scale 0-1) and then multiplied with each other. The streets with the highest values (1) are those that are closest to school, have most children living along them and the highest betweenness. Based on this analysis it is possible to see what streets are the most important in children's movement patterns when travelling to school and other activities in the neighborhood. When combining this analysis

1 To get the data for children's home addresses, data for all children living in the same base district was captured based on the general population data and then the total number of children living in each base district was divided equally between all address points within the base district.

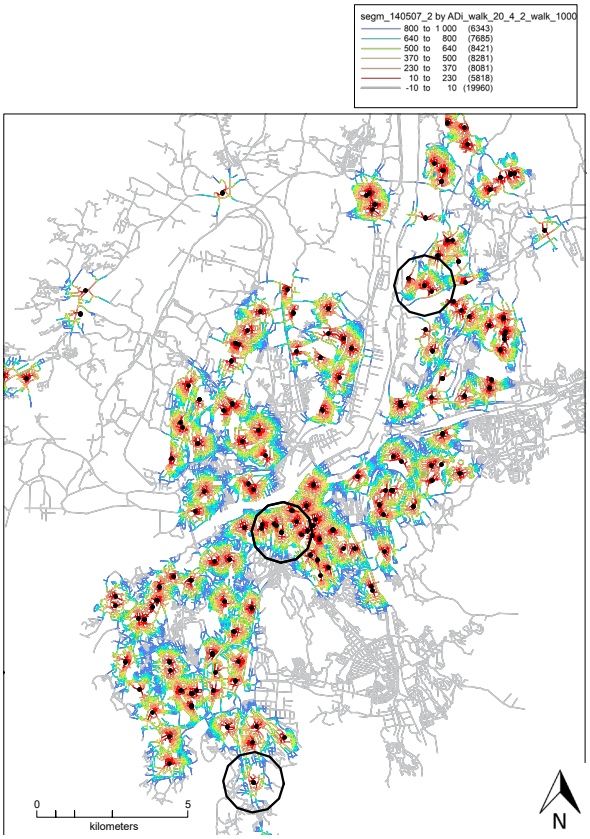
with the traffic safety analysis it is possible to find the streets that are the most relevant to improve in terms of traffic safety.

Analysis on a municipal level

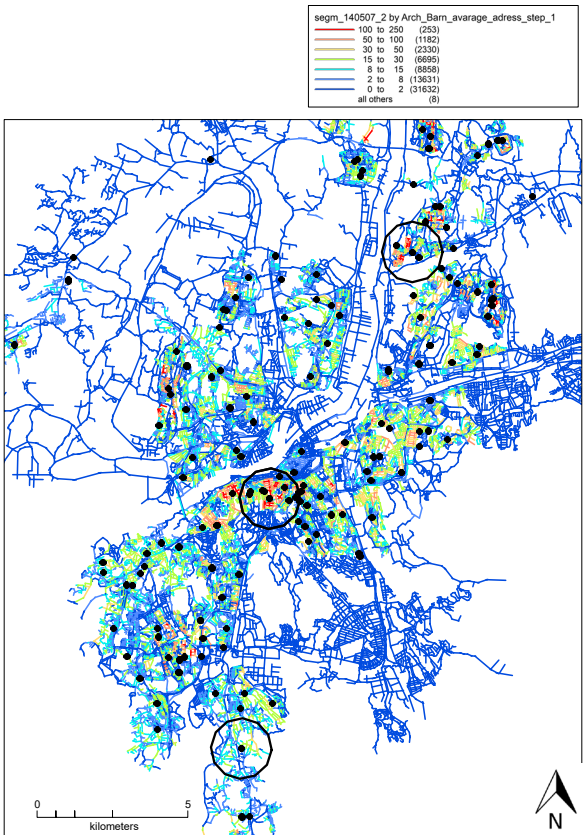
It is also interesting to study the analysis on an overall municipal level. Since the analysis is done for the whole municipality it is possible to see the streets that seem to be the most important ones on a large scale as well. The result can possibly be misleading as the same ranges are used for the whole map. This makes the streets in the periphery less integrated with the whole street network which means that streets in these areas will look unimportant even if they actually are very important on a local scale. It is therefore important to be careful when analysing the result and drawing conclusions based on the overall analysis. For the analysis to be more relevant the ranges have to be customized in some places in order to get a result showing the most important streets on a local scale. However, this method makes it easy to study large areas at the same time. To be able to study traffic safety for the different areas the only thing to be added are the traffic safety aspects. This information has to be gathered in other ways, for example through inventories and by studying GIS data including information about different streets.

Analysis:Municipal level

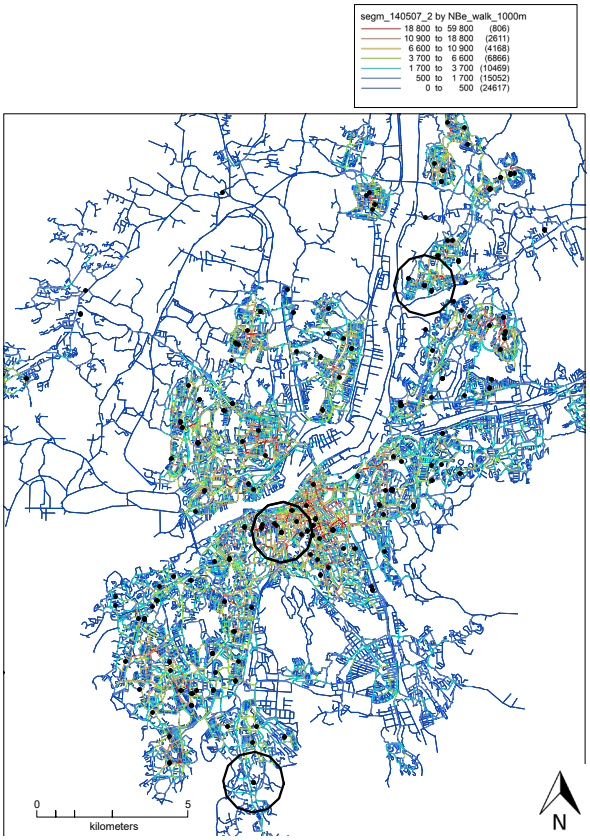
Attraction distance 1000m



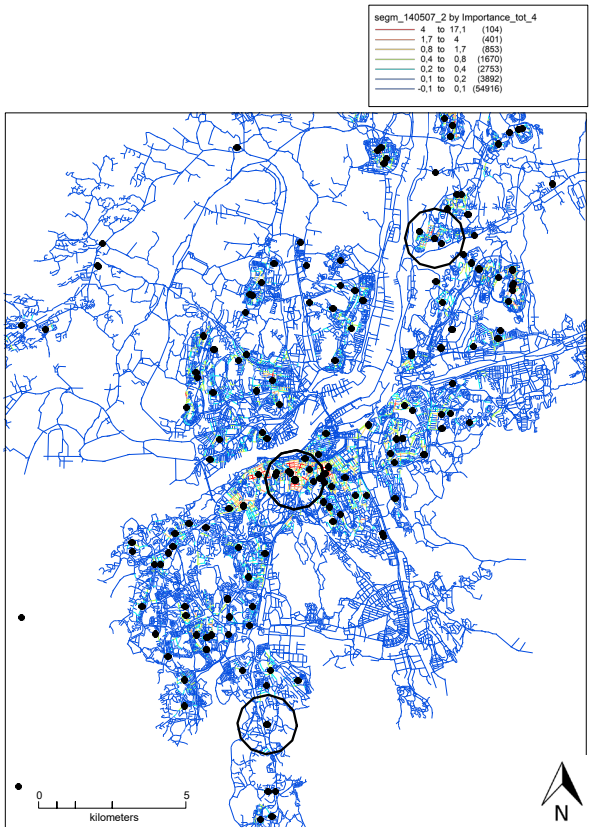
Attraction reach 1 step



Betweenness 1000m

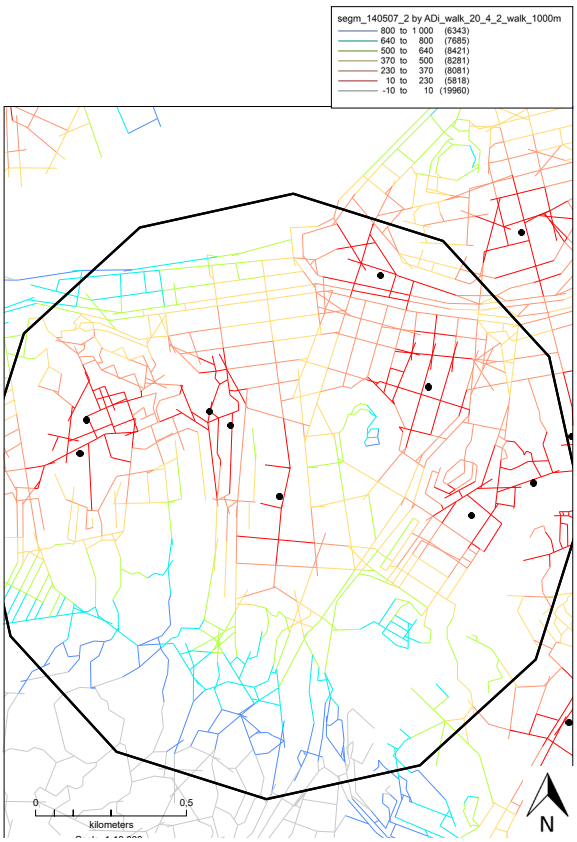


Importance

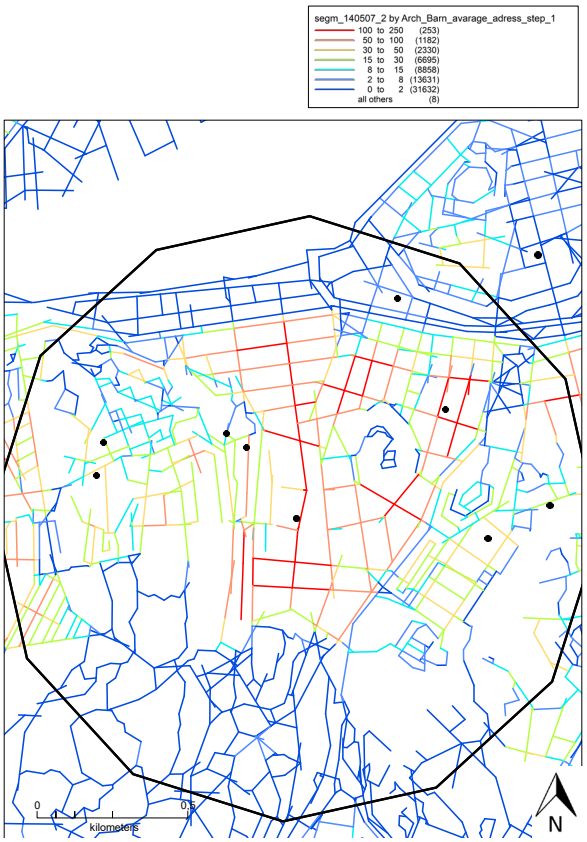


Analysis: Nordhemsskolan

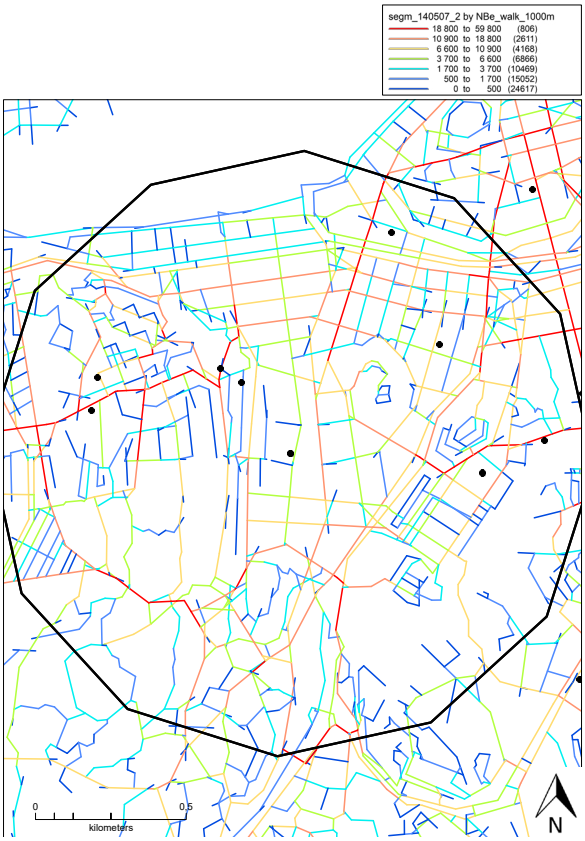
Attraction distance 1000m



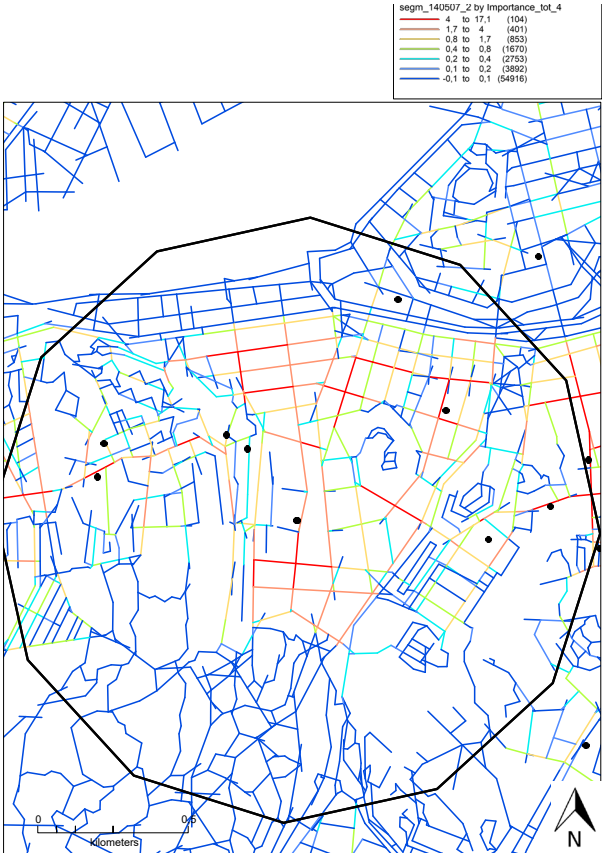
Attraction reach 1 step



Betweenness 1000m

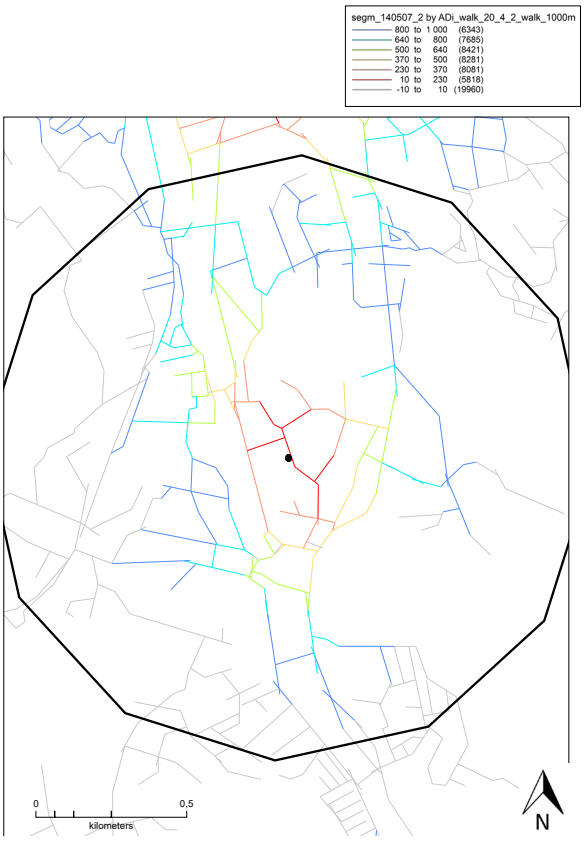


Importance

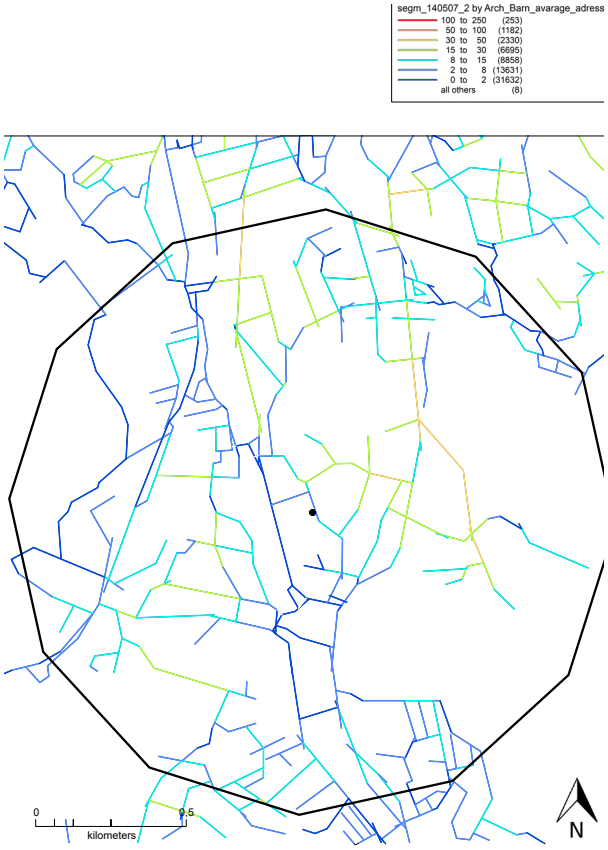


Analysis:Hovåsskolan

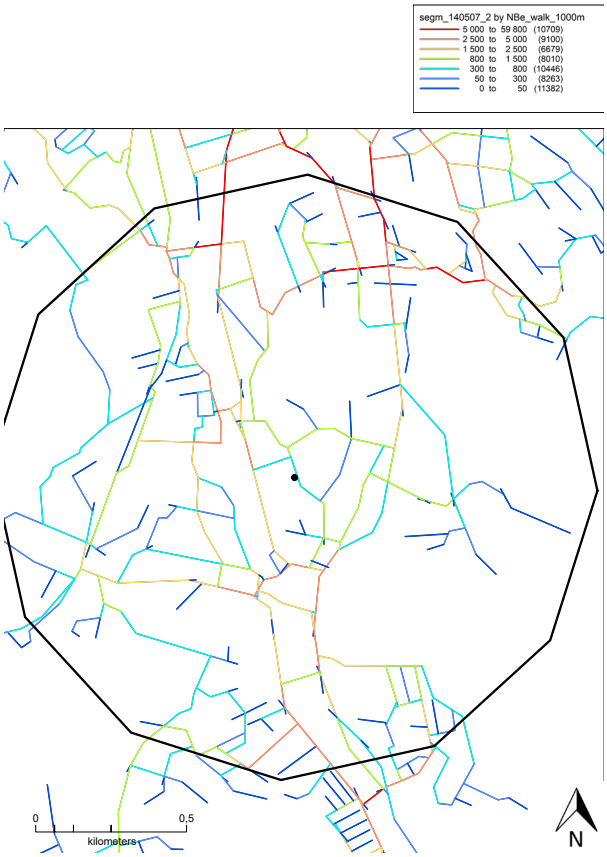
Attraction distance 1000m



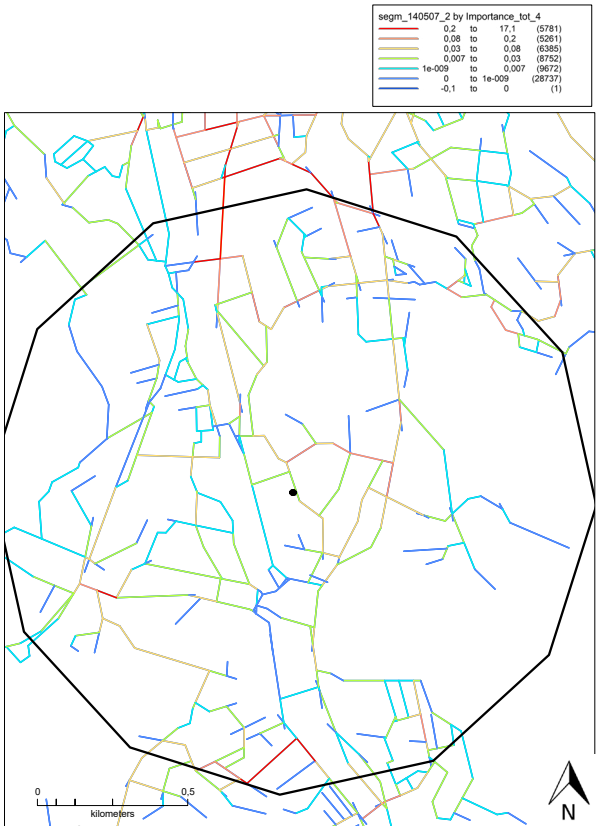
Attraction reach 1 step



Betweenness 1000m

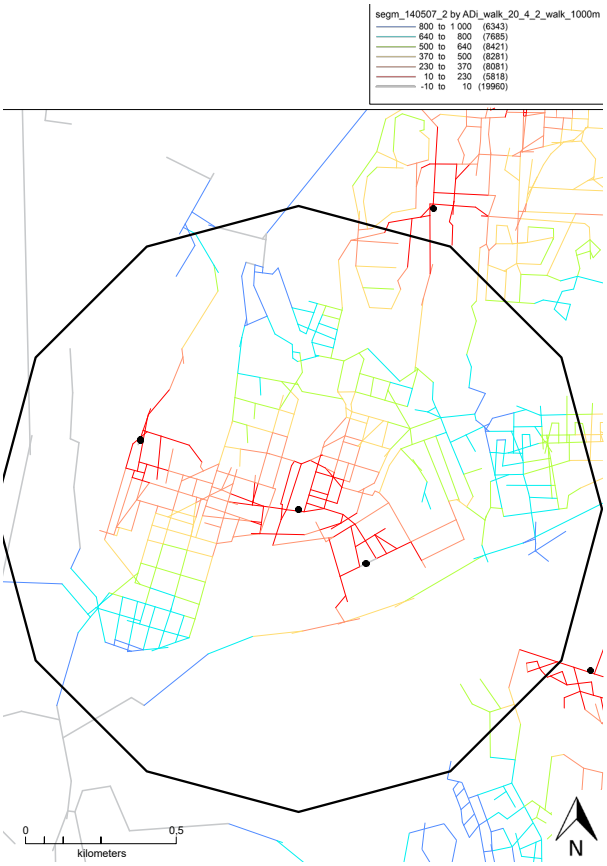


Importance

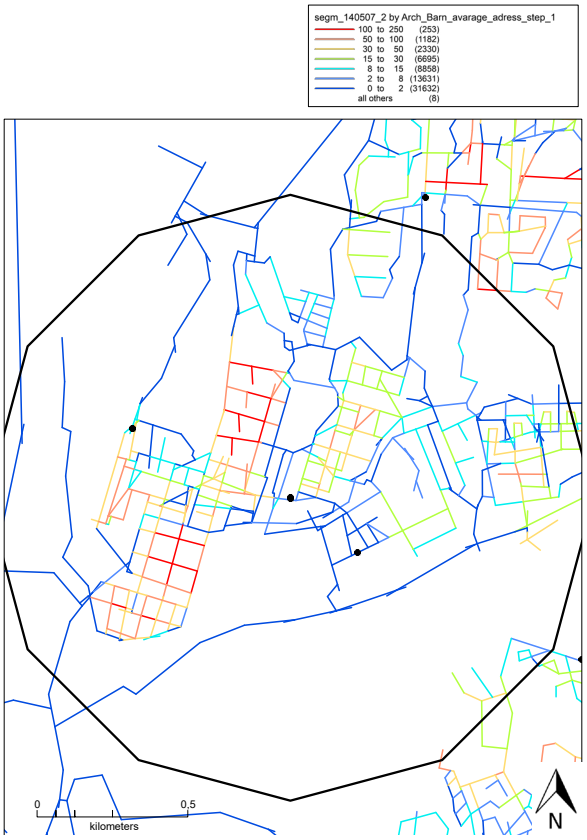


Analysis:Hjällboskolan

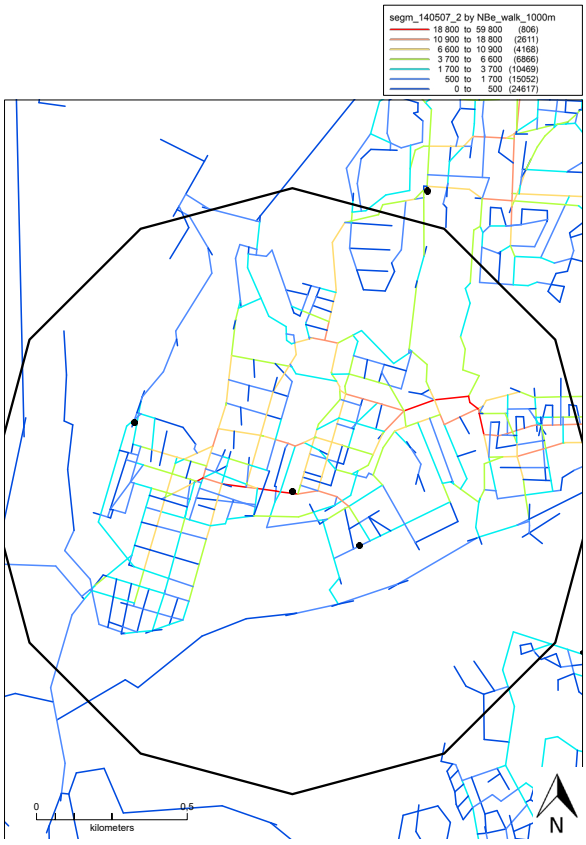
Attraction distance 1000m



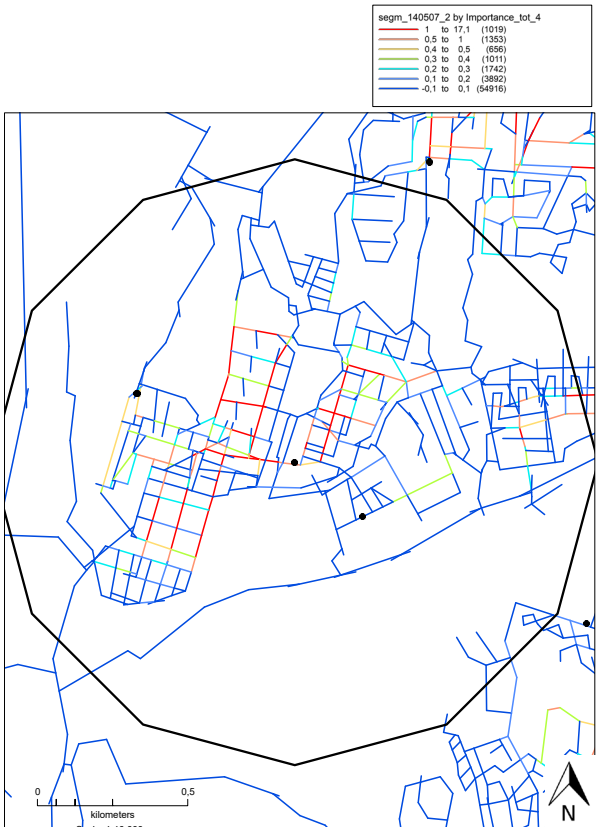
Attraction reach 1 step



Betweenness 1000m



Importance



Observations

Nordhemsskolan 7/4 8:15-8:30. Several children, around 7 years old, walked by themselves to the school and all of them were taking the stairs up to the school. One child walked in the company of an adult. Since there are stairs in some places and since the school is located on a hill there was only one child cycling with his dad. Also, there were no bicycles in the bicycle stands. No cars dropping off children were observed and there was not much traffic on the street next to the school. There were still many cars parked along the street next to the school.

Bicycle stand, Nordhemsskolan

Hovåsskolan 19/4 8:00- 8:30 During the observation three cycling children were observed. Two of these children were cycling by themselves and one younger child cycled in the company of a walking adult. At the school's parking stands, there were 42 bicycles parked which means that most of the children had already cycled to school when observation was made. 11 mopeds were parked at the school which means that some children over 15 choose to drive a moped to school. Around 15 children of different ages walked by themselves or in groups to school during the observation and at least 20 children were driven to the school in a car. Along the street next to the school there was quite a lot car traffic and there was a specific spot where parents drop of their children.


Bicycle stand, Hovåsskolan

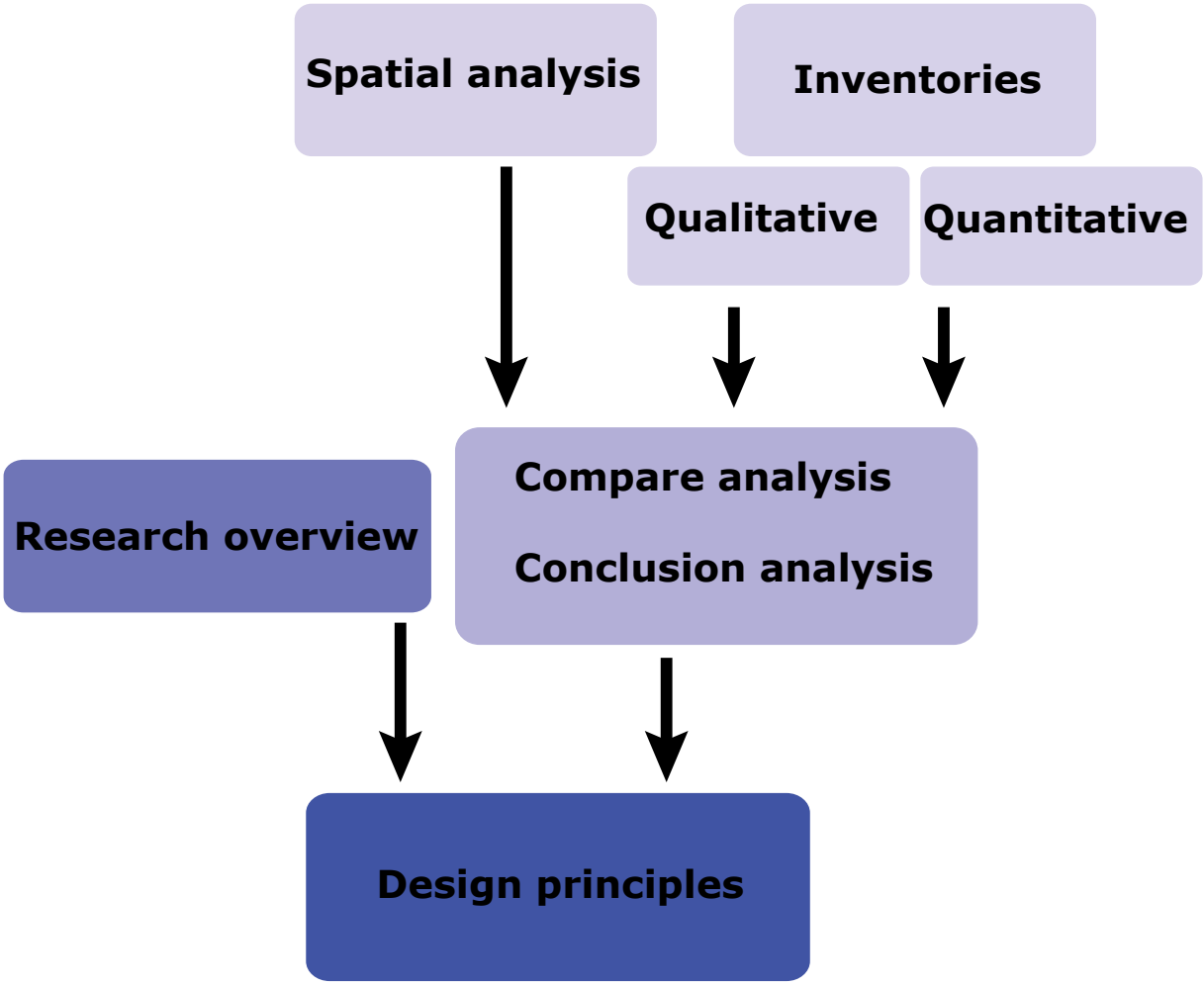
Hjällboskolan 8/5 8:00-8:25
I did not see any children at all cycling to school and there were no bicycles parked at the bicycle parking. There is only one bicycle stand at the school. There was one child being driven to school and around 12 children walked by themselves or in groups to the school during the observation. Around four children arrived by bus and walked to the school from the bus stop that is located just next to the school. The tram stop is also located very close to the school and this means that some children not living in the surrounding neighbourhood probably take the tram or the bus to school. During the observation, I did not see if any children came with the tram. In general, there is not much car traffic in connection to the school and it seems that most children walk by themselves to school.


Bicycle stand, Hjällboskolan

Conclusion observations

The observations showed that there are not many children cycling to the studied schools. There are a few children cycling to Hovåsskolan, but more children walking was observed. The low number of children cycling can be due to different reasons, such as the children live very close or very far from school, their parents do not allow them to cycle, a hilly terrain (especially for Nordhemsskolan) or they do not own a bicycle. Another reason for a low number of cyclists might be a lack of an established bicycle culture at the schools.

Analysis process



One the following pages a conclusion of the spatial analysis and the result from the inventories will be presented for each school site. It is the final conclusion from all different analysis that is presented and this result is then the base for the design principles and the detail design proposals. Different maps is used to illustarate the results.

Nordhemsskolan

Legend

Nordhemsskolan

Studied area

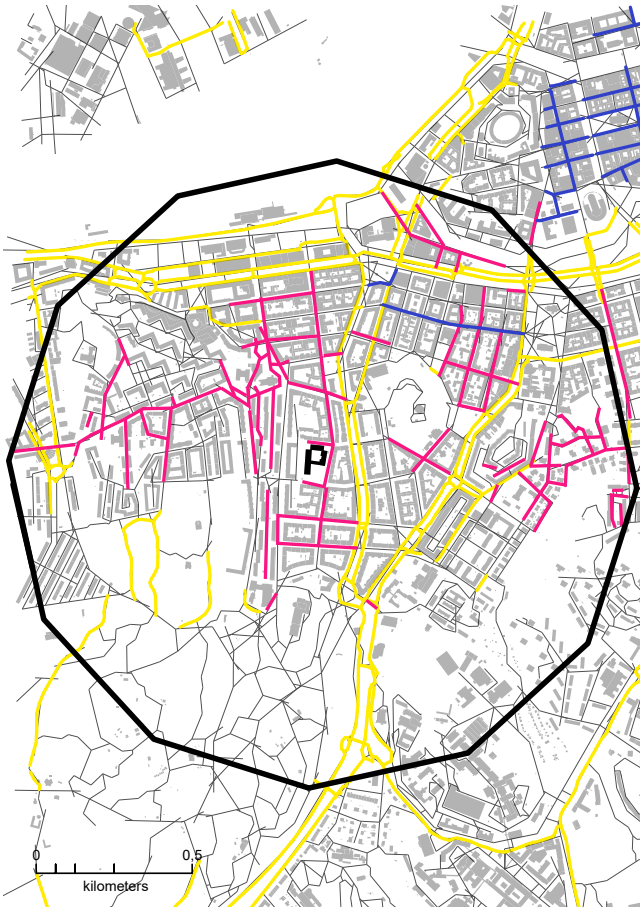
Other schools

Bicycle paths

Pedestrian streets

Most important streets, based on spatial analysis, that are not traffic safe

Traffic safe streets, based on inventory



Map showing number of addresses with a traffic safe school way. Red stands for traffic unsafe and green for traffic safe.

Hovåsskolan

Legend

Hovåsskolan

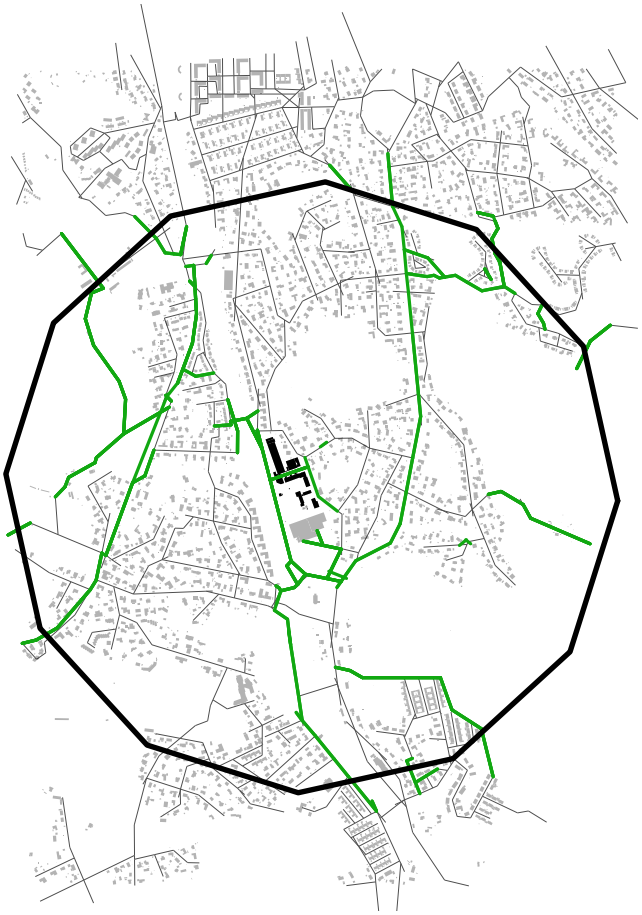
Studied area

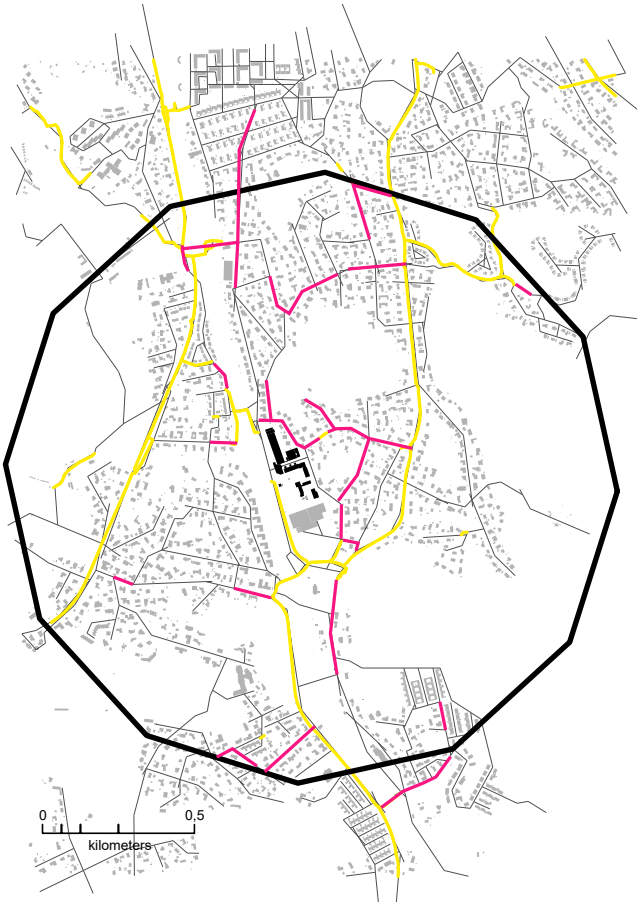
Other schools

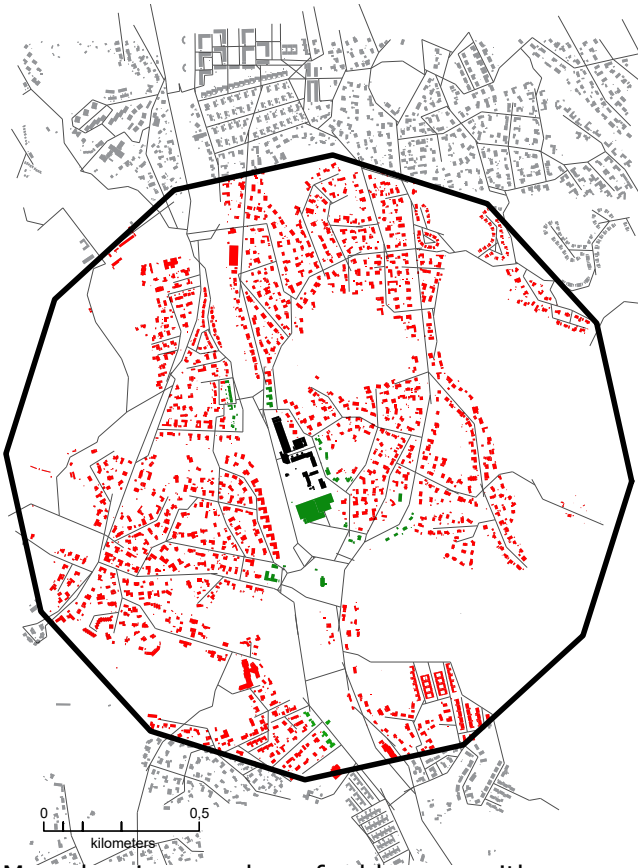
Bicycle paths

Most important streets, based on spatial analysis, that are not traffic safe

Traffic safe streets, based on inventory







Map showing number of addresses with a traffic safe school way. Red stands for traffic unsafe and green for traffic safe.

Hjällboskolan

Legend

Hjällboskolan

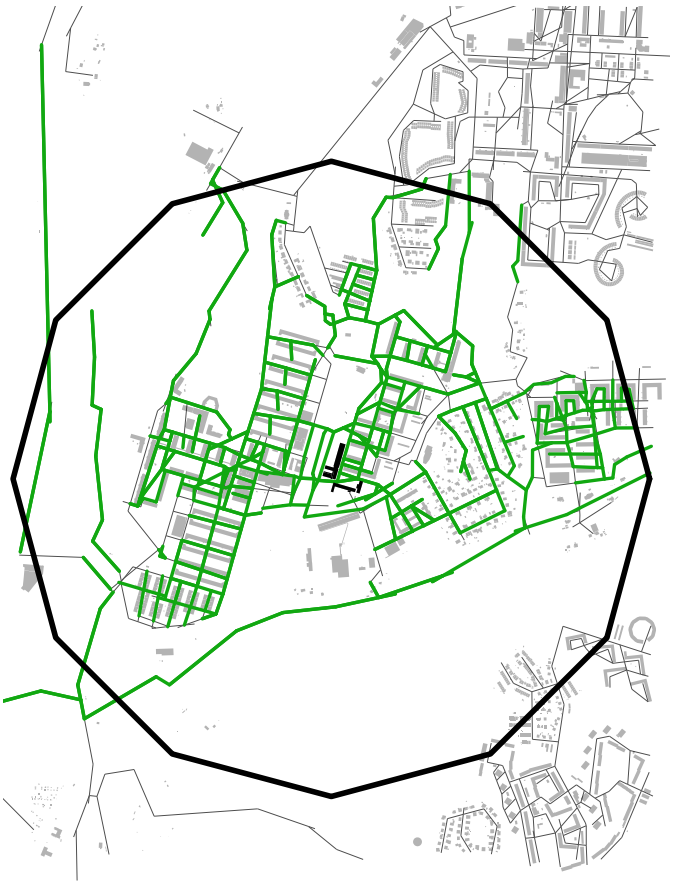
Studied area

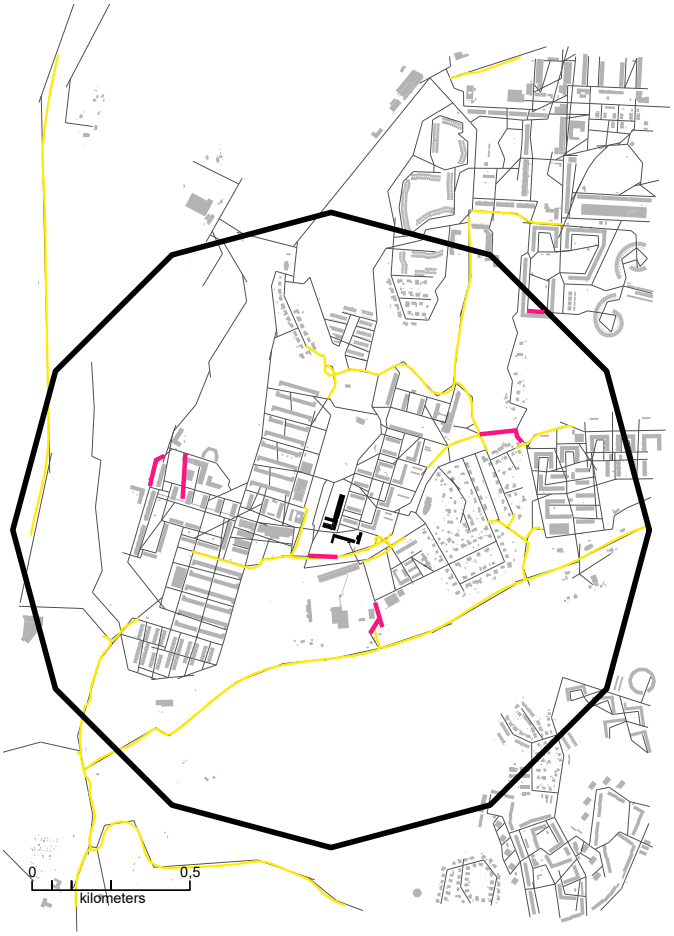
Other schools

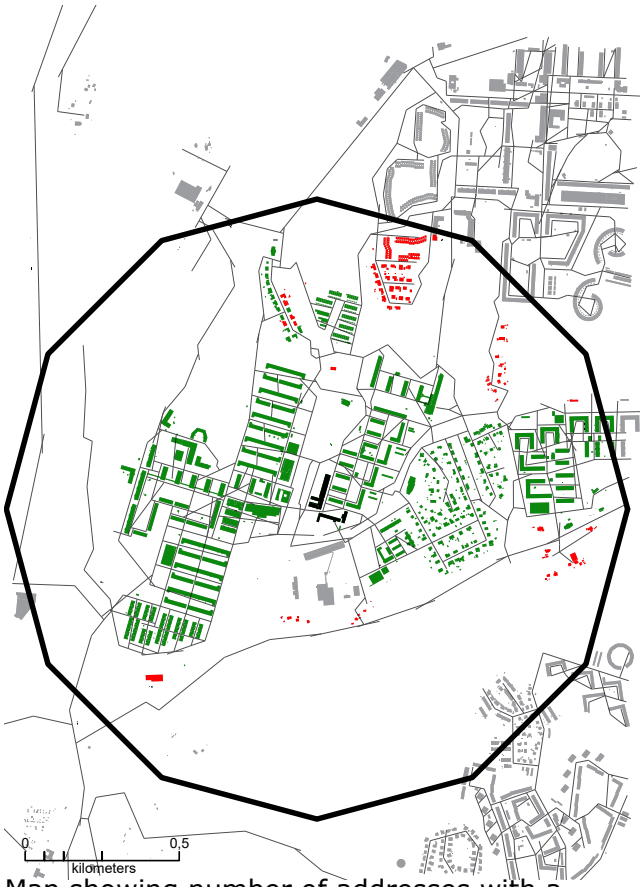
Bicycle paths

Most important streets, based on spatial analysis, that are not traffic safe

Traffic safe streets, based on inventory







Map showing number of addresses with a traffic safe school way. Red stands for traffic unsafe and green for traffic safe.

Part 4- Design

Design principles

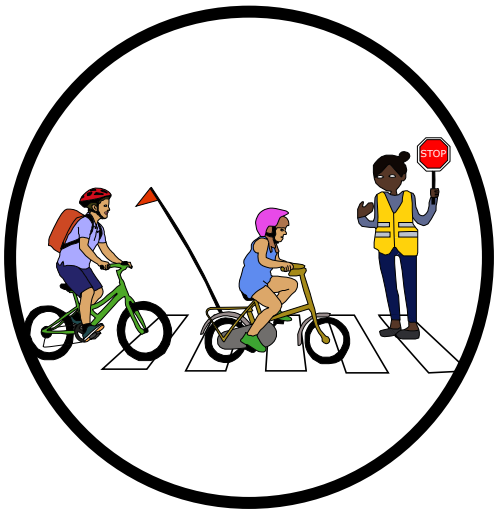
The design principles are a contexture of the results from the spatial analysis, the inventories and the research overview. The most important streets from the spatial analysis have been studied. These are the streets that are closest to the schools, have the most children living along them and have the highest betweenness. During the inventories, all traffic unsafe streets were captured. A lot of knowledge about the existing traffic situation was gathered during the inventories of the three school sites. This knowledge has helped me to understand how streets are constructed and work in the different areas today.

The information from the spatial analysis has mostly been helpful in finding missing links in the existing bicycle network and in finding out which streets are the most relevant to improve. The spatial analysis does, however, not say anything about how to physically improve the network. That is why it is also important to create design principles showing how to physically improve the bicycle network and traffic safety. Design principles, in this case, highlight and exemplify various aspects that are extra relevant and important to include when designing bicycle friendly environment for children. They are guidelines explaining what to focus on when planning bicycle paths.

Almost all the physical design proposals, in the different design manuals, focus on controlling and lowering the speed for motorized traffic and making space for cyclists. Based on this a claim can be made that space and speed

are the basic elements when making design proposals for bicycles (Jägerhörk et al., 2011:31-39, Göteborg, 2015:11, Andersen, 2012:9, SKL, 2008:54). The design principles are therefore all connected to both speed and space in some way. It is mostly the physical structures that are presented but some examples might also inspire more children to start cycling. The principles focus on general design solutions that can work for several different sites. It is important to improve traffic safety on streets in direct connection to schools since these will be the most frequently used ones by children on their way to school. Enough space and speed regulations are two basic elements when planning for bicycles. The design principles are divided into four different main headings which are: safety, comfort, accessibility and playfulness. These headings then have sub headings which are more like design examples. Below all the design principles are describe one by one.

1. Safety



Safety might be the most important design principle because if the traffic system is not safe for cyclists less people will dare to cycle and then the other aspects do not matter. This applies particularly to children. Even if children are not capable of feeling unsafe their parents will (probably) do and will then not let them cycle anyway. A traffic safe bicycle network is good for everyone, regardless of age. If bicycle networks are developed and improved to meet the highest requirements for traffic safety, which are those of young children, the network will be traffic safe for everyone. School ways that are safe and secure generate a higher number of children walking and cycling to school (Jägerhök et al., 2011:95). All the school ways in the three studied areas are not traffic safe at the moment and there is a need to improve traffic safety.

Safety is a decisive factor in whether children can cycle on their own or not. The results from the analysis show that there is a lot of traffic unsafe streets and crossings in the area of Nordhemsskolan and Hovåsskolan which makes movability for children limited. In the area of Hjällbo the traffic situation is different since almost all streets for cars are separated from pedestrians and cyclists. The analysis, based on the traffic safety criteria, shows that a lot of streets are classified as traffic unsafe because the speed limitat is set to 50km/h. This shows the importance of speed limits. During the inventories, I saw that a lot of cars drove fast on the local streets leading to single family houses. This means that there is a need for decreasing the speed limit on streets like these.

Traffic safety has to be improved on these streets in order to increase the number of children that can cycle safely. In the area of Hjällbo most of the

pedestrian and bicycle paths are separated from motorized traffic which makes them traffic safe already. The combination of inventory and spatial analysis has also made it possible to find the most relevant streets for which to improve traffic safety standards. It is also important to improve traffic unsafe crossings. If the streets are improved the traffic system as a whole, will still be traffic unsafe if the crossings are not improved as well. This knowledge is of extra interest since it is very expensive to improve all traffic unsafe streets.

The analysis shows that the streets closest to school are very important which is obvious since all children have to use these streets when travelling to school. The analysis also shows that all these streets are not traffic safe for the studied school areas. As shown by the research overview, many parents experience the traffic situation around schools as traffic unsafe when parents drop off or pick up their children by car. During the observation at Hovåsskolan I experienced this situation myself. There was a lot of traffic on the street next to the school because many parents drove their children to school. The street is not a thoroughfare which means that only cars going to the school use this street. This in turn means that if the parking spaces and the drop off spaces were moved a bit further away from the school there would not be any traffic on that street. This would make the street more traffic safe. The street could then also be turned into a wide bicycle path which would encourage cycling.

Traffic safety can be improved in many ways and there are several design examples showing how to handle certain problems. Below three solutions for increasing traffic safety are described.

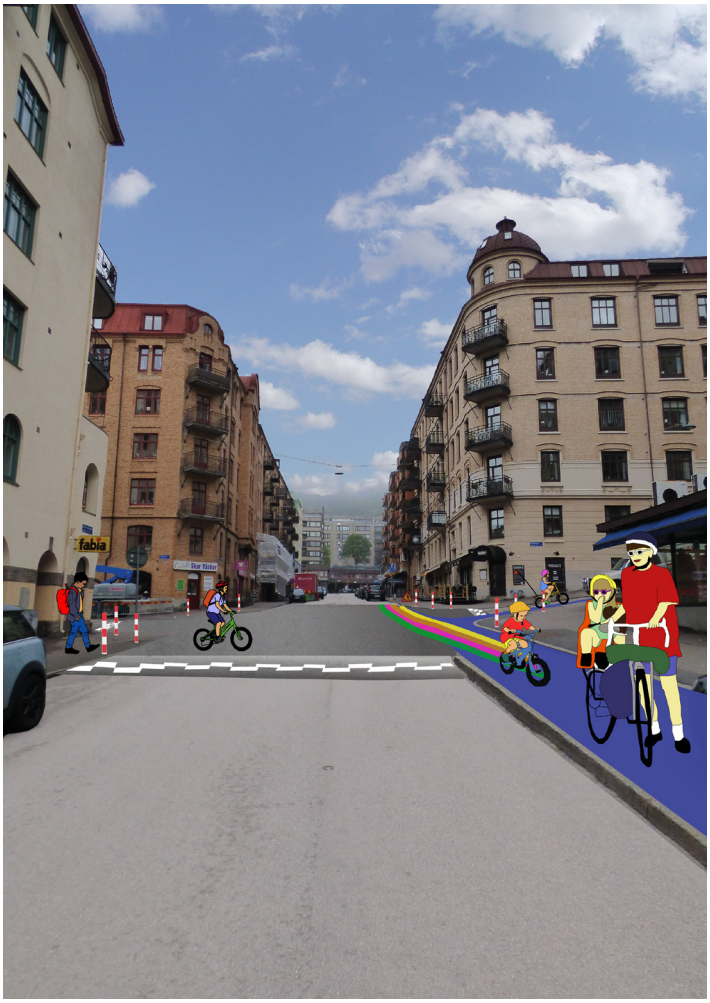
1 A. Strategic int ersections

Intersections are weak points of the traffic system. Most cycling accidents take place at intersections (Andersen et al., 2012B 2012:76). Intersections are weak points because a lot of things happen at the same time and several road users can be entering the intersection at the same time. Conflicts easily arise between drivers and cyclists as they can come from all different directions. Therefore, it is important to focus on and make sure that intersections are traffic safe.

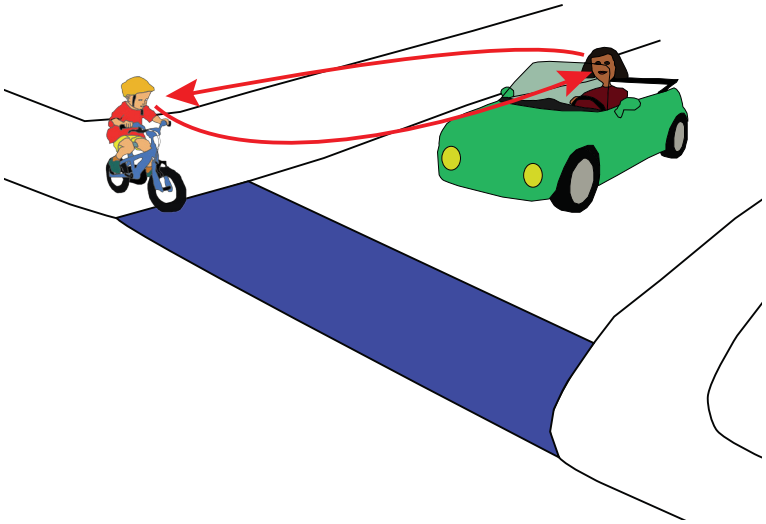
Several solutions can be put in place to improve traffic safety at intersections and one example is to build a so called raised intersection. This is a plateau bump which means that motorized vehicles must slow down and give way for cyclists and pedestrians. This is a solution that is relatively common in Denmark (Andersen, 2012:17).

It is important that drivers and cyclists have mutual visibility so they see each other in a crossing. In more sensitive intersections where it is necessary to pay extra attention to a possible conflict between drivers and cyclists a so-called cycle crossing may be established. The crossing can be painted in a certain colour to draw attention to cyclists crossing the street. For traffic safety, purposes, it is important that cyclists are visible for drivers. A study

has shown that cycle crossings in signalized intersections resulted in a 36 % decrease of bicycle accidents (Andersen et al., 2012B:97). This shows that visibility is very important especially when it comes to children, since they are smaller and therefore harder to see for drivers.



Example raised intersection



Example cycle crossing

1 B. Reduced parking space

The area closest to the school is often the most traffic unsafe space. Parents dropping off and picking up their children cause a lot of traffic. The analysis also shows this problem. Prohibiting parking in the area closest the school reduces traffic and makes the area more traffic safe. Driving and parking can also be prohibited during certain times of the day, to decrease the amount of traffic during peak hours when children are on their way to school. To make it possible to drive children to school, a special drop off space, a little bit away from the school, can be created. This is something that is used in certain places already, for instance in Huddinge municipality. Some schools in Huddinge have drop off spaces in connection with the school and the location for these spaces have been decided by students, teachers and traffic engineers in collaboration. The site should be located a short distance from school where it is possible to stop with a car. The introduction of drop off spaces has made the area closest to the school more traffic safe, as less cars now pass by (Huddinge, 2017).

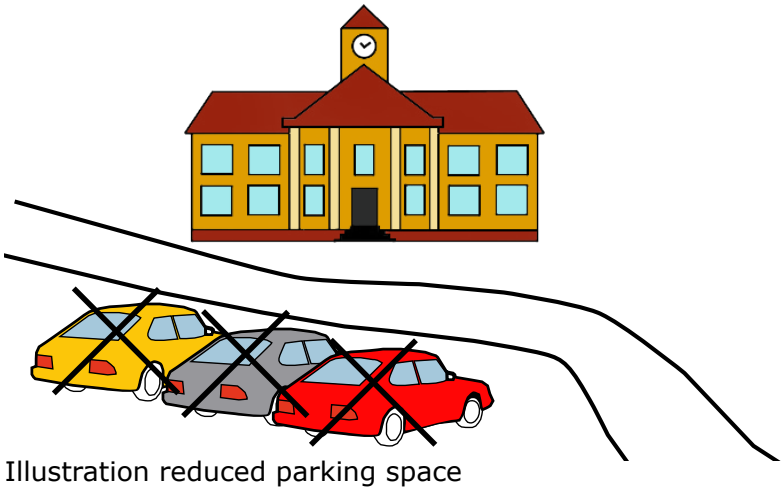
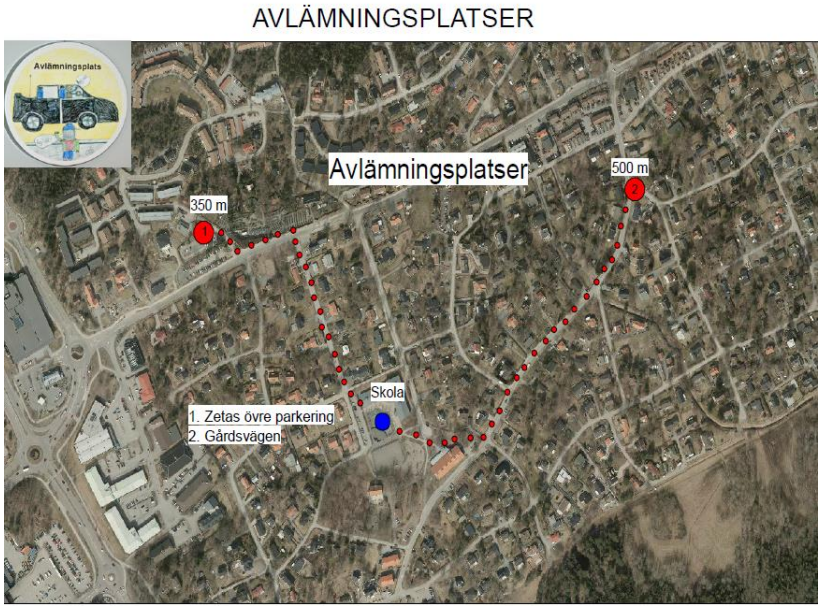


Illustration reduced parking space



Map showing drop off spaces at a school in Huddinge municipality (Huddinge, 2017)

1 C. Speed limits

Speed is essential and one of the most important aspects when it comes to traffic safety. There are different kinds of speed limited streets like shared space, cycling streets or local streets within a living area. To secure the speed limitation there is often a need for physical structures that reduce speed (Andersen et al., 2012B:68). Shared spaces mean that all road-users share the street on equal conditions. The speed limit is set to 8km/h which allows children to safely cycle or play in the street. When shared spaces are implemented it is important to control the speed and ensure that the speed does not exceed 8km/h. Of course, not all streets can be transformed into shared spaces but it is one potential solution. Even speed regulations of a maximum of 30km/h increase traffic safety since most people survive a collision if a car driving at 30km/h hits them (Trafikverket, 2015:6,10). Bicycle and pedestrian traffic tends to increase, particularly among children and the elderly, in areas where the speed has been reduced. The lower the speed, the more children can play and cycle safely on the streets. Small children can also learn how to cycle in low speed areas (Andersen et al., 2012B:68,75).

There are several tools to use to limit speed around schools, one example is electronically variable speed signs. The lower speed limits can then be restricted to the hours when children are in the area around the school. The driver can also see his or her own speed which results in lower speed. This solution has been tried out, for instance in Denmark and Norway. In Norway, it resulted in a speed reduction of 2-11km/h (Andersen, 2012:10).

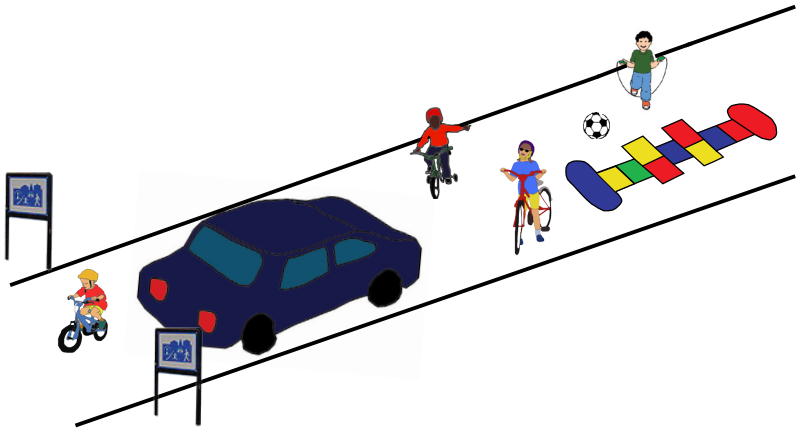
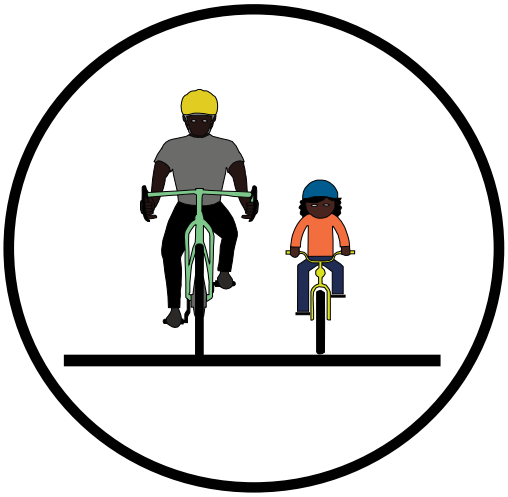


Illustration showing shared space

A project called "Living road" was tried out in two residential areas in Odense municipality (Denmark). The purpose of the project was to reduce speed limits to make the areas more traffic safe and friendlier for cyclists and pedestrians. Residents living in the areas were involved in the project in order to create a sense of ownership. The speed limit was reduced to 30km/h in the areas. One result of the project was that the number of cyclists increased by 62% in one area and remained unchanged in the other area. A project like this is interesting as it includes residents and makes them a part of the project. People involved in the project will be more willing to change their behaviour and also lower their speed when driving in the area (Andersen, 2012:12).

2. Comfort



Cyclists are a very exposed traffic group both to other vehicles but also to weather conditions. Therefore it is especially important to make the traffic system as comfortable as possible for cyclists. Cyclists are sensitive to the formation of the network and the maintenance of the roads. In many cases parents need to accompagny their children to school and then it is important that the network is comfortable. Parents tend to value comfort more than children. They also tend to be more stressed so if one wants parents to cycle with their children to school, or other places, it is very important that the bicycle network has a high level of comfort.

The analysis shows that there is little space, in general, for cyclists in the three studied areas. Most of the space is reserved for cars, car parking spaces and pedestrians. Some streets do have bicycle paths or bicycle lanes along them, but these are often narrow and not always suitable for children. On some of the narrow bicycle paths there are also a lot of commuter cyclists that cycle fast which makes it dangerous for cyclists with a different speed to share the same space. Below two different examples of increasing comfort but also safety for cyclists are explained further.

2 A. Spaces for fast and slow cyclists

There needs to be enough space for cyclists so that both slow and fast cyclists can feel safe when cycling. To make it safe and comfortable the bicycle path can for instance be divided into different parts for different cyclist groups. This can be done with height differences or different colour coding. It will also be more comfortable to cycle if there is enough space for children and parents to cycle side by side. The amount of motor traffic, the speed of the motorized traffic and what cyclist groups will use the path should influence the choice of bicycle solution. An efficient way of segregating different road user groups from each other is to separate them with a kerb. Most of the time children do need a segregated cycle path to be safe (Andersen et al., 2012B:57,75,81). It is also advantageous to divide the network into fast, local and recreative paths. These different types of paths can then be designed differently based on the different conditions and requirements of the different cyclist groups. Bicycle paths for commuter cyclists need to be created so it is possible to cycle fast and local paths leading to local destinations such as schools have to be extra traffic safe.

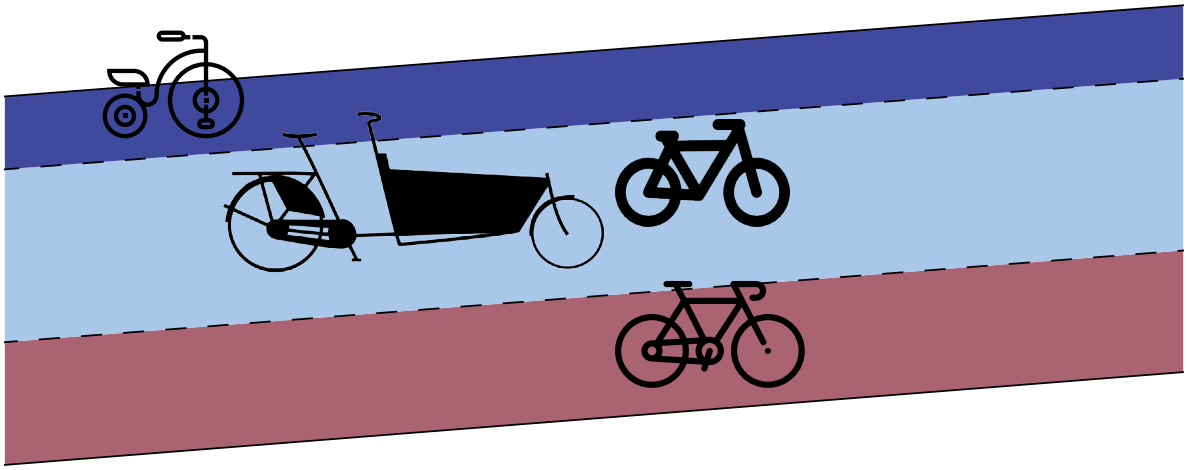


Illustration showing one design solution for fast spaces for fast and slow cyclists

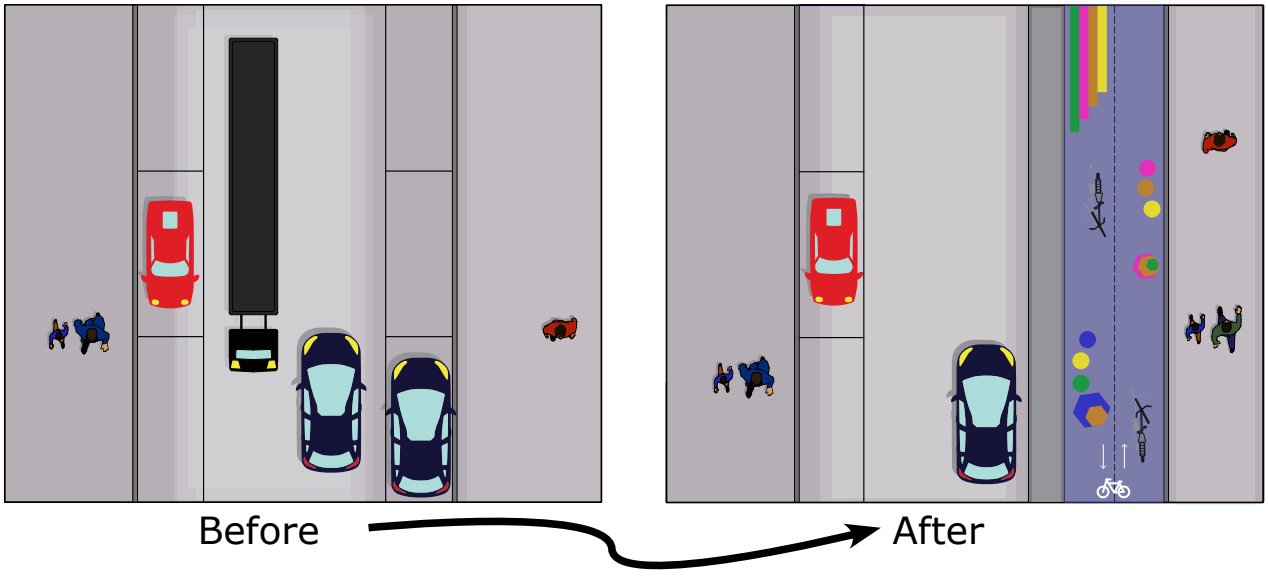
In Gothenburg, the bicycle network is divided into three different types; commuting network, overall network and local network. There is a need for a network that is coherent where cyclists can cycle fast. The commuting network should be designed to make it possible for cyclists to cycle at different speeds. This network is then complemented with a local network that is more enclosed. The purpose of the local network is to bring the cyclists all the way to their destinations. In turn, the overall network makes it possible to cycle longer distances (Gothenburg, 2015:11). It is good to continue improving this way of working with the network on various levels. It is important to minimise the potential conflicts between fast and slow cyclists.

2 B. Redistribution of space

Redistribution of space means that more space should be given to cyclists. Reserving more space for cyclists is one simple and effective solution for increasing traffic safety. It is however relatively expensive to create separate bicycle paths and on some existing streets there could be a lack of space for adding a bicycle path along the street. In cases where redistribution is possible it can be done by making it clear which part is for cyclists and which is for cars. Separated bicycle paths along a street for cars can also be constructed. Studies have shown that the more bicycle paths, the more cyclists (Jägerhök et al., 2011:95). An easy and cheap alternative is to paint a part of the street to clearly show that that space is for cyclists and pedestrians. This is suitable for streets with a small amount of traffic, for example local streets in suburbs. Based on the analysis this kind of solution could be tried out in the area around Hovåsskolan. When creating a bicycle path connecting to an existing street one solution is to transform potential parking spaces along the street into a bicycle path instead. Then the space for moving cars will remain the same and the only change is that some parking spaces are removed. However, this solution is of course not suitable for all streets. On some streets, there is a need for parking spaces along the street, especially parking spaces for disabled. In these cases, there is a need to find another solution to give more spaces to cyclists.

When planning for bicycle paths the start and finish of the path is essential. The transition between the bicycle path and the street should be smooth with ramps or similar connecting the two different parts. The start and finish should also clearly be shown with colouring, signs or similar (Andersen et al., 2012B:85).

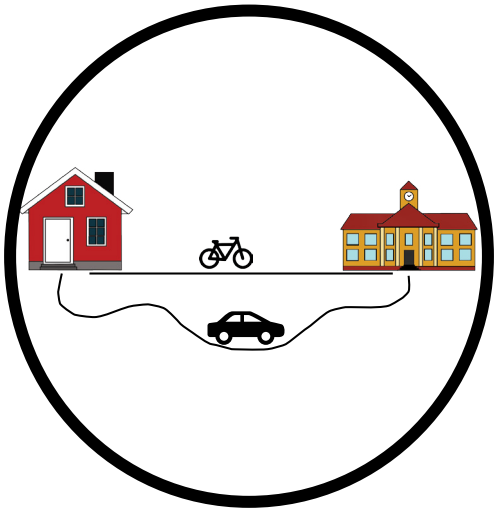
The analysis shows that there is a need for more space for cyclists, especially in the area around Nordhemsskolan and Hovåsskolan. The overall bicycle network passes through both areas but is not connected to the schools. Around the schools most of the street space is reserved for cars.



Sketch showing example on redistribution of space on street in city center

Example on redistribution of space on a local street in a suburb area

3. Accessibility



Accessibility and connectivity are two important aspects to focus on when constructing an effective and useful bicycle network. The bicycle network has to be accessible for children so they can and want to cycle. It is also important that different parts of the network are well connected to each other and to different destinations. The accessibility aspect is also important from parents' perspectives. The bicycle network should be accessible enough to make it attractive for parents to cycle with their children to school. If the bicycle network is inaccessible it is straight away easier for parents to drive their children or take the bus to school. The accessibility aspects can also be connected to traffic safety. If the bicycle network is traffic safe but not accessible the network will probably not be used that much. The cyclists that are not afraid of traffic and cycle anyway will then probably just use a more accessible, but less traffic safe road, which is not suitable for children. An accessible bicycle network makes it easier and more attractive to cycle to school, but also to other places. To make people cycle it is important that it is easy to cycle and one aspect of this is making the network direct and accessible. It is also the access to the network itself that counts. If you have a traffic safe network right outside your door, it is more likely that you start cycling, because then it is easy. Taking the bicycle should be the easiest way of travelling (Faskunger, 2008:17, Jägerhök et al., 2011:95).

When new bicycle paths are constructed it is important to analyse the potential of the path, who the users will be and what routes cyclists are likely to use to access the new path. Spatial analysis is a good method to use to study these things. The analysis made in this thesis shows that the overall bicycle network is not connected to the studied schools. The main bicycle network is visible in the analysis which makes it clear that it does not pass any of the studied schools. Overall it seems that the overall bicycle network is not connected to local destinations such as schools. There were also several missing links identified in the overall bicycle network. The spatial analysis captures the most important links in the street network and the result is therefore valuable when trying to find missing links and important routes where bikability needs to be improved. Below two different principles describe how the analysis can be helpful when improving the bicycle network.

3A. Missing links

The bicycle network is never stronger than its weakest link. Missing links are parts in the network that do not meet the required traffic safety standards. These missing links have to be improved in order to create a better and more traffic safe bicycle network. It can be difficult to find the missing links but the

most important ones have been identified in the analysis. Spatial analysis is an easy and efficient way of seeing the most important missing links. It is also helpful that it is possible to include different destinations when making spatial analysis. It makes it possible to find out how different important destinations can be linked. When trying to locate the missing links the focus should be on the destinations rather than the traffic and the path itself (Andersen et al., 2012B:57). The spatial analysis is helpful to use when trying to find potential streets suitable for bicycle traffic.

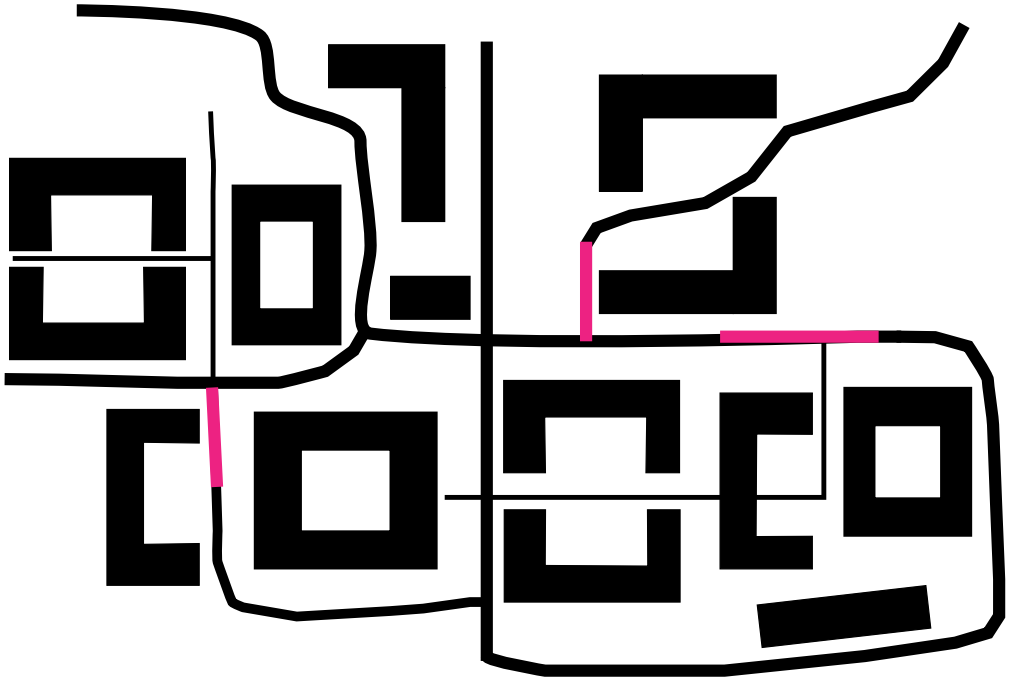


Illustration showing missing links

3 B. Coherent network

A coherent and direct bicycle network is essential to make people cycle. School children need to feel safe when cycling and therefore the bicycle network needs to be close to their home. If the route to the school is a heavily trafficked major road the route should, if possible, be an alternative route rather than along this road. The alternative route can be located along smaller roads or even through parks.

It is important that the bicycle network in the city does not overlook local destinations in the city such as schools. The overall bicycle network tends to connect destinations more on a municipal level within the city. This is something that can be seen in the analysis when studying the bicycle network on a municipal level. Since children tend to cycle mostly in their neighbourhood there is a need to also improve the bicycle network and adapt it to a local scale.

Looking to create a coherent network is a well-known and established principle that Gothenburg municipality already mentions in their bicycle programme (Göteborg, 2015:34). However, this is still an important principle to stress.

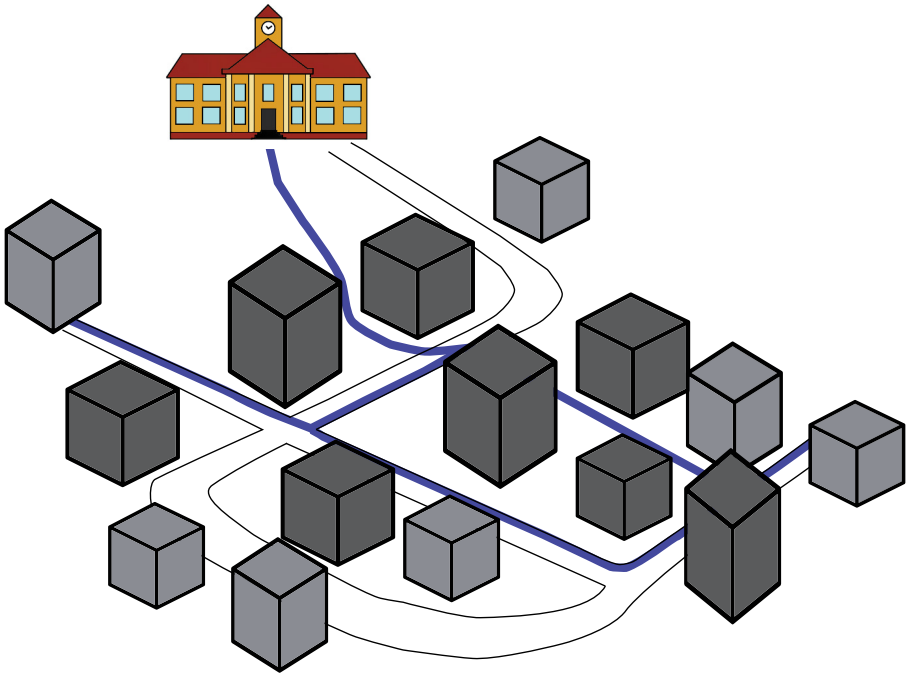
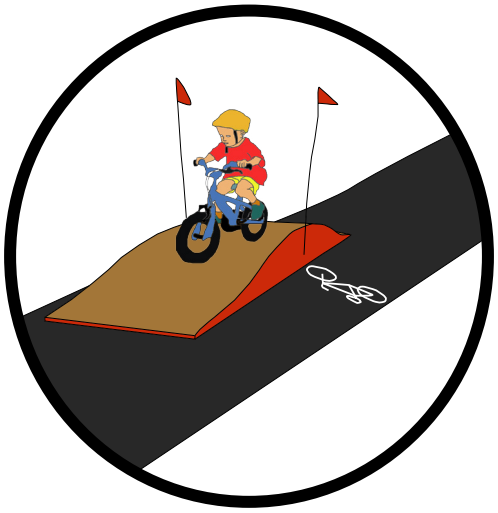


Illustration showing coherent network to school

4. Playful



Cycling should be fun and playful. Children see cycling as a way of playing which makes it important to design the bicycle network so it is possible, but also safe, to combine cycling with playing. The design of the bicycle network does not have to be childish and designed only for children, but the design should be adapted to children's needs, which includes spaces for playing. This is of course especially important in places where a lot of children cycle, for instance around schools. Children develop through new knowledge and they gain their knowledge when being among others when they can discover the surrounding area on their own. Children discover their surroundings by playing (Björklid,1992:3).

Since many of the streets in the studied areas do not meet the traffic safety standards for children the streets are not good spaces for playing. All streets might not be suitable for playing, but since children learn by doing it is still important that children have access to streets for cycling and playing. When they cycle they also practise how to behave in traffic. The analysis shows that streets suitable for playing are mostly local streets with less continuous traffic. Based on the analysis it is also possible to find specific spaces that would be suitable for a more playful bicycle design for playing but also for educational purposes.

4 A. Playful practises

Bicycle paths can be designed in a more playful way in recreation areas. Different colouring, ramps or similar can be helpful and inspiring tools used when children practise cycling. To a large extent, playful practise is about learning how to cycle and how to behave in the traffic system. In Denmark, it is common that schools have cycle classes on the schedule in school. Different kinds of ramps and other things that will make children practise their traffic behaviour are then used. Playful paths can both be constructed for an educational purpose but also for making it playful and fun to cycle. One example from Denmark is the mobile bicycle path with a mobile structure including different devices that should make the children more secure in traffic. The children exercise their balance, how to control the cycle in difficult situations and when to give signal in a secure way (Cyklistforbundet, 2013:12-13). This kind of bicycle obstacle course helps children practise their cycling ability and is also playful at the same time. Instead of having a mobile structure the obstacle course can be located in a park or similar.

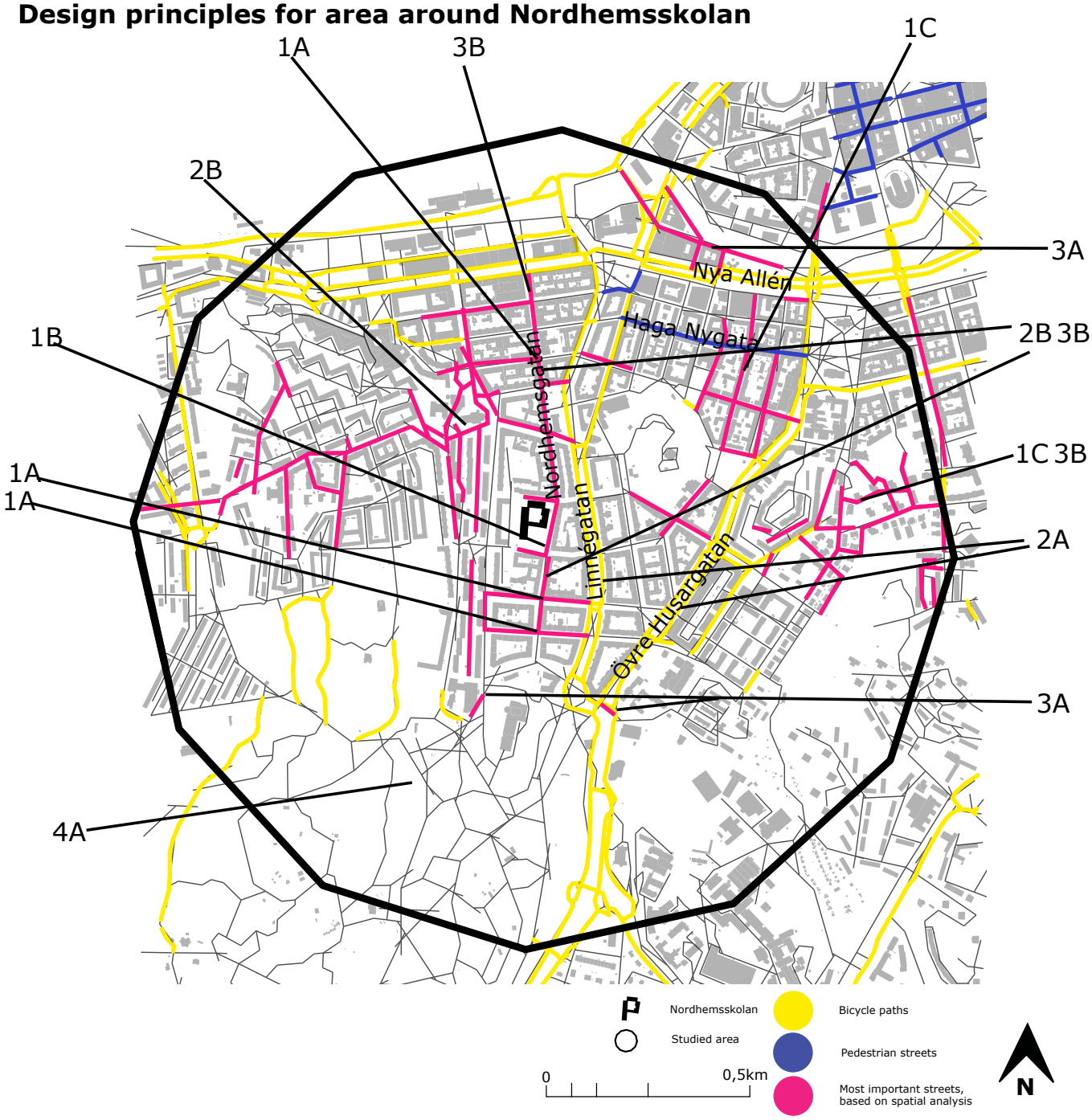
Example playful practise painted path

Design principles- translated into Nordhemsskolan

Introduction

To illustrate how the design principles can be connected to and used in one of the studied areas the principles were shown in an example for the area around Nordhemsskolan. The proposal for how the principles can be used in the area is just an example of using the design principles and translating the analysis into a more concrete design proposal. Since some of the design principles are similar, o several of them can be used to solve the same problems. Several different principles can also be used for the same site to make it as good as possible. Below the design proposal for where all the different design principles can be applied in the area will be shown and described further.

Design principles for area around Nordhemsskolan



1A- Strategic intersections

It is necessary to improve intersections in several places in the area, but the most important places are the ones closest to the school. Either of the two different kinds of strategic intersections works for intersections in the area.

1B- Reduced parking spaces

This design principle is of course most suitable for the area closest to the school. Today there are parking spaces along the streets surrounding the school. The streets Övre Djupedalsgatan and Övre Majorsgatan are two short dead-end-streets and here the parking spaces can be kept but the hours for parking can be regulated so it is not allowed to park there during peak hours in the morning. It could be hard to create a designated drop off space in this area, but since only 8% of the children in this city district are driven to school the driving parents probably do not constitute a big problem.

1C- Speed limit

The speed limit can be reduced in several places in the area which would also be good in order to improve the atmosphere and the public life in the area. However, the most important change is to reduce the speed along Nordhemssgatan which is the street leading to the school. It would also be advantageous to reduce the speedon the streets in the area of Haga would since several of these streets are very important for children's routes to school. Since Haga Nygata, in Haga, is already a pedestrian street it seems easy to lower the speed for some of the surrounding streets as well, even if the speed limit is set to 30km/h.

2A- Spaces for fast and slow cyclists

It is most important to make different spaces for fast and slow cyclists on the overall bicycle paths where there are a lot of different kinds of cyclists and especially where there are cyclists cycling fast. In this area, it is mainly on Linnégatan, Nya Allén and Övre Husargatan that this kind of solution has to be implemented since these are the main bicycle paths in the area. They arealso a part of the overall bicycle network which means that a lot of cyclist's cycle here.

2B- Redistribution of space

Today there are many streets without bicycle paths or bicycle lanes in the area. To make the area more bicycle friendly there is a need to give cyclists more space which makes a redistribution of some street spaces necessary. Another solution is to reduce the speed on the street to make it traffic safe to cycle in mixed traffic. The design principle 1C describes how speed limits can be introduced. It is most urgent to create a bicycle path along Nordhemsgatan, the street where the school is located, since this street is

used by almost all children on their way to school. The parking spaces along the street can then be converted to a bicycle path. Bicycle paths can also be added to other streets in the area that are important for children's movements patterns and that are not traffic safe at the moment. This design principle is general and the changes to the distribution of street space between different transport groups need to be studied in detail for each street to make a good design proposal.

3A- Missing links

In the analysis, it is easy to find where the most important missing links in the area of Nordhemsskolan are. These links are essential to improve in order to make the bicycle network better. The missing links that were identified in the area were mainly two short parts in the south of the area and an area in the northern part (these can be found on the map below). The streets that need to be improved are important streets that are not considered traffic safe according to the analysis. So, if these streets are improved the network as a whole will be improved. This shows that improvements in certain important places can make a difference on a larger scale. It is also important to connect the bicycle network to a local scale creating paths leading to local destinations as well.

3B- Coherent network

The existing bicycle network in the area is more or less just passing through the area and therefore by-pass local destinations such as the school. In order to improve the bicycle network, it needs to be coherent and connected to local destinations as well. If bicycle paths that connect Nordhemsskolan to the existing bicycle network leading along Linnégatan were added, the network would be more coherent and better connected with the school. Improving the bicycle path on the missing links (design principle 3A) will also contribute to making a more coherent network in the area.

4A- Playful practises

The southern part of the studied area, the recreation area of Slottskogen is a good area for creating a playful and educational bicycle obstacle course. This area is suitable because there no vehicles are allowed in the area which makes it traffic safe enough for these purposes. The obstacle course can then be used by schools for traffic security education and by children playing cycling in their spare time.

Part 5- Discussion

Introduction

In this chapter, a general discussion of and reflections on the overall result will be presented and the research questions will be answered and discussed. The main focus in the thesis has been the process of combining different analysis methods. It is mainly the combination of a qualitative and a quantitative method that has been studied. This has been done in order to find out what the existing traffic safety situation for the studied school sites looks like. The design principles show how physical design solutions can improve the traffic safety for streets.

How can a combination of spatial analysis and inventories be used to find the most relevant streets to improve in terms of traffic safety?

The different methods are used separately and then the result from the two methods are combined. It is when these results are combined that the actual result and final analysis, that answer the questions asked in the thesis, can be studied. The two methods could have been used separately but this would have generated different results and analyses. The positive aspect of combing the methods is generating broader results. Even if the spatial analysis is done on a large scale it is still interesting to use this method to find out which streets that are the most important ones for children's routes to school. When combining the spatial analyses and the inventories it is possible to see what streets are the most relevant to improve the traffic safety for. This is

something that cannot be done using only one of the methods, or any other methods. This makes the combination of spatial analysis and inventories unique in that sense. The analysis tells us where, but not how, improvements are most relevant to do.

When spatial analysis is used for a small area it is necessary to adapt the analysis to each site so that it shows what is asked for. Since the analysis is done on a large municipal scale the ranges sometimes need to be changed in order to see any differences within the street network for the smaller area. This have been one of the issues with using spatial analysis for studying three school sites located in different parts of the municipality. In the betweenness analysis many streets in the area around Nordhemsskolan show a high value since this area is located in the central part of the city. In the same analysis, the streets around Hovåsskolan show low values because this area is located in a suburb at the outskirts of the municipality. In order to make the analysis relevant for Hovåsskolan the ranges were adapted to show differences within the smaller area as well. Nevertheless, changing the ranges is not an issue as long as it is clear to the reader this was done and the reader does not think that the analysis has the same ranges throughout. The attraction distance analysis, showing the closest streets within a radius of 1000m from the school, is on the other hand an analysis that does not have to be adapted to fit the different areas. This analysis starts from the location of each school. Since children do not travel a long distance to school it is very important to make sure that all analyses are adapted to the local scale so each analysis is focusing on the local streets.

It is important to critically review the results both from the spatial analysis and the inventories. Even if the result from both methods are based on set criteria the results cannot be seen as an objectively true. The criteria set are based on several choices made by people and therefore cannot be completely objective. The results from the inventories are for instance completely dependent on the traffic safety criteria since these determine whether a street is traffic safe or not. If the traffic safety criteria had been different the results would also have been different. Thus, even if the results from the spatial analysis can be used in different ways and be interpreted differently, the conditions for making the analysis are still the same regardless of who is doing it. However, the most difficult part is not making the analysis but rather analysing and understanding how it can be used.

It might appear unnecessary to carry out a spatial analysis to find the most important streets since the studied areas are relatively small and there are not that many different routes to school to choose between. The lack of alternative school routes means that it is potentially easy to see what streets are the most important ones, without using spatial analysis. One can for instance suppose that the streets closest to the school will be used by most children since all children have to use one of these streets to get to school. The relevance of using spatial analysis depends on the complexity of the street network around the school. The more streets the more complex it is to

decide what streets are the most used ones. Another problem can also be that even if not all streets are equally important, almost all streets are somewhat important. This is because children live in in all parts of the area which means that every street will be a residential street for one or more children. However, spatial analysis might be better to use when studying bicycle potentials on a larger scale, or studying other things on a smaller scale. On a small scale, it is for instance more relevant to study what streets are the most integrated ones and therefore also the most suitable for services or similar. However, if the knowledge data required for the spatial analysis is already available, it is quite easy and quick to do the actual analysis. This makes it easy to visually show which streets are the most important, and what the result is based on. Therefore, the method is still relevant to use in order to get as much knowledge as possible about the street network at the site. It has been relevant to try out the combination of methods to discover the usefulness of the combination, especially since the focus in this thesis has been to study the value of combining the methods and the analysis process. The need for new methods within the bicycle planning field also makes it relevant to try out new and innovative approaches. When methods and combinations of methods are tried out in a new way one of the main results is to evaluate the usefulness of the new analysis method and what could have been done differently.

What design principles can be used for improving traffic safety for schools in Gothenburg?

The most interesting design principles created in this thesis are the ones connected to the spatial analysis, for instance the principles missing links and coherent network. These are the most interesting because they are directly connected to the result from the spatial analysis.

How relevant the design principles are for different areas of Gothenburg depends on what the traffic safety standard is today. The inventories have only been done for three school sites which means that the traffic situation around all other schools has not been captured. The design principles might, for instance, be less important for areas like Hjällbo as a lot of the streets in areas similar to Hjällbo are traffic separated. This means that there is no need for physical improvements to improve the traffic safety standard in these areas. However, there might be other aspects, that are not physical, that need to be looked at to improve traffic safety. These potential aspects are not studied. Since the analysis in this thesis only focuses on traffic safety standard, it is not possible to come up with design principles focusing on other aspects connected to safety. In the area around Nordhemsskolan there are, on the other hand, a lot of physical improvements needed to increase traffic safety. In this case, the design principles can be used as guidelines for what to focus on. The studied areas have different conditions since they are located in different parts of the municipality and because the building typologies are different. Since the areas display these dissimilarities, design principles can be more or less suitable for each of the sites. However, the design principles

are of a general nature which makes it possible to adapt them to the specific needs of different areas.

Conclusions

The results from the observation show that even if the area of Hjällbo is the most traffic safe area no one cycled to Hjällboskolan. Several children cycled to Hovåsskolan even though more streets there were considered traffic unsafe. A reason for this can be that children attending Hjällboskolan might live so close to school that it is easier to walk than cycle to school. In Hovås the children live spread out over a larger area which means that more children have a longer distance to school, a distance more suitable for cycling.
To get a better and more extensive result from the case study it would have been useful to also make surveys and/or workshops about cycling at the different schools. Surveys and/or workshops would have been great complements to the quantitative analysis part of the case study. Surveys could have been used to ask children how they travel to school and what streets they use. It would also have been interesting to hand out questionnaires to parents and ask them questions about traffic safety and what street they experience as traffic unsafe. The streets pointed out as traffic unsafe could in turn be studied more carefully to better understand how to improve traffic safety. Workshops with children, teachers and parents could then be used to come up with ideas on how to improve traffic safety but also how to increase cycling to school in general. Due to a tight time limitation, there has unfortunately not been time enough to be able to do this.

The design principles are only focusing on physical improvements but the work of trying to increase the number of children cycling to school is more complex than just improving the physical traffic safety. A big part of the discussion is about the attitudes to cycling and the willingness to cycle. Children's ways of travelling to school start with parents' attitudes to transportation and their transportation behaviour. In order to increase the proportion of children cycling to school an attitude change has to happen, and this starts with parent's attitudes to cycling and their willingness to let their children cycle. Even if the psychological aspects do not strictly belong to the field of architecture they are still very important to keep in mind when planning for bicycles. Therefore, it would have been interesting to add psychological aspects to the design principles as well. Since this master's thesis has a tight time limitation and because it is done in the field of architecture it was not possible to include the psychological aspects of the problem when the design principles were created. In the end, it is important to remember that physical improvements still are important pieces in the cycling puzzle.

Part 6- References

Andersen T. (2012). *Healthy and Bicycle-Friendly School Roads - Guide with ideas for healthy and active transport*. Copenhagen. The Danish Cancer Society

Andersen T., Bredal F., Weinreich M., Jensen N., Riisgaard-Dam M., Kofod N. M., (2012B) *Collection of Cycle Concepts 2012.* Cycling Embassy of Denmark

Berglund K., Sjöström J., Åström B. (2004). *Hela staden, från mellanrum till stadsrum*. Stockholm: Svensk byggtjänst

Broo, R., Lagerqvist, M., Lövsund, J. (2006). *Undersökning angående barns säkra skolvägar*. Borlänge. Vägverket.

Boverket (2015). *Gör plats för barn och unga! En vägledning för planering, förvaltning och utformning av skolans och förskolans utemiljöer.* Karlskrona, Boverket

Björklid, P. (1992). Forskning om barn och trafik. Stockholm. Stockholms universitet Institutionen för pedagogik och didaktik

Björklid p. Gummesson M. (2013). *Children's Independent Mobility in Sweden*. Stockholm, Borlänge. The Swedish transport administration.

Caldenby C., Linde Bjur G., Ohlsson S. *Guide till Göteborgs arkitektur.*

Arkitektur förlag AB

Cyklistforbundet. (2013). *Skole cyklings håndbog*. Copenhagen. Cyklistforbundet

Denmark.dk. *Superkilen celebrates diversity in Copenhagen.* http://denmark.dk/en/lifestyle/architecture/superkilen-celebrates-diversity-in-copenhagen

Denscombe M. (2009). *Forskningshandboken- för småskaliga forskningsprojekt inom samhällsvetenskaperna*. Lund. Studentlitteratur

Everett C. (2016) *Cykelns och cyklingens historia.* Naturskyddsföreningens cykelnätverk. www.so-rummet.se

Faskunger J. (2007). *Den byggda miljöns påverkan på fysisk aktivitet En kunskapssammanställning av regeringsuppdraget "byggd miljö och fysisk aktivitet"*. Östersund. Statens folkhälsoinstitut

Faskunger J. (2008). *Aktiv transport- på väg mot bättre förutsättningar för gång- och cykeltrafikanter.* Östersund. Statens folkhälsoinstitut

Faskunger J. (2008B) *Barns miljöer för fysisk aktivitet – samhällsplanering för ökad fysisk aktivitet och rörelsefrihet hos barn och unga*. Östersund. Statens folkhälsoinstitut

French G., Steer J., Richardson N., (2014) *Sustrans Design Manual Handbook for cycle-friendly design*. Bristol. Sustrans

Groot, R. d. (2007). *Design manual for bicycle traffic*. Utrecht. Ede.CROW.

Gummesson M. (2007). *Barns säkra tillgänglighet till skolan*. Göteborg. Chalmers tekniska högskola

Göteborg (2009). *År 2020 Fler rör sig i staden. Men färre skadas i trafiken. TRAFIKSÄKERHETSPROGRAM 2010–2020.* Göteborg. Trafikkontoret

Göteborg (2015). *Cykelprogram för en nära storstad 2015-2025*. Göteborg. Trafikkontoret

Hillier, B. (1996). *Space is the machine*. London. Space syntax.

Hillier, B., Iida, S. (2005). *Network and Psychological Effects in Urban Movement. London. Bartlett School of Graduate Studies*. London. University College London.

Hillier B., Vaughan L. (2007) *The spatial syntax of urban segregation.* London. Progress in Planning 67

Johansson, C., Leden L. (2008). *SYBAS –Underlag till handbok för systematisk*

trafikplanering för barn. Luleå. Luleå tekniska universitet Institutionen för Samhällsbyggnad Avdelningen för Arkitektur och infrastruktur

Johansson R., Rådberg J., (1997). *Stadstyp och kvalitet*. Stockholm. Byggforskningsrådet

Johansson L. E., Lagercrantz M. (2016) *Två hjul som förändrar världen.* Ordfront

Jägerhörk T., Kihlborg L. Nordström T., (2011). Cykelstaden - *En idéskrift om stadsplanering för mainstreamcyklistens återkomst*. Stockholm. White arkitekter AB, Spacescape AB

Klarqvist B. (1993). *A space Syntax Glossary*, Nordisk Arkitekturforskning

Koch, D. (2004). *Spatial systems as producers of meaning – the idea of meaning in three public libraries.* Stockholm. Royal institute of technology school of architecture
København (2013). *Kommunes retningslinjer for vejprojekter*. Copenhagen. Teknik- og Miljøforvaltningen
Center for Trafik, Cykelprogrammet

Marcus, L. (2006). *Spatial Capital and how to measure it – An outline of an analytical theory of urban form*. Stockholm. Kungliga Tekniska Högskolan

Midtland, K., (1995). *Seks-åringer som fotgjengere Seks-åringers forutsetninger for å ferdes trygt i trafikkenog risikofaktorer på skolevegen*. Oslo. TransportØkonomisk institutt

NACTO. (2017). *Urban street design guide*. New York. National Associations of City Transportation Officials

Odense (2003). *Evaluering af Odense – Danmarks Nationale Cykelby.* Odense.

Oslo, (2015). *Oslo Sykkelstrategi 2015-2025*. Oslo. Oslo kommune

Pucher J., Buehler R., (2012). *City Cycling*. Massachusetts Institute of Technology

Regeringen, (2016). Regeringsbeslut 2016-12-22 N2016/07594fTS. Linköping. Statens väg- och transportforskningsinstitut

Rådberg Johan (1988). *Doktrin och täthet i svenskt stadsbyggande 1875-1975.* Stockholm. Statens råd för byggnadsforskning

SOU, Statens offentliga utredningar (2012). *Ökad och säkrare cykling – en översyn av regler ur ett cyklingsperspektiv*. Stockholm. SOU

Ståhle, A. (2005) *Mer grönt I tätare stad*. Stockholm. Kungliga Tekniska Högskolan.

SKL, Vägverket, (2008) *Rätt fart i staden Hastighetsnivåer i en attraktiv stad*. Stockholm, Borlänge. SKL

SKL. (2008) *Shared space Trafikrum för alla*. Stockholm. Sveriges Kommuner och Landsting

SKL, Trafikverket, (2010). *GCM-handboken Utformning, drift och underhåll med gång-, cykel- och mopedtrafikanter i fokus*. Stockholm, Borlänge. Sveriges Kommuner och Landsting. Trafikverket

Trafikverket (2013). *Children's Independent Mobility in Sweden*. Borlänge, Stockholm. Trafikverket

Trafikverket, (2015). *Nationellt cykelbokslut 2014 Hur utvecklas cyklandet i Sverige och vart är det på väg?* Borlänge. Trafikverket
Trafikverket, (2015A). *ROAD SAFETY Vision Zero on the move*. Borlänge. Trafikverket

Vägverket 2004, *Värderingsunderlag för barnkonsekvensanalyser, Publikation 2003:37*. Borlänge. Vägverket

Vägverket, *Sverige kommuner och landstig, (2008). Rätt fart i staden, hastighetsnivårer i en attraktiv stad*. Borlänge. Vägverket

Vägverket, (2008B). *An independent review of road safety in Sweden.* Borlänge. Vägverket

Webpages:

Göteborg (2015) Goteborg.se. https://goteborg.se/wps/portal/start/forskola-och-utbildning/grundskola/hitta-grundskolor/!ut/p/z1/04_Sj9CPykssy0xPLMnMz0vMAfIjo8ziAwy9Ai2cDB0N_N0t3Qw8Q7wD3Py8fdxdTMz0wwkpiAJKG-AAjgb6kUD95vEmRu4Ghl4mht4WZk7mBo4-zqH-5i6O7u6GhvrB-lH6UcWpRWWZyakllQWp-pFa-gW5EVUhjoqKAPrSm4U!/dz/d5/L2dBISEvZ0FBIS9nQSEh/

Goteborg.se. http://goteborg.se/wps/portal/start/kommun-o-politik/kommunfakta/kort-kommunfakta/!ut/p/z1/hY5BC4IwHMU_jdf9p6Xbuq2DkVoaBNkuobGmoE7matCnz45B0bs93u_xHggoQQzVo1WVbfVQdbM_i-hS-MmBrn2O8w2L8faYFvE-zXKyC-H0DxBzjH-IY0hAtHWP3LVHGAVBSGhAGaNkSVnEyHufD_WCKhBG3qSRBt3NfKuxdpxWHvawcw4prVUn0SQ9_K3R6MlC-QHC2JfPTJ74C7REzB0!/dz/d5/L2dBISEvZ0FBIS9nQSEh/#htoc-0

Huddinge. (2017). http://www.huddinge.se/sakraskolvagar

Nationalencyklopedin (2017), Friskolereformen.http://www.ne.se/

Time line image sources:

www.kottetoys.se

www.museumvictoria.com.au

www.ssplprints.com

www.oldbike.wordpress.com

www.digitaltmuseum.se. Vänersborg museum

www.bicycling.se. Lennart af Petersens, Stockholmskällan

www.lulea.se

SCAFT 1968 (1967): *Riktlinjer för stadsplanering med hänsyn till trafiksäkerhet*, Statens planverk

www.cykelframjandet.se

www.bicyclestore.tumblr.com

www.steadysaabin.com/cars/saab-93/

www.bikerackcyclocross.com/bicycle-and-health

Other image sources:

https://werunandride.com/2013/02/15/copenhagen-shows-the-world-how-its-done-on-public-biking/ *Copenhagen shows the world how it's done on public biking* Photo: Keith Hauser

NACTO. (2017). *Urban street design guide*. New York. National Associations of City Transportation Officials

https://divisare.com/projects/204075-TOPOTEK-1-BIG-Bjarke-Ingels-Group-Superflex-Urban-Revitalization-Superkilen *Bicycle stand in the park.* Photo:Torben Eskerod

https://divisare.com/projects/204075-TOPOTEK-1-BIG-Bjarke-Ingels-Group-Superflex-Urban-Revitalization-Superkilen *Overview of Superkilen.* Photo:Iwan Baan

http://denmark.dk/en/lifestyle/architecture/superkilen-celebrates-diversity-in-copenhagen/ *Superkilen celebrates diversity in Copenhagen*
Photo: Superflex