CHALMERS

Paving the way for cyclists in Göteborg

Proposal for a bicycle-friendly design of Skånegatan

Master of Science Thesis in the Master's program Geo and Water Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover:
3D model showing the proposed layout of the cycle track at Burgårdens gymnasium.

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ABSTRACT

Cycling is one of the most sustainable and efficient modes of transport and increased bicycle traffic would be beneficial for both individuals and society. The City of Göteborg is said to promote cycling and has set as a goal to increase the bicycle share of all trips from 10% today to 12% until 2012. A bicycle-friendly infrastructure has in various studies been found to play a key role in facilitating bicycle traffic and the aim of this master's thesis is to compile a proposal for a new design, based on the needs of cyclists, for Skånegatan in central Göteborg. The stretch was chosen for its significance in the main bicycle network and for its demanding mixture of traffic types. The proposal is to a large extent based on Dutch guidelines and results from focus groups in a related master's thesis work carried out in parallel to this. So called 'push and pull' measures are applied, i.e. conditions for cyclists are improved as conditions for motorized traffic are restrained. This includes e.g. widening the cycle track to 3.0 m and in some places cutting a lane for motorized traffic. In addition to cycle track width, separation from other traffic is a key issue and in the proposal cyclists are well separated from motorized traffic. Curbstones as well as green areas with trees have been used to physically separate cycle traffic from pedestrians.

Key words: cycle tracks, safety, continuity, separation, visionary design

Bana väg för cyklister i Göteborg
Förslag till en cykelvänlig utformning av Skånegatan
Examensarbete inom Geo and Water Engineering

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SAMMANFATTNING

Cykling är ett av de mest hållbara och effektiva transportsätten och en ökad cykeltrafik skulle gynna både individen och samhället. Göteborgs Stad säger sig främja cykling och har satt som mål att öka cykeltrafikandelen av alla resor från dagens 10 % till 12 % år 2012. Studier visar att en cykelvänlig infrastruktur spelar en viktig roll för att påverka andelen cyklister och syftet med detta examensarbete är att utarbeta ett förslag på en ny utformning, baserad på cyklisternas behov, av Skånegatan i centrala Göteborg. Sträckan valdes för dess betydelse i stomcykelnätet och för dess komplicerade blandning av olika trafikslag. Förslaget baseras till stor del på nederländska riktlinjer och resultat från fokusgruppsdiskussioner som genomförts i ett parallellt examensarbete. Så kallade ”push and pull”-åtgärder tillämpas, dvs. cyklisternas förutsättningar förbättras medan förutsättningarna för biltrafiken begränsas. Detta innebär till exempel att cykelbanan breddas till 3,0 m och att ett körfält för biltrafik tas bort på vissa ställen. Utöver att cykelbanan breddas är separering mellan olika trafikantgrupper en viktig fråga och i det framtagna förslaget är cyklisterna väl separerade från motortrafiken. Kantsten såväl som grönområde med träd har använts som fysisk separering mellan cykeltrafik och fotgängare.

Nyckelord: cykelbanor, säkerhet, kontinuitet, separering, visionär utformning

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Preface

This master's thesis has been carried out in the spring of 2010 as part of a bicycle promoting project on behalf of the construction company NCC in Göteborg. The work has been carried out at the Department of Geo Engineering, Road and Traffic group, Chalmers University of Technology, Sweden. The aim has been to challenge the accustomed way of traffic planning and to present a proposal for a new design of Skånegatan in central Göteborg based on cyclists' requirements. We would like to thank our supervisor Gunnar Lannér at Chalmers and Per Kinell, Anders Björnek and Marie Alpsten at NCC for valuable discussions and comments. The staff at The Traffic and Public Transport Authority of Göteborg (Trafikkontoret) has also been helpful in our work.

The work has been equally divided between the authors of this report.

Göteborg June 2010

Andreas Fredriksson and Jimmy Hansson

1 Introduction

1.1 Background

The cities of today are predominantly planned and built with cars in mind and Göteborg is no exception. People walking or going by bicycle in particular are often set aside in order to facilitate motorized traffic and are not given the same priority in terms of available space in the traffic environment. Cars have become part of everyday life for many people as a symbol for mobility, convenience and freedom, which have led to accustomed habits when choosing mode of transport but also in the process of city planning. Going by car is, however, an unsustainable as well as inefficient way to get around in the city and when commuting to and from the city on shorter distances.

Hence, a change of focus is required in order to enable a sustainable development of the city. The Västra Götaland region has set as a goal to increase the number of workplaces with 40 000 and the number of inhabitants with 30 000 within the city center of Göteborg by 2020 (K2020, 2009). This is, however, not possible unless a substantial portion of the car traffic is transferred to walking, cycling or public transport. Today 46% of all trips in Göteborg are less than 4 km (Nya Vägvanor, 2010), whereas only approximately 10% of all trips in Göteborg are made by bicycle (Trafikkontoret Göteborgs Stad, 2010), which suggests there is a great potential for transport modes other than car.

Studies have shown that a good bicycle infrastructure leads to a higher share of bicycle traffic, thus the focus of this thesis is on design of bicycle facilities. Improving the conditions for cyclists and hence make more people to go by bicycle means reduced motorized traffic, less environmental load and also better public health.

In recent years, the City of Göteborg has made efforts to create a coherent area called Evenemangsstråket connecting the event and entertainment facilities along Skånegatan between Korsvägen and Ullevi stadium in central Göteborg. The concerned stretch is also part of the main bicycle network in Göteborg, which means it should be given priority in terms of good standard, availability and capacity. The stretch is hence to serve both as an efficient connection in the bicycle network and as an attractive strolling area for intermittently large numbers of pedestrians, which e.g. sets requirements on separation. The current layout of the area is, however, not satisfying in terms of the aspects mentioned above and a further step in the effort of making cycling a more competitive mode of transport would be to improve the accessibility for cyclists and pedestrians and to create a more attractive traffic environment.

1.2 Purpose

The overall purpose of the bicycle promoting project carried out at NCC is to formulate ideas and investigate measures to make Göteborg a more sustainable and attractive city for cyclists and others to live, work and study in. The aim is to challenge traditional habits and patterns by emphasizing the benefits of cycling in terms of health, time saving, economy, environment, congestion etc, i.e. to use logical arguments to promote cycling and to try to make it a more natural part of city planning.

The aim of this thesis is to investigate factors and measures that influence bicycle traffic and then present a visionary bicycle-friendly design of Skånegatan based on guidelines, survey results and experiences from elsewhere in order to show how the planning of a traffic environment can be more influenced by the needs of cyclists. Innovative and unconventional thinking is essential when shifting focus from the needs of motorized traffic. The idea is that the new proposed design of Skånegatan can serve as a demonstration facility that emphasizes important principles that should be applied throughout the bicycle network in order to make cycling a more attractive mode of transport.

1.3 Method

First an extensive literature study was performed in order to form a background and to present the current situation for cyclists. Important aspects and figures connected to bicycle traffic were retrieved and put in relation to set goals on national and local level. The potential to increase bicycle traffic in Göteborg was then evaluated based on discussions with The Traffic and Public Transport Authority of Göteborg (Trafikkontoret) and documented experiences and assessments in literature.

The concerned stretch along Skånegatan was investigated through surveys on site and studies of maps and photographic material in order to identify problems and improvement possibilities. Dutch guidelines has been used – with Swedish guidelines as a comparison – as a basis in the analysis of requirements on bicycle infrastructure and in the process of compiling a proposal for a new design of the cycle route. Also requirements from focus group discussions in a related master's thesis work within the same project at NCC have been taken into consideration. 3D models showing representative parts of the stretch have been compiled in order to visualize the concepts of the proposal.

1.4 Delimitations

In this thesis, focus is put on the cycle route along Skånegatan, but changes for motorized traffic and pedestrians are also necessary in order to improve the conditions for cyclists. The aim is to present a proposal on an overview level in terms of design and general layout, based on the needs of cyclists.

2 Bicycle traffic conditions

This first chapter of the thesis seeks to give an understanding of the problems that several Swedish, but also many foreign cities, are facing in the transport system. More and more agree that the situation that we have reached today, where the car has been the focus of urban infrastructure development, is not sustainable in a long term perspective, neither from an environment, space nor health point of view. A change is necessary and the bicycle has been proposed as an alternative in this context, meeting the requirements in terms of space as well as environment and health.

First a comprehensive overview is given on current bicycle traffic, where questions such as why people go by bicycle and what share of all trips that is made by bicycle are dealt with. Objectives and visions, for the bicycle traffic on national as well as local level, are presented and the current bicycle infrastructure in Göteborg is described. The chapter concludes with an evaluation of the potential to increase bicycle traffic, which also supports the purpose of the thesis, i.e. to design bicycle infrastructure in such a way that more people are motivated to go by bicycle instead of car.

2.1 Current situation

Today's infrastructure is to a large extent built from the perspective of motorists. Roads and streets for motorized traffic are given much more space in cities than cycle tracks, sidewalks and green areas. Major shopping centers are established outside the cities, which makes going by car more or less a prerequisite in order to utilize its services. This is likely to a large extent due to the symbolic value in terms of high status and success that the car came to represent in the postwar period. Everyone who could afford it bought a car and society developed from there. However, as the awareness of the environment and sustainability issues connected to car traffic gains acceptance more and more realize that it is time to slow down the accustomed development and set a new course for the future.

One reason for car traffic to be reduced is its high degree of inefficiency. Many cars in commuting traffic have no passengers at all and a car driver carrying no passengers is not only transporting herself, but also a vehicle of approximately 20 times her body weight. In addition, the efficiency of the most common gasoline engine, the spark ignition engine, is only around 30% at maximum load and at lower loads even down to 15% (Andersson, 2010). Going by car requires roughly 435 kcal/passenger kilometer, whereas the energy consumption when going by bicycle is approximately 15 kcal/passenger kilometer, which gives a factor of 29 in a comparison of the two modes of transport (Vägverket et al., 2007).

Besides the significant inefficiency of the spark ignition engine, the exhaust emission control does not reach full capacity on short distances. Surveys show that short car trips (less than 3-4 km) account for only 3.1% of the total driving distance, whereas the share of car traffic emissions caused by short trips is 26% (Vägverket, 2000).

An increasingly evident problem in today's cities is the shortage of space. Although many cities are built with cars in mind, streets and roads are often congested due to a significant increase in motorized traffic since the cities were built, but also because improvements in infrastructure as a rule generate more traffic.

Sedentary people are an economic loss for society, both in terms of decreased productivity and impaired public health, which also is a major issue on a personal level. To get more people to go by bicycle instead of car would thus not only improve the public health and physical wellbeing of people; it would also result in less congestion and shorter queues, which in turn means a more efficient use of the infrastructure and the traffic environment, benefiting the transports that nevertheless have to be made by motorized traffic. In investigations made by The Institute of Transport Economics in Norway the socioeconomic benefit of investments in bicycle infrastructure is estimated to be 3-14 times higher than the investment cost and 50-70% of this benefit is due to improved public health (Sælensminde, 2002).

Is it possible to make these major infrastructural changes that are required in order to shift the focus of city planning and to get more people to go by bicycle? A significant reconstruction of large parts of Swedish cities would be necessary. To change an already established society is often far more difficult and costly, than if it would have been done from the beginning. An example of a city where the bicycle was in focus already from the planning stage is the Dutch city of Houten with approximately 48 000 inhabitants. In the late 1970s the city experienced a strong growth and the city planning was then based on the cyclists' perspective. For instance it is not possible to go by car between the 16 zones that the city is divided into without first entering the ring road around the city. However, the zones are well connected with an extensive bicycle network, which means that many people choose to go by bicycle instead of car, since it is a much more effective way to travel. (Vägverket et al., 2007)

The problem that traffic planners are facing today is not only how to get people to go more by bicycle, but also how to get people to drive less car. Increased cycling does not always mean a corresponding decrease in car driving, since increased bicycle traffic often is at the expense of public transport. One way to reduce car traffic and thereby also increase bicycle traffic in a way that has proved to be efficient is to use so called 'push and pull' measures, where conditions for cyclists are improved as the conditions for motorists are obstructed. These kinds of measures are dealt with in more detail in Section 2.5.1.

One argument against increased bicycle traffic is the high proportion of injured cyclists. In 2009 a total of 49 cyclists were seriously injured from traffic accidents in Göteborg (Trafikkontoret Göteborgs Stad, 2010). Cyclists account for 40% of all moderately or seriously injured from traffic accidents in Göteborg, whereas only 10% of all trips are made by bicycle. The risk of a fatal traffic accident is 3.6 times greater for a cyclist compared to a car driver and 5.8 times greater if compared to a car passenger (Vägverket et al., 2007). These figures are based on the number of accidents per passenger kilometer. However, the value of improved health on both individual and societal level is greater than the value associated with the high number of bicycle accidents (Trafikkontoret Göteborgs Stad, 2009). The safety for cyclists is thus in every aspect an important factor in the design of bicycle infrastructure.

2.2 Current bicycle traffic

Approximately 105 000 trips are made by bicycle in Göteborg every day, corresponding to roughly 10% of the total number of trips. Although the total number of trips varies slightly from one year to another, the proportion of bicycle trips has

remained steady at around 10% in recent years. (Trafikkontoret Göteborgs Stad, 2009; Trafikkontoret Göteborgs Stad, 2010)

On a national level the share of all trips made by bicycle is also roughly 10%, which is equal to almost one billion bicycle trips every year (Vägverket et al., 2007). This figure is, however, low compared to countries where cycling has a more prominent role in the society such as Denmark (around 20%) and the Netherlands (around 25%) (Ministry of Transport, Public Works and Water Management, 2009).

The share of all trips made by bicycle has varied widely over the years; in 1989 a national travel survey concluded that only 5-6% of all trips were made by bicycle, which shows a significant increase in bicycle traffic in the last two decades. However, this should be put in relation to that the bicycle share in the 1950s was about five times higher than today, which clearly shows that car traffic has increased dramatically and gained a dominant position in the traffic environment. This development has naturally also affected the way today's cities are planned and constructed. (Trafikkontoret Göteborgs Stad, 1999)

With a bicycle share of around 10% Göteborg is in line with the national average, but it is still relatively low in comparison with cities such as Malmö, Västerås, Uppsala and Umeå, where the bicycle share is 25-35%. The reasons for these higher shares are probably that there is a distinct cycling tradition and a large concentration of students in these cities. (Vägverket et al., 2007)

When asked what their main mode of transport is for trips to work, studies or other daily activities, 16% of the Göteborg respondents answered that they go by bicycle. 39% go by car, 31% go by public transport and 11% walk, see Figure 2.1. In the figure it appears to be little difference in men's and women's cycling habits, but more detailed studies show that men more often use the bicycle for slightly longer trips, whereas women use it for shorter trips. In e.g. Denmark and the Netherlands, women constitute the majority of cyclists (Vägverket et al., 2007). Cycling habits are not very influenced by age, but the place of residence is evidently of significant importance. Residents in the city center of Göteborg use the bicycle the most, whereas residents of Hisingen use it the least, probably partly due to the barrier effect caused by the Göta Älv River.

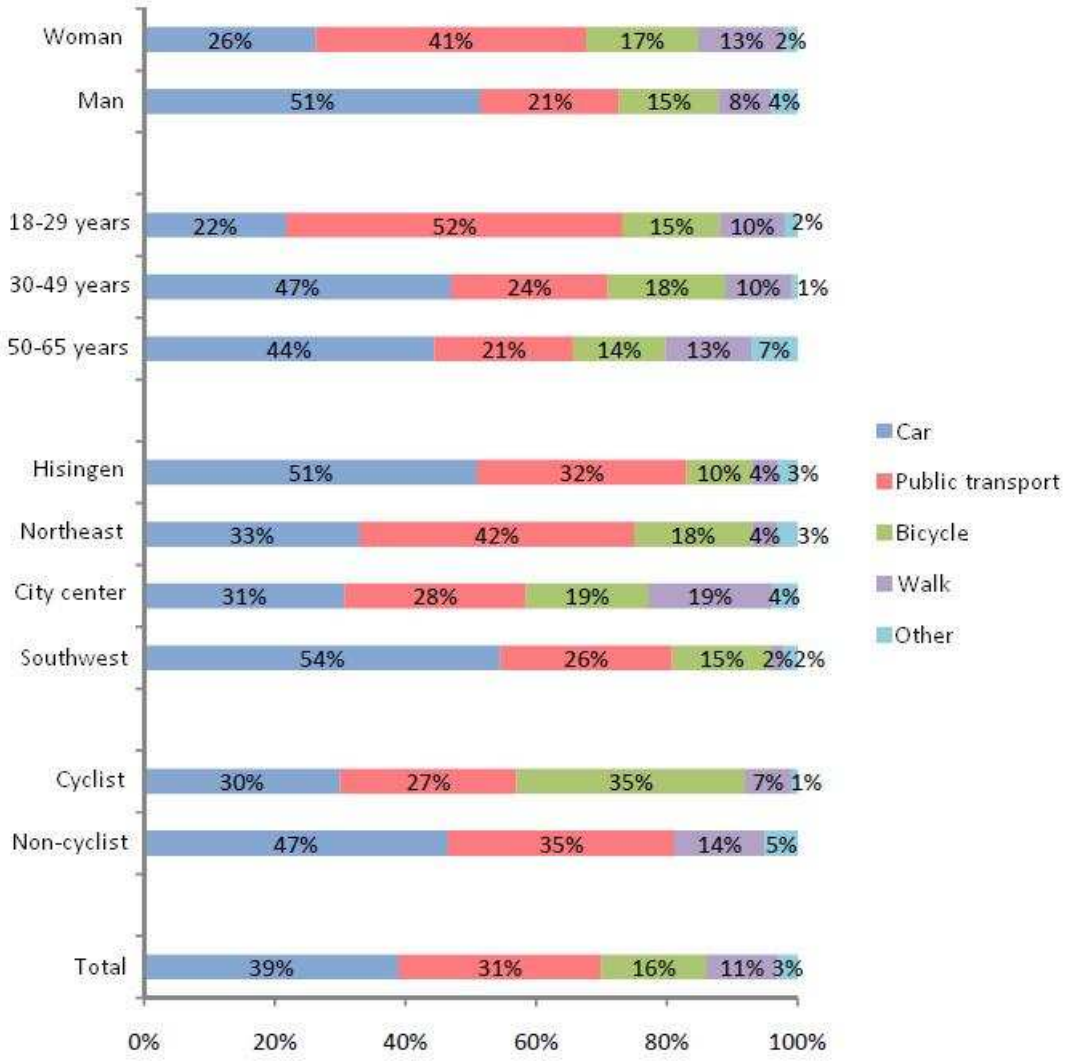

Figure 2.1 Distribution of respondents' main mode of transport for trips to work, studies or other daily activities in Göteborg (Splitvision Research, 2009).

In a survey carried out among cyclists in Göteborg in 2008, 61% of the respondents stated that they use the bicycle to perform miscellaneous errands, 56% use the bicycle to get to work and 48% use their bicycle for recreational purposes. In the same survey the respondents were also asked why they use the bicycle and the most commonly stated reason was physical exercise and health with a share of 36%, followed by that it is a fast mode of transport (33%). The respondents also mentioned economic reasons (9%), that cycling is pleasurable and relaxing (8%) and environmental reasons (7%). The main reason not to go by bicycle at a given moment, when it would have been possible, is the weather, which was given as a reason by 48% of the respondents. (Splitvision Research, 2008)

There are major variations in the bicycle traffic during a year; in southern and central Sweden three times as many bicycle trips are made in the summer compared to the winter period, whereas there is a factor of ten difference between summer and winter bicycle traffic in northern Sweden. According to a survey made in Göteborg approximately half of the cyclists use their bicycle during the entire year, whereas the

other half use their bicycle primarily in the period April-October. (Vägverket et al., 2007)

In a traffic count conducted on Skånegatan on April 12, 2010 the helmet usage among cyclists was found to be 59% in the morning and 49% in the afternoon. One reason for the slightly higher helmet usage in the morning is thought to be that a larger share of the cyclists in the morning are commuting to work; this group tend to use helmet more often than leisure cyclists. The found values are well in accordance with the report *Cykelåret i Göteborg 2009* (Trafikkontoret Göteborgs Stad, 2010), published by the traffic and public transport authority of Göteborg, where the helmet usage is stated to be 53% in 2009 and rising (Figure 2.2).

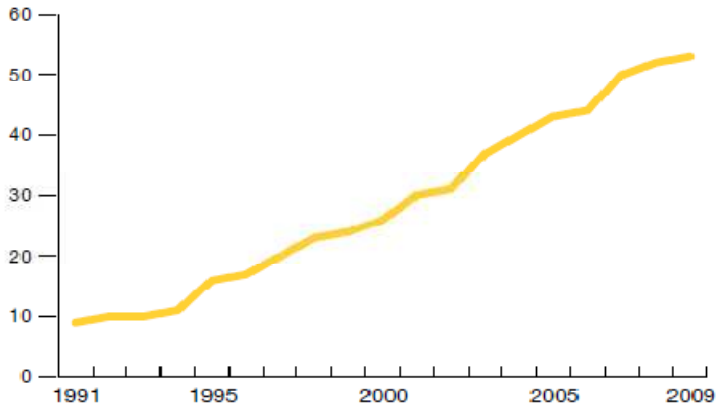

Figure 2.2 Diagram showing the helmet usage in percent over time in Göteborg. (Trafikkontoret Göteborgs Stad, 2010)

2.3 Existing bicycle infrastructure in Göteborg

The cycle network in the Göteborg area has a total length of approximately 600 km, whereof 460 km is on separate cycle tracks and 140 km in mixed traffic. In streets with mixed traffic the speed limit is set to 30 km/h (Göteborgs Stad, 2009a). The bicycle network is divided into three categories; the main network, the overall network and the local network (Stadsbyggnadskontoret, 2009).

The main network consists of the most prioritized cycle tracks in terms of maintenance, traffic safety measures and right of way in intersections where it is practically applicable (Göteborgs Stad, 2009a). The aim is also that these cycle tracks should have a uniform design with high standard and good availability. The main bicycle network consists of four stretches that all originates in the city center:

- City center – Mölndal (along Skånegatan, Södra vägen and Mölndalsvägen)
- City center – Älvsborgsbron (along the south shore of Göta Älv)
- City center – Biskopsgården (via Hjalmar Brantingsgatan)
- City center – Partille (via Olskroken, Munkebäck and Torpavallsgatan)

(Stadsbyggnadskontoret, 2009)

The overall network consists of cycle tracks and streets with mixed traffic that connect the different parts of the city. Safety, comfort and continuity of the overall network shall be high, but not be given the same priority as in the main network

(Stadsbyggnadskontoret, 2009). The main network and the overall network can be seen in Figure 2.3.

The third type of bicycle infrastructure in Göteborg is the local network, which constitute the finest mesh in the bicycle network connecting local destinations to the overall network, e.g. stretches through parks and residential areas (Stadsbyggnadskontoret, 2009).

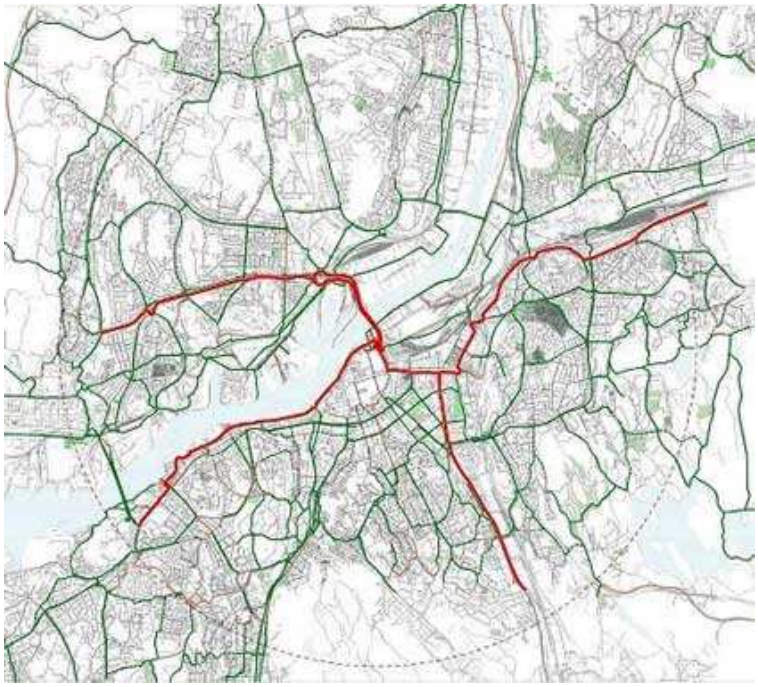

Figure 2.3 Map showing the main bicycle network (red) and the overall bicycle network (green) of Göteborg. (Göteborgs Stad, 2009)

2.4 Objectives and visions

In evaluating the current development of bicycle traffic, the set objectives and visions on national and local level can be useful as a background.

2.4.1 National objectives

On August 31, 2009 the transport authorities published *Förslag till Nationell plan för transportsystemet 2010-2021 (Proposal for National Plan for the Transport System 2010-2021)* (Vägverket et al., 2009), where the national objectives for bicycle traffic are summarized as follows:

> *The share of pedestrian and bicycle traffic for short trips should increase. Combined trips including walking, cycling and public transport should be facilitated and bicycle tourism in Sweden should be developed.*

The deficiencies identified in this report include that cyclists outside built-up areas, but partly also inside built-up areas, to a large extent have to cycle on road courses or shoulders of varying width. The fact that cyclists run a much higher risk than motorists of being injured in traffic is also mentioned. Another deficiency in many

places (*remark* e.g. in the Göteborg area) is that there is no possibility to bring the bicycle on the bus or the train and furthermore that many bus stops and railway stations do not have a sufficient number of secure bicycle parking racks.

The report gives no clear strategy on how to achieve the set objectives, but it emphasizes the importance of seeing the bicycle as an attractive mode of transport. Since approximately half of all trips by car are shorter than 5 km there is thought to be a large potential to transfer a significant portion of these trips to bicycle.

2.4.2 Local objectives

The most recent objectives for bicycle traffic set up in Göteborg were published in 1999 in the report *Cykelprogram för Göteborg 1999* (Trafikkontoret Göteborgs Stad, 1999). The main focus is to increase bicycle traffic and to lower the number of people injured or killed in bicycle accidents. The objectives are described below:

- *The bicycle traffic share (of the total number of road user movements) is to increase with nearly 50% until 2012 from a mean value for the years 1994-1996, i.e. from 8-9% to 12% [1] – and it is mainly motorists that should change mode of transport to bicycle.*
- *This increase is to be coincident with an improvement of traffic safety for cyclists – the total number of injured cyclists is to decrease with 25% and the number of killed and seriously injured is to decrease with 35% until 2008 from a mean value for the years 1995-1997[2]. In a long term perspective nobody is to be killed or seriously injured from traffic accidents.*

A clear strategy to reach these objectives is not presented.

The bicycle program of 1999 was followed up in 2006 in the report *Cykel i Göteborg 2006 – uppföljning av Cykelprogram för Göteborg 1999* (Trafikkontoret Göteborgs Stad, 2006), where it was investigated to what extend the set objectives were reached. It is established that measurements of the number of cyclists are so deficient that it is difficult to verify whether the objective has been reached or not. The second objective, to improve traffic safety for cyclists is easier to check and a distinct reduction in the number of accidents is evident in the concerned period. However, no figures are given; only that the objective to decrease the number of killed and seriously injured cyclist with 35% has been reached and exceeded. The fact that the measurements of the number of cyclists are deficient should be taken into consideration, since a part of the decrease in the number of killed and seriously injured cyclists could be due to a general decrease in the number of cyclists.

2.5 Potential to increase bicycle traffic

A coherent, easily comprehensible, safe, secure bicycle network in beautiful and relatively quiet surroundings is important in order to make it attractive to go by bicycle. This is expressed in *Trafik för en attraktiv stad* (Vägverket et al., 2007) and

[1] I.e. an increase from 120 000 to 180 000 bicycle trips per day.
[2] The annual mean value for the period 1995-1997 is a total of 831 injured and 198 killed or seriously injured. The goal is to decrease these numbers to 625 and 130.

mentioned factors influencing transport quality for cyclists include signposting, topography, separation between cyclists and pedestrians, pavement standard, winter maintenance, presence of lighting and vegetation, design and safety of bicycle crossings, access to weather-protected parking and the possibility to securely lock the bicycle. These are examples of measures that can be taken to increase bicycle traffic.

According to the Dutch guidelines in *Design manual for bicycle traffic* (CROW, 2007) there are five basic requirements that can be set on a bicycle-friendly infrastructure. These are cohesion, directness, safety, comfort and attractiveness. By working resolutely on improvements within these areas the bicycle as a mode of transport can be made more attractive and more people can be motivated to start cycling or to cycle more.

The vast majority of bicycle trips are shorter than 5 km, which often is considered an acceptable distance to go by bicycle for most people (Trafikkontoret Göteborgs Stad, 1999). Given that half of all car trips are also shorter than 5 km in many Swedish cities (Vägverket et al., 2009) and that 46% of all trips shorter than 4 km are made by car in Göteborg (Nya Vägvanor, 2010) there is a great potential to increase cycling by transferring traffic from car to bicycle. There is also a large potential to transfer travel by public transport to bicycle, as over 40% of all public transport trips are shorter than 5 km (Trafikkontoret Göteborgs Stad, 1999).

In the bicycle program for Göteborg from 1999 (Trafikkontoret Göteborgs Stad) it is estimated that the bicycle share of all traffic can increase to 25-28%, equivalent to 375 000 bicycle trips per day, compared to 120 000 bicycle trips per day when the bicycle program was adopted. This estimation is based on the fact that the share of bicycle traffic is low in Göteborg compared to many other cities and that many short trips are made by car or public transport. Surveys show that in general it is possible to transfer 10-50% of car trips shorter than 3-4 km to bicycle (Nilsson, 1995).

In the bicycle program for Göteborg from 1999 (Trafikkontoret Göteborgs Stad) the City of Göteborg also presents a number of local factors that are said to limit the potential increase, for instance that Göteborg is a hilly and windy city. Also the fact that Göteborg is a sparse city with long distances and the barrier effect caused by Göta Älv are considered to counteract an increase in bicycle traffic. In addition to this, a number of other general factors that pose obstacles are mentioned, such as cold and precipitation, high perceived risk of accidents, high risk of bicycle thefts, that cycling causes sweating and that a bicycle is not appropriate when transporting goods and luggage. A relatively cold climate does not, however, have to influence bicycle traffic negatively, at least not during the summer months, when the bicycle share in Umeå is almost in level with the Netherlands (Nilsson, 1998).

Bicycle investments in Gävle and Lund also show that it is possible to increase bicycle traffic while reducing the number of bicycle accidents. In many cases an increase in bicycle traffic makes cyclists more visible in the traffic environment, which in turn makes other road users more aware of and more alert to cyclists as a group. (Vägverket, 2000)

2.5.1 Measures for increased bicycle traffic

There are several theories about what measures that can be taken to motivate people to cycle more and there have been studies to see what effect different measures have. According to Rietveld and Daniel (2004) it would be possible to influence bicycle use

by means of so-called ‘push and pull’ measures. The idea is to improve the conditions for cyclists by introducing various ‘pull’ measures such as increased traffic safety, safer bicycle parking and the possibility to shower and get changed at the destination. This is done in connection with the introduction of so-called ‘push’ measures for motorized traffic such as higher taxes on fuel, increased parking fees or introducing congestion charges. In this way it would be possible to transfer traffic from one mode of transport to another.

The impact of such ‘push and pull’ measures has been studied by Stradling (2001), who found that different measures have different effects on different parts of the population. For instance it appeared that younger people and people driving small cars would consider changing mode of transport in case another mode of transport was made more attractive. Older people and those with low incomes would consider a change in their way of travel if going by car was made more expensive. A third group consisting of people owning more expensive cars and who partly also use their car as part of their work was found not to be affected at all by any of the measures. This study hence shows that not only positive encouragement but also restraints in the conditions for other modes of transport can influence the share of bicycle traffic.

What ‘push’ measures have the largest impact on bicycle use? A number of studies point out bicycle-friendly infrastructure as an important measure in order to make people use the bicycle more. For instance Kingham et al. (2001) concluded that improved infrastructure was the most important factor, followed by bicycle facilities and safety, less traffic and economic incentives, in order to increase bicycle traffic. Similar findings emerged in a study by Dickinson et al. (2003), where 47% of the respondents replied that they would cycle more if the bicycle routes to work were improved. The same study also showed that 34% would cycle to work if there was less traffic on the roads. Also several other studies (Ryley, 2006; Hunt & Abraham, 2007; Tilahun, Levinson, & Krizek, 2007; Wardman, Tight, & Page, 2007) show that the most important factor in order to make more people to go by bicycle is a bicycle-friendly infrastructure, followed by good quality bicycle facilities at the destination and shorter travel time.

In summary, there is a potential to increase bicycle traffic in Göteborg and an important aspect in making more people to go by bicycle is to improve the infrastructure for cyclists.

3 Current conditions and deficiencies of Skånegatan

Skånegatan between Korsvägen and Ullevi stadium is a part of the so-called Evenemangsstråket in central Göteborg, connecting e.g. The Swedish Exhibition & Congress Centre, Universeum, Scandinavium, the movie theatre Bergakungen and Ullevi stadium, see Figure 3.1. In addition, the stretch is also part of the main bicycle network between Mölndal and Göteborg city center and should have certain priority and be well suited for bicycle commuting. In order to comply with these requirements a high degree of separation between cyclists and pedestrians is necessary, since the stretch also serves as a strolling area. The event and entertainment facilities are concentrated to the east side of Skånegatan, which is why most bicycle and pedestrian traffic is located here. This is also where a reconstruction is proposed.

Figure 3.1 Overview of the concerned area. The red rectangle shows Evenemangsstråket on Skånegatan. (Trafiken.nu, 2010)

The pedestrian traffic along Skånegatan is relatively extensive, especially in conjunction with events along the stretch, e.g. at Ullevi stadium and Scandinavium and in the evening hours at the movie theatre Bergakungen. It is thus important that pedestrians have enough space and also that the separation from bicycle traffic is sufficient in order to achieve a good standard of safety. In the current layout of the stretch cyclists and pedestrians are generally only separated by a difference in paving; the cycle track is paved with asphalt and the footpath with paving bricks. There is hence no physical separation, which makes pedestrians use the cycle track occasionally.

To get an idea of the range of the bicycle traffic on the concerned stretch, an on-site study was made on April 12, 2010 where the number of cyclists, in what direction they were cycling and the share of cyclists that used helmet was investigated. The measurements were conducted from 07.00 to 09.00 in the morning and from 15.00 to 18.00 in the afternoon. The maximum hour was obtained between 07.30 and 08.30

with a total of 142 cyclists. In the afternoon the maximum was between 16.45 and 17.45 with a total of 125 cyclists. These values are seen as guideline values in the further work; although the flow can be significantly higher at other occasions it is still in the same order of magnitude and does not affect the design. In the morning, the majority of cyclists were going towards the city center (76%), as was the case in the afternoon, however, substantially less dominant (57%).

The motorized traffic along Skånegatan varies on different stretches. The least traffic flow is at Burgårdens gymnasium school between Valhallagatan and Engelbrektsgatan with an annual average daily traffic of 8 600 vehicles and a total of 790 vehicles in the maximum hour. The part of Skånegatan that has the most traffic is between Hugo Levins väg and Ullevigatan with an annual average daily traffic of 17 500 vehicles and a total of 2 240 vehicles in the maximum hour. These values are measured in 2009. (Göteborgs Stad, 2009b)

3.1 Current layout

To simplify the description of the area, the stretch has been divided into five parts. The stretch starts in the south, where part A extends from Korsvägen north along Mässans gata, via The Swedish Exhibition & Congress Centre and Scandinavium until the intersection with Valhallagatan. This intersection is part B. Part C is the stretch from Valhallagatan past Burgårdens gymnasium, the movie theatre Bergakungen and Katrinelundsgymnasiet until the intersection with Hugo Levins väg. Part D is the intersection with Hugo Levins väg and part E is then the final stretch until Ullevigatan in the north. In this chapter all parts are described in more detail and the deficiencies considered most serious are listed.

Part A: Between Korsvägen and Valhallagatan the cycle track is currently divided. North of Korsvägen the northbound track is lead onto Mässans gata, where it is mixed traffic, whereas southbound bicycle traffic uses an approximately 0.8 m wide asphalted cycle track on the mall between Mässans gata and Skånegatan (Figure 3.2). On the east side of Mässans gata, there are four parking spaces for disabled people, a loading zone for deliveries, a zone for a waiting taxi, space for boarding and alighting, a number of motorcycle parking spaces and four ten-minute parking spaces. The footpath is located next to the building and the risk of conflicts between pedestrians and cyclists is hence very small.

Figure 3.2 The transition from a two-way cycle track to mixed traffic on Mässans gata. Picture taken from the south.

In order to reduce the speed of motorized traffic on Mässans gata, it is equipped with speed reducing measures such as the speed bump shown in Figure 3.3. However, there are no signs stating any lower speed than 50 km/h. The speed bump has such a design that it does not affect the speed of cyclists, but cars slowing down considerably for the speed bump in front of cyclists can be an obstacle. There have also been observations of motorists that are using Mässans gata in order to evade the queues at the traffic light on the parallel Skånegatan. These motorists often drive at high speed, which definitely is not beneficial for the safety of cyclists.

Figure 3.3 Speed bump on Mässans gata. Picture taken from the north.

Along The Swedish Exhibition & Congress Centre and Scandinavium there are two large gates for major deliveries to the buildings. These must be available also after a reconstruction.

Just south of the intersection with Valhallagatan the cycle tracks return to a common 2.45 m wide two-way cycle track, Figure 3.4. This part is poorly marked and it is hard to know where to go when going by bicycle from the north. The road marking once made to clarify that Mässans gata crosses a cycle track is in such bad condition that it is hardly distinguishable any more.

Figure 3.4 After the pedestrian crossing the cycle tracks continues as a common two-way cycle track until the intersection. Picture taken from the south.

Identified problems on part A:

- Lack of continuity
- Cycling in mixed traffic means a higher risk of a collision between car and bicycle
- The southbound cycle track is too narrow and does not allow cyclists to pass
- Unclear how to cycle when going south

Part B: Where the cycle track crosses Valhallagatan it goes parallel to the footpath and is located approximately 7.5 m from Skånegatan. On the north side of Valhallagatan the cycle track connects to the cycle track from Gårda in the east and it makes a sharp bend before continuing north along Skånegatan (Figure 3.5 and Figure 3.6). There is currently no satisfying solution to the conflict between cyclists and pedestrians

The traffic light regulation of the intersection has two phases, in the first one the traffic along Skånegatan, including cyclists, has green light and in the second one, traffic from Valhallagatan (including cars turning right onto Valhallagatan) has green

light when cyclists have red light. The proportion of green light time for cyclists in the intersection is relatively high, but could be further increased by lowering the priority of traffic on Valhallagatan. There is no push button for cyclists at the traffic light; cyclists are automatically given green light when motorized traffic in the same direction have green light. Cyclists have often green light at night, since the traffic signal then automatically switches to green light along Skånegatan. (Kronborg, 2009)

Figure 3.5 The area just north of the intersection with Valhallagatan. The cycle track makes a sharp bend before continuing north parallel to Skånegatan. Picture taken from the south.

Figure 3.6 The same area as in the previous picture. Picture taken from the north.

Identified problems on part B:

- Poor separation between cyclists and pedestrians – large risk of conflicts
- Sharp bends

Part C: The stretch extending north along Skånegatan from Valhallagatan until the intersection with Hugo Levins väg has a uniform design with a cycle track that is between 2.10 and 2.35 m wide. The cycle track is asphalted and runs parallel to a footpath paved with bricks (Figure 3.7 and Figure 3.8).

A major problem on this stretch is that the cycle track and the footpath only are separated by a difference in paving and that the few bicycle symbols painted on the cycle track are worn. This makes it hard for pedestrians to know where to go and some seem to use the cycle track just as well as the footpath. This is particularly evident outside the movie theatre Bergakungen, where large numbers of people can come out at the same time and walk right onto the cycle track.

Figure 3.7 Cycle track and footpath parallel to Skånegatan. As can be seen in the picture pedestrians do not always walk on the footpath. Picture taken from the south.

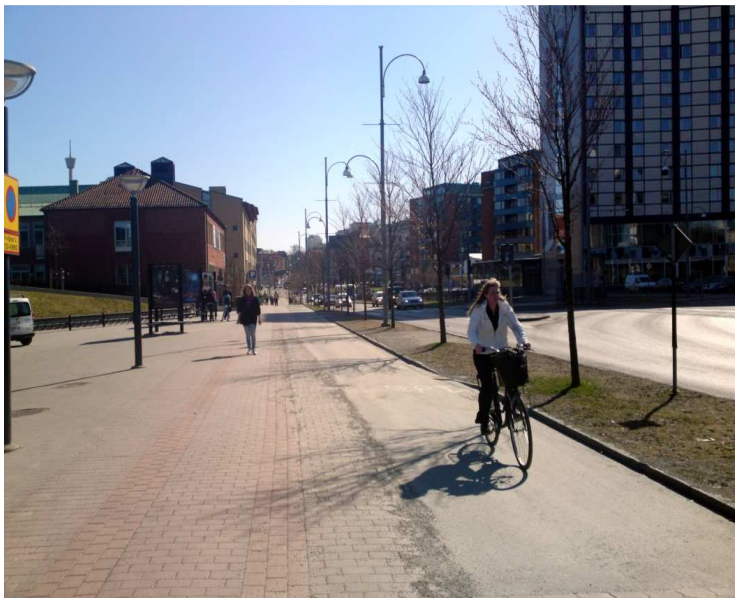

Figure 3.8 Cycle track and footpath along Skånegatan. The movie theatre Bergakungen is to the left. Picture taken from the north.

Where the cycle track crosses exits for motorized traffic it is paved with red bricks (Figure 3.9). This is to make motorists aware of that they cross a cycle track. The exits are also paved with cobblestone in order to reduce the speed of turning cars. In addition to the exits that cross the cycle track, there is also some motorized traffic on the cycle track itself; some delivery trucks have to drive a short distance on the cycle track to reach the movie theatre Bergakungen, but also some parents leaving their children at the nearby preschool choose to drive on the cycle track and the footpath for a shorter distance.

Figure 3.9 One of the exits crossing the cycle track, paved with red bricks. Picture taken from the south.

Identified problems on part C:

- Poor separation between cyclists and pedestrians – large risk of conflicts
- Many exits crossing the cycle track
- Motorized traffic on the cycle track
- On some stretches the cycle track is only about 2 m wide

Part D: Just south of the intersection with Hugo Levins väg the cycle track makes a bend before crossing the street (Figure 3.10). Also in this intersection there are often conflicts between cyclists and pedestrians. The traffic signal regulating the intersection has three phases, where cyclists only have green light in one of these phases. There are no push buttons for cyclists; they are automatically given green in every phase cycle (Kronborg, 2009).

Figure 3.10 The intersection at Hugo Levins väg. Picture taken from the south.

Identified problems on part D:

- Poor separation between cyclists and pedestrians – large risk of conflicts
- The traffic light has three phases; cyclists have green light only in one of these

Part E: North of Hugo Levins väg, the cycle track and the footpath are separated by a line of trees; the cycle track runs close to Skånegatan, whereas the footpath is located on the other side of the line of trees closer to Ullevi stadium (Figure 3.11). The signposting and marking in the pavement is, however, very unclear, making many pedestrians to walk in the cycle track. Since the cycle track is only 2.0 m wide on this stretch it can be difficult for cyclists to pass pedestrians.

The area between the cycle track and the boarding and alighting zone along Skånegatan is very narrow and there is a substantial risk for cyclists to run into

opened car doors. Persons boarding and alighting from the parked vehicles are also likely to be on the cycle track at times.

Figure 3.11 Cycle track passing Ullevi stadium. The cycle track and the footpath are separated by a line of trees, but the cycle track is poorly marked and many pedestrians use it. Picture taken from the south.

On the last stretch of part E, the cycle track and the footpath run next to each other and once again the only separation is the difference in paving (Figure 3.12).

Figure 3.12 Intersection between Skånegatan and Ullevigatan. Picture taken from the south.

Identified problems on part E:

- Partly poor separation between cyclists and pedestrians – risk of conflicts
- The cycle track is only 2.0 m wide
- Lack of space between the cycle track and the boarding and alighting zone

4 Requirements on bicycle-friendly infrastructure

It has been shown in a number of studies that a cycling infrastructure of good quality leads to a higher share of bicycle traffic in the modal split and it is hence a prerequisite if the bicycle is to strengthen its status as an important part of the traffic system. According to the Dutch *Design manual for bicycle traffic* (CROW, 2007) the requirements for a bicycle-friendly infrastructure can be expressed in terms of cohesion, directness, safety, comfort and attractiveness. These five main aspects should influence the design of any bicycle network, connection and facility and are generally considered equally important. Below is a brief description of these aspects followed by applications of importance on road sections and intersections on Skånegatan.

Requirements on cohesion are connected to the need of a complete and comprehensive bicycle infrastructure in order to make the bicycle a feasible option as a mode of transport. The network has to provide connections between various important points of departure and destinations, i.e. to make it possible for people to use the bicycle as a part of their everyday life, not least when commuting to and from work. In order to fully utilize the network it is also important that it is integrated with other modes of transport, e.g. that it offers connections to major transport nodes. Factors that also concerns cohesion include consistency of quality throughout the network, the ease of finding the way and that the network offers the possibility to choose a suitable route.

Directness in the bicycle network and hence the traveling times are important factors in terms of competitiveness compared to the car. A high degree of directness is achieved by providing cyclists routes that are as direct as possible and by keeping detours to a minimum. If it is faster and more convenient than going by car many motorists will consider using the bicycle for short trips. Detour distances, delays and traffic flow speed are criteria possible to use in order to set values on directness.

Cyclists are vulnerable road users since they share the traffic space with motorized traffic that has significantly higher speed and larger mass. They lack the protective devices that benefit car drivers, such as a cage construction, airbags and a crumple zone. The safety of the individual cyclist can be improved by the use of a helmet and a bicycle in good condition, but from a design point of view this inherent vulnerability is not possible to influence. However, the conditions in which cyclists travel are a matter of design and one of the main issues is to minimize the encounters with fast motorized traffic by means of separation in space or time. This safety requirement is well supported by accident figures. Other important principles for a high degree of safety include reducing speed at potential conflict points and avoiding obstacles at the side of the road. The guidelines used locally in Göteborg (TPU) states that if the safety requirements are met, the share of cyclists will increase.

Comfort is a requirement connected to criteria like pavement smoothness, inclines, the chance of stopping when cycling and nuisance from traffic and weather. Since bicycles do not have a suspension system as sophisticated as a car it is extra important to provide an even and smooth pavement for cyclists. The required physical effort from the cyclist is closely related to comfort; excessive exertion from e.g. steep inclines but also irregularity of the exertion, e.g. when repeated stopping and starting, makes cycling less comfortable. The degree of nuisance and delay caused by

insufficiencies and shortcomings in the bicycle infrastructure hence decides the level of comfort.

Even though attractiveness might be hard to describe or measure it still should play an important role when designing bicycle infrastructure. When deciding whether to go by bicycle or not and what route to take, different factors are valued differently by each individual, which makes cycling behavior somewhat difficult to predict. Perception is a key issue that comprises psychological factors related to the attractiveness of the bicycle infrastructure. Social safety is a particularly important aspect since it has been shown to have a significant influence on the decision to use the bicycle, not least in the evening and at night.

4.1 Aspects of requirements applicable on Skånegatan

The aspects of requirements for a bicycle-friendly infrastructure presented above are here applied on road sections and intersections.

4.1.1 Road sections

When designing road sections for bicycle traffic the most important aspect to consider is the function it is to serve, both in terms of bicycle and other traffic. The function is to a certain extent governed by the policies adopted and since the concerned stretch along Skånegatan is part of the main bicycle network it should have priority compared to other stretches in terms of good standard and availability according to the comprehensive plan of Göteborg, adopted by the city council in February 2009. The road sections in the main bicycle network should have a uniform design and signposting and they should be given priority in terms of traffic safety and social safety measures such as lighting (Göteborgs Stad, 2009a).

Factors that are essential in the process of determining the layout include the intensity of the bicycle traffic and the intensity and speed of the motorized traffic. Although these values can differ significantly on a certain stretch, it is not a problem in itself since the important thing is that every road section meets the requirements set for it. Continuity and recognisability of the route is, however, an essential aspect.

All requirements for a bicycle-friendly infrastructure that are applicable on road sections are possible to express in terms of directness, safety, comfort and attractiveness, although many quality preferences can not be related to one requirement only. The aspects of these requirements that are applicable on the road sections along Skånegatan are presented below. Unless otherwise stated the presentation is based on *Design manual for bicycle traffic* (CROW, 2007).

Directness in distance and time

In order to achieve a good degree of directness it is crucial to avoid unnecessary bending and winding of road sections. On cycle tracks in city center environments, such as Skånegatan, this is not a major problem, since they often follow the street and are practically straight. Limited crossing possibilities at roads with heavy traffic can, however, imply a derogation in the directness of a connection. This problem can partly be solved by allowing two-way traffic on cycle tracks along such roads, reducing the need for cyclists to cross the road. On the other hand, directness is not

only a matter of geometry, but also time. Directness in time is related to the average speed and the opportunity to keep riding without any interruptions or decelerations. Delays caused by this should not exceed 15%.

Dutch guidelines suggest a design speed of 30 km/h for road sections on cycle routes and main cycle routes, i.e. cycle routes with an intensity of more than 500 bicycles per day, which means that it should be possible to ride at this speed in normal conditions. Swedish guidelines have similar suggestions and set 30 km/h as a design speed for the main bicycle network. It is, however, questionable if such a speed is possible to keep on the concerned road sections along Skånegatan with present design. The design speed sets requirements on the road section in terms of width, the view of the road and the traffic flow speed. Particularly the width of the road sections is of importance because if it is too narrow, cyclists are forced to use a lower speed. Minimizing delays for cyclists at intersections is a major issue in terms of directness in time; this is dealt with in Section 4.1.2.

Separation

Separation between traffic types is a requirement in case of significant speed differences in order to provide a safe traffic environment for cyclists. As a general rule according to both Dutch and Swedish guidelines, bicycle traffic should be separated from motorized traffic if the speed exceeds 30 km/h due to the limited ability of a human to withstand the violence from a vehicle collision at greater speed. The degree of separation is of great importance also for the experienced safety, but the disadvantage of this increased safety is that cyclists might underestimate risks at intersections and also keep a higher speed when approaching intersections. A cycle track is the safest solution from a separation point of view; the risk of accidents is lowered, the traffic nuisance from e.g. noise and exhaust fumes can be reduced and the negative influence from parked vehicles is avoided. According to TPU the bicycle infrastructure in the main network should be separated from motorized traffic as much as possible. In cases where separation is not possible an alternative solution can be to reduce the speed difference, i.e. to lower the speed of motorized traffic.

The separation between cyclists and pedestrians is also an important factor in the design of a cycle track. A clear separation where cyclists and pedestrians do not have to intrude on each others designated areas is desirable. On major bicycle stretches in the city center TPU suggests a slightly elevated footpath separated from the cycle track with low a curb, which has to be designed in such a way that it does not pose a safety risk. In the normal case cycle tracks and footpaths are only separated by a difference in paving.

Design manual for bicycle traffic offers an option diagram for road sections inside the built-up area, which based on road category, speed of motorized traffic and bicycle network category provides guidelines on what bicycle facility (cycle track, cycle lane etc.) to choose on a given road section. According to the diagram a bicycle intensity of 500-2500/day in combination with Skånegatan being categorized as a district access road with a maximum speed of 50 km/h the most appropriate bicycle facility is a separate cycle track. This is also the case in the present design. Swedish guidelines for separation are based on the speed and intensity of motorized traffic and state that a cycle track gives a good quality (the highest quality grading of three possible levels) for a 50 km/h road. However, the layout of the cycle track has to meet a number of requirements.

Dimensions

A cycle track with a sufficient width allows safe passages, enough room for evasive maneuvers if necessary, appropriate margins in respect to other traffic and it also helps preventing delays connected to capacity. The guidelines regarding the width of the cycle track take into consideration the rush hour intensity of bicycles and whether it is a one-way or two-way track. According to Dutch guidelines a one-way cycle track is often preferable, but if there is not enough space for a cycle track on each side of the road and if a two-way cycle track can help preventing crossing movements allowing cycle traffic in both directions on the cycle track can be a feasible solution. These conditions apply for the concerned stretch along Skånegatan, which makes a two-way track advisable.

In a bicycle count conducted on Skånegatan in the rush hour in the morning and in the afternoon on April 12, 2010 the rush hour intensity in two directions was 142 bicycles/hour at the time. This is by no means a statistically reliable figure but it still gives an indication on the traffic volumes. Dutch guidelines recommend a track width of 2.50 to 3.00 m for rush hour intensities of 50-150 in two directions. Swedish national guidelines (VGU) set a standard width of a cyclist to 0.75 m and also provide design values for dimensions required between and adjacent to cyclists in two different margin classes. If the current layout of the cycle track along Skånegatan was designed according to margin class A, which means that cyclists and pedestrians do not have to adjust to each other, it should have a width of 2.75 m. Margin class B requires that cyclists and pedestrians adjust to each other to some degree; if designed according to margin class B a total cycle track width of 2.00 m is said to be sufficient. The guidelines used locally in Göteborg (TPU) by the traffic and public transport authority are partly based on VGU and seeks to provide principles for a uniform approach in the design of bicycle infrastructure. According to TPU two-way bicycle tracks in Göteborg should have a width of minimum 2.00 m, but normally 2.50 m in central parts and 2.30 m elsewhere. The current layout of the cycle track along Skånegatan has a width of 2.00-2.55 m.

4.1.2 Intersections

Serious traffic accidents involving cyclists are in a majority of the cases caused by collisions with cars. This is why the design of intersections in the bicycle network is essential for the safety of cyclists. The aim of every intersection must be that it is comprehensible to all road users, so that misunderstandings and accidents can be avoided. A key issue in achieving this is to minimize the number of conflict points, which however can be in contradistinction with other requirements such as a proper traffic flow. This can in turn put demands on the number of lanes and the traffic situation might no longer be sufficiently comprehensive without some regulation of traffic by means of traffic lights. The speed of the various road users is also an important factor at intersections since the speed is the critical parameter for the outcome of an accident. Of the five main requirements on bicycle infrastructure directness, safety and comfort are applicable on intersections.

Directness in time is important in general, but especially at intersections in routes that are used by many cyclists, which often is the case in the main bicycle network. Preventing delays is a key issue that can be achieved by giving cyclists right of way where possible, which also is the policy in Göteborg according to local guidelines. In

cases where this is not possible the risk of waiting at intersections can be minimized by using traffic lights with remote detection on the cycle tracks. When traffic lights are used the cycle time of the traffic light regulation is subject to requirements, especially in terms of maximum waiting time for cyclists.

Safety is considered the most important requirement in the design of an intersection. A roundabout is, however, a safer solution than an intersection with traffic lights, which often are installed in order to facilitate the flow of motorized traffic. Since motorized traffic generally constitute the dominating traffic flows in intersections, traffic lights are often designed with cars in mind. Studies have, however, shown that cyclists as a rule have to wait for long periods, in many cases unnecessarily, since there are measures to shorten waiting times for cyclists. Research made in the Netherlands show that green light times for motorized traffic at intersections in many cases are set unnecessarily long. Shorter cycle times are beneficial for cyclists and in many cases it was also proven possible to shorten the cycle time, improving the flow of bicycle as well as other traffic.

Studies have shown that waiting for traffic lights is one of the main sources of delay for cyclist, especially in larger cities. Important to bear in mind is also that cyclists are more sensitive than motorists to energy losses and discomfort associated with braking and accelerating at an intersection. The waiting time and the chance of stop are important factors when evaluating the directness and general bicycle-friendliness of a traffic control system. The average waiting time is obtained by multiplying the probability of stop by the average waiting time on stopping. Reducing the probability of stop and the red-light time are measures that can be used to minimize the average waiting time. According to Dutch guidelines an average waiting time of 15 seconds or less is considered good, whereas more than 20 seconds is regarded poor.

4.2 Requirements from focus groups

A related master's thesis work (Koorp & Persson, 2010) has been carried out in parallel to this thesis, investigating the needs of different groups of cyclists. Through discussions in focus groups, various thoughts have been obtained on what is good in the current bicycle infrastructure, what can be improved and what could be changed if you were allowed to envision with no restraints. In this section, the results from the focus group interviews considered applicable in the proposal for the new design of Skånegatan are presented. The aim is to take these opinions into consideration as much as possible when compiling the proposal for the new design.

Safety is an aspect often discussed in the focus group interviews. It is important to feel safe when cycling in order for people to consider the bicycle as an attractive mode of transport. This applies for a cycle route as a whole, but safety is particularly important at intersections. Good visibility and low speed of motorized traffic are essential in the design of an intersection and so are regulations and traffic signal configurations in order to avoid misunderstandings. In the focus groups, the separation of various types of traffic is considered very important between intersections. Good lighting is also important along the whole cycle route.

Other views include continuity of the cycle track, good road markings and road signs clearly showing where cyclists and pedestrians are supposed to be. In order to enable continuous cycling without unnecessary stops, higher priority for cyclists at intersections is proposed, e.g. that a so called 'green wave' follows cyclists between

signal regulated intersections. Green wave means that the intervals between the green times in the intersections are adjusted to the speed of the cyclists in order for the traffic light to switch to green before the cyclists arrive. A high quality, smooth pavement is also an important factor from a comfort point of view.

In terms of facilities along the cycle track, secure bicycle parking is mentioned as being most important; good possibilities to securely lock your bicycle should be provided at the start point as well as the destination. It is also important that it is easy to find the way, good signposting with clear destination and distance information is desirable. Access to bicycle pumping stations is also a factor facilitating for cyclists.

5 Proposal for reconstruction of Skånegatan

As presented in the introduction, the aim of this thesis is to create a visionary bicycle-friendly design of Skånegatan, which is presented in this chapter. The design is partly inspired by the Dutch *Design manual for bicycle traffic* (CROW, 2007), mainly in terms of widths, but also regarding directness and separation. The design is also based on the requirements from the focus groups mentioned earlier. Different ideas have been discussed in order to present the proposal considered the most appropriate.

The main idea in the design has been to create a continuous, safe and comfortable cycle track, fulfilling the requirements set by Swedish as well as foreign handbooks. This idea has resulted in a 3.0 m wide two-way cycle track separated from the walking area by a 20 cm wide and 5 cm high curbstone. The width of the track ensures a good availability that also will be sufficient for an increased future bicycle traffic. The curbstone is low enough to be easily crossable, but still apparent enough not to be passed by mistake. The cycle track will also be clearly marked with a centerline on all road sections and there will be painted bicycle symbols and arrows on the pavement. This makes it easier for cyclists to know which side to cycle on and it also makes pedestrians more aware of the cycle track.

To clear the way for the new 3.0 m wide cycle track, different solutions have been applied at different stretches. In some places, green areas have been changed and in some places the walking area has been affected. At the movie theatre Bergakungen the proposal is to cut one of the lanes in order to give more space to cyclists and pedestrians but also to create a more enjoyable traffic environment. Other measures taken to improve the surroundings include planting trees between the cycle track and the road but also installing new lighting along the stretch in order to make the area safer and more attractive.

Along The Swedish Exhibition & Congress Centre an all new cycle track has been proposed where Mässans gata is today. This is the biggest change on the stretch, but it is also the stretch where a reconstruction is needed the most. The cycle track has been straightened at some places in order to increase the availability for cyclists, but it also improves the continuity of the cycle track.

In order to increase the safety, the traffic signal regulation in the intersection at Valhallagatan has been proposed to be changed to avoid conflicts between turning vehicles and cyclists going straight on. The bicycle crossings are proposed to be painted blue to make motorists more aware of the crossing.

All figures in this section can be seen in Appendix I-VIII.

5.1 Part A: The Swedish Exhibition & Congress Centre

Today the northbound cycle route at The Swedish Exhibition & Congress Centre runs in mixed traffic on Mässans gata, while the southbound cycle track runs on a separate narrow strip in the mall between Mässans gata and Skånegatan (Figure 5.1). None of these solutions is satisfying. To direct cyclists into mixed traffic always increases the risk of conflicts with motorized traffic. It also is a disadvantage for cyclists in terms of availability when cars are parking along the street or slowing down considerably at the speed bumps on the stretch. Although the City of Göteborg claims that all streets in Göteborg with cycle routes in mixed traffic have a speed limit of 30 km/h, there are

no signs stating this, which means that the speed limit for Skånegatan (50 km/h) applies for Mässans gata too. (Göteborgs Stad, 2009)

Some people have also been observed using Mässans gata as a shortcut to bypass the traffic and also avoid one of the traffic lights on Skånegatan. Motorists taking this shortcut, often at high speed, are a great risk to cyclists. The fact that the southbound cycle track runs on a refuge – in some places the cycle track is only 0.8 m wide – makes it impossible to pass other cyclists. The footpath outside The Swedish Exhibition & Congress Centre is currently 4.3 m wide.

Cars also have to cross the southbound cycle track when entering and exiting Mässans gata. In these places the cycle track is paved with red bricks or placed after a speed bump in order to make drivers aware of the crossing.

Since the stretch passing The Swedish Exhibition & Congress Centre is part of the main bicycle network, the cycle tracks given the highest priority in Göteborg, it is quite surprising that there are such deficiencies in the design. A change of the situation for cyclists is considered necessary in order to make cycling more attractive and a proposal for a new design has been developed.

Figure 5.1 3D model showing the current layout of the cycle route at The Swedish Exhibition & Congress Centre.

The proposal in order to solve the mentioned problems is to replace Mässans gata and build a 3.0 m wide two-way cycle track. The proposal also includes a widening of the footpath from 4.3 m to 5.0 m (Figure 5.2). The cycle track and the footpath are separated by a 20 cm wide and 5 cm high curbstone. This separation prevents pedestrians from entering the cycle track by mistake, but is easily crossable for cyclists as well as pedestrians. The low height of the separation also eliminates the risk that the cyclists' pedals hit the curbstone.

The parking spaces and loading zones along Mässans gata are in the proposal located along Skånegatan instead. With this solution people parking in these parking places have to walk across the cycle track to reach the footpath closest to the building, but this is considered a minor problem compared to the advantages of the new wide two-

way cycle track. Parallel parking along Skånegatan is not regarded as a problem, since the same solution is applied at the opposite side of the street.

The wide refuge between the new parking places and the new cycle track gives, in addition to space for more secure bicycle parking racks, more space for opening car doors without the risk of an accident with a cyclist.

The Swedish Exhibition & Congress Centre also has two gates for major deliveries, which must be available also after the reconstruction. Since the use of these gates is very limited (approximately 50 deliveries per year) a suitable solution is to construct passages for delivery trucks to cross the refuge and the new cycle track along Skånegatan.

Figure 5.2 3D model showing the proposed layout of the cycle track at The Swedish Exhibition & Congress Centre.

5.2 Part B: The intersection at Valhallagatan

The intersection at Valhallagatan is rather large and complicated, but since the cycle track passes on the east side of it, cyclists are only affected by a part of the intersection. Just south of the intersection, the 2.45 m wide cycle track makes a small bend and it crosses the street parallel to the pedestrian crossing (Figure 5.3). On the north side of the intersection, the cycle track makes a sharp turn to the left and then to the right before continuing north along Skånegatan. From here the cycle track is 2.1 m wide. The separation between cyclists and pedestrians only consists of a difference in paving material.

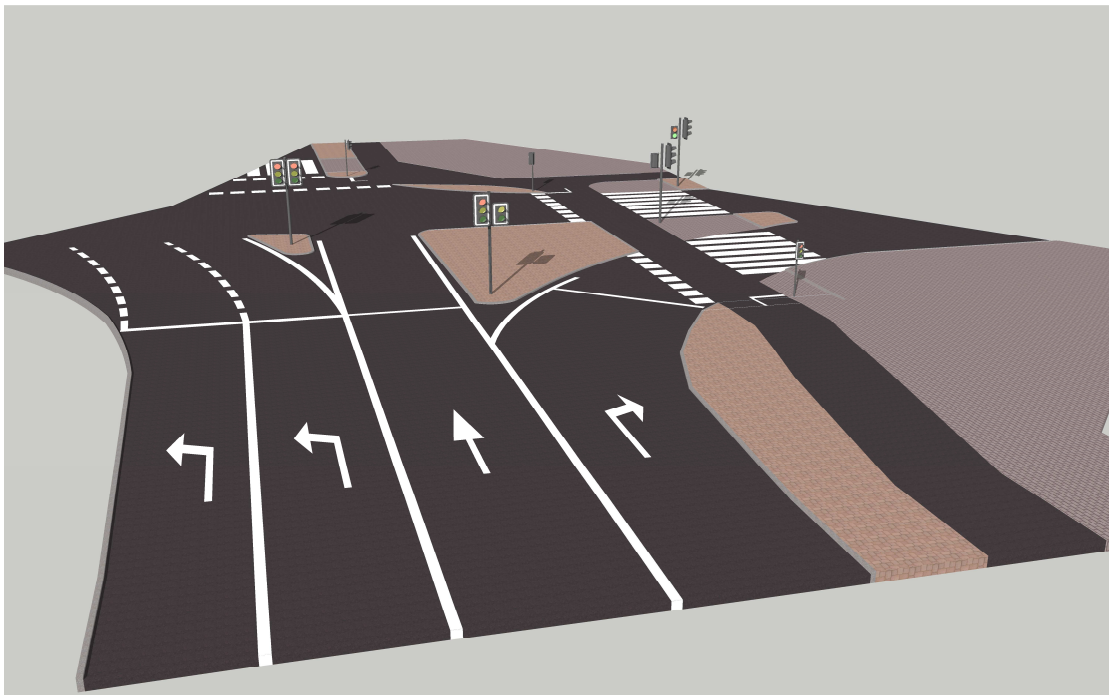

Figure 5.3 3D model showing the current layout of the intersection at Valhallagatan.

The part of the intersection affecting cyclists is currently regulated by a traffic signal with two phases. In the first phase, traffic along Skånegatan (including cyclists) and traffic turning right onto Valhallagatan from Skånegatan have green light, whereas traffic coming from Valhallagatan has red light. In the second phase, traffic coming from Valhallagatan and traffic turning right onto Valhallagatan from Skånegatan (additional two-light turn signal) has green light. Other traffic along Skånegatan (including cyclists) have red light (Figure 5.4). At night, the traffic signal automatically switches to green along Skånegatan.

This signal configuration causes conflicts between cyclists crossing Valhallagatan and motorists turning right from Skånegatan. However, this configuration makes the green light time for cyclists relatively high, but it could be improved further and the safety in the intersection could be increased.

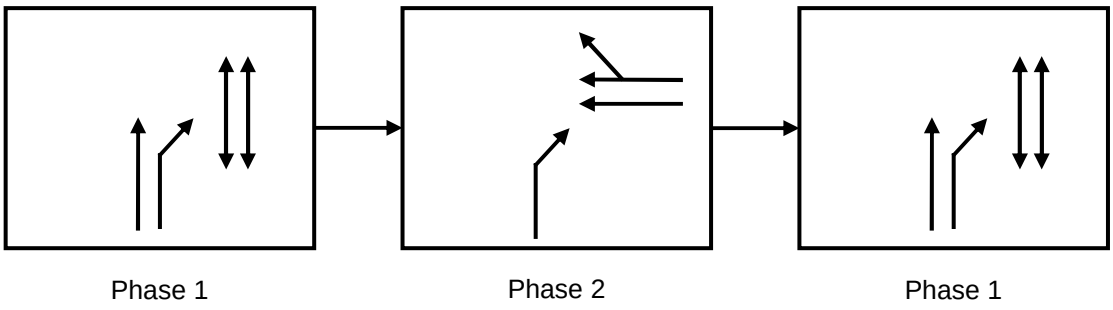

Figure 5.4 Current signal configuration. Phase 1: northbound traffic and traffic turning right on Skånegatan as well as bicycle traffic in both directions have green light. Phase 2: traffic turning right on Skånegatan and traffic on Valhallagatan have green light.

The proposal is to let the 3.0 m wide two-way cycle track continue also on this stretch. It is straightened in order to avoid the bend just south of the intersection. Due to the straightening, the cycle track is located slightly more to the west, which makes the sharp turn north of the intersection a bit gentler. This re-localization of the cycle track means that the stop line for traffic turning right from Skånegatan has to be drawn back a bit.

The shape of the walking area north of the intersection is also changed slightly outside Burgårdens gymnasium in order to make it easier for cyclists to pass. To make motorists aware of that they cross a cycle track, the bicycle crossings are painted blue. This is a method used in several cities in Europe (e.g. Copenhagen) and it is also recommended by Svenska cykelsällskapet (Swedish Bicycle Association) (Svenska cykelsällskapet, 2010).

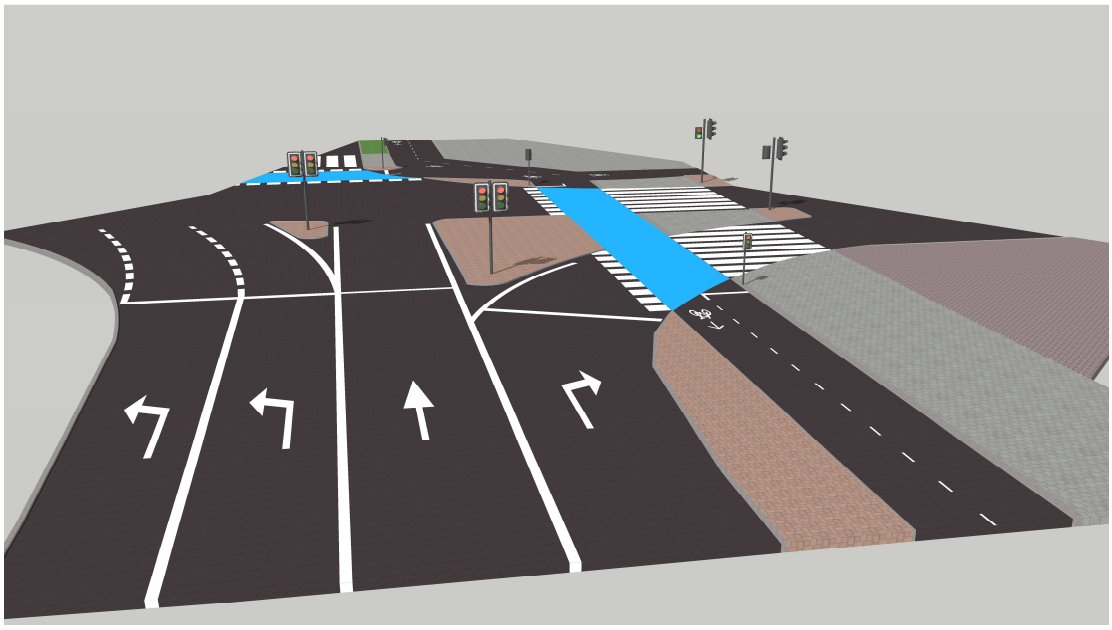

Figure 5.5 3D model showing the proposed layout of the intersection at Valhallagatan.

To increase the safety in the intersection, a change in the signal configuration is proposed. Safety would increase if traffic turning right onto Valhallagatan was given its own three-light turn signal instead of following the same signal as traffic along Skånegatan. This means traffic is not allowed to cross the cycle track when cyclists along Skånegatan have green light (Figure 5.6), which would decrease the risk of collisions between cyclists and cars without affecting the green light time for cyclists, since turning traffic only get green light at the same time as traffic coming from Valhallagatan, when cyclists have red light anyway. In order for this solution to be practicable it is important that the turning lane is long enough so that waiting cars do not block the adjacent lane. This three-light turn signal would follow the signal regulating the traffic coming from Valhallagatan. To minimize the red light time for cyclists these signals would only give green light when there are vehicles in these lanes and they would immediately go back to red light when the vehicles have passed. This requires detecting devices in the ground. (Kronborg, 2009)

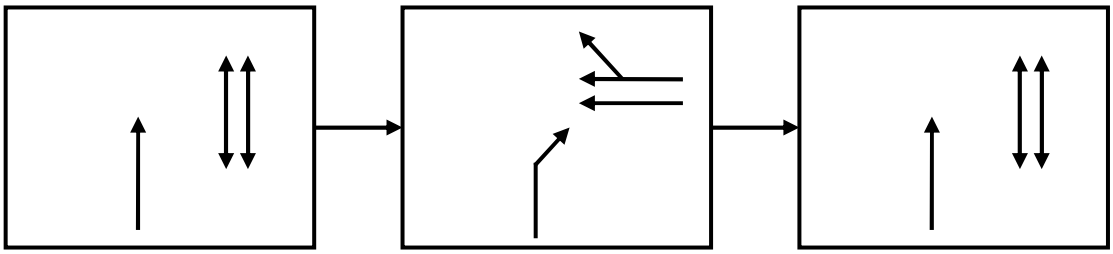

Figure 5.6 Proposed signal configuration. Phase 1: northbound traffic on Skånegatan and bicycle traffic in both directions have green light. Phase 2: traffic turning right on Skånegatan and traffic on Valhallagatan have green light.

5.3 Part C: Burgårdens gymnasium and movie theatre Bergakungen

The stretch passing Burgårdens gymnasium currently consists of a 3.35 m wide footpath and a 2.1 m wide two-way cycle track without centreline (Figure 5.7). The separation between the cycle track and the footpath only consists of a difference in paving material, which often makes pedestrians use the cycle track. This is also due to that there often are large numbers of pedestrians close to the cycle track, since it passes both a tram stop and a high school.

The cycle track is so narrow (only just over 2 m wide) that it is difficult to pass other cyclists, especially when encountering oncoming traffic. The 4.75 m wide road running between the cycle track and the tram stop must retain its current width in order to allow passings in case of an emergency.

Figure 5.7 3D model showing the current layout of the cycle track at Burgårdens gymnasium.

In order to solve the above mentioned problems, a high degree of separation between the cycle track and the footpath is proposed (Figure 5.8). As on the other stretches on Skånegatan it should consist of a 20 cm wide and 5 cm high curbstone. The proposal also implies a small change in the widths of the footpath, the cycle track and the mall. From a continuity point of view it is important that the cycle track along Skånegatan has a constant width, which is why the cycle track also in this case is proposed to be 3.0 m wide with a two-way configuration with centerline. The cycle track will also be provided with bicycle symbols and arrows in the pavement in order to increase the road users' awareness of the cycle track and on which side to cycle.

The new width of the cycle track of 3.0 m makes the footpath slightly more narrow, 3.0 m, and the grass area becomes a bit smaller; the width decreases from 2.2 m to 1.6 m. The road for motorized traffic is unchanged. In the grass area there will be trees and also lighting for the road as well as the cycle track.

Figure 5.8 3D model showing the proposed layout of the cycle track at Burgårdens gymnasium.

At the movie theatre Bergakungen the proposal is to cut one of the two lanes for motorized traffic in order to give more space to pedestrians in connection to the movie theatre. This will also provide more space for cyclists and green areas.

5.4 Part D: The intersection at Hugo Levins väg

The traffic signal in this intersection runs in three phases; in the first one, traffic along Skånegatan has green light, in the second one, the traffic crossing Skånegatan has green light and in the third one the traffic turning left from Skånegatan has green light. In the latter two phases, cyclists on Skånegatan have red light.

It is difficult to make any changes to the traffic regulation of the intersection, since all three phases are needed for the intersection to be safe. To change the regulation to two phases is not possible, since traffic turning left in that case might be stand stilled on the tram tracks in the middle of Skånegatan.

The proposal is to straighten the cycle track and paint the bicycle crossings blue. The cycle track will also to be marked with bicycle symbols.

5.5 Part E: Ullevi Stadium

At Ullevi Stadium, the approximately 2 m wide cycle track is at some parts separated from the walking area by a row of trees (Figure 5.9). In spite of this many pedestrians use the cycle track. Bicycle symbols to make clear that it is a cycle track are only painted on the pavement in each end of the stretch and there is no centerline.

On the other side of the row of trees there is a vast walking area extending all the way to the stadium.

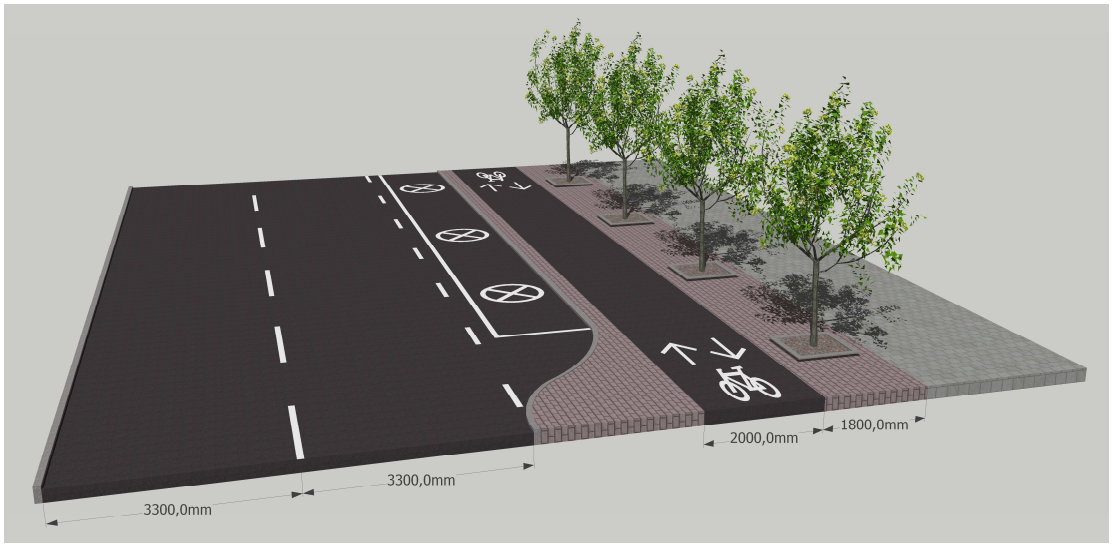

Figure 5.9 3D model showing the current layout of the cycle track at Ullevi Stadium.

If the cycle track was built further away from the road, there would be space for a wider area between the cycle track and the boarding and alighting zone (Figure 5.10). This extra space prevents car doors from being opened into the cycle track, but it also provides an area for people getting out of their cars. This area is also proposed to be used for street lighting of the road.

Also on this stretch, the cycle track is widened to 3.0 m in order to provide good availability and continuity along the entire street. The cycle track is also painted with bicycle symbols, arrows and centerline in order to make it clear to road users that it is a cycle track and what side to cycle on. Cycle track road signs will be put up along the stretch.

On the stretch passing Ullevi stadium the cycle track is separated from the walking area by a 2 m wide green area with trees. This type of separation is possible to cross, but prevents pedestrians from entering the cycle track by mistake. Street lighting for the road as well as the cycle track will be put up in the green area.

Figure 5.10 3D model showing the proposed layout of the cycle track at Ullevi Stadium.

6 Discussion and conclusions

The City of Göteborg is said to be a bicycle-friendly city, where focus is put on increasing the share of bicycle trips and lower the number of injured and killed from bicycle accidents. The work on traffic safety has been relatively successful and the statistics on accidents show a decreasing trend. However, the goal regarding the share of bicycle traffic does not seem to be reached in time and there is doubt whether the bicycle share is increasing at all. As been showed in this thesis, the bicycle infrastructure is not satisfying at the moment; this also applies for the main bicycle network, which is said to be the most prioritized bicycle routes. This is evident on the bicycle route along Skånegatan (which is part of the main bicycle network) where cyclists partly have to share the street with motorized traffic, cycle on too narrow tracks and constantly have to watch out for pedestrians on the cycle track. If the bicycle traffic in Göteborg is to increase, the current policy on bicycle infrastructure is evidently not sufficient.

Several other Swedish cities have considerably higher bicycle shares (25-35%), which show that there is a great potential to increase the bicycle traffic also in Göteborg. To comply with the goals to substantially increase the number of inhabitants and workplaces in the city center of Göteborg a change in modes of transport is necessary. Increased cycling is a feasible and sustainable option in this respect, but in order to increase bicycle traffic a sufficient infrastructure is necessary.

By focusing on continuity, safety, comfort and attractiveness a proposal for a new bicycle-friendly design of Skånegatan has been compiled. The cycle track is 3.0 m wide along the entire stretch and the risk of conflicts between cyclists and pedestrians is minimized by a clear separation. The safety has also been increased in the intersections since a changed traffic signal configuration is proposed in one of the intersections and by painting the bicycle crossings blue. The conditions for pedestrians are also improved in the proposal, since they on many parts of the stretch are given more space and do not have to worry about cyclists. In some places constraints on motorized traffic has been applied in order to reduce traffic on Skånegatan and hence create a more attractive environment for cyclists and pedestrians.

The proposal is considered practicable and shows that it is possible to reconstruct a bicycle route by relatively small means and make it more attractive to go by bicycle. If the ideas in the proposal had been taken into consideration already in the planning stage the extra cost would have been small.

If the principles used in the proposal for a new design of Skånegatan were applied throughout the city on the main and overall bicycle network the conditions for cyclists would be improved considerably and going by bicycle would be more attractive. It would also be a way for The City of Göteborg to show that cycling is considered an important and prioritized mode of transport, as it is said in the bicycle program of 1999. In 2012 a new bicycle program for Göteborg is to be presented and this would be a great opportunity to take the bicycle policy one step further and really set a new, more sustainable course for the future.

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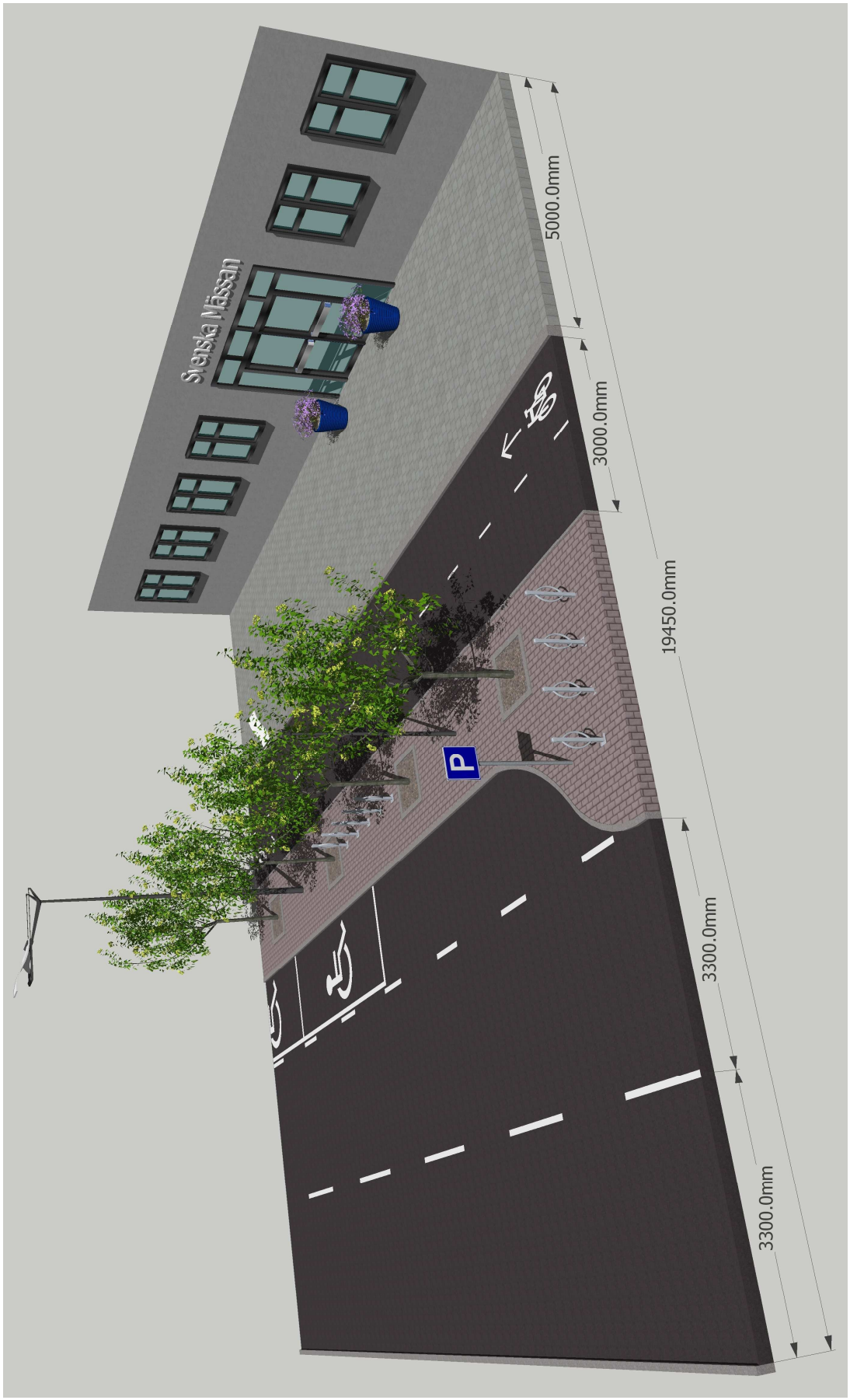
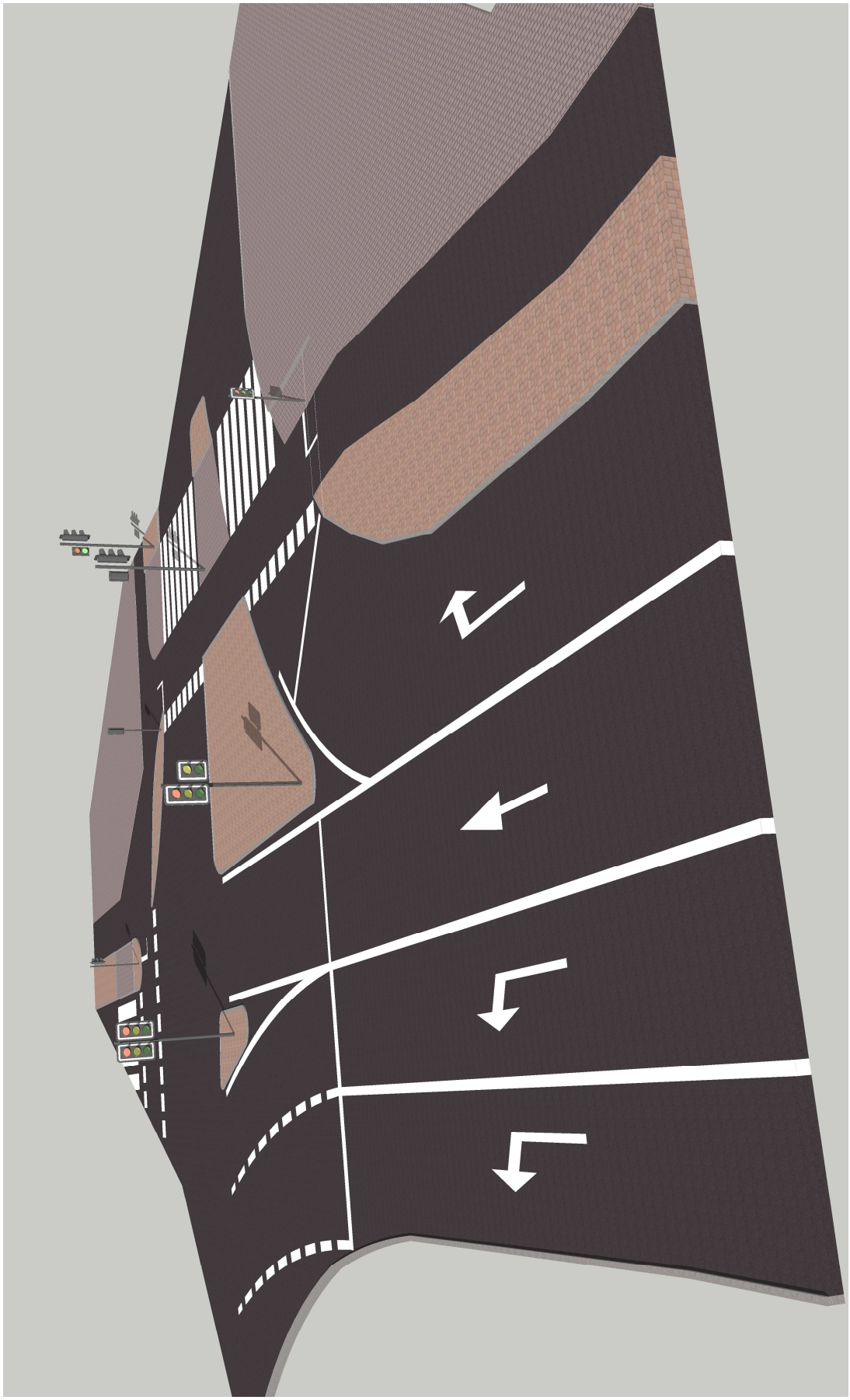
Appendix I – Part A: current layout

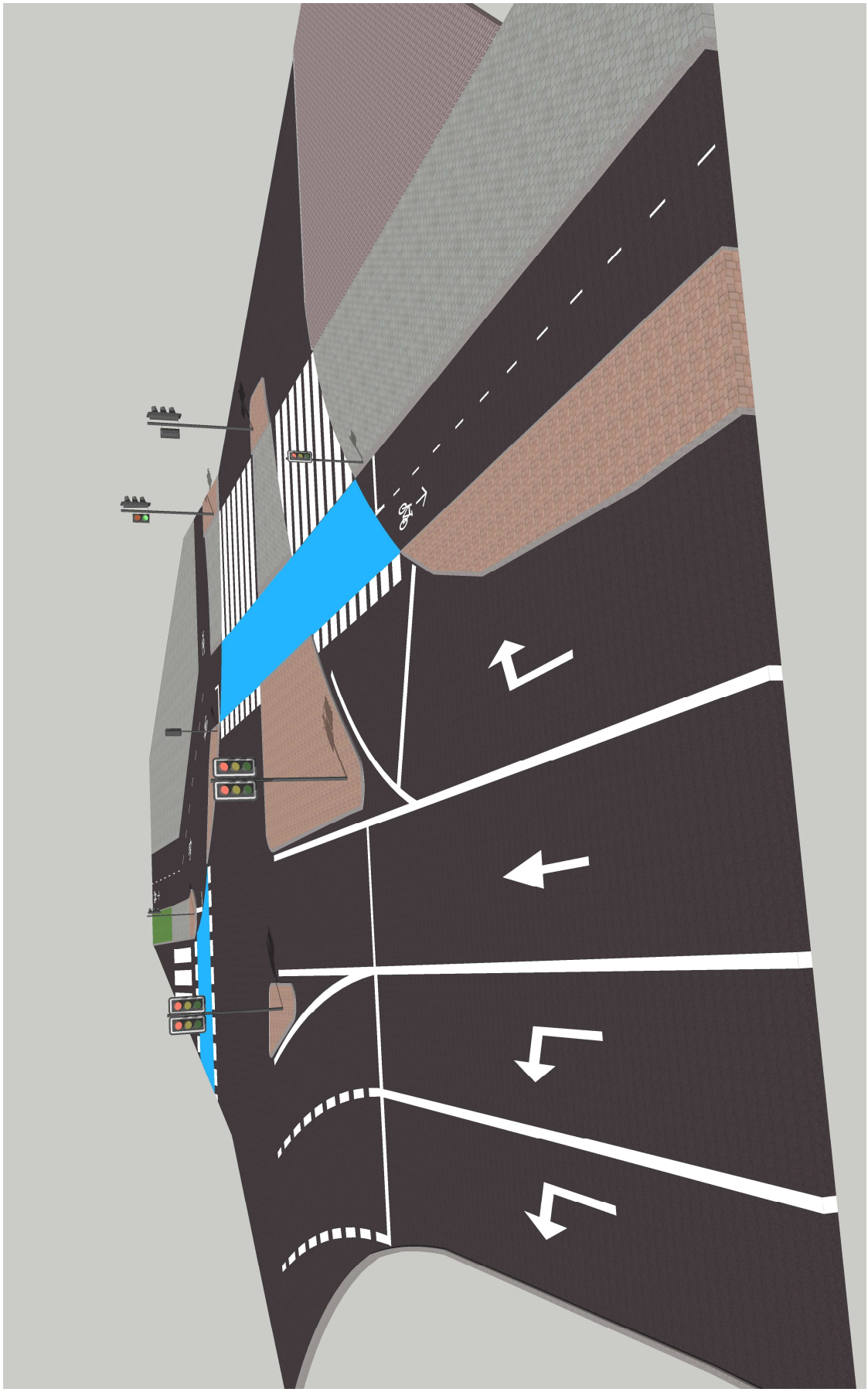
Appendix II – Part A: proposed layout



Appendix III – Part B: current layout



Appendix IV –Part B: proposed layout



Appendix V – Part C: current layout

Appendix VI – Part C: proposed layout

Appendix VII – Part D: current layout

Appendix VIII – Part D: proposed layout