

CHALMERS



Improvements in the traffic system of Gothenburg

A case study on Express Bus Rosa including analysis and proposals of actions

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

JIMMY JOHANSSON

Department of Civil and Environmental Engineering

Division of GeoEngineering

Road and Traffic Research Group

CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden 2013

Master's Thesis 2013:43

MASTER'S THESIS 2013:43

Improvements in the traffic system of Gothenburg

A case study on Express Bus Rosa including analysis and proposals of actions

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

JIMMY JOHANSSON

Department of Civil and Environmental Engineering
Division of GeoEngineering
Road and Traffic Research Group
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2013

Improvements in the traffic system of Gothenburg

A case study on Express Bus Rosa including analysis and proposals of actions

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

JIMMY JOHANSSON

© JIMMY JOHANSSON, 2013

Examensarbete/Institutionen för bygg- och miljöteknik,
Chalmers Tekniska Högskola 2013:43

Department of Civil and Environmental Engineering
Division of GeoEngineering
Research Group Road and Traffic
Chalmers University of Technology
SE-412 96 Göteborg
Telephone: +46 (0)31 – 772 1000

Cover: Separate bus lane in central Gothenburg.

Reproservice/Department of Civil and Environmental Engineering Göteborg, Sweden
2013

Improvements in the traffic system of Gothenburg

A case study on Express Bus Rosa including analysis and proposals of actions

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

JIMMY JOHANSSON

Department of Civil and Environmental Engineering

Division of GeoEngineering

Research Group Road and Traffic

Chalmers University of Technology

ABSTRACT

A modern city in today's society requires development on many different fronts. It is about growth in areas such as economy, social values, politics and technology. In order to create a sustainable urban development, or a sustainable urbanisation which is the inner process, an efficient transport system is required. The opportunity for sustainable transport is, with a well-functioning public transport system for feasible commuting and basis for flexible travel, essential to a city's competitiveness. To meet this increase in population and simultaneously form a sustainable urban development, an investment in sustainable transport is required. This is now being implemented in Gothenburg through investments via the so-called West Swedish Solution. The aim of this thesis is to implement improvements in the traffic system in Gothenburg. It will be to identify roads, streets and other sections in the traffic environment in Gothenburg where accessibility and traffic safety needs to be improved and more effective solutions needs to be implemented. A case study will be conducted on the new express bus route Rosa that runs from Klareberg in northern Gothenburg to Snipen in the south. This thesis will identify problems and present proposals for action for improvement. This thesis is limited to only regard the traffic environment that affects express bus Rosa in Gothenburg. An important aspect to mention is that this thesis will only address problems directly relating to traffic, from a traffic engineering perspective. This means that parameters such as passenger comfort or the frequency express bus Rosa does attend stops are not at issue in this thesis. Several problems have been identified. Among these were then three interesting items chosen for further analysis and proposals of actions were presented. Klareberg, Kärra Centrum and the stretch between Nordstan and Heden have been proposed for change. Further investigations include detailed analyses of the selected features and a review of all the other problems identified. It is a solid collection with many items which can certainly give different effects. Cost estimates have not been developed in this work, the measures being considered to maintain a relatively low cost, but is obviously important in the end, when decisions on action occurs.

Key words: Traffic system, Gothenburg, traffic safety, accessibility, Express Bus Rosa, Klareberg, Kärra Centrum, Nordstan, Heden

Förbättringar i trafiksystemet i Göteborg

En fallstudie på expressbusslinje Rosa med analys och åtgärdsförslag

Examensarbete inom Infrastructure and Environmental Engineering

JIMMY JOHANSSON

Institutionen för bygg- och miljöteknik
Avdelningen för Geologi och geoteknik
Forskargrupp Väg och Trafik
Chalmers Tekniska Högskola

SAMMANFATTNING

En modern stad i dagens samhälle kräver utveckling på många olika fronter. Det handlar om tillväxt inom bland annat ekonomiska, sociala, politiska och tekniska värden. För att skapa en hållbar stadsutveckling, en hållbar urbanisering som det handlar om, krävs effektiva transportsystem. Möjligheten till hållbara transporter med ett väl fungerande kollektivtrafiksystem för möjlighet till pendling och grund för flexibelt resande är väsentligt för en stads konkurrenskraft. För att möta denna befolkningsökning och samtidigt forma en hållbar stadsutveckling krävs en satsning på hållbara transporter. Detta genomförs nu i Göteborg genom satsningar via det så kallade Västsvenska paketet. Målet med detta examensarbete är att genomföra förbättringar i trafiksystemet i Göteborg. Det handlar om att identifiera vägar, gator och andra avsnitt i trafikmiljön i Göteborg där till exempel framkomlighet och trafiksäkerhet behöver förbättras samt effektivare lösningar implementeras. En fallstudie kommer genomföras på den nya expressbusslinje Rosa som löper från Klareberg i norra Göteborg till Snipen i söder. Denna uppsats kommer att identifiera problem och presentera förslag till åtgärder för förbättringar. Detta examensarbete begränsas till att enbart se till trafikmiljön som påverkar expressbusslinje Rosa i Göteborg. En viktig del att nämna är att detta examensarbete endast kommer ta sig an problem som härrör direkt till trafiksystemet, ur ett trafiktekniskt perspektiv. Det innebär att paratmetrar som passagerarnas komfort eller med vilken frekvens expressbusslinje Rosa trafikerar hållplatserna inte är aktuella i detta examensarbete. Flera problem har identifierats och bland dessa valdes tre intressanta objekt ut för vidare analys och förslag till åtgärder presenterades. Klareberg, Kärra Centrum och sträckan mellan Nordstan och Heden har föreslagits för förändring. Ytterligare undersökningar inkluderar djupare analyser av de valda objekten samt en genomgång av alla de övriga problem som identifierats. Det är en gedigen samling med många objekt som säkerligen kan ge olika effekter. Kostnadsbedömningar har inte utarbetats i detta arbete, åtgärden ansågs hålla en relativt låg kostnadsnivå, men blir självklart viktiga i slutändan när beslut om åtgärd sker.

Nyckelord: Trafiksystem, Göteborg, trafiksäkerhet, framkomlighet, expressbusslinje Rosa, Klareberg, Kärra Centrum, Nordstan, Heden

Notation

Trafikverket has been named its Swedish name through the report. It is the Swedish Transport Administration.

Glossary

Accessibility - Framkomlighet, tillgänglighet

Case studie - Fallstudie

Congestion charge - Trängselskatt

Designation - Beteckning

Highway 158 - Riksväg 158

Traffic and Public Transport Authority - Trafikkontoret Göteborgs Stad

West Swedish Solution - Västsvenska Paketet

Contents

1.	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	PURPOSE	1
1.3	LIMITATIONS	2
1.4	METHODOLOGY	2
1.5	LAYOUT OF THE REPORT	2
1.6	LITERATURE	3
2.	EXPRESS BUS ROSA	4
2.1	BACKGROUND	4
2.2	STATISTICS ON EXPRESS BUS ROSA	4
2.3	STRETCH	8
2.4	SECTIONS	9
2.4.1	Klareberg – Mystängen	10
2.4.2	Mystängen – Klareberg	11
2.4.3	Klareberg – Lillekärr Södra	12
2.4.4	Lillekärr Södra – Hjalmar Brantingsplatsen	13
2.4.5	Hjalmar Brantingsplatsen – Nordstan	14
2.4.6	Nordstan – Heden	15
2.4.7	Heden – Linnéplatsen	16
2.4.8	Linnéplatsen – Marklandsgatan	17
2.4.9	Marklandsgatan – Radiomotet	18
2.4.10	Radiomotet – Hovås Nedre	19
2.4.11	Hovås Nedre – Skintebo	20
2.4.12	Skintebo – Snipen	21
2.5	VEHICLES	21
2.5.1	Volvo	22
2.5.2	Solaris	22
3.	INTERVIEWS WITH PASSENGERS	24
3.1	QUESTIONS AND ANSWERS	24
3.2	SUMMARY	26
4.	PROBLEM IDENTIFICATION	27
4.1	DEFINITION	27
4.2	PROBLEMS ON EXPRESS BUS ROSA	28
4.2.1	Klareberg – Mystängen	28
4.2.2	Mystängen – Klareberg	28
4.2.3	Klareberg – Lillekärr Södra	29
4.2.4	Lillekärr Södra – Hjalmar Brantingsplatsen	29
4.2.5	Hjalmar Brantingsplatsen – Nordstan	30
4.2.6	Nordstan – Heden	30
4.2.7	Heden – Linnéplatsen	31
4.2.8	Linnéplatsen – Marklandsgatan	31
4.2.9	Marklandsgatan – Radiomotet	31
4.2.10	Radiomotet – Hovås Nedre	32
4.2.11	Hovås Nedre – Skintebo	32
4.2.12	Skintebo – Snipen	32
5.	PROPOSALS FOR ACTIONS	34

5.1 KLAREBERG	34
5.1.1 Presentation of Klareberg	34
5.1.2 Proposals in Klareberg	35
5.2 KÄRRA CENTRUM	38
5.2.1 Presentation of Kärra Centrum	38
5.2.2 Proposals in Kärra Centrum	40
5.3 NORDSTAN – HEDEN	43
5.3.1 Presentation of Nordstan - Heden	43
5.3.2 Proposals on Nordstan – Heden	44
6. DISCUSSION	45
6.1 GENERAL IDEAS	45
6.2 COST ESTIMATES	46
6.3 THE DIFFERENT SECTIONS	46
6.3.1 Discussion on Klareberg	46
6.3.2 Discussion on Kärra Centrum	47
6.3.3 Discussion on Nordstan – Heden	47
6.4 FURTHER SUGGESTIONS	47
7. CONCLUSIONS	48
REFERENCES	49

Preface

This master thesis is the final step in the Master's Programme Infrastructure and Environmental Engineering at Chalmers University of Technology. It comprises 30 credits and was written in Gothenburg from January 2013 to May 2013.

The thesis has been carried out by Jimmy Johansson and has been performed at the Swedish Transport Administration. Supervisor has been Ulla-Stina Ingemarsson, traffic analyst at the Swedish Transport Administration and university lecturer Gunnar Lannér has been examiner. The author would like to thank them both for their advice and encouragement throughout the writing of this thesis.

Finally, the author would also like to thank Magnus Lorentzon at Västtrafik for his support and also the informants from Veolia Transport Sverige AB. A thank you is also extended to my opponent David Lindvert for valuable feedback on the report.

Göteborg June 2013

Jimmy Johansson

1. Introduction

A modern city in today's society requires development on many different fronts. It is about growth in areas such as economy, social values, politics and technology. Sustainable development is now generally accepted and the Swedish government is also working with these values (Miljödepartementet, 2013).

In order to create a sustainable urban development, or a sustainable urbanization which is the inner process, an efficient transport system is required. The opportunity for sustainable transport is, with a well-functioning public transport system for feasible commuting and basis for flexible travel, essential to a city's competitiveness.

1.1 Background

According to the Transport Strategy for Gothenburg, which was under consideration for comment at the time of the production of this thesis, the City of Gothenburg in 2035 will have a population increase of 150 000 and 80 000 more jobs (Trafikkontoret, 2013). This urban development is based on the master plan adopted in 2009 by the municipal government of the City of Gothenburg and is intended to be the basis for the city's future development.

To meet this increase in population and simultaneously form a sustainable urban development, an investment in sustainable transport is required. This is now being implemented in Gothenburg through investments via the so-called West Swedish Solution. This includes improvements to roads and railways, bus routes, for trams and bicycles (Trafikverket, 2013a).

The West Swedish Solution is financed partly through congestion charges in Gothenburg, which was introduced on 1 January 2013. This is expected to change traffic flows in the city where many streets and roads is expected to have a reduced or smoothed traffic flow while others have impaired mobility due to traffic increases. It can also affect road safety and create other problems in the traffic.

To identify these changes and solve the problems related to them is in the interest of several instances in Gothenburg. Operators like Trafikverket and Västtrafik will somehow be involved in the disturbances that arise in connection with the introduction of congestion charge. Dialogue between them will be required to fix the problems that arise in a smooth and efficient manner.

1.2 Purpose

The aim of this thesis is to implement improvements in the traffic system in Gothenburg. It will be to identify roads, streets and other sections in the traffic environment in Gothenburg where accessibility and traffic safety needs to be improved and more effective solutions needs to be implemented. A case study will be conducted on the new express bus route Rosa that runs from Klareberg in northern Gothenburg to Snipen in the south.

This thesis will identify problems and present proposals for action for improvement. It can range from small, simple solutions to more advanced technical solutions.

1.3 Limitations

This thesis is limited to only regard the traffic environment that affects express bus Rosa in Gothenburg. In areas where several other parameters play a role, such as at bus stops Nordstan, Heden and Linnéplatsen is the problem identification, as far as possible, focused on the environment around express bus Rosa and its effect.

An important aspect to mention is that this thesis will only address problems directly relating to traffic, from a traffic engineering perspective. This means that parameters such as passenger comfort or the frequency express bus Rosa does attend stops are not at issue in this thesis.

There is an inherent limitation in this thesis. It is designed and produced by a student during one semester, that is, for 30 credits. Resources are therefore somewhat limited, and allowing to limit the report has been an important part of getting a final product.

1.4 Methodology

In order to create a thesis of good quality, a structured work has been an important part. The first thing to do was to get an understanding on how express bus Rosa is run. This has meant that, for example, understand the traveling needs, how it runs in the city and at an early stage the potential problems that may exist.

Subsequently, a problem identification has been made. The methodology for this has mainly been through travel on the line to actively find sore spots. To further gather information on express bus Rosa, interviews were conducted with both travelers and drivers on the route. These have mainly been implemented on the bus and bus stops.

From this information, analyzes were conducted in order to improve the current situation where the aim is to increase accessibility and traffic safety for express bus Rosa. Use of established traffic analysis, statistical analysis and technical tools such as GIS (Geographical Information System), road construction and flow models end in results that include both conceptual investigations but also concrete suggestions.

In order to establish credibility in the analysis and proposed actions, the discussion and presentation of solutions is an important part of the thesis. In these sections, there is scope for further questions and explanations of the analyzes performed.

1.5 Layout of the report

- **Chapter 1** introduces the reader to this thesis. There are, for example, information about the background of the issue, what the purpose of the report is and what limitations there are.
- **Chapter 2** provides background and information about Express Bus Rosa. The stretch is presented, broken down in various sections of the route, and also a background to its development. There is also information about the vehicles used on the route.

- **Chapter 3** presents results from interviews with passengers on Express Bus Rosa.
- **Chapter 4** highlights the problems identified along the corridor.
- **Chapter 5** presents proposals for the suggested solutions.
- **Chapter 6** contains a discussion of the analyses and proposals presented earlier in the thesis.
- **Chapter 7** presents the conclusions of the report.

1.6 Literature

In order to establish knowledge for further work on the problem identification, a literature study has been completed. Material like articles, scientific studies and recognized literature on traffic engineering have been studied and researched. Information about the various stakeholders Trafikverket and Västtrafik and their respective roles and the issues they own have also been collected.

2. Express bus Rosa

In this chapter, a description of the express bus Rosa is presented, the bus route this thesis deals with. There is a background to the creation of the line and an explanation of its route. It includes pictures that show how the line on aerial maps, a list of all the stops served and additional text that provides more information about the affected areas served.

2.1 Background

Express Bus Rosa was put into service when Västtrafik shifted its schedule on December 9, 2012. It is part of Västtrafik's efforts for the urban traffic in Gothenburg 2012 - 2014 where five express bus routes now became eight (Västtrafik, 2011). Rosa is a combination and amalgamation of previous lines 42, 80, 89 and 142 (Västtrafik, 2012). Express Bus Rosa extends from Klareberg in the north, through central Gothenburg, and to the south and Snipen.

The following lines were replaced by Express Bus Rosa:

Table 1: Bus lines replaced by Express Bus Rosa (Västtrafik, 2013a).

Line	From	To
42	Gerrebacka	Linnéplatsen
80	Snipen	Nils Ericsson Terminalen
89	Snipen	Frölunda Torg
142	Gerrebacka	Gothenburg City

2.2 Statistics on Express Bus Rosa

Express Bus Rosa has since the start had a proper number of travel numbers. It has established itself as the line with the second highest number of boarding's, as shown in the diagram below. It also appears to follow the same travel patterns as the other express bus lines, with highs and lows on the same days and times.

Antal påstigande expressbussar

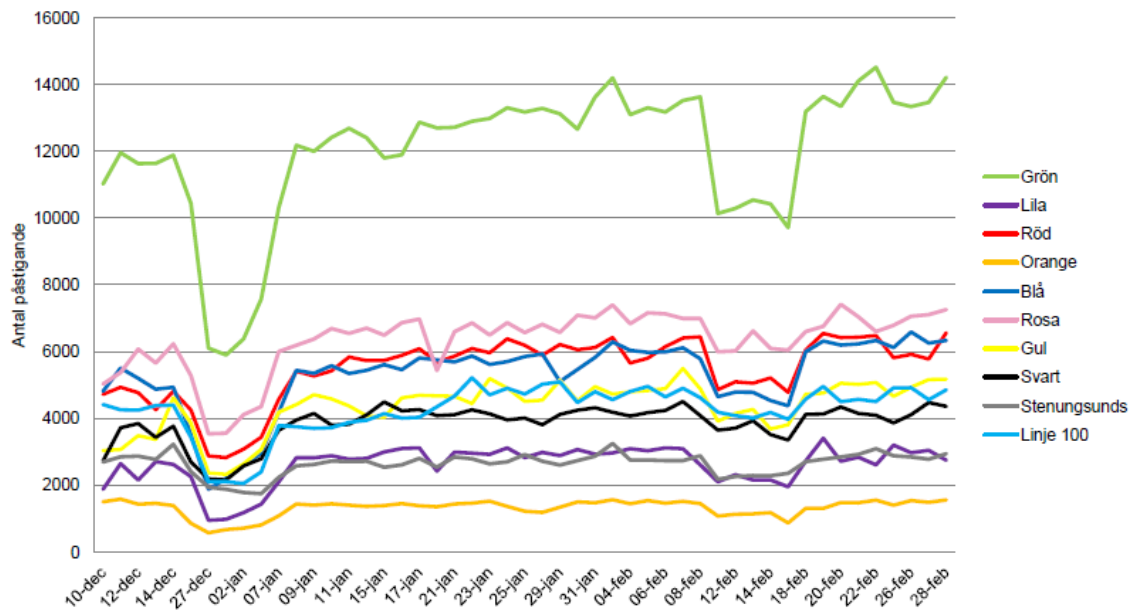


Figure 1: Number of boarding's on Express Bus Routes (Västrafik, 2013b).

During the period December 10 2012 till February 28 2013, Express Bus Rosa had somewhere around 6000 to 7000 boarding's per day. The apparent decline in late December and early January is due to decline in commuting during the Christmas and New Year's period. The schools winter break in Gothenburg in February also offers a clear effect in this chart.

It is also possible to examine how travel is developing during a day. In figure 2 below, express buses are following the same pattern as other public transport analyzed by Transportstyrelsen. Notably, however, they do not have the same acute pattern such as regional trains but have smoothed the peaks and valleys. This is due to the flexibility in the departure among the passengers and short distances to stop positions.

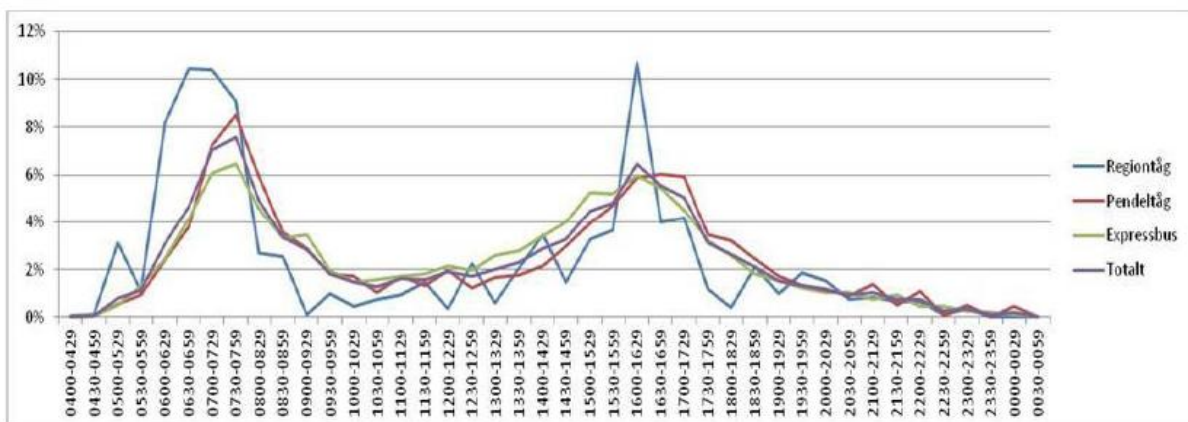


Figure 2: The travel quantity divided during a day (Västrafik, 2013b).

Another interesting parameter to look at is whether punctuality is good on the line or not. There is an overall correlation between bus rapid transit (orange), city line bus (blue) and express bus (red) where it is clear that punctuality is worse on the express bus routes. A positive difference, improved punctuality, takes place in December 2012 when the new timetable is introduced and it is also affected by the holidays for Christmas and New Year. This effect flattens out in January, February and March, but still a significant improvement than before.

The aim for punctuality of buses and coaches is currently that levels of 80% of departures are on time (Västtrafik, 2013b). This objective is met not for the first three months but parameters such as weather situation (season) and running-in period for new systems and congestion play a role. It is likely that the punctuality target will draw closer to the objectives even more during the summer period as holiday season draws down on travel, leading to higher margins in journey times.

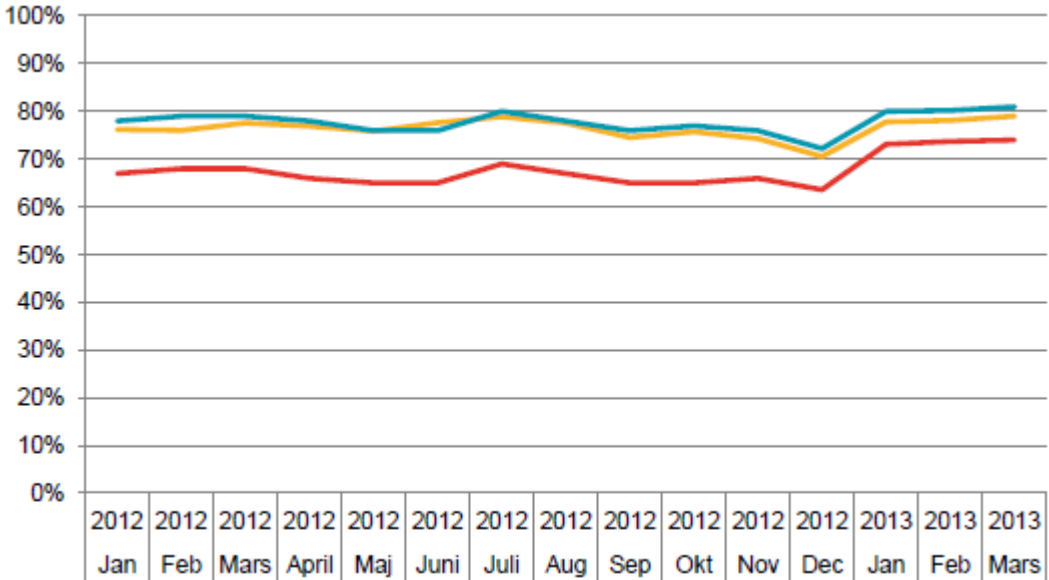


Figure 3: The level of punctuality for bus rapid transit (orange), city line bus (blue) and express bus (red) (Västtrafik, 2013b).

Additional data for express bus Rosa is how many of the seats that are occupied during the trip. The following chart is compiled during seven occasions between December 2012 and April 2013, during the morning hours of 07 and 09. The blue bar indicates occasions with plenty of seating, the yellow bar cases where there have been few vacant seats and the red bar shows instances of standing passengers.

In the diagram, the graph representing Rosa is on the third and fourth lines. The third row shows the journeys starting in Billdal in the south which goes north toward central Gothenburg. The fourth line represents trips that go from Gerrebacka in the north and are south-bound. It is clear that a travel from the southern areas many times exceeds the supply of

available space on the vehicle. In other words, there is room for expansion, such as higher frequency of traffic or vehicles with higher capacity.

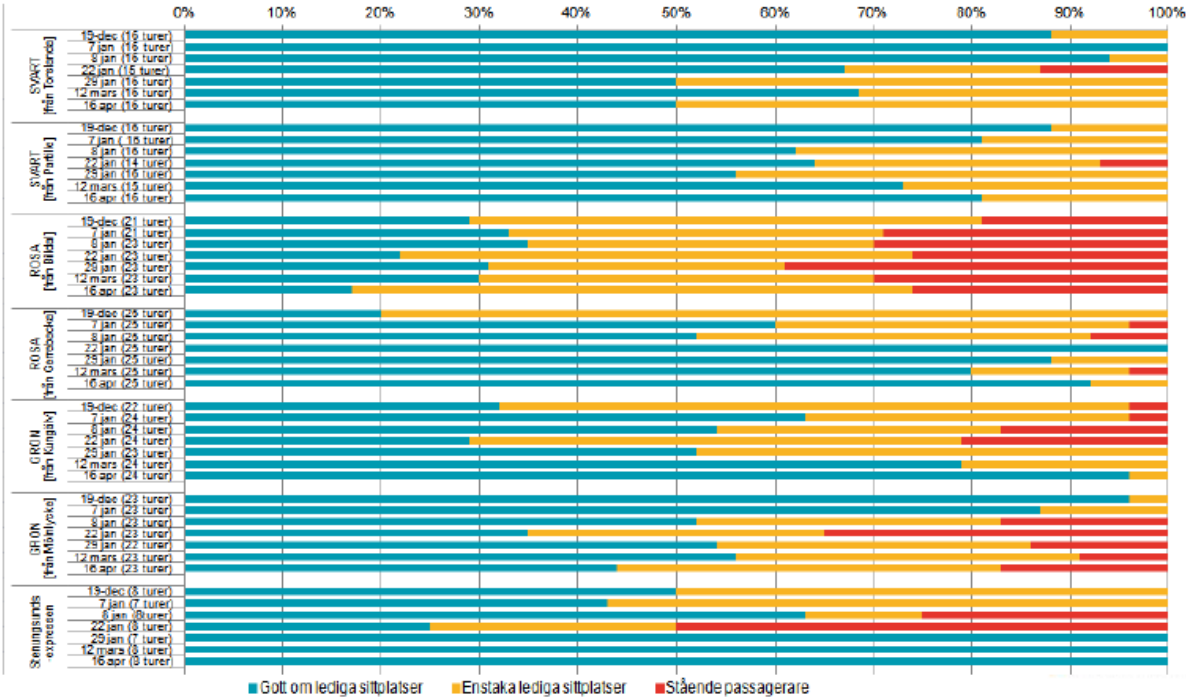


Figure 4: Level of seat occupation on Express Bus Rosa (Västtrafik, 2013b).

Travel times along the route were also analyzed after the introduction of the congestion charge in January 2013. The following diagram presents the travel times during the morning hours 06:30 to 08:30 and on six different occasions. It has not been evaluated for the entire stretch of express bus Rosa but for the Green and Blue lines, which tangential Rosa for longer distances. It is on the stretches Snipen - Linnéplatsen (Blue) and Eriksdal - Nordstan (Green). They operate via Highway 158/Dag Hammarskjöldsleden and E6, roads Express Bus Rosa also traffic.

On the stretch Snipen - Linnéplatsen, which in this study is represented by the blue line, a pretty clear change can be analyzed. Previous travel time, from January 2012 was 26 minutes for the distance, while after the introduction of congestion charging it was down to 20 minutes in March 2013. This can be traced to that Highway 158 has undergone renovations and long stretches now consists of separate bus lanes.

Express Bus Grön operates between Eriksdal in Kungälv and south to Nordstan in the central parts of Gothenburg. In the analyzes of the actual travel time a small but distinct difference is identified. Before it took 22 minutes, but now it only takes 20 minutes, which corresponds to a travel time reduction of 9.1%. This is due to the expansion of bus lanes on the E6 but also to a reduction in congestion in terms of traffic. Travelling time extension has been reduced from 73% to 11%, where 100% corresponds to a doubling of travel time compared to free-flow (Västsvenska Paketet, 2013).

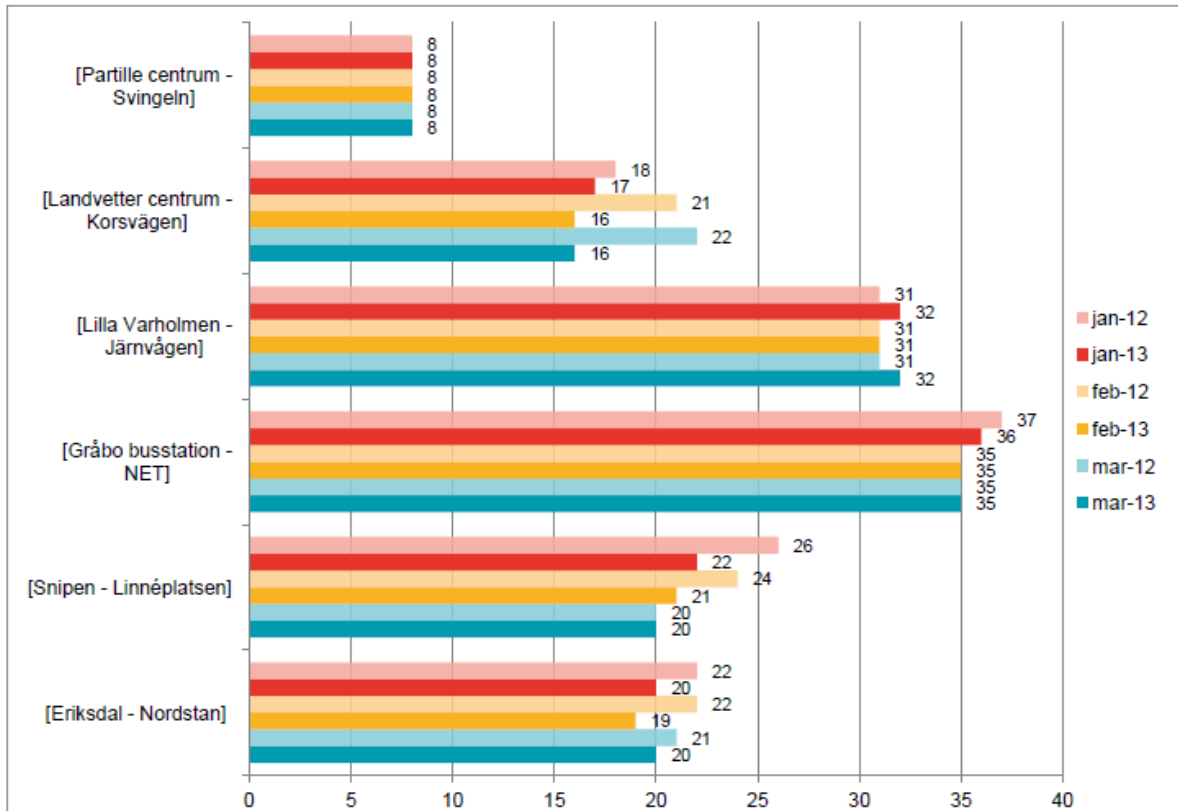


Figure 5: Travel times on different routes around Gothenburg (Västsvenska Paketet, 2013).

2.3 Stretch

Express Bus Rosa has a clear route in a north-south direction. It has its northern starting point in the northeastern parts of Hisingen in the area of Klareberg. In this northern point of the route, an extra loop around Gerrebacka Gård and Mystängen is covered. Rosa then runs south through the Kärra Centrum to the central parts of Gothenburg where Hjalmar Brantingsplatsen, Nordstan and Heden is served followed by Linnéplatsen.

In the continuing journey southwards, Rosa passes major stops Marklandsgatan and Radiomotet before it moves on via Highway 158, Säröleden. On the way to terminus Snipen it passes neighborhoods like Askim, Hovås and Billdal.

The line is also differentiated in the southern end. Some departures have beginning and ending at the stop Skintebo while some goes all the way down to Snipen. This applies during the early morning and afternoon tours.



Figure 6: Aerial photo of the stretch for Express Bus Rosa.

2.4 Sections

The following part presents the different sections of the route. They are divided in the same way as Västtrafik choose to divide them into their schedule with the major bus stops marked. This ensures high relevance and recognition, and it gives a reasonable relationship between the different sections. In the individual sections, information is provided including its length, travel time, stops, type of area served, age structures and a description of the road sections.

The lengths specified for each section are estimates made using digital measuring tools and presented mainly to give an idea of the scale, they should not be seen as exact values. The travel times specified for the different sections are the same as Västtrafik's schedule applicable from 9th December 2012 to 14th December 2013. In the case of different travel times, they differ because of high and low volume during the day.

2.4.1 Klareberg – Mystängen

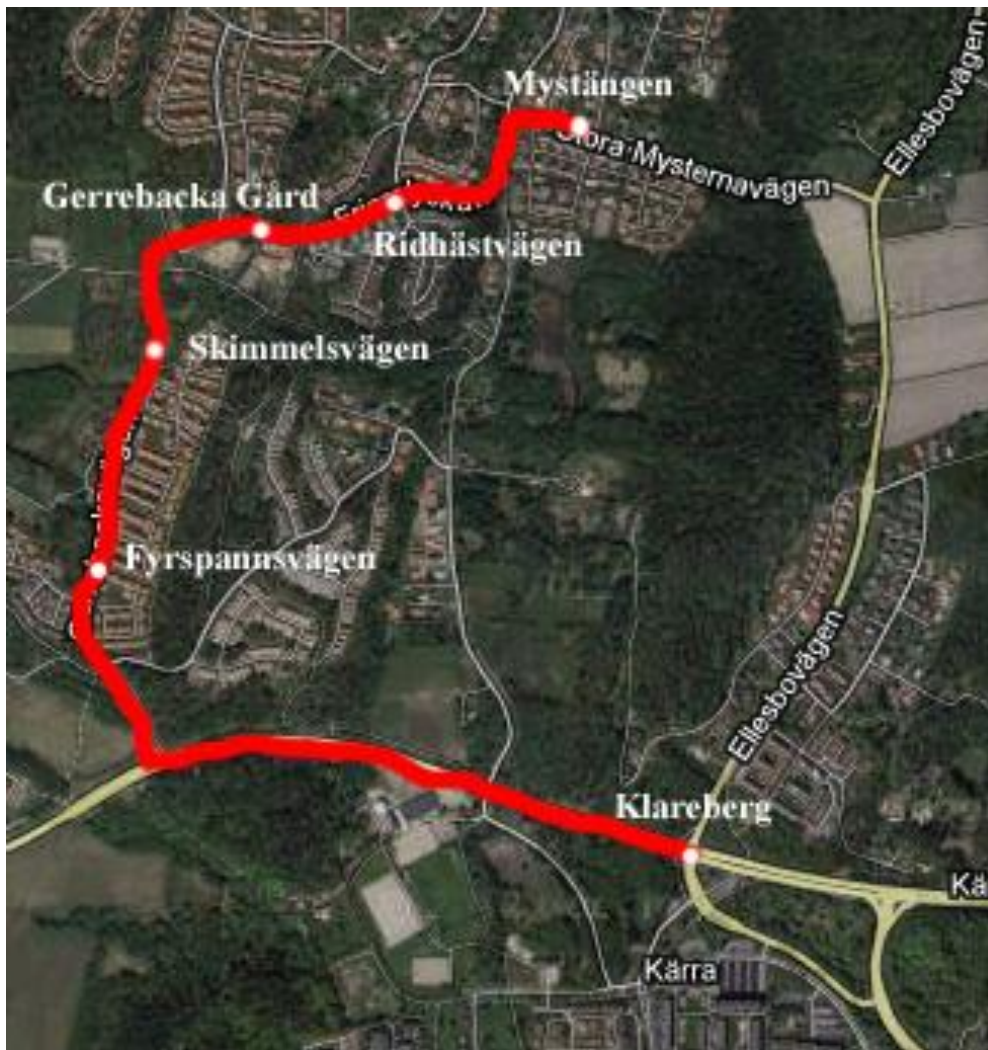


Figure 7: Aerial photo of the stretch Klareberg – Mystängen.

Bus stops: Klareberg, Fyrspannsvägen, Skimmelsvägen, Gerrebacka Gård, Ridhästsvägen, Mystängen

Length: 2,7 kilometers

Travel time: 6 – 7 minutes

Description: This stretch passes quiet residential areas and the people living here is first and foremost families with children, but it is a mixed clientele. In the area around Gerrebacka Gård, it is close to nature and at the end, near Mystängen, residential areas are most common again.

2.4.2 Mystängen – Klareberg

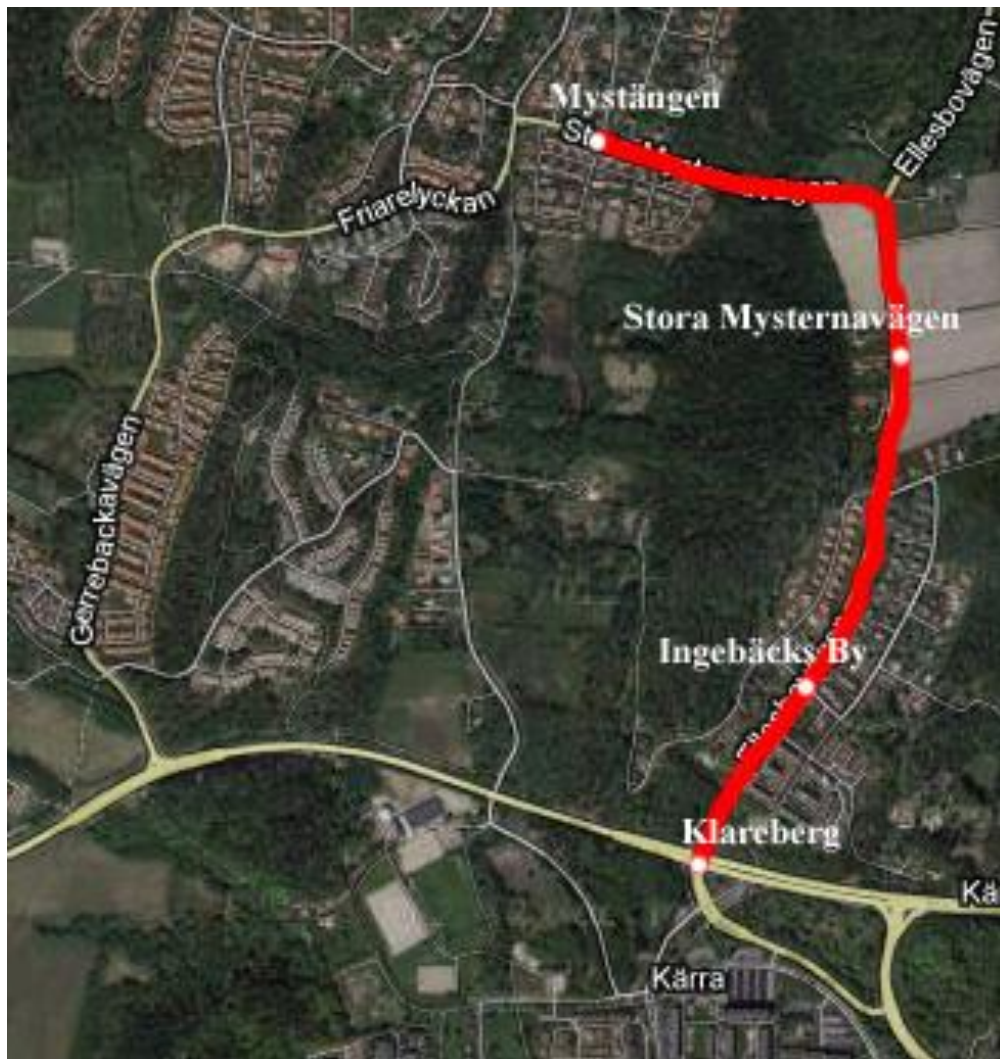


Figure 8: Aerial photo of the stretch Mystängen – Klareberg.

Bus stops: Mystängen, Stora Mysternavägen, Ingebäcks By, Klareberg

Length: 1,7 kilometers

Travel time: 4 – 5 minutes

Description: This stretch starts in Mystängen with an area of terrace houses and then continues south along Ellesbovägen where the environment is of more rural character. Ingebäcks By consists of villas and terrace houses and finish off the route before Klareberg.

2.4.3 Klareberg – Lillekärr Södra



Figure 9: Aerial photo of the stretch Klareberg – Lillekärr Södra.

Bus stops: Klareberg, Burmans Gata, Lillekärr Norra, Kärra Centrum, Kärra Kyrka, Lillekärr Södra

Length: 1,3 kilometers

Travel time: 3 – 5 minutes

Description: The route runs from Klareberg and throughout Kärra with several different types of areas. There are terraced areas and apartment buildings, detached villas and also school, sports hall and a town center with shops and services operated.

2.4.4 Lillekärr Södra – Hjalmar Brantingsplatsen



Figure 10: Aerial photo of the stretch Lillekärr Södra – Hjalmar Brantingsplatsen.

Bus stops: Lillekärr Södra, Hjalmar Brantingsplatsen

Length: 9,4 kilometers

Travel time: 11 – 12 minutes

Description: This stretch gives a feeling of express travel when Rosa runs from Lillekärr to Hjalmar Brantingsplatsen on southern Hisingen. Most of the journey is via E6 and Lundbyleden at high speeds and with good road standards.

2.4.5 Hjalmar Brantingsplatsen – Nordstan

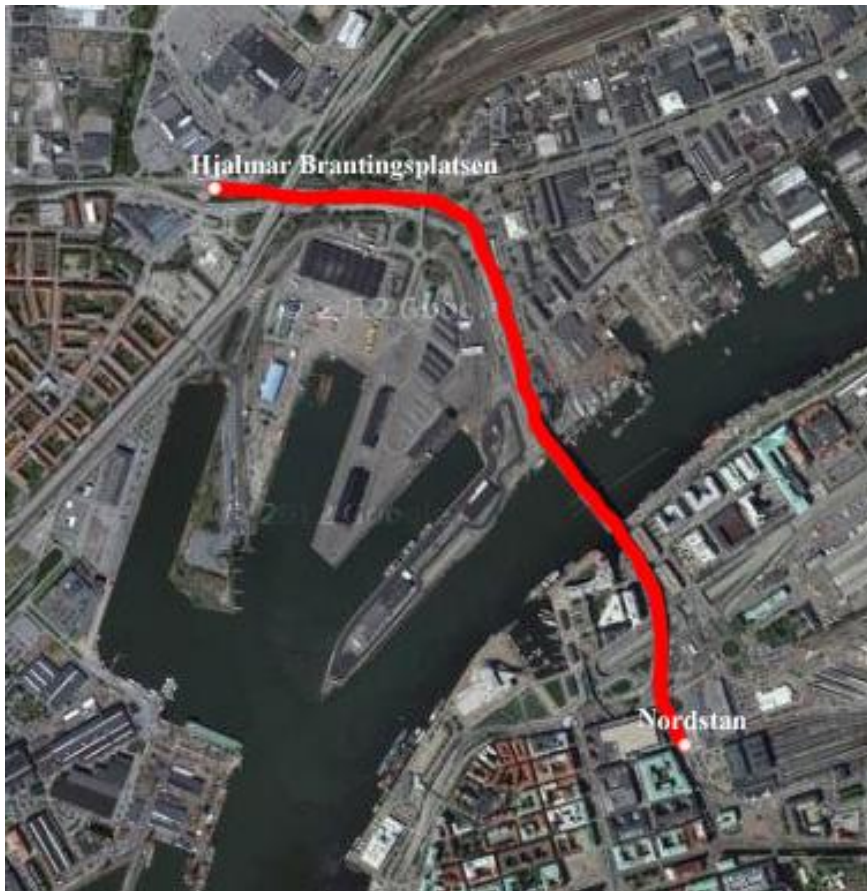


Figure 11: Aerial photo of the stretch Hjalmar Brantingsplatsen – Nordstan.

Bus stops: Hjalmar Brantingsplatsen, Nordstan

Length: 1,8 kilometers

Travel time: 5 minutes

Description: One of the shortest intermediate routes and it runs between the two nodes Hjalmar Brantingsplatsen and Nordstan. The traffic environment is intense and there is a mixture of buses, cars, trams, cyclists and pedestrians.

2.4.6 Nordstan – Heden



Figure 12: Aerial photo of the stretch Nordstan – Heden.

Bus stops: Nordstan, Heden

Length: 1,2 kilometers

Travel time: 5 minutes

Description: The route runs through an urban area and in highly regulated traffic. In the short distance there are nine traffic signals that may give differences in travel time along this section of road.

2.4.7 Heden – Linnéplatsen



Figure 13: Aerial photo of the stretch Heden – Linnéplatsen.

Bus stops: Heden, Pilgatan, Linnéplatsen

Length: 2 kilometers

Travel time: 6 - 7 minutes

Description: This route begins in Nya Allén and then bus Rosa turns up on Sprängkullsgatan. The road then turns into Övre Husargatan on the last part until Linnéplatsen. Much of the route is separate bus lane.

2.4.8 Linnéplatsen – Marklandsgatan



Figure 14: Aerial photo of the stretch Linnéplatsen – Marklandsgatan.

Bus stops: Linnéplatsen, Marklandsgatan

Length: 2,5 kilometers

Travel time: 4 minutes

Description: Express Bus Rosa leaves Linnéplatsen via a separate bus lane but enters the regular lane at Dag Hammarskjöldsleden. It leaves the highway and turns into the node at Marklandsgatan, where this section ends.

2.4.9 Marklandsgatan – Radiomotet



Figure 15: Aerial photo of the stretch Marklandsgatan – Radiomotet.

Bus stops: Marklandsgatan, Radiomotet

Length: 3 kilometers

Travel time: 4 minutes

Description: The bus runs from Marklandsgatan, via Dag Hammarskjöldsleden and to the stop Radiomotet where the section ends.

2.4.10 Radiomotet – Hovås Nedre



Figure 16: Aerial photo of the stretch Radiomotet – Hovås Nedre.

Bus stops: Radiomotet, Pilegården, Askims Stationsväg, Trollängen, Askimsbadet, Hovåsskolan, Hovås Nedre

Length: 3,7 kilometers

Travel time: 6 - 7 minutes

Description: The section begins with the passage of Järnbrottsmotet for further travel south along Highway 158, also known as Säröleden. Periodically, the bus stops in an area consisting mainly of housing.

2.4.11 Hovås Nedre – Skintebo



Figure 17: Aerial photo of the stretch Hovås Nedre – Skintebo.

Bus stops: Hovås Nedre, Lyckhem, Bassås, Uggedal, Hästebäck, Skintebo

Length: 4 kilometers

Travel time: 6 - 7 minutes

Description: This segment begins at the bus stop Hovås Nedre and follows Highway 158 until Brottkärrsmotet. Then it runs through Billdalsvägen and Skintebovägen to the stop Skintebo.

2.4.12 Skintebo – Snipen

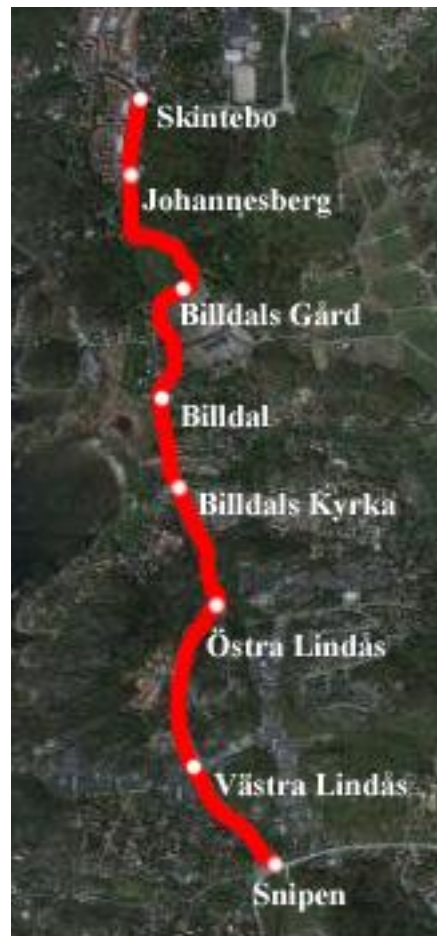


Figure 18: Aerial photo of the stretch Skintebo – Snipen.

Bus stops: Skintebo, Johannesberg, Billdals Gård, Billdal, Billdals Kyrka, Östra Lindås, Västra Lindås, Snipen

Length: 3,4 kilometers

Travel time: 8 minutes

Description: Varied environment on this stretch that passes villa houses, terrace houses, open lands and institutions such as schools, nursing homes and stables.

2.5 Vehicles

For a deeper investigation of express bus Rosa, a review of the vehicles running on the line is also required. The transport company that handles the traffic is Veolia Transport Sverige AB and this chapter presents information on the different types of buses they use, such as number of seats, bus lengths and looks.

Veolia Transport Sverige AB operates the line with two different vehicles, from two different manufacturers. It is buses from Swedish company Volvo and from the Polish company Solaris¹. The models are similarly looking and are both so-called bogie buses with room for both seated and standing passengers.

2.5.1 Volvo

The buses from Volvo mainly consist of model Volvo 8900 which was introduced to the market in 2011. They have the following attributes:

Length: 14,797 meters

Width: 2,55 meters

Height: 3,30 meters

Curb weight: 14 762 kilograms

Total weight: 21 870 kilograms

Number of seats: 47

Number of standing room: 51

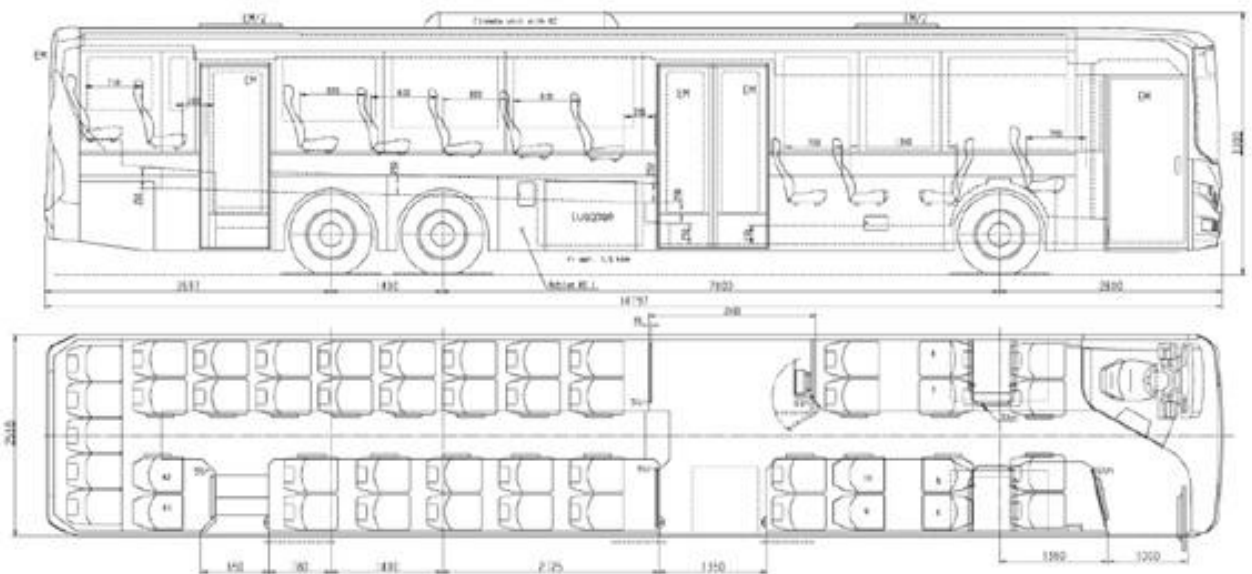


Figure 19: Interior of Volvo 8900².

2.5.2 Solaris

The buses run on line Rosa from the company Solaris is of the model Urbino 15 and were manufactured in 2010³. They are constructed in Poland and have the following attributes:

Length: 14,59 meters

¹ Fredrik Jähnke Verkmästare Veolia Transport Sverige AB, E-mail 8th May 2013.

² Fredrik Jähnke Verkmästare Veolia Transport Sverige AB, E-mail 8th May 2013.

³ Mikael Dalin Verkmästare Veolia Transport Sverige AB, E-mail 14th May 2013.

Width: 2,55 meters

Height: 3,40 meters

Curb weight: 14 602 kilograms

Total weight: 24 000 kilograms

Number of seats: 48

Number of standing room: 70



Figure 20: Solaris Urbino 15.

Both bus models are similar to each other, both in appearance and in terms of physical dimensions. They also have relatively equal capacity and both of them are used throughout the day, one is not specially used in the morning traffic. The geometric dimensions can be of importance when regarding road design, parameters such as the width, height, turning radius and similar concerns this.

3. Interviews with passengers

In efforts to identify problems along the route and get a deeper insight, there have been interviews done with passengers on Express Bus Rosa. A total of 50 people have been consulted and they have been scattered on the entire line stretching to get a better overall picture. The interviews were completely voluntary and the selection was random, except for an ambition that a mix of different ages has been backed.

3.1 Questions and answers

1.) Age?

0-25: 10

26-50: 21

50-65: 8

65-: 11

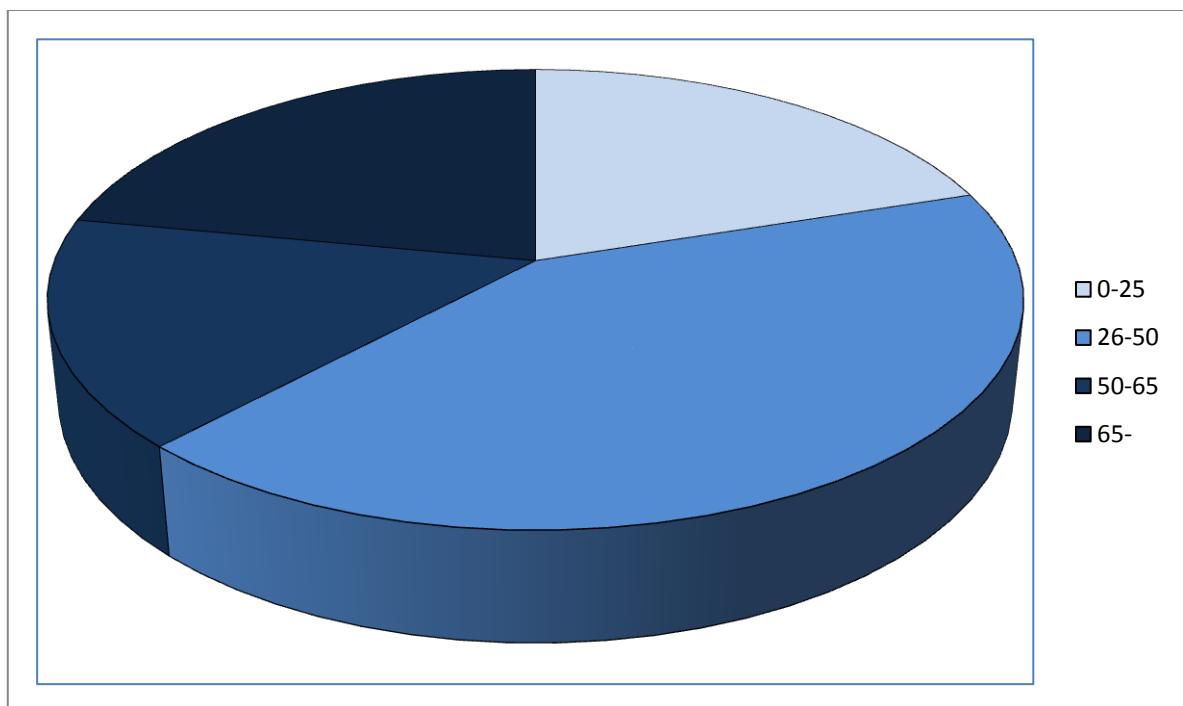


Figure 21: Distribution of ages among the consulted passengers.

2.) How often do you travel on Express Bus Rosa each week?

0-1: 2

2-7:10

8-15:29

15-: 9

3.) What is your most common destination when travelling to Gothenburg?

Nordstan: 24

Marklandsgatan: 10

Linnéplatsen: 7

Hjalmar Brantingsplatsen: 6

Radiomotet: 2

Pilgatan: 1

Heden: 1

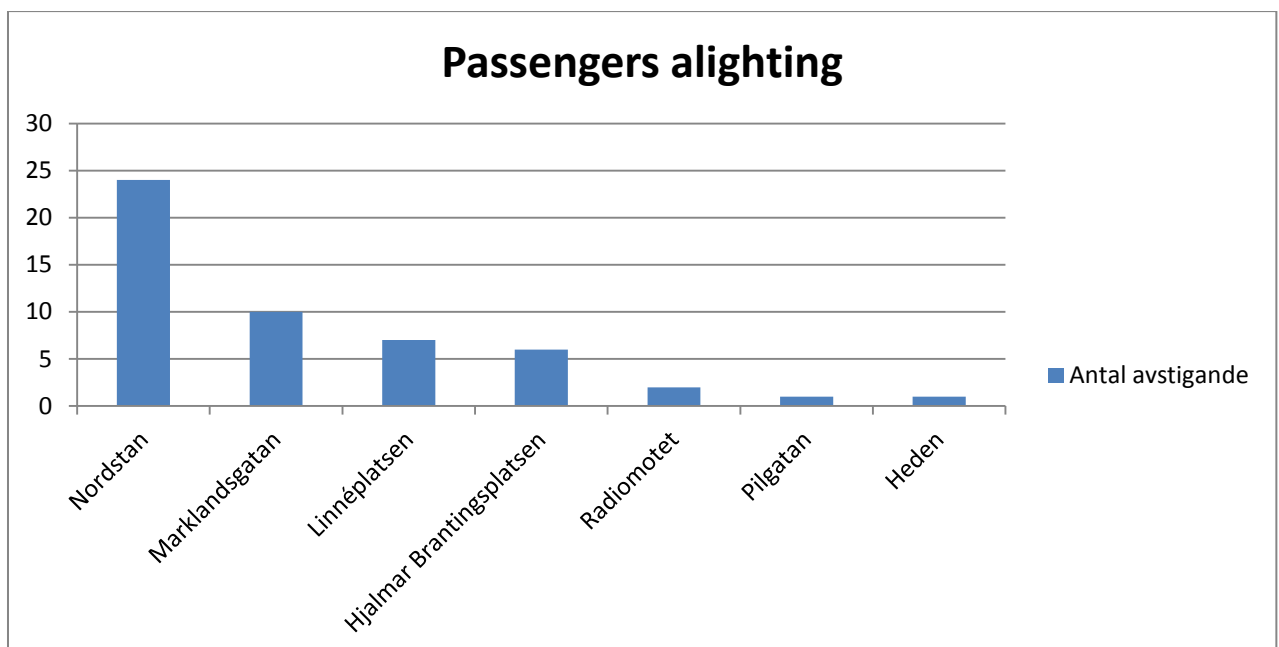


Figure 22: Number of passengers alighting at each stop.

4.) What improvements can be done on Express Bus Rosa?

- Very often queues to the stop at Nordstan
- Bus often halted on the stretch between Nordstan and Heden
- At times short distance between stops
- Often red light at the traffic signal at Linnéplatsen

5.) Are there any stop missing or any alternative route?

- Järntorget
- Frölunda Torg (arriving from Snipen/Highway 158)

6.) Are you happy with Express Bus Rosa?

Yes: 48

No: 2

3.2 Summary

Most passengers on Express Bus Rosa are happy with the service. The people consulted in these interviews were very positive about the route and found it a good way to commute to central Gothenburg.

The most significant outcome is that almost half of the passengers were heading for the stop at Nordstan. This could come into consideration for other traffic analyzes made by Västtrafik to satisfy the required needs.

It is also interesting that most of the comments from the passengers are regarding objects around Nordstan. There is also a complex situation that most passengers want to go where the traffic is most intense and therefore not really helping this situation.

4. Problem identification

This chapter presents the various problems that have been identified on the route for Express Bus Rosa. It regards both large and small problems, and the structure is the same as the sections presented in earlier chapters. A description of how a problem is defined is also included as an explanatory part.

4.1 Definition

The traffic system is a complex environment in which many parameters play a role in both regarding the experience and function of it. A so called problem can therefore be of a variety of shapes. In this report, it means something that affects mobility, comfort, safety and perceived sense of express traffic, as this Master Thesis deals with Express Bus Rosa in a case study.

The concept of accessibility can also be described by the level-of-service concept (Mannering, Washburn & Kilareski, 2009). It involves a qualitative assessment of a particular traffic under certain prevailing circumstances. It is presented in six different levels presented in the table below:

Table 2: The different level-of-services for a traffic system.

Level of service	Description
A	Free flow, effects of an incident quickly absorbed, not affected by other traffic
B	Close to the free flow, noticing other road users in the system but can control own speed
C	Almost free flow, but at this level the freedom to maneuver is small and congestion may occur when incidents happen
D	The speed decreases as the flow increases and at this level the physical and mental comfort reduces
E	At this level the traffic level is close to the capacity of the road and the small changes in flow provides significant implications
F	Traffic jam, very low speeds

This term is most often used in connection with highway evaluations but can also be applied to other types of roads. In this project it is mostly used as a reference to different types of traffic situations.

The parameter comfort can include many different parameters. This can be, for example that there are vacant seats on the bus, there is a fresh and clean bus and that the stops have a standard (Vinnova, 2001). These opinions also tend to differ depending on whether it is a regular bus running in the city or an express bus. On a city bus, the factor of cleanliness and good smell are most important but on an express bus the most important is that there are vacant seats (Karlsson & Larsson, 2010). In this report, it will also refer to technical

solutions such as speed bumps, sharp turns and queuing, all considered to have a negative influence on the comfort experience.

As this report reflects on road safety the discussion will take speed at the stops and areas with residential housing into account. It may also include the placement of stops compared to natural flow of people, or the risk of people taking short cuts. The impression of express traffic is an experience of that the traffic goes quickly, without unnecessary stops or detours.

4.2 Problems on Express Bus Rosa

In the problem identification that follows, a description of the various obstacles along the way that have existed through observations, interviews and experiences are presented. This structure follows Express Bus Rosa from north to south but the problem identification has taken place in both directions.

4.2.1 Klareberg – Mystängen

The initial leg of the extra loop that runs towards Gerrebacka includes the stop and public transport hub Klareberg. It also includes traveling on Hisingsleden, a road with a higher traffic load after the introduction of congestion charges (Västsvenska Paketet, 2013).

- As the bus is to enter Hisingsleden it may well be lining up with both buses and cars, but also a relatively long stop at the traffic signal.
- There are few marked pedestrian crossings at Klareberg, even though there is a significant pedestrian flow from the nearby neighborhoods.
- The traffic to the loop in Gerrebacka has a special set up. In the morning, the bus starts at Klareberg and run through the loop and then direct further south. In the afternoon, you need to change buses to reach Gerrebacka. This is somewhat unclear for inexperienced travelers.
- From the aggregate board at Klareberg it is impossible to see the designation of the stops. It makes it difficult for travelers who are not familiar with the area to find the right stop.
- Along Gerrebackavägen, the bus runs at low speed and there are many speed bumps on the route. However, this means that the sense of express traffic is dropped and another question that arises is whether the work environment for drivers is affected by these speed bumps.

4.2.2 Mystängen – Klareberg

On the stretch between the stops Mystängen and Klareberg, which is the completion of the extra loop bus Rosa traffics in Gerrebacka, have the following problems and ideas identified:

- When the bus is to enter Ellesbovägen from the Stora Mysternavägen, it connects via a T-junction. There have been sightings at relatively low traffic on this road, where the bus has had to wait to enter the road. At higher loads, or at least at a range of cars which means that the bus cannot enter the road, the bus would have to wait longer at the intersection. It is not currently a regulated signal.

- Along Ellesbovägen, there are several small slip roads where drivers from both roads need to raise attention, especially at night, rain or other weather conditions that impair visibility conditions further. The bus was also overtaken by cars on this short stretch and although the view is certainly relatively good, in combination with the aforementioned exits it can be an issue for road safety.
- Where Ellesbovägen connect to Hisingsleden and bus Rosa are about to cross the road to get to the bus stop Klareberg, there is a traffic signal. This does not prioritize the bus so it may have to wait for green signal.
- When Rosa turns into the stop at Klareberg and head for position A, this curve is seen as very narrow. This particular speed is high and it can cause discomfort, especially for children, elderly or people with disability.

4.2.3 Klareberg – Lillekärr Södra

Between Klareberg and Lillekärr Södra, the bus passes the center of Kärra with both a service center and a church and several interesting problem formulations have been noticed.

- At stop Lillekärr Norra, which is adjacent to a local school, it can be a problem to access the road again after stopping. This would be primarily during the busy morning hours during heavy traffic. This problem can also occur at major events in the nearby Lillekärrshallen when there at certain times can be a lot of traffic in the area.
- Kärra Centrum leaves many question marks in this analysis. It is an area where buses stops while pedestrians cross the street to get to the residential areas, the shopping center and other services. It leads to problem with accessibility as there are queues into the stop, which is only one in each direction. There are heavy shortages in traffic safety as there are no pedestrian crossings and the area is very busy. There are provisional elements to make the passage narrower and to lower the speed on the stretch.
- Accessibility is not optimal at the stop at Kärra Kyrka. There are some narrow passages and the bus runs at low speed.

4.2.4 Lillekärr Södra – Hjalmar Brantingsplatsen

In this section, Express Bus Rosa runs very quickly from the northern to the central Hisingen and the large public transport hub Hjalmar Brantingsplatsen. Most of the route consists of highway, with bus lanes, and it is also the longest leg in this structure of Rosa.

- In the area around Lillekärr Södra, the residential buildings are located very the bus street. With 5-minute traffic on Express Bus Rosa and more bus lines passing, it may seem disturbing to properties that do not have any special noise insulation.
- Bus lanes much of the route south towards Hjalmar Brantingsplatsen makes the route done quickly and certainly with a sense of express traffic. Also the connections into the stop are separated bus lanes, and also regulated by signals with priority for buses. This allows Express Bus Rosa to go straight at the stop without major interruption. A

paradoxical problem arises when, as the line has too much time compared to the scheduled time. It simply goes too fast so the drivers must drive slower so as not to be too early in the stop position. When the traffic flow is strong at Hjalmar Brantingsplatsen there is no room to wait at the stop, there has to be a quick stop and then proceed. It also occurs a queue at the bus stop at Hjalmar Brantingsplatsen.

4.2.5 Hjalmar Brantingsplatsen – Nordstan

This distance is short and includes only the end stops but is still relevant to study in this format as it is a sensitive stretch.

- Göta Älvbron is very important on this section, and there are several things to comment about it. The positive is that there is a separate lane for bus and tram, which means queues are not as likely in the worst rush hour traffic. However, there is a speed reduction due to the condition of the bridge so the bus runs very slowly across the middle part of the bridge structure. It is also a bumpy experience because the road surface is in poor condition and the bus runs in tram tracks. In the event of bridge opening, delays may also be experienced.
- At stop Nordstan, a remodeling has occurred due to the investments in the West Swedish Solution and the express buses now have a bus stop on their own. Despite this, waiting times still occur as there are queue at the bus stop.

4.2.6 Nordstan – Heden

This stretch is in the central parts of Gothenburg and also only consists of the two the end stops. Traffic is dense and there are several problems identified along the corridor.

- Although this distance is relatively short, there is nine traffic signals in total. It can lead to large differences in travel time depending on the outcome of the signals.
- A large part of the route is made up by bus lanes to facilitate the public transport traffic. However, the bus driver does not always use this and this inconsistency can be distracting for both passengers but also other actors in the traffic system. It is also very dense in the bus lane which decreases the accessibility.
- To some extent, the bus runs in the tram tracks, resulting in a less stable experience on board. This can be a problem if one aim is to use the bus as a working place, or at least a space for recreation.
- From interviews with drivers on the stretch, Polhemsplatsen has come up as an area that often encounters problems with accessibility. There is a lot of traffic and especially from many different directions at the same time. Pedestrians and bicycles are also in motion in the area, which also affects road safety.
- Drivers on the stretch have also commented on the traffic signal at the intersection of Nya Allén/Sten Sturegatan. There is a feeling among them that there is very often a stop at this signal, something that is even more disturbing when it already takes long time for a short distance.

4.2.7 Heden – Linnéplatsen

Another section in central Gothenburg, leading from central downtown to the western center is the one between Heden and Linnéplatsen. This part has undergone major changes, with the investments in the West Swedish Solution, but there are nevertheless some things to comment about.

- In Nya Allén, Express Bus Rosa switches from the right lane to the middle lane, which in peak traffic can be problematic in terms of accessibility.
- Along the corridor, there are still many road works and it is sometimes a bumpy ride, from which the effects have been discussed previously.
- As the bus turns from Nya Allén and onto Sprängkullsgatan it passes a tight curve at high speed, which can cause an uncomfortable feeling.
- Sprängkullsgatan has a steep slope and the speed is very low, since there are several crossings for pedestrians along the way. It is also a relatively busy place with a lot of pedestrians and cyclists in motion as this is a common passageway for transportation between the city centre and Järntorget.

4.2.8 Linnéplatsen – Marklandsgatan

In this section, the character of the environment surrounding Express Bus Rosa changes. It leaves the urban environment and the passages consist of rather large roads with wide sections and high speeds.

- There is a bus lane from the bus stop at Linnéplatsen until the traffic signal that is controlling the traffic at Dag Hammarskjöldsleden. It can stand still for a while at this point when traffic is dense on the road.
- Express Bus Rosa then run at a good pace until the exit onto Marklandsgatan's bus stop, where there are a bus lane but a traffic signal that gives cyclists priority at the crossing which can cause jams.
- Marklandsgatan is a busy bus stop and it may then be queue at the stop position. The location is very important for Rosa as there are many passengers who go on and off here.

4.2.9 Marklandsgatan – Radiomotet

Like many of the sections in central Gothenburg, this stretch consists only of the two ends stops. It is a straightforward transport in large parts with good road standards, and problems identified on the route follows.

- Long stop at the traffic signal from the bus stop at Marklandsgatan.

- On Dag Hammarskjöldsleden, the bus drives at high speed and it is often very crowded in both directions, so there are question marks around road safety. If an accident were to occur, this would not be a good situation.
- When traveling south Rosa turns into the stop position at Radiomotet and then it is regulated by a traffic signal to enter Dag Hammarskjöldsleden. At this traffic signal, there may be waiting time.

4.2.10 Radiomotet – Hovås Nedre

Major investments have been undertaken in this section as part of the West Swedish Solution. Much of the route is now expanded with a separate bus lane and the standard of Highway 158 may now be regarded as very good.

- The experienced feeling of express traffic is lost as the bus stops are perceived to come very close, sometimes not even a minute of travel time between them. It complements Express Bus Blå and other lines from the southern parts, but it should perhaps be revised how often Rosa should stop.
- There is one experience among interviewed drivers that it is stressful to keep up with scheduled times as it is pretty tight.
- There is a large passenger base on the route and it may in some respects have negative effects on the experience of the trip. For example, buses are often crowded early on the stretch, which has negative effects on comfort.

4.2.11 Hovås Nedre – Skintebo

In this corridor, Express Bus Rosa continues along Highway 158 until it exits at Brottkärrsmotet and continues to run along with Billdalsvägen.

- As the bus Rosa exits Highway 158, bus lanes ends.
- Around the stop Bassås, the roadway is narrow; there are speed bumps and pedestrian crossings. Good for road safety, but obviously worse for accessibility.
- The stops Bassås and Lyckhem are adjacent to Brottkärrsmotet and have a somewhat peculiar position towards each other. It is a strange relationship because they are closer to each other in different directions than their own respectively stop.

4.2.12 Skintebo – Snipen

The end of the south-bound journey goes through Billdal and on rural roads which are curvy and narrow. The trip ends at the stop Snipen on the county border to Halland.

- The first impression of the route is that the speeds are low; there is no feeling of express traffic. The roads are winding and narrow, sometimes bordered by tree-lined avenues which also give an even more narrow impression.

- At the stop Västra Lindås, the traffic safety level on the road is high as it is not possible to pass the bus as it stands at the bus stop.
- At stop Snipen, unlike in Klareberg, Express Bus Rosa only has one stop position. It is very clear where passengers wait to go on the bus Rosa.

5. Proposals for actions

This chapter presents the proposals of actions for some selected parts of the route. These are items that are considered particularly important to address regards to traffic safety and accessibility. The selected objects will first be presented and then the proposed actions are presented.

5.1 Klareberg

The first item identified as interesting is the traffic environment around Klareberg. It is the major hub in the north on Express Bus Rosa's route and there are several areas for improvement. Below follows a presentation of Klareberg looks and functions and then follows some proposals of actions.

5.1.1 Presentation of Klareberg

At the stop at Klareberg, Express Bus Rosa both begins and ends its journey in the northern parts. From here, the extra loop serving the area around Gerrebacka also starts and ends. There are six bus stops at Klareberg and Express Bus Rosa operates three of these.

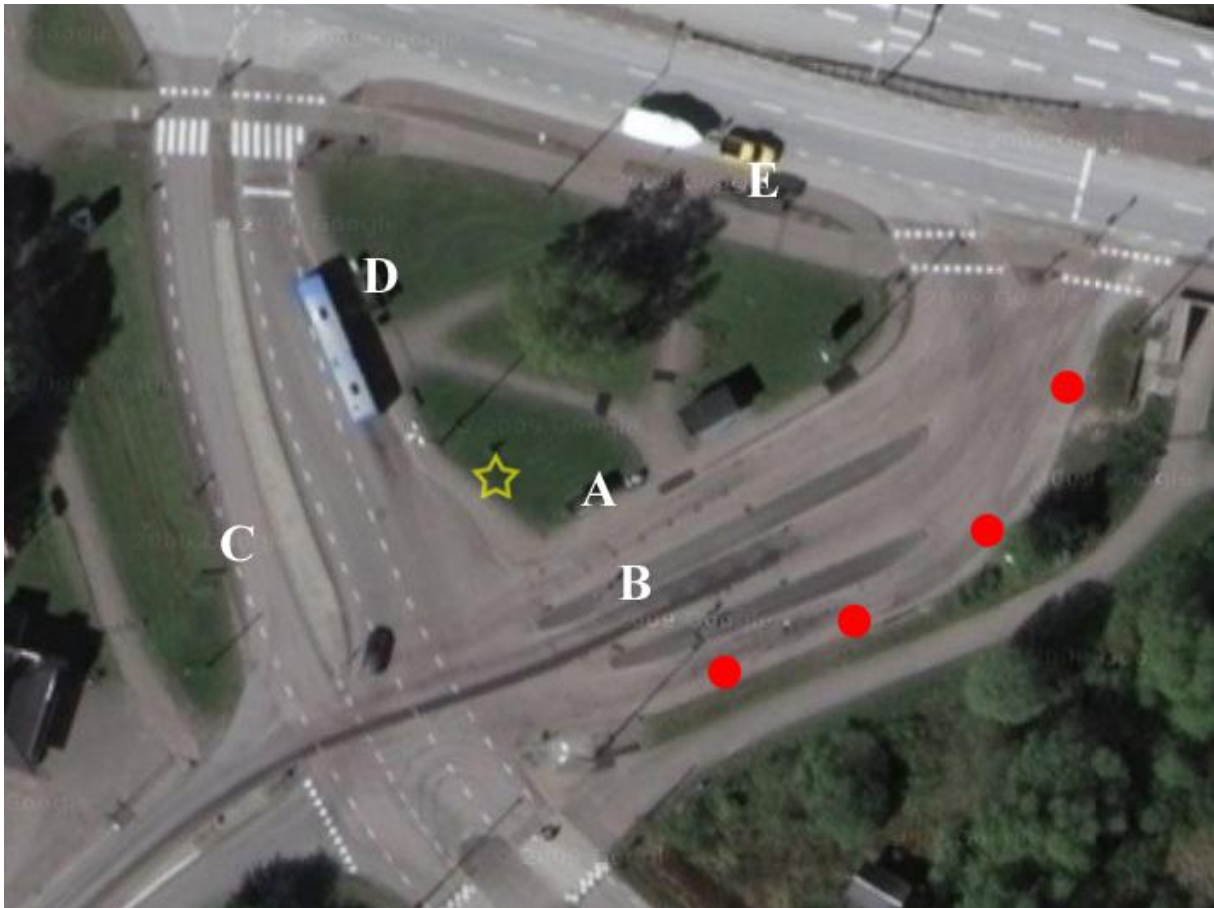


Figure 23: Aerial photo of the hub Klareberg.

Express Bus Rosa operates at position A, B and D, the other stops work for other lines. The yellow star marks the location of the electronic sign displaying upcoming departures. The buses are also parked temporarily, such as when drivers have a break. These locations are marked in the figure with red dots.

The problems at Klareberg have been presented before. It is about traffic safety on the bus stop where there is no pedestrian crossing, as it sometimes can be many pedestrians and buses operating on the site. It also involves clarifying the different stop designations. As it is now, they are very unclear for travelers who are not familiar with the area. A third identification is that the traffic signal regulating the traffic out on Hisingsleden leads to buses queued here in Klareberg.

5.1.2 Proposals in Klareberg

To improve traffic safety at Klareberg, the most obvious solution is to add proper crosswalks. They should be designed so that they are positioned in front of the bus as it stands at the bus stop so as to pass it after being stagnant. By doing this, the driver does not have to change the way they drive the bus, it is enough to start at a time none passes the crossing.

Below are sketches of how it could look like. It is both an aerial photo that presents the proposal from the top but also a street scene with the crosswalk plotted.



Figure 24: Aerial photo displaying the proposed crosswalk at Klareberg.



Figure 25: Sketch of crosswalk in Klareberg.

A second problem was that it is difficult to get an overview of the designation of the various stops. From the electronic display this is not possible. The proposal is to simply highlight the designation, the letters used, on different sides of the bus stops so that they can be seen from several different angles.

The current situation is there is no consequence on how it is displayed, it varies between the different stop. Ideally, it should be visible from the electronic display. There may also be installed a map of Klareberg and the various stops. It could be placed at the same poles as the electronic display. It would make it easier for travelers who are not so familiar with this hub.



Figure 26: The electronic board displaying departures coming up.

Figure 26 shows the location of the electronic board, and thus there is a possibility to attach a map at the same posts as the board is attached on.

The third proposal for Klareberg is to program the traffic signal controlling the traffic to Hisingsleden so that it gives priority to public transport. This is a common solution at intersections where it is important to have good accessibility for public transport. In the current situation there is waiting time and queue at the traffic signal, both for buses in service but also those who are not in service.

The following figure illustrates the current traffic signal and also how a queue is often formed at the site.



Figure 27: The traffic signal at Klareberg.

The proposed measures for Klareberg are independent of each other, so they can be prioritized as desired. They may also be bound to very low costs compared to the differences in safety, service and accessibility they result in.

5.2 Kärra Centrum

The second item to be analyzed in-depth and which will have a presentation of proposals for action is Kärra Centrum. Below is a presentation of the site and the measures proposed.

5.2.1 Presentation of Kärra Centrum

The stop at Kärra Centrum is a lively area with lots of people and traffic. There are also studies that suggest that this will increase by 2015, which will lead to additional traffic of

vehicles and pedestrians (WSP, 2012). A review of the traffic safety and accessibility in the area is therefore important to ensure the future demand in relation to this expected trend.

Kärra Centrum offers several different types of service. There is a grocery store, pharmacy, bank, barber shop and pizzeria. Also library, dentist and florist shop is available. So this is a place with wide range that should appeal to most people who live in the area.

The figure below shows the placing of the stops at Kärra Centrum. At position A, Express Bus Rosa runs south toward Gothenburg city center. From B position B, which has been temporarily moved south about 60 meters, Express Bus Rosa runs north toward Klareberg. The yellow area marks the center building.

In the northern part of the image, just above the stop position A, temporary barriers are placed to create a narrower passage. Its aim is to bring down the speed of the vehicles passing by.

Along the western side of the bus street are large stones placed as a kind of barrier. This is to discourage passage over the street in inappropriate places.

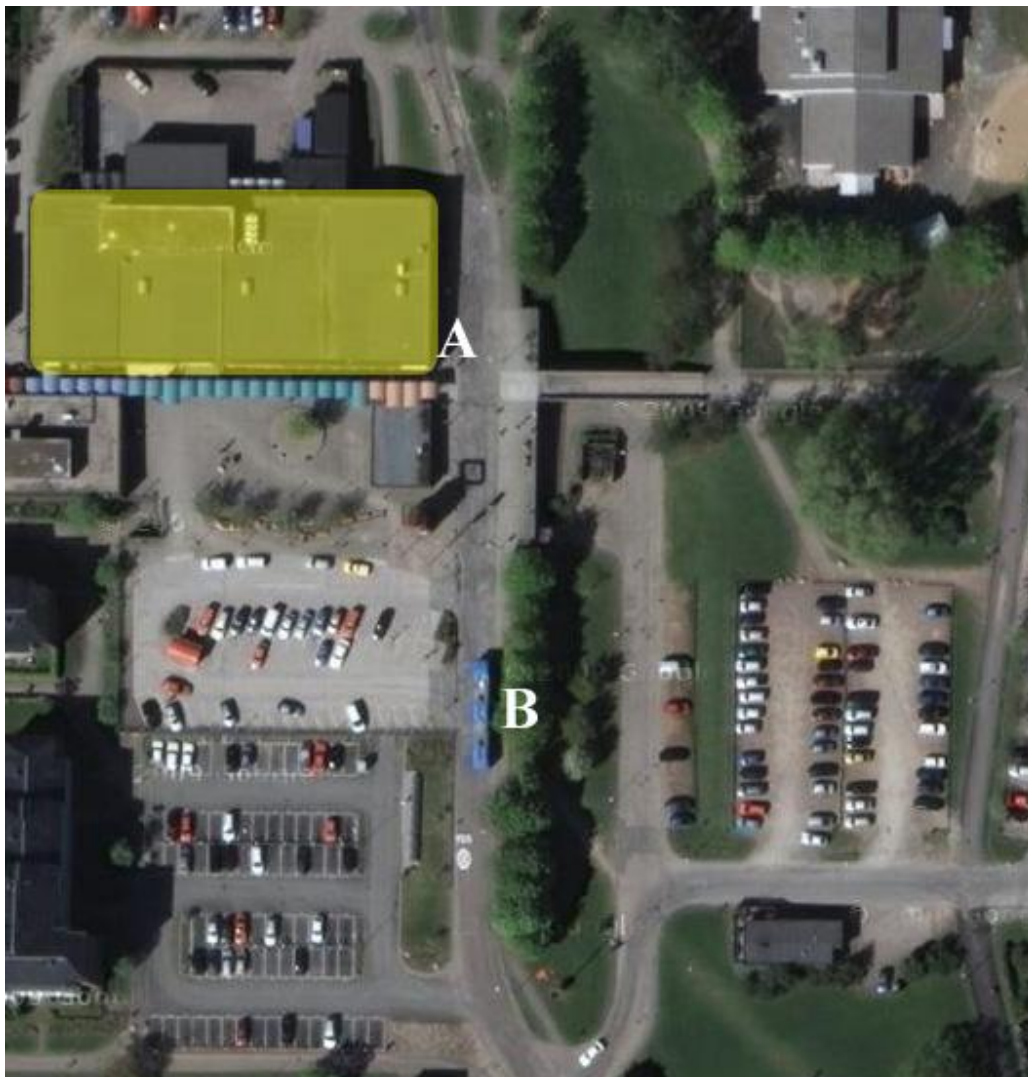


Figure 28: Aerial photo of Kärra Centrum.

5.2.2 Proposals in Kärra Centrum

There are several different measures that are possible to implement at Kärra Centrum. The following figure illustrates how it is possible to improve the situation with regard to traffic safety and accessibility:

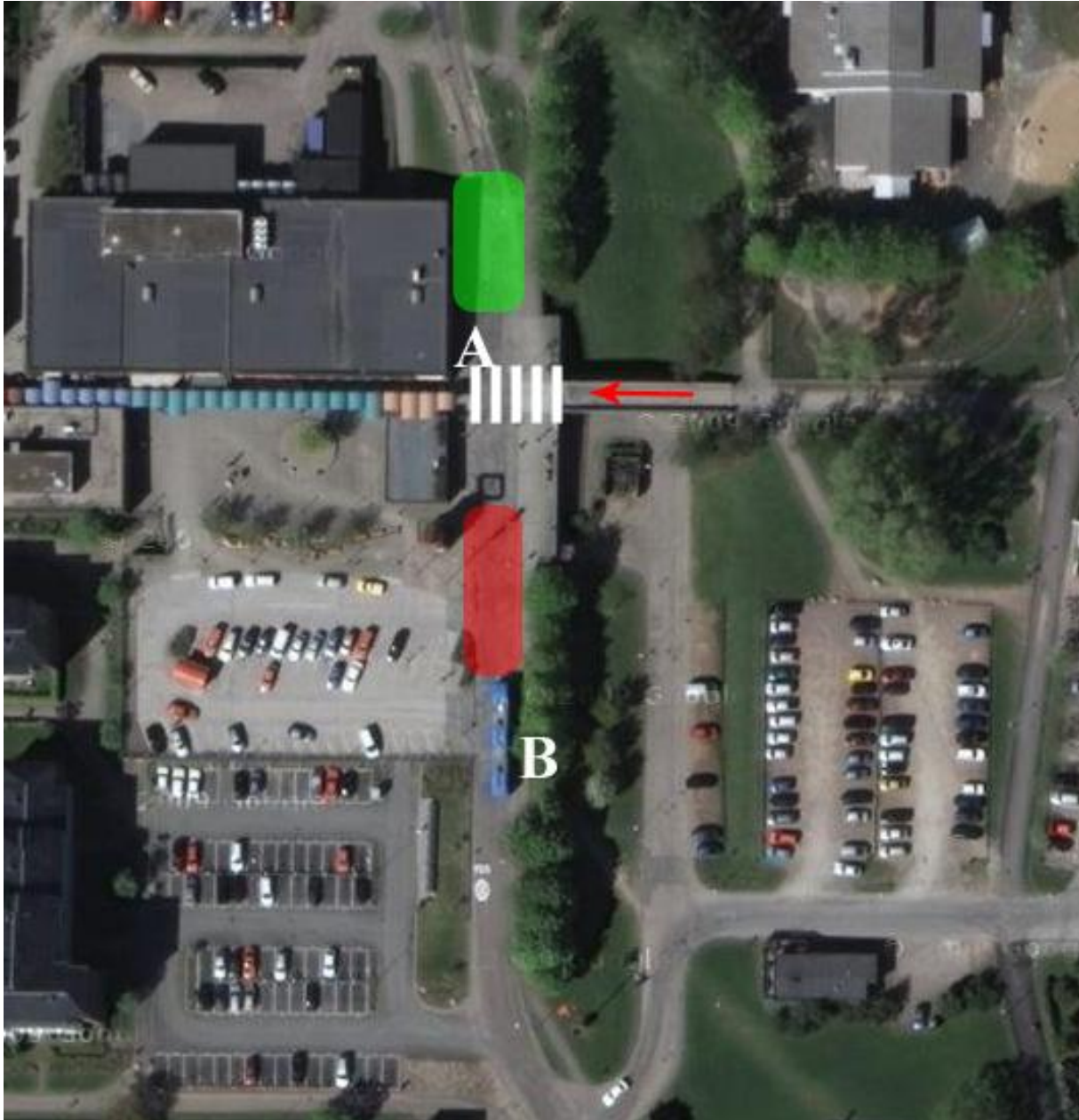


Figure 29: Proposals of actions at Kärra Centrum.

As before, the stop positions are marked with their letter designations. The red arrow indicates a flow of pedestrians moving from the residential area to the east, including the large parking lot and to the center building. The green area marks the aforementioned barriers and the red area marks an area where there is a high risk of pedestrians crossing the road.

The most prominent measure of this object is to create a pedestrian crossing in front of bus stop, location A. There are currently no markings or traffic safety measures done despite the

flow of pedestrians at this point. Road marking, signage and improved lighting are three simple steps that would improve this situation. A sketch of the design follows.



Figure 30: Sketch of proposed crossing at Kärra Centrum.

In figure 29, the green area marked a place where temporary barriers are currently deployed. They serve their purpose now but should quickly be replaced by permanent refuges to ensure traffic safety. It would also be good for the overall impression of the place as it right now gives a cluttered and messy impression on the visitor. The following illustration highlights in red how the temporary barriers are placed at the moment.



Figure 31: Red markings for temporary barriers at Kärrens Centrum.

In Figure 29, there is also a red marked area. In this area, there is a significant risk that pedestrians who just stepped off the bus or are heading for the stop at position B will take a short cut across the road. The picture below illustrates how it looks. The barrier rail lying in the road surface will prevent passage over the road but it is not fully safe as there is still a great risk of stepping out on the road.

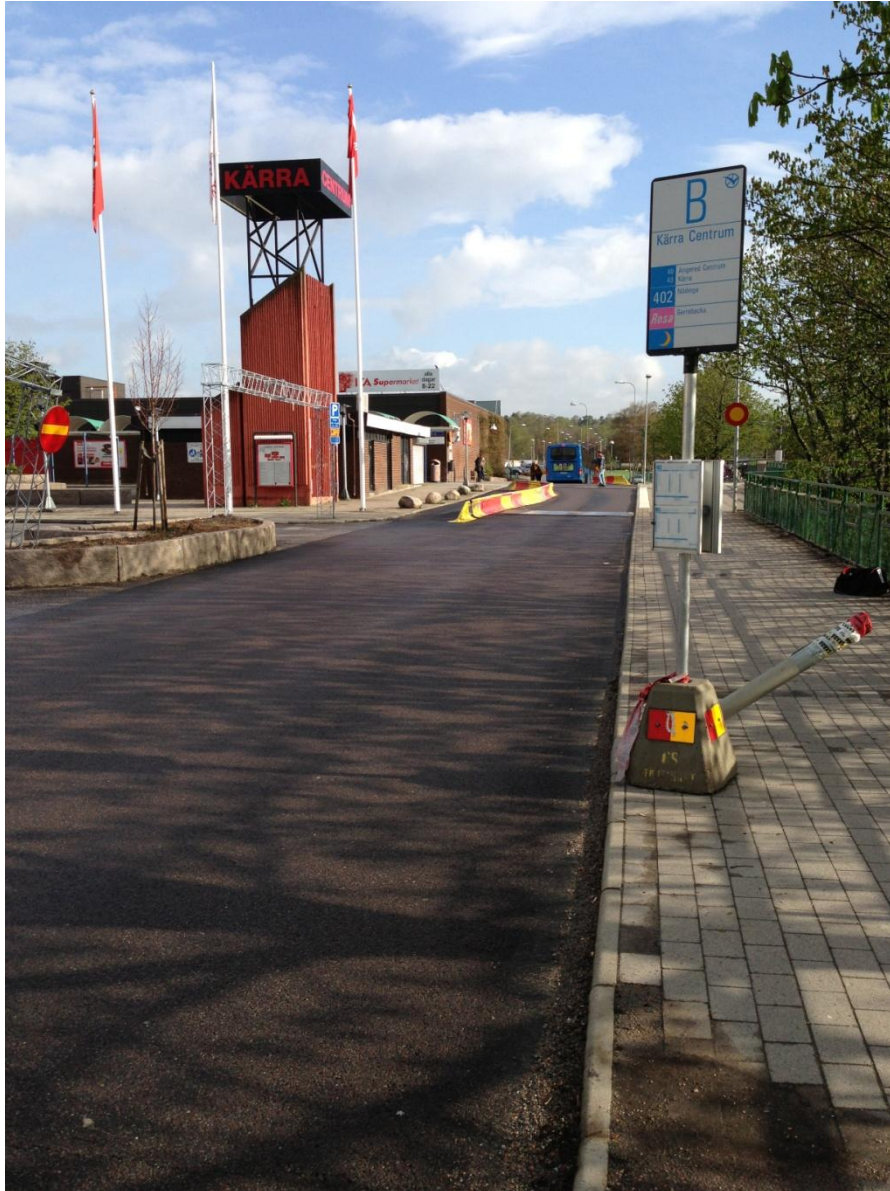


Figure 32: The stop position B at Kärre Centrum and the temporary barrier.

A measure for this problem is that the barrier is being converted into a permanent refuge. The position of the stop should also be made permanent for clarity towards passengers. In order to avoid unwelcome passes over the road, some kind of fence should be installed. One suggestion is that it follows the edge of the pavement towards the proposed crossing. Another suggestion is that it is built at the refuge.

5.3 Nordstan – Heden

The third object that has been identified and selected for further proposals of actions is the stretch between Nordstan and Heden. It differs from the other two as it is a whole corridor rather than a single stop. A short presentation of the object follows, including a proposal.

5.3.1 Presentation of Nordstan - Heden

The route has previously been presented in chapter 2.4.6. It is located in central Gothenburg and includes only the two end stops. Express Bus Rosa runs the 1.2 kilometers in

approximately five minutes. The problems identified on the route are particularly the many traffic signals that give differences in the speed of travel and travel time. Figure 33 shows the distance with a red line and the traffic signals are marked with white dots.

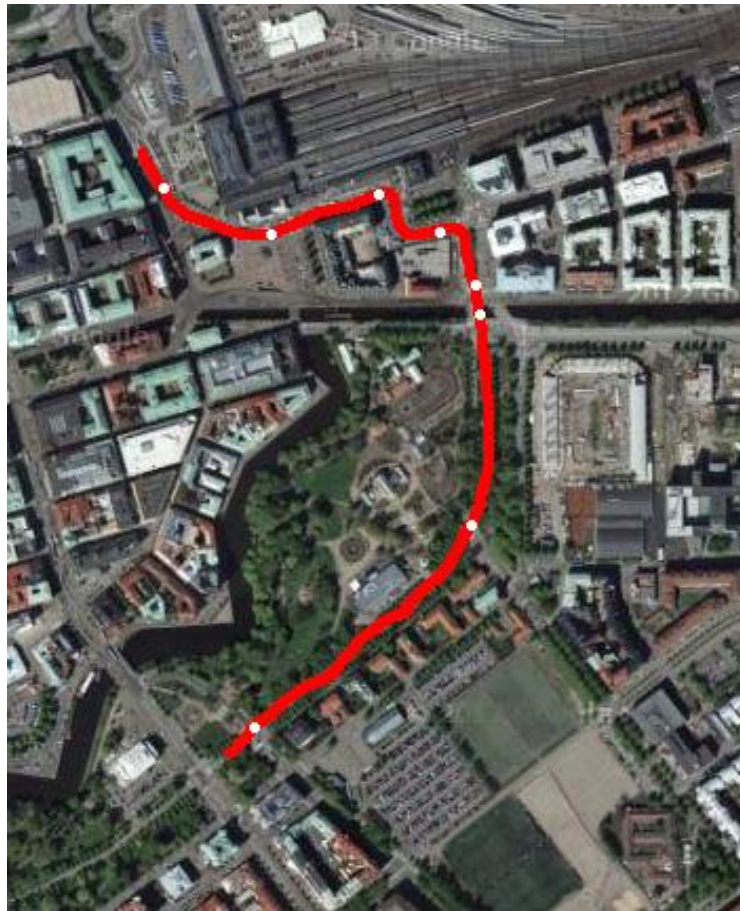


Figure 33: The stretch between Nordstan and Heden in central Gothenburg.

5.3.2 Proposals on Nordstan – Heden

On the whole stretch, there are a total of 8 different traffic signals. This can bring big differences in travel times, the worst case several minutes even though the stretch is a short distance in the meters counting. Bus lanes are already deployed in many parts of this section so the primary measure proposal is to treat the traffic signals.

The on-site observations have not indicated any significant benefits for the bus at the traffic signals. Therefore, an adaptation of the so-called BHOVRA technology could mean improvements. It is simply a technique for prioritizing buses at traffic signals and is an evolution of the traditional technology. With such a system installed delays at traffic signals could be minimized and Express Bus Rosa able to traffic the distance in a more effective way, since for example the level of service would improve and move towards better values.

6. Discussion

This chapter presents a discussion on the content of the report. Various ideas will be explained, how the purpose has been achieved and what could have been done different. First there is a general overview and then focus is on the different objects presented in the suggestions. Finally, a discussion on future challenges and analyzes is generated.

6.1 General ideas

This project aims to create improvements in the traffic system in Gothenburg. In a case study, it has revolved around the stretch of Express Bus Rosa, one of Västtrafik's express bus routes in Gothenburg. This has resulted in an analysis of a mixed traffic environment with different road owners, both Trafikverket and the City of Gothenburg.

As this thesis is written at Trafikverket, the idea was originally to truly identify problems along the roads where just Trafikverket has responsibility. For Express Bus Rosa this means stretches at Hisingsleden, E6 and Highway 158. In the end, it was not many relevant links to precisely those road sections, as they are deemed to be in very good condition with regard to traffic safety and accessibility.

The aforementioned roads have in many cases undergone renovations in connection to the West Swedish Solution. On both E6 and Highway 158, a long distance is separate bus lane where Express Bus Rosa has very good accessibility. It has simply been a situation where it has not been much to remark on these stretches.

Therefore, there could be a discussion if more contact should have been had with the Traffic and Public Transport Authority in Gothenburg, as most of the problems have been identified on their roads. However, a future contact is not impossible. Contact with Västtrafik was made already in the decision stage of which express bus route to be chosen and it was at their request as line Rosa were selected for analysis.

In this thesis, the focus has been on improving the transport system with respect to traffic safety and accessibility. Factors such as comfort or the buses frequency of departure relating to vacant seats have not been under consideration. This is considered to be more associated with the contractor, in this case, Veolia Transport Sverige AB, and client Västtrafik's responsibility.

For an even more reliable analyzes, more interviews could have been conducted with travelers on the route. In this report, a target of 50 passengers was set because of the resource limitation due to the number of writers and weeks available. In order to statistically ensure the survey, it would have been useful with more, therefore has no deeper analysis of the issues been made but a simpler presentation.

A number of driver interviews were also conducted during the work. They were completely voluntary and the drivers were completely anonymous with their views. These were random and many good opinions and additions were made to the study.

6.2 Cost estimates

In the startup of this thesis a possibility of implementing cost estimates for the selected object's proposals of action were discussed. As the process went on, however, these were not considered as they were considered to be somewhat unreliable.

Instead it was decided to implement the assumptions of what was reasonable for each object. It had not been especially likely to rebuild the entire interchange Klareberg so in this study, focus was on simple and effective measures that were considered to have relatively low costs of implementation. This left the unreasonable alternatives out at an early stage and resources could be laid on the options that are now presented.

6.3 The different sections

In the report, the entire route has been divided into smaller sections, in the same structure as Västtrafik have chosen. During the analysis, it became clear that this structure fit very well as the problems identified was spread pretty much equally among them. There was then no need to worry so much over this division, although other ideas of structure existed.

For example, the sections could have been divided so they had the same number of stops in each section. In total there were 38 stops on the route and through a thoughtful breakdown it could possibly have given certain routes more attention.

The items that were selected for further analysis were the three places that were considered to have the greatest need for action in the current situation. This based on parameters of traffic safety and accessibility. Below is a deeper discussion of these items and which thoughts have been regarding the proposed actions.

6.3.1 Discussion on Klareberg

At the stop in Klareberg, a discussion whether an expansion of the whole hub should occur is possible. There might be sufficient with a small station center at the site which is located near both E6 and Hisingsleden, including Angeredsbron. A commuter parking could accommodate travelers from north of Gothenburg who may then choose to travel with public transport into the city center.

Another thing that appeared during the work is if the bus stops are optimally placed at Klareberg. As it is now bus Rosa uses three different bus stops and it causes confusion for both drivers and passengers. The drivers have expressed that sometimes they themselves are unsure of what position they will dock and it happens that there is misunderstanding between them and travelers.

At Klareberg, the idea of was also raised the idea of whether the crossing which is now positioned to reach the stop position C is enough. There is a detour and the risk of pedestrians taking short-cuts is imminent. Possibly another crosswalk is needed at the site, a connection between position C and position A, to minimize the risk of pedestrians in the road area. Traffic at Klareberg is relatively dense and come from several different directions.

6.3.2 Discussion on Kärra Centrum

This stop is the one that should be prioritized first for action if such a discussion would appear. One question that has come up is if there are already plans for a rebuild because there are temporary barriers in the road and the situation on the ground is not very good.

An alternative solution at the object that also has been considered is to move the bus to the west side of the center building. That would solve the problem at the object site but the reason why it was not carried out any further studies is that there are several negative aspects. Among other things, it would require major renovations, the trip would be longer and the problem would only be moved as there is a flow of people also from the west side.

An additional crossing point has also been under consideration. This is just north of the bus stop location B. Such a placement would increase the traffic safety for pedestrians but also have negative consequences. Accessibility would deteriorate as the Express Bus Rosa would have an additional potential stopping point.

You can also discuss whether a fence would affect the impression of the area. An excessively negative impression is not favorable neither for the shopkeepers in the shopping center, the residents in the area or public transport.

6.3.3 Discussion on Nordstan – Heden

This object is different in the sense that it regards a whole section, rather than just a stop. The big problem here was the fact that eight traffic signals regulate traffic on the relatively short distance. The proposed action with controlled signals that prioritize bus services can be difficult to apply in the real case. The traffic environment is complicated in this place and also from other directions, traffic can be important to prioritize.

6.4 Further suggestions

For future work there are several areas in which development can be created. For example, the route Nordstan - Heden can be implemented in software for traffic simulation and further analyzed. Then the surrounding traffic can be illustrated and an overview of the route can be obtained. Such work was considered too time consuming in this report.

In-depth analyzes of each object in itself is necessary to actually implement the proposed measures. It is hoped that this report can provide inspiration and guidance for improvement in the traffic in Gothenburg in general and for express bus Rosa in particular.

7. Conclusions

This thesis has been prepared at Trafikverket in Gothenburg and has aimed to improve the transport system in Gothenburg. It has linked to the Express Bus Rosa and several problems have been identified. Among these were then three interesting items chosen for further analysis and proposals of actions were presented.

A list of 40 items were compiled, both major and minor problems that were considered to be in contention of improvement. The main items are summarized below:

- At Klareberg there is a proposal to increase traffic safety by extension of pedestrian crossings. This would lead to reduced passages in the road and therefore also lower the risk of accident. Clarification of the different stop positions designation is also a simple but effective measure that increases the availability at Klareberg. Programming the traffic signal leading to Hisingsleden is also one of the proposals for measures to increase accessibility.
- Kärra Centrum has great potential to improve traffic safety. An expansion of pedestrian crossings, traffic islands and permanent fence would generate major improvements in this location. Since there are already much people moving around in the area and this is expected to increase, this is considered a high priority.
- The third that was identified with additional interest was the section between Nordstan and Heden in central Gothenburg. A proposal of a control of traffic signals that gives priority to bus services in the current signals was given.

Further investigations include detailed analyzes of the selected features and a review of all the other problems identified. It is a solid collection with many items which can certainly give different effects. Cost estimates have not been developed in this work, the measures being considered to maintain a relatively low cost, but is obviously important in the end, when decisions on action occurs.

References

- Karlsson, J. & Larsson, E. (2010). Passengers' Valuation of Quality in Public Transport with Focus on Comfort (Electronic) Available:
<http://publications.lib.chalmers.se/records/fulltext/126949.pdf> [2013-04-14]
- Manning, F.L., Washburn, S.S. & Kilareski, W.P. (2009). *Principles of highway engineering and traffic analysis*. John Wiley & Sons, Inc. Fourth Edition.
- Miljödepartementet (2013): *Hållbar utveckling* (Electronic) Available:
<http://www.regeringen.se/sb/d/1591> [2013-05-13]
- Trafikkontoret (2013): *Göteborg 2035 – Trafikstrategi för en nära storstad* (remiss) (Electronic) Available: <http://goteborg.se/wps/portal/enheter/projekt/stadsutveckling-2035/Trafikstrategi> [2013-05-13]
- Trafikverket (2013a): *Vad är Västsvenska paketet?* (Electronic) Available:
<http://www.trafikverket.se/Privat/I-ditt-land/Vastra-gotaland/Vastsvenska-paketet/Vad-ar-Vastsvenska-paketet> [2013-05-13]
- Vinnova (2001): Om hur folk väljer färdmedel (Electronic) Available:
www.vinnova.se/upload/EPiStorePDF/vr-01-22.pdf [2013-03-15]
- Västsvenska Paketet (2013): *Effekter av trängselskattens införande – Redovisning 25 april* (Electronic) Available:
http://www.trafikverket.se/PageFiles/96362/vastsvenska_paketet_redovisning_130425.pdf [2013-05-21]
- Västtrafik (2011): *Verksamhetsplan 2012-2014* (Electronic) Available:
<http://www.vasttrafik.se/#!/om-vasttrafik/dokumentbibliotek/> [2013-05-21]
- Västtrafik (2012): *Pling* (Electronic) Available:
<http://www.vasttrafik.se/Documents/Dagens%20Pling/Pling%20121205.pdf> [2013-05-21]
- Västtrafik (2013a): *Göteborgs stadstrafik* (Electronic) Available:
<http://www.vasttrafik.se/#!/om-vasttrafik/vastsvenska-paketet-vasttrafik/trafikforandringar-den-9-december--linje-for-linje/goteborgs-stadstrafik/> [2013-05-21]
- Västtrafik (2013b): *Bildspel - Trängselskatt i Göteborg - Västtrafik 25 april 2013* (Electronic) Available: <http://www.trafikverket.se/Privat/I-ditt-land/Vastra-gotaland/Vastsvenska-paketet/Utvarderingar-och-matningar---Vastsvenska-paketet/> [2013-05-21]
- WSP (2012): Strategi för utveckling av Kärra Centrum (Electronic) Available: Google search: Strategi för utveckling av Kärra Centrum [2013-04-22]