Thesis 166

Pedestrians' safety and accessibility
- A study of the situation at Pärnu mnt in central Tallinn

Urban Nordh
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Lund Institute of Technology
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Keywords:
Pedestrian, traffic safety, accessibility, impaired capacity, Pärnu mnt, Tallinn

Abstract:
The aim with this thesis is to analyse problems that pedestrians have within a specific area in central Tallinn and thereafter propose changes in the physical design to improve the pedestrians' safety and accessibility. The study indicates that there are various factors that affect the pedestrians' situation at the studied site. The factors that mainly affect the pedestrians' situation is the high speed of motorized vehicles, the high share of car drivers driving against red and that most car drivers ignore their obligation to give priority to pedestrians at an unprotected pedestrian crossing. Changes in the physical design are thereafter proposed in order to prevent the car drivers' incorrectly behaviour and to facilitate for pedestrians.

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Preface

This thesis concludes my civil engineer education at Lund Institute of Technology. The thesis has been done in cooperation with OÜ Stratum in Tallinn. Supervisors have been Prof. András Várhelyi at the Department of Technology and Society, Lund Institute of Technology and Dago Antov at OÜ Stratum.

I want to thank András Várhelyi for his excellent help and support during the whole thesis and Dago Antov for providing me with Estonian statistics needed to carry the thesis through. I also want to thank the staff at the Department of Technology and Society for lending me equipment needed for the field study.

Finally I want to thank my family and friends for their support and the Liib-Siplane family for their hospitality during my stay in Estonia.

Lund, July 2007

Urban Nordh

Glossary

There are a few expressions in this report that need an explanation or a definition to secure that the readers and the author of this report refer to the expressions in the same way.

Traffic safety	"Low risk of personal injury in the traffic" (Svenska kommunförbundet, 1998)
Accessibility	"Tells the easiness which different road users can reach the cities' work places, services, recreations and other activities" (Svenska kommunförbundet, 1998)
Level of service	"The part of accessibility that describes the time needed for movements in the traffic network as a pedestrian, cyclist, bus passenger or as a car driver" (Svenska kommunförbundet, 1998)
Vulnerable road user	Pedestrians and cyclists
Impaired capacity	"The limitation in a persons' ability to perform an activity in a way that is considered normal" (Svenska kommunförbundet, 1994)
Mixed traffic	Different road user types are mixed in the same area
Mnt	The shortening of the Estonian word maantee (road)

Summary

In the Estonian National Traffic Safety Program 2003-2015 it is stated that an especially big problem in Estonia is the number of pedestrians that are run over by vehicles. Statistics concerning the number of killed pedestrians in the traffic within the EU also confirm this statement. The number of killed pedestrians in the traffic per million inhabitants in Estonia is far over the average within the EU.

The aim of this thesis is to identify the problems and needs pedestrians generally have in the traffic and also to make a review of measures in the physical design that can be used to satisfy the pedestrians' needs. At a specific site, selected for the field study, the interaction between pedestrians and motorized vehicles are analysed and a proposal of changes in the physical design is presented. The aim of the presented changes is to make the street link safer and more accessible for pedestrians.

The selected site for this study is located in the city centre of Tallinn, where pedestrian accidents occur in a greater extent than in other parts of Estonia. The characteristic of the selected site is the lively street life with lots of people in motion. Various target points like shops, a park and proximity to public transport contribute to the high flows of pedestrians within the area. In between of all these activities is though a big street with high flows of motorized vehicles, Pärnu mnt. The street is wide, which contributes to high speeds of the motorized vehicles. The high speeds combined with the high traffic flow constitute a barrier for the pedestrians.

While planning for pedestrians it is very important to be aware of that the pedestrians are not a homogenous group. The pedestrians' capacity varies which affects their ability to use the street in a safe way. Many have got impaired capacity in one way or another and the variety in the capacity should be the determining factor while designing the street. The impaired capacity can appear as limitations due to age, such as impaired mobility, vision and hearing. Impaired capacity can also appear due to mental disabilities and suffering of allergy. Except for the division made on basis of physical and mental conditions it is also possible to divide pedestrians into groups on basis of their ability to walk freely. Use of equipment, occupation of hands and the size of the group the pedestrian is walking among are various examples of activities that might affect the pedestrians' ability to walk freely.

The field study showed that the speed was very high at the signal controlled pedestrian crossing and at the unprotected pedestrian crossing. The average speed at the signal controlled pedestrian crossing was 47.1 km/h and 20-30 % of the drivers were driving above the speed limit. The average speed at the unprotected pedestrian crossing was 50.3 km/h and between 40 and 50 % of the drivers were driving above the speed limit.

The traffic flow during the evening rush hour (16.00-17.00) was 1012 respectively 1230 vehicles per hour. The total number of pedestrians that crossed the street during the evening rush hour was 3322 pedestrians per hour. 2848 of the pedestrians crossed the street at the signal controlled pedestrian crossing and the others did it at the unprotected pedestrian crossing. The average waiting time for those who crossed the street at the unprotected pedestrian crossing was 5.6 seconds. 73 % of the pedestrians had to wait at the unprotected pedestrian crossing and the average waiting time among them was 7.6 seconds.

Interviews were made with randomly chose pedestrians at the signal controlled pedestrian crossing and at the unprotected pedestrian crossing. The majority of the pedestrians answered that car drivers have priority at the street link and about 80 % answered that car drivers are breaking traffic rules. According to the pedestrians the most common traffic rules that are broken are that car drivers do not stop at the unprotected pedestrian crossing, speed is too high and car drivers are driving against yellow/red light.

The pedestrians refer to the traffic pace as stressful rather than calm and about half of the pedestrians answered that they feel more unsafe than safe as a pedestrian at the street link. About 70 % answered that they feel unsafe when crossing the unprotected pedestrian crossing and the most common reason for it was that they were unsure if the cars would stop or not. The second most common reason was that the cars in the second lane keep on driving when cars in the first lane stop. The majority of the pedestrians answered that they feel safe when crossing the signal controlled pedestrian crossing. Those who answered that they feel unsafe mentioned the speed of the cars and driving against red light as reasons.

The behavioural studies showed that almost all car drivers are driving against yellow light. About 50 % are driving against red light during the first second it is red and about 20 % are driving one second after the signal turned red. Further, the behavioural studies showed that only about 20 % of the car drivers gave priority to the pedestrians at the unprotected pedestrian crossing, even that the law says they have to.

The changes in the physical design of the street that are suggested to improve the pedestrians' safety and accessibility at the street link are for example raised pedestrian crossings, narrowing of the carriageway by refuge islands and prohibited areas. The purpose of these measures is to make it easier for the pedestrians to cross the street. The refuge island in the middle of the carriageway makes it possible for pedestrians to take a break in the middle and they do not have to cross the carriageway in a row. The narrowed carriageway combined with a raised pedestrian crossing will hopefully contribute to lower the speed, prevent car drivers from driving against red and also contribute to that car drivers give priority to pedestrians at the unprotected pedestrian crossing in a higher extent. Lights are also installed at the unprotected pedestrian crossing and the crossing is proposed to be made in a deviant material or colour to make car drivers more attentive. These measures will hopefully result in that pedestrians are more visible and easier to recognize. The tram stop at the unprotected pedestrian crossing is also moved towards the signal controlled pedestrian crossing, where platforms for tram travellers are installed. Finally, the design of the bus lane is changed to prevent car drivers from using it to overtake the queue in front of the unprotected pedestrian crossing.

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1. Introduction

1.1 Background

In the Estonian National Traffic Safety Program 2003-2015 it is stated that the number of pedestrians that are run over by vehicles in Estonia is an especially big problem. This alarming description of the situation is also confirmed by the statistics concerning killed pedestrians in the traffic in 2004, where Estonia had 43.7 killed pedestrians per million inhabitants. This should be compared with the average within the EU-25 in the same year, which was 24.5 killed pedestrians per million inhabitants [*](Estonian Road Administration, 2007) and (Stratum, 2006). Compared with the average within the EU, the number of killed pedestrians in Estonia is almost twice as high. A comparison between the countries within the EU-25 can be seen in figure 1.

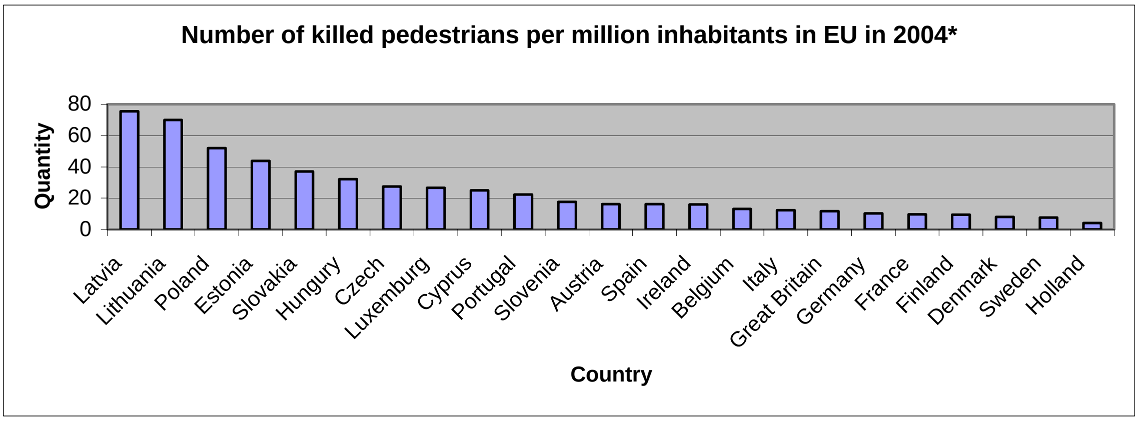

Figure 1. Number of killed pedestrians per million inhabitants in EU in 2004.

As seen in figure 1, Estonia belongs to the group of countries that show the worst statistics concerning killed pedestrians in the traffic. The pedestrians' safety situation in Estonia seems to be urgent and it is therefore of great interest to study their situation and try to find possible ways to improve it.

Pedestrians' situation must be studied and analysed in field in order to be able to point out the special problems behind this situation. The focus in this study is on the pedestrians' safety needs in the traffic on the local level and how the design of the street environment can help to fulfil these needs and thereby improve the pedestrians' situation. A specific site was selected for the study and it is located in the city centre of the Estonian capital, Tallinn. The characteristic of the selected site is a lively street life with lots of people in movement. The main walking street connects with a park and a big shopping centre within the studied area which gives big flows of pedestrians. Main points for all kind of public transport are also located in connection to the area and that is also a factor that generates pedestrians to this area. These basic conditions justify giving priority to the pedestrians in this part of the city in order to improve their safety and accessibility. Although, at the present situation the pedestrians compete with motorized vehicles about time and space.

[*] Result from Greece and Malta was missing and is therefore not included in the calculated average. The result from Ireland is from 2003 and the result from Latvia is from 2005. The results from Belgium, Cyprus, Lithuania and Slovakia are from 2002.

1.2 Aim

The aim of this study is to:

- identify what problems and needs pedestrians generally have in traffic
- make a review on possible measures in the physical design of the street in order to satisfy the pedestrians' needs
- analyse problems that pedestrians have within a specific area in central Tallinn by field observations
- propose relevant changes in the physical design in order to improve the pedestrians' safety and accessibility within the above mentioned area

1.3 Limitations

Pedestrians' safety depends on many factors and one of them is the design of the street, which is in focus in this study. Other aspects concerning pedestrians' safety are only touched superficially in this study.

The description of measures in the physical design of the street is only made briefly. The design of the measure itself and their exact effect on safety is not described.

Only measures that are relevant to carry out in city environment are discussed, measures like flyover- and motorway junctions are for example not discussed. The changes in the design that have been suggested might affect other means of transport in a negative way, it is for example likely that the level of service for motorized vehicles will be reduced. A deep analysis of the affects on other means of transport would take too much time and is therefore not done.

1.4 Method

The study began with a literature survey from books, articles and the internet to identify problems and needs that pedestrians generally have in the traffic and how to satisfy these needs by measures in the physical design. On basis of the literature survey a certain street link of Pärnu mnt in central Tallinn was observed to identify specific traffic problems. The field studies included ocular inspection, speed measuring, counting of vehicular and pedestrian flow, counting of queue lengths, pedestrians' waiting time at an unprotected pedestrian crossing, interviews with pedestrians and behavioural studies. Proposals of changes in the physical design are based on the results from the field study. More detailed descriptions of the methods for each part of the field study are presented in chapter 4.

2. Literature survey

The purpose of this chapter is to give an account of the needs pedestrians have and how to satisfy their needs by different measures in the physical road infrastructure. This will be used as the basis for the changes in the physical road infrastructure of the studied street link later on in the report.

2.1 Pedestrians as road users

Defining an average pedestrian is very hard because almost everybody walk sometimes (Holmberg and Hydén, 1996). While planning for pedestrians, it is very important to realize that it is not a homogenous group and that they have different basic conditions. This has to be taken into consideration and the variety in peoples' capacity should be determining while designing the streets (Svenska kommunförbundet, 1994).

Many have got impaired capacity in some way and the most common type of disability is due to age. These disabilities might appear as impaired mobility, impaired vision and impaired hearing. Other common disabilities, which necessarily do not have to be due to age, are allergy suffering and mental disabilities (Svenska kommunförbundet, 1994). Except for the mentioned types of pedestrians, which are categorized on basis of their mentally and physically conditions it is also possible to categorize them depending on the equipment they use, the occupation of their hands or the size of the group they are walking with. These are all factors that influence the pedestrians' possibilities to walk freely (Gunnarsson, 1995).

2.2 Different basic conditions - different problems and needs

Depending on the difference in pedestrians' basic conditions they face different problems (Gunnarsson, 1995). Typical problems that pedestrians within each group are likely to face and needs that the problems result in are listed below.

2.2.1 Age

How well children manage to get around in the traffic depend on their individual level of maturity. Children have limitations that affect their situation in the traffic. Their field of vision is not totally developed before 12 years of age and their hearing ability is also limited. The fact that children are short makes it harder to see them and they are more likely to be hidden behind something that blocks the view, therefore they have a need of clear sight so they can be seen easily (Svenska Kommunförbundet, 1994).

Other factors that complicate for children in the traffic is their lacking ability of understanding traffic rules and some do not know the difference between left and right (Gunnarsson, 1995). Children also tend to act irrationally because of their lacking ability to control themselves and stay focused. Their attention is easily drawn to something distracting which might make them act impulsive (Underlien Jensen, 1998). To minimize these problems they have a need of easily understandable traffic environment, where they do not have to concentrate on many contemporary happenings (Svenska kommunförbundet, 1994).

Elderly are the dominating group among people with impaired capacity. This often appears as reduced ability to move, see and hear (Svenska Kommunförbundet, 1994). The reduced ability to move might cause slower walking pace, difficulties to walk longer distances and using steps with differences in heigh (Gunnarsson, 1995). According to the reduced ability to move, elderly also have bigger problems to make avoidance manoeuvres (Underlien Jensen, 1998) and their balance worsens as well (Svenska Kommunförbundet, 1994). Needs that occur due to the reduced ability to move are described in chapter 2.2.2.

It is also common among elderly that sight and hearing get gradually worse. Elderly need more light and clear contrasts to see well and the eye has harder to shift between light and dark, which might result in that they get dazzled easier. When the ability to hear get worse it often appears as difficulties in locating what direction different sounds comes from and that some sounds are harder to hear than others (Svenska Kommunförbundet, 1994).

Elderly also tend to have problems to manage many impressions at the same time, which might result in that they take in more information than they can handle and the result might be that they get confused and unsure and thereby estimate the situation wrong. Others take in too little information or focus on wrong signals because of their lacking ability to intake and react on information. (Bernhoft et al, 2003). These problems result in a need of a traffic environment where they do not have to focus on many contemporary happenings (Svenska Kommunförbundet, 1994).

2.2.2 Impaired mobility

As mentioned earlier, impaired mobility often occur according to age but many also suffer from impaired mobility constantly or in shorter periods of their life. Usual problems among persons with impaired mobility are difficulties to walk longer distances, walk fast, walk in stairs and on leaning streets or even to walk at all. These difficulties complicate the situation for those persons that are suffering from these problems and they might be limited in many situations. Crossing a street can for example be hard if you can not walk fast (Svenska kommunförbundet, 1994).

Persons with impaired mobility have a lot of needs to be able to get around in the traffic. They are sensitive to uneven surfaces, and therefore need even surfaces with good friction and without holes. Differences in height are also a big problem for persons with movement disabilities and the need of low edges on pavements and low steps in stairs is obvious. Persons with impaired mobility also have a need of short crossings to be able to cross a street, as it might take longer time for them to cross it compared with others (Svenska Kommunförbundet, 1994).

Many of those with movement disabilities also need aids to be able to walk. Their problems and needs will be described in chapter 2.2.7.

2.2.3 Impaired vision

Persons with impaired vision can be either blind or partially sighted. Both these groups have difficulties to orientate and need technical aids to be able to explore their surroundings. Their ability to assimilate written information varies depending on the extent of the handicap and these factors complicate their ability to notice dangers. They also have problems to cross streets and avoid obstacles (Svenska Kommunförbundet, 1994).

This category of pedestrians has needs of logical designed streets and environment with clear contrasts to be able to orientate themselves. It is also important that the surface is even, as their ability to avoid obstacles is reduced. Those who are partially sighted might also be able to assimilate written information if it is written with carefully chosen size, color and contrast and if it is lit up (Svenska Kommunförbundet, 1994).

The technical aids that persons with impaired vision are using can also result in problems, which are described in chapter 2.2.7. Children and elderly are represented in this category of pedestrians as well and their specific problems are described in chapter 2.2.1.

2.2.4 Impaired hearing

The main problem for persons with hearing impairments is to locate what direction different sounds come from (Svenska Kommunförbundet, 1994). Problem that might occur in the traffic according to their handicap is that it might be hard for them to hear approaching cars (Gunnarsson, 1995).

2.2.5 Allergy sufferers

If allergy sufferers come in contact with materials that they are allergic to, it might cause an allergic reaction and for some persons the reaction might be so powerful that they are not able to move (Svenska kommunförbundet, 1994). Asthmatic persons might get breathing problems or eye irritations when they are exposed to traffic emissions (Gunnarsson, 1995). These problems lead to needs of awareness when deciding materials that will be used and also if plants are placed in connection to the street (Svenska Kommunförbundet, 1994).

2.2.6 Mentally retarded

Typical problems that mentally retarded persons face are the lacking ability to understand traffic rules and signs, orientating themselves and understanding risks (Gunnarsson, 1995). Further, they might have problems to manage complicated traffic environments, where they have to intake many impressions at the same time. Easily understandable traffic environment and short crossings can make the situation easier for mentally disabled persons (Svenska Kommunförbundet, 1994).

2.2.7 Use of equipment

This category of pedestrians includes both persons with some kind of disability who need an equipment to get around and those who are using equipment for activities. Examples of equipment in the first group are crutch, wheelchair and walking frame and in the second group roller-skate and skate boards (Gunnarsson, 1995). Persons that are using aids to walk need more space and they also have demands on the surface to be even, without holes, and also that it can take high pressure. A big difference in height is also a problem and the height of pavements and the steps in stairs have to be small. Persons that are sitting in wheelchairs are also shorter than usually, which result in a higher risk of not being seen because of something that blocks the view. This could be avoided by clear sight so they easily can be seen (Svenska kommunförbundet, 1994).

Persons with impaired vision that are using aids to orientate themselves also belong to this category of pedestrians. Persons that are using a companion that guide them can have problems to walk on streets that are too narrow because they need to walk beside the companion. They therefore have a need of wide streets and it is also of great importance that the surface is even so the ones that use a cane to orientate do not get stuck in holes or other unevenness (Svenska Kommunförbundet, 1994).

In the groups that are using roller-skates and skate boards are accidents most common among children and youths. Among skateboarders most accidents happen in sport grounds and on pavements and streets (Konsumentverket, 2001). Among roller-skaters most accidents happen on pavements and streets (Konsumentverket, 2001). The reason to the accident among roller-skaters are in 41 % of the cases a spontaneous loss of balance and 40 % reported that the cause of the fall was that they were striking a stationary hazard, which includes defects in the street (International inline skating association, 2006).

2.2.8 Occupation of hands

This category of pedestrians include persons that are guiding children, pushing a pram or a shopping trolley, carrying something, walking an animal or have their hands free. Depending on the extent of the activity they have different possibilities to walk freely and not being distracted by anything (Gunnarsson, 1995).

2.2.9 Group size

Depending on the size of the group that the pedestrian is walking among they will have different possibilities to walk freely and not being distracted by anything (Gunnarsson, 1995).

2.3 Traffic safety principles

Fundamental requirements to achieve a safer traffic environment can be divided into five traffic safety principles. These five principles are listed below (Lu et al, 2006):

- Road network functionality
- Recognisability and predictability
- Traffic homogeneity
- Driving task simplification
- Error forgivingness

These principles are guidance's to factors that have to be taken into consideration while designing streets in order to improve the traffic safety (Lu et al, 2006).

2.3.1 Road network functionality

The design of the streets should result in a functional use of the road infrastructure and it should also prevent unintended use. This principles' starting point is in the design and use of the streets at the network level. The functional use can be achieved by natural functional behaviour or the functional behaviour of the driver has to be induced (Lu et al, 2006).

2.3.2 Recognisability and predictability

The road users' limitations should be the determining factor when designing the road environment and the road environment should also be informative concerning how road users are expected to behave. All road users should understand every manoeuvre that have to be done and it is therefore of great importance that the traffic situations are simple and easily understandable. Predictable behaviour of the road users should be achieved by creating traffic situations that are familiar to them (Lu et al, 2006). Traffic safety requirements within this category are made to avoid search behaviour, make road categories recognisable and limit the number of standard traffic solutions (Lu, 2007).

2.3.3 Traffic homogeneity

Making the traffic homogenous aims to minimize the difference in speed, direction and mass when collisions between road users and between road users and obstacles occur. This principle can be expressed in three speed rules: do not mix motor vehicles with vulnerable road users at higher speeds than 30 km/h, do not use level road crossings at speeds higher than 50 km/h and do not have opposite traffic at higher speeds than 70 km/h without separation (Lu et al, 2006). Traffic safety requirements that are related to this safety principle are to avoid conflicts with oncoming- and with crossing traffic. Other related safety requirements are to separate different means of transport, to reduce speed at potential conflict points and finally to avoid obstacles along the carriageway (Lu, 2007).

2.3.4 Driving task simplification

The drivers' capacity can be improved by simplifying the driving task. The aim is to reduce the effort of driving and the needed attention for some parts of it. Further, the aim is to make the decision making easier for the driver. Improvement of the drivers' capacity and reduction of the workload are two traffic safety requirements that are related to this category (Lu et al, 2006).

2.3.5 Error forgivingness

No matter how safe the traffic environment is, there will always be mistakes made as long as the human factor is involved. The focus of this principle is based on when the mistake is already made and what can be done to minimize the consequences of the mistake. The mistake can be ward off at an early stage or the focus have to be turned to different ways to soften the consequences when an accident no longer can be avoided (Lu et al, 2006).

2.4 The speeds’ impact on the safety

The speed of motorized vehicles has an impact on the safety. Both the number and the severity of the accidents increase with increased speed. Another factor that affects the number of accidents is the homogeneity of the speed, low variance in speed on a certain road result in fewer accidents. If an accident happen, speed determines the severity of the accident and the probability of death increase with increased speed, see figure 2 (Várhelyi, 1996).

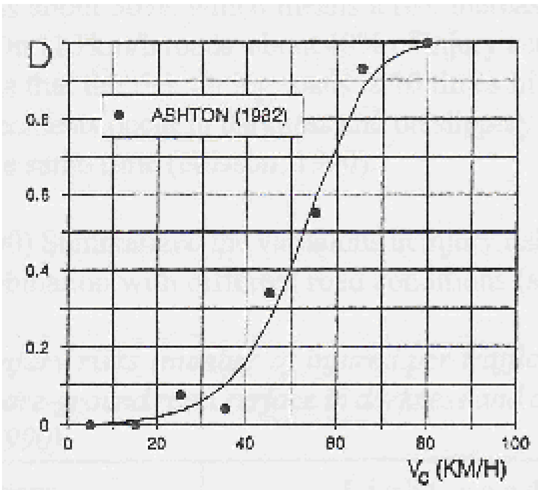

Figure 2. Probability of death when getting hit by a car at different speeds (Pasanen, 1992)

Figure 2 shows that the risk of being killed when getting hit by a car is almost eight times higher when the speed is 50 km/h than it is when the speed is 30 km/h.

Except for the safety aspect, the pedestrians’ accessibility is also affected by the speed of the motorized vehicles. Cars, travelling with high speed create barriers that complicate or make it dangerous to cross the road (Várhelyi, 1996).

2.5 Physical road infrastructure measures for speed reduction

Various measures in the physical design can be used to meet the specific needs that pedestrians have and to fulfil the guidelines stated in the traffic safety principles. To make the measures more effective it is recommended, or even needed, to combine them. As seen in chapter 2.4, the speed has a direct impact on the safety and many of the measures that can be used to improve the safety therefore aim to reduce the speed. The measures that are useful can be divided into two types of measures, speed reducing measures and measures that aim to improve the safety and general environmental qualities. These measures can also be divided into subgroups depending on their properties. These groups of measures are (Svensson and Hedström, 2003):

- Vertical speed reducing measures
- Horizontal speed reducing measures
- Optical safety measures
- Regulatory measures

2.5.1 Vertical speed reducing measures

Speed hump

Building speed humps is an effective way to slow down the speed of motorized vehicles. It can be used to lower the speed at critical points (Svenska kommunförbundet, 1998). Speed humps are long and it can have either a flat or a circular top, see figure 3 (Pau and Angius, 2001). Streets where speed humps are built get lower traffic volumes and the number of accidents is reduced on these streets (Elvik and Vaa, 2004).

Figure 3. Example of a speed hump (Vägverket, 2007)

Speed bump

Speed bumps are, compared with the speed humps, shorter but it has about the same height. The top of the speed bump is circular or parabolic and the height of it is depending on the speed limit. The purpose of the speed bump is to force the driver to reduce the speed at critical points (Pau and Angius, 2001).

Speed cushions

Speed cushions are designed as a narrowed hump, smaller than the lane width, see figure 4 (Towliat, 2001). It is usually designed as a square or rectangle with a flat top and the purpose of it is that trucks, busses and emergency vehicles should not suffer from the discomfort that ordinary cars will do. Trucks, busses and emergency vehicles have a bigger space between the wheels and they can thereby pass the obstacle without being affected of it while cars have to go over the cushion with at least one wheel (Pau and Angius, 2001). Speed cushions are suitable to use on local and arterial roads with heavy traffic (Towliat, 2001).

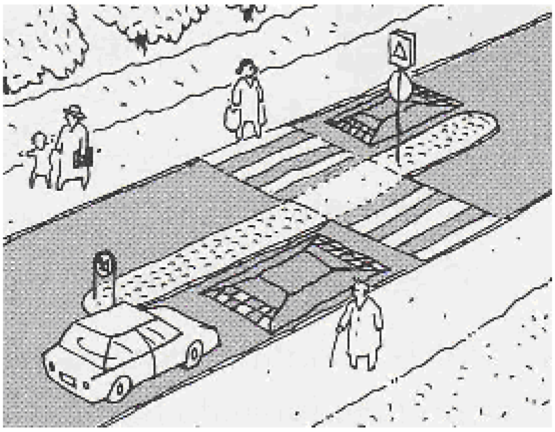

Figure 4. Speed cushions (Svenska kommunförbundet, 1998)

Raised intersection and crossing

Pedestrian crossings can be raised above the carriageway. That makes the crossing more visible and it also reduce the speed of the arriving cars. It is also possible to raise whole intersections to achieve lower speed and to make drivers pay more attention to pedestrians, see figure 5. As the raised area is made in the same material as the surrounding walking paths are, it is important to make marks that indicate where to go so visually impaired can use the arrangement in a safe way (Svenska kommunförbundet, 1998).

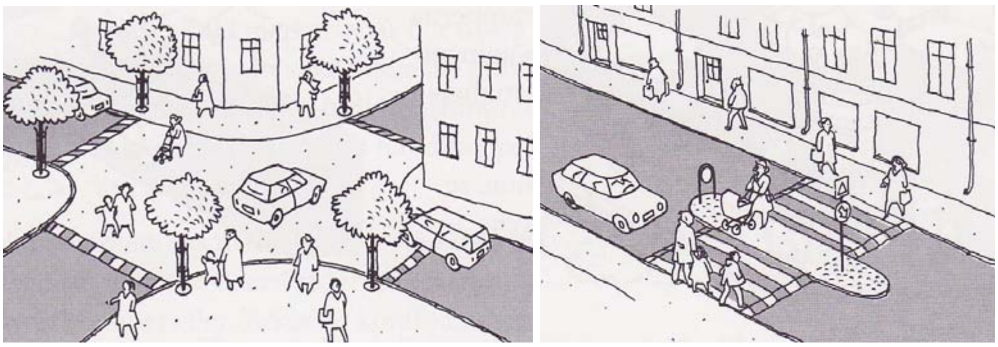

Figure 5. Examples of raised intersection and a raised pedestrian crossing (Svenska kommunförbundet, 1998)

Rumble strips

Rumble strips are a part of the carriageway and their aim is to make drivers more attentive (Institution of highway and transportation, 1997). The rumble strips are made of a material that create knocks, vibrations or noise within the car (Elvik and Vaa, 2004). These knocks, vibrations and noises make the ride uncomfortable and alerts drivers to slow down the speed. Rumble strips are an effective way to reduce speed and accidents, especially when used at places where the speed is high and the driver has to be alerted to changes in driving conditions. It is though important to be aware of that rumble strips are not recommended to use at locations where people easily are bothered because of the noise that the rumble strips produce (O'Flaherty, 1997).

2.5.2 Horizontal speed reducing measures

Street narrowing

The purpose of narrowing the street is to force the car drivers to lower the speed and also to make it easier for pedestrians to cross the street. To make the measure more effective it is preferred to combine it with a refuge in the middle of the street (Englund et al, 1998). Wider pavements, a raised area in the middle of street, parking space along the carriageway and plants are examples of methods that can be used to make the street narrower, see figure 6 (Svenska kommunförbundet, 1998).

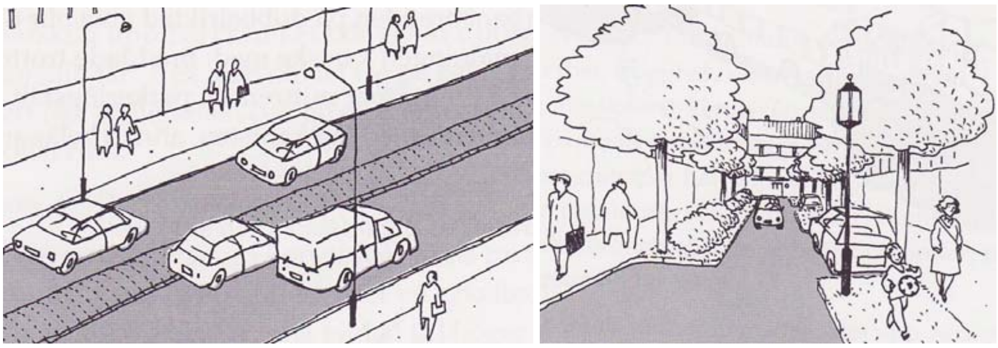

Figure 6. Two examples of measures to narrowing the street (Svenska kommunförbundet, 1998)

Chicane

Chicanes have a speed reducing impact on the traffic. The aim is to force the drivers to make a move sideways and thereby reduce the speed and also change the field of vision, see figure 7 (Englund et al, 1998). It is important that it is not possible to make short cuts and that can be prevented by combining the chicane with refuges. It is recommended that the move sideways should be at least one lane width (Institute of Transportation Engineers, 2006).

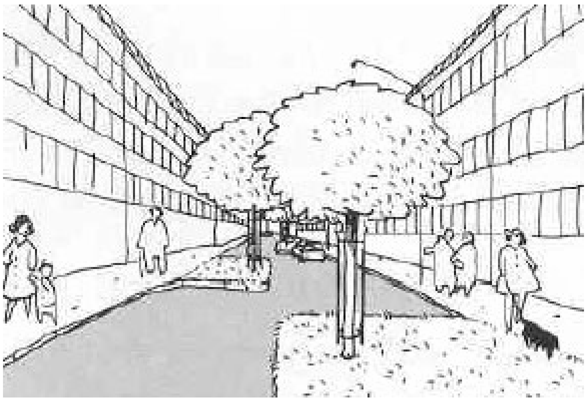

Figure 7. Chicane made by plantings (Svenska kommunförbundet, 1998)

Roundabout

Installing a roundabout is an effective way to decrease the speed, see figure 8. Not only the number of accidents between cars decreases, but also accidents where pedestrians are involved decrease both in number and degree of severity (Svenska kommunförbundet, 1998). Positive properties of roundabouts are that it forces the drivers to lower the speed and it also contributes to a better interaction between car drivers and vulnerable road users. The lower speed also makes it easier for the car drivers to detect the vulnerable road users in time (OECD, 1998).

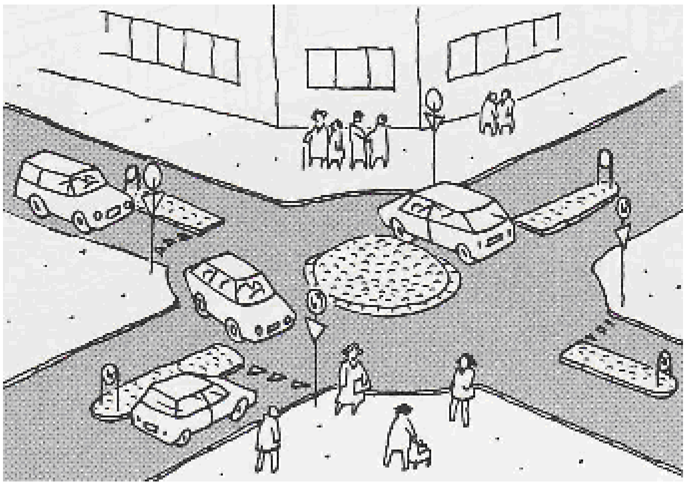

Figure 8. A small roundabout (Svenska kommunförbundet, 1998)

2.5.3 Other physical safety measures

Refuge island

Refuge islands have many useful properties while providing for pedestrians. Depending on their shape and width they can narrow the street so they work as a speed reducing measure and they can also prevent certain manoeuvres such as over taking other cars and turning left (Svenska kommunförbundet, 1998). Refuge islands also improve the pedestrians' possibilities to cross the street, as it makes it possible to make a break in the middle of the street, see figure 9 (Institution of highway and transportation, 1997). By installing a refuge island the flow of motorized vehicles gets split up and there is only a need for the pedestrian to concentrate on traffic from one direction at the same time. This contributes to make the traffic situation easier and more understandable for the pedestrians (Svenska kommunförbundet, 1994).

The width of the refuge is of great importance to make sure that everybody that cross the street should fit on it on the peak hour. Persons with wheelchairs, rollators and other equipments are also in a need of more space than others and the size of the refuge is very important from their point of view as well (Institution of highway and transportation, 1997). Persons with impaired vision have a need of wide refuges and it should also be a low edge or a surface in another material than the surrounding to simplify for them (Svenska kommunförbundet, 1998).

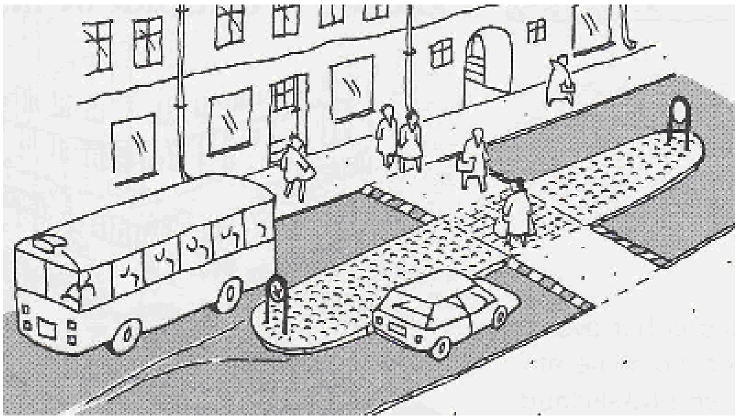

Figure 9. Raised pedestrian crossing with a refuge island (Svenska kommunförbundet, 1998)

Pavements and footpaths

Many pedestrians feel unsafe when they are walking in mixed traffic. Footpaths can be used to physically separate pedestrians from motorized vehicles. The intention is to increase the pedestrians' safety. The physical separation between the pedestrians and the motorized vehicles can be made by pavements and footpaths. The pavement is usually raised above the carriageway and separated with kerbstones. The footpaths are usually separated by a wide area between the carriageway and the footpath (Elvik and Vaa, 2004). Factors like width and leaning of the street must be taken into consideration when building footpaths and pavements (Svenska kommunförbundet, 1994). A study that compare two areas, one with footpaths and the other without, showed that the number of accidents was greater in the area without footpaths (Underlien Jensen 1998).

Fence and guard rails

Fences and guard rails should only be installed at places where it is certain risk of accidents due to pedestrians that cross the street at not suitable places (Institution of highway and transportation, 1997). The purpose of the fences and guard rails is to lead pedestrians to places where they can cross the street in a safe way and also to separate vulnerable traffic from the motorized traffic, see figure 10 (Svenska Kommunförbundet, 1998). Studies have showed that accidents with pedestrians involved have reduced significantly after the installation of guard rails and fences (Underlien Jensen, 1998). Factors that have to be taken into consideration when fences and guard rails are placed out is that it should not limit the visibility and it should not be possible to make short cuts (Svenska Kommunförbundet, 1998).

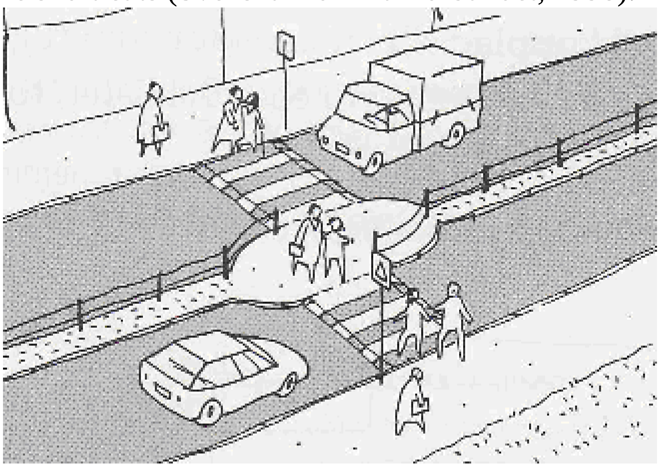

Figure 10. Fences that prevent the pedestrians from crossing the street at not suitable places (Svenska kommunförbundet, 1998)

2.5.4 Optical safety measures

Gateway

Gateways can be used to clarify that a new type of street with other conditions is starting. Using gateways is a good way to inform the road users that they are going into a city or a residential area or that they have to lower the speed. The gateway can be made by plants, lighting poles, a raised area or other arrangements, see figure 11. The best result of the gateway is when visual measures are combined with traffic calming measures (Svenska kommunförbundet, 1998).

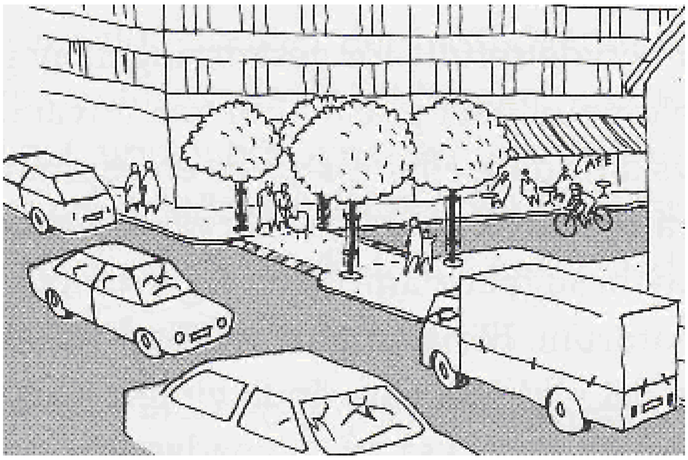

Figure 11. A gateway with a raised pedestrian crossing and plants (Svenska kommunförbundet, 1998)

Lighting

Increased lighting at places where pedestrians cross the street makes them more visible and increase thereby the pedestrians' traffic safety in darkness. Other places where lighting can be needed are places where it might be a need to make steps more visible, for example at information places and at public transport stops (Svenska kommunförbundet, 1998). Studies have showed that the number of accidents where pedestrians were involved dropped when road light was installed or when the existing light was improved (Underlien Jensen, 1998).

Material, colour and shape

Using a deviant material, colour or shape is a good way to make road users more attentive. It can also be used in an informative purpose or give information to road users about how to behave. For example choosing a deviant colour at crossings and exits and making pedestrian crossings with cobblestone makes road users more attentive and give them information to act carefully. Materials with an uneven surface also result in vibrations and sounds that contribute to lower speed (Svenska kommunförbundet, 1998). It is though very important to use materials that are not too uneven because that could result in difficulties for persons with impaired capacity (Svenska kommunförbundet, 1994).

An important factor for pedestrians with impaired vision is the presence of guide lines, something that the visually impaired can follow. If the pedestrian is partially sighted the guide line can be a contrasting colour. Those who are blind need guide lines that are possible to follow by the cane they are orientating with, which could be a material that differs from the surrounding material (The Swedish Association of the Visually Impaired, 2007).

Street furniture

Street furniture can be used to redefine the street space, strengthen the impression of gateways and also contribute to the visual effect of a narrow street (Institution of highway and transportation, 1997). Street furniture, such as traffic signs, can also be used to control behaviour and to give information to the road users (Elvik and Vaa, 2004).

Planting

Plants can be useful to strengthen the effect of gateways and traffic calming measures. When planting plants it is of great importance to make sure that they do not limit the visibility, limit persons ability to use the street and that there is no risk that it result in danger to the drivers of motorized vehicles (Svenska kommunförbundet, 1998).

2.5.5 Regulatory measures

Unprotected pedestrian crossing

Unprotected pedestrian crossings aim to lead the pedestrians to a point where it is suitable to cross the street and also to increase the attention of the drivers that there are pedestrians crossing the street. The motorized traffic should not drive faster than 30 km/h at the point of the crossing and it is recommended to combine the unprotected pedestrian crossing with traffic calming measures to secure that the speed is not higher than 30 km/h (Svenska kommunförbundet, 1998).

The risk of being involved in an accident is higher at unprotected pedestrian crossings than it is at crossings without marks. A study showed though, that if the unprotected pedestrian crossing is raised the speed is reduced and 3-6 times more drivers gave precedence to the pedestrian than the case was at the regular unprotected pedestrian crossing (Englund et al, 1998).

Signal controlled pedestrian crossing

At places where a marked pedestrian crossing does not provide enough safety to the pedestrians it could be signal controlled instead, see figure 12. The signal can be regulated automatically or the pedestrian have to press a button to receive green light. Studies have showed that the number of pedestrian accidents drop when signal controlled crossings are installed (Elvik and Vaa, 2004).

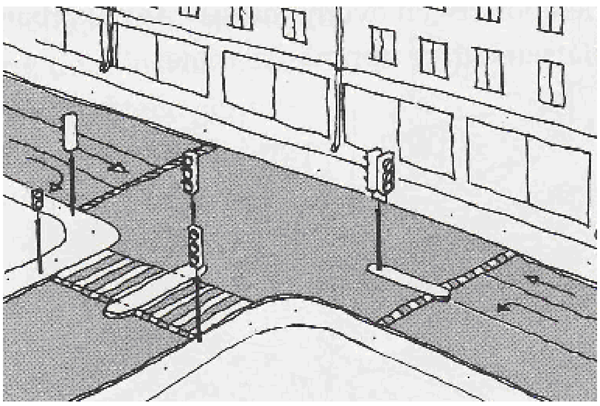

Figure 12. Signal controlled crossing (Svenska kommunförbundet, 1998)

2.5.6 Area-wide measures

Woonerf

Woonerf is an area where vulnerable road users are mixed with low speed motorized vehicles. The streets are narrow and there are no separate facilities, like pavements, for pedestrians. Trees, planters, parked vehicles and street furniture are placed out on strategic places to slow down the traffic (Pedestrian and bicycle information center, 2006). The street should have a structure that contributes to the impression that car drivers have to drive with low speed and be more careful (Svenska Kommunförbundet, 1996).

The risk of conflicts between different road users is greater when they are mixed in the same area. The speed is though very low on these streets which result in a lower risk of conflicts. When streets are changed from an ordinary street to a yard street, the number of serious conflicts usually decreases drastically (Svenska kommunförbundet, 1996). The aim of this measure is to decrease the volume of motor traffic and create an area available for public use (Pedestrian and bicycle information center, 2006).

Shared space

The principle of shared space is similar to the woonerf. Vulnerable road users are mixed with motorized vehicles. The fundamental principle is that the character of the street should give information to the road users about expected behaviour. Regulations, like speed bumps and traffic lights do not contribute to a social behaviour and should therefore not be used. Making the road users interact, they will have to negotiate about the priority. The speed is therefore automatically decreased. All road users have the same rights and obligations and everybody have to show respect and adapt to the situation. The main differences from the woonerf are that the mixed traffic is regulated at the woonerf and vehicles have to give priority to pedestrians (Hammarin and Warnelid, 2006).

3. Analysis of the present situation

The purpose of this chapter is to give a brief overview of the pedestrians' situation in Tallinn and to give an introduction to the studied street link.

3.1 Tallinn

The organisation of the road infrastructure in Tallinn can be seen in figure 13.

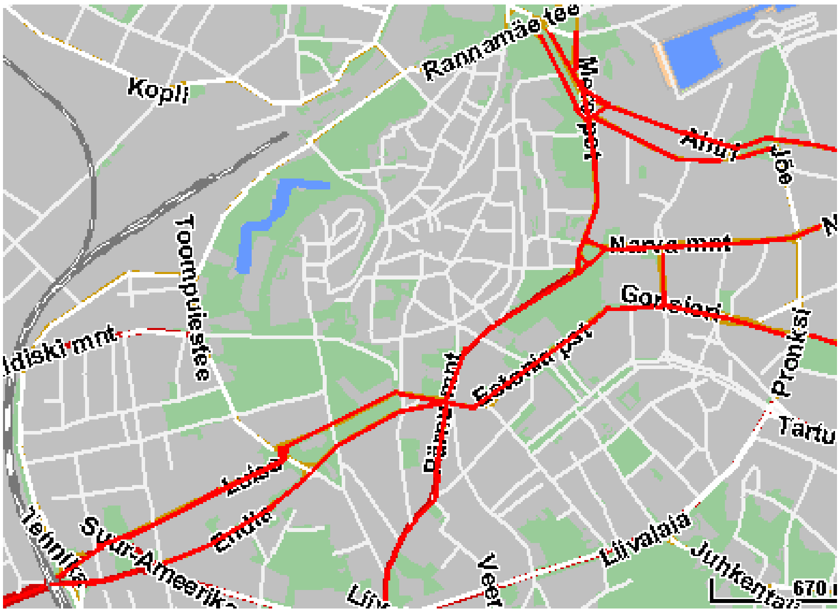

Figure 13. Central Tallinn with marked throughfares that have a high load factor (Eniro, 2007)

There is no by-pass route around central Tallinn and it is therefore big roads that are going into and through the city centre. These roads are marked in figure 2 and they are used as throughfares to get from one side of the city to the other. In 2005, the traffic flow on these roads varied between 700 and 3100 cars per hour during the evening rush hours (Stratum, 2005 b). The roads marked on the map are generally wide roads with two or more lanes in each direction. Except for the ordinary traffic, there is also public transport running on all of these roads. There are three types of public transport in Tallinn (buss, trolley buss and tram) and more than one type operates on some of the marked roads.

3.1.1 Pedestrian accidents in Tallinn

Pedestrians are run over by cars in greater extent in the bigger cities in Estonia than in smaller cities and the problem is especially big in Tallinn (Stratum, 2006). The total number of pedestrian accidents and the total number of killed pedestrians in Tallinn during the last four years can be seen in table 1.

Table 1. Number of accidents with pedestrians in Tallinn 2003-2006 (Stratum, 2006)

	2003	**2004**	**2005**	**2006**
Accidents	358	366	332	279
Killed pedestrians	9	18	9	13

The number of accidents presented in table 1 is based on accidents reported to the police. About half of the pedestrian accidents in Estonia occur in Tallinn and the fact that about one third of the people in Estonia lives in Tallinn indicate that the problem is of greater extent in Tallinn than in other parts of Estonia.

It is very likely that many accidents that occur are not reported to the police and the number of accidents is therefore likely to be higher than the figures in table 1 indicate.

The distribution in time of these accidents can be seen in figures 14-15.

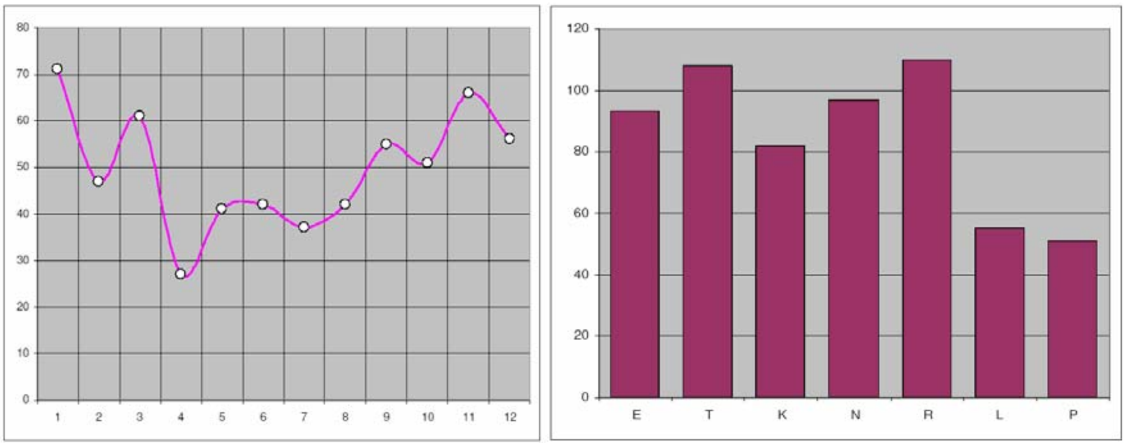

Figure 14. Distribution of pedestrian accidents in time in Tallinn. To the left: Distribution over the months. To the right: Distribution over the week days, where E-P is Monday-Sunday (Stratum, 2006)

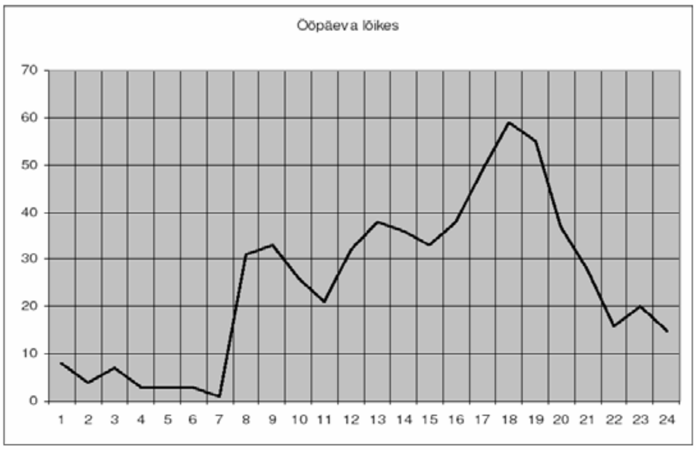

Figure 15. Distribution of pedestrian accidents during the day (Stratum, 2006)

Figures 14 and 15 show that most accidents occur during the winter, especially in January and November. There are a noticeable lower number of accidents during the spring and summer, April to August. Further, there are more accidents on working days than it is during the week ends and the peak of the week is on Fridays and on Tuesdays. Finally, most accidents occur between 16.00 and 20.00. Noticeable is also that there are peaks during the morning rush hour and during the lunch time as well.

Distribution of street element where pedestrian accidents occur in Tallinn can be seen in figure 16.

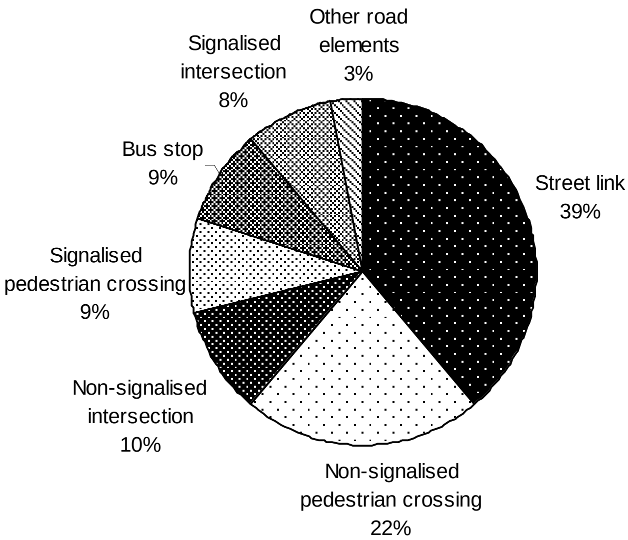

Figure 16. Location of pedestrian accidents in Tallinn, 2002-2005 (Antov, 2006)

Figure 16 shows that the majority of the pedestrian accidents in Tallinn occur at a street link. Noticeable is though that accidents happening in the vicinity of a specific road element are included in this category, which might affect the result. Apart from the accidents at street links, accidents at non-signalized crossings are most common (Antov, 2006). Four of the street elements in figure 16 are represented at the studied street link; street link, non-signalised pedestrian crossing, signalised pedestrian crossing and bus stop.

3.2 The studied street link

The street link that has been studied is located in the city centre of Tallinn and it is limited by the park it runs through. To get from the new town to the old, the natural way is to walk through the park and then cross Pärnu mnt. This results in high flows of pedestrians that cross the street at the crossings within the park.

3.2.1 Target points

As the area is located in the city centre there are many different target points in connection to it. There are shops, restaurants, cafés, cinemas, museums, theatres, night life and other activities for pleasure everywhere in the area and in direct connection to it. These activities generate people to the area and thereby also pedestrians. There are also schools, hospitals and apartments in connection to the area, which also contribute to the high flow of pedestrians (Tallinn homepage, 2007 a). Some of the above mentioned activities can be seen in figure 17.

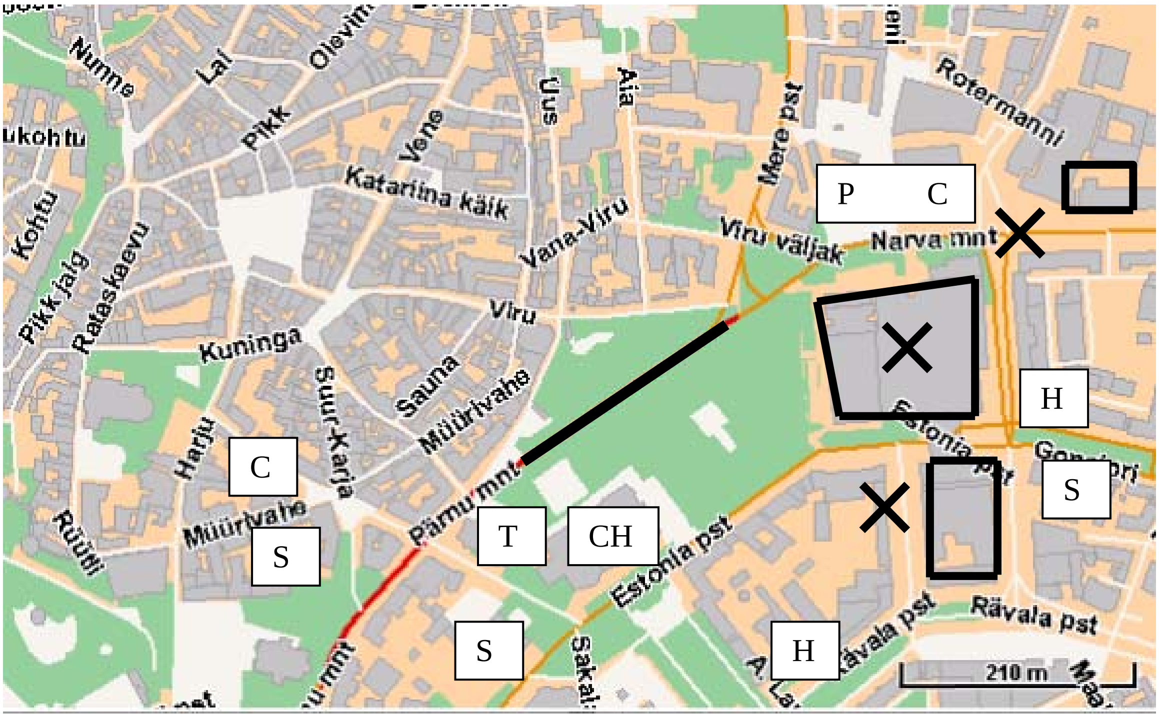

Figure 17. Main target points in connection to the studied street link. The squares symbolizes shopping centres, crosses public transport stops and S stands for school, H for hospital, P for post office, CH for concert hall, C for cinema and T for theatre. (Eniro, 2007)

The old city is located northwest of the studied street link. There are various target points within the old city, cafés, restaurants, night life, shops, museums and tourist attractions are located all over the old city. Except for the schools marked out on the map, there are another six schools within the old city and a few more south of the area that is covered by figure 17.

The shopping centres marked out on figure 17 are the main shopping centres in the city and except for shops there are also other services within them, for example bank service, restaurants, cafés and tourist information.

Main stops for all available public transport modes in Tallinn are located in direct vicinity to the studied street link. The main stop for busses is located under the shopping centre marked out in figure 17. This bus terminal is the start and/or end station for many bus routes. All trolley busses with a route from/to the city centre depart/arrive at the stop marked out with a cross in the southeast on the map (figure 17). The main tram stop is located at Narva mnt, see figure 17. This station is not a start/end station but more like a transfer point, which all tram routes goes through.

There are also cultural activities in the vicinity of the street link, for example theatres, a concert hall and cinemas. The main cultural activities are marked out on figure 17, but there are also a lot of other places to go that are not marked out.

3.2.2 Basic conditions

The studied street link has two lanes in each direction, is 24 meters wide, 203 meters long and has tram tracks in the middle of the street, see figure 18.

Figure 18. An overview of the studied street link

The lanes are generally wide, the width differs between 3 and 4.5 meters, see figure 19.

Figure 19. The lanes are very wide

After the signal controlled pedestrian crossing the lane in the middle towards Pärnu mnt is moved towards the tram tracks and cars and trams use the same lane, see figure 20.

Figure 20. Trams and cars use the same lane in one direction

The lane closest to the pavement in direction towards Pärnu mnt is only used by busses and there are bus stops along it, see figure 21.

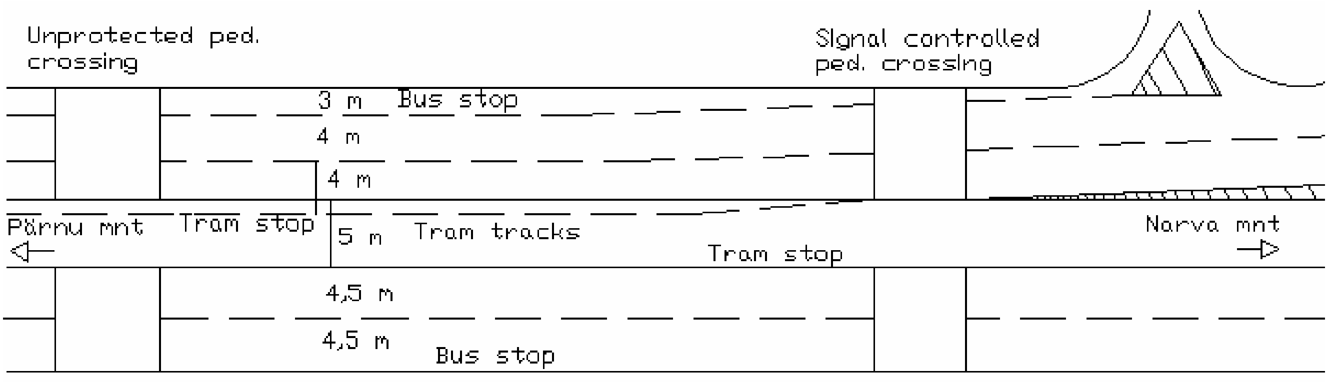

Figure 21. Sketch of the street link

There are no refuge islands at the pedestrian crossings and the pedestrians thereby have to cross the 24 meter wide street in a row, see figure 22.

Figure 22. The street does not have any refuge islands

There are no platforms at the tram stops, which means that tram travellers are walking right out on the street while getting of the tram. Cars arriving on the same time as trams have to stop behind the tram to let tram travellers on and off the tram, see figure 23.

Figure 23. Cars stop behind the tram when passengers get off

Car drivers are also by law obligated to stop at the unprotected pedestrian crossing to let pedestrians cross the street. Worth to mention is also that the law state that it is forbidden to drive against yellow light in the traffic signal (Lavrentjev, 2002).

3.2.3 Traffic

The traffic flow on Pärnu mnt, during the evening rush hours in 2005, was 1613 cars per hour in the direction towards Pärnu mnt. The traffic flow, at the same time, in the direction towards Narva mnt was 1165 cars per hour (Stratum, 2005 b).

There are also two types of public transport operating on the studied street link, bus and tram. The location of the bus stops and tram stops can be seen in figure 21. There are eight bus lines and two tram lines that have their routes on the street. Two bus lines have their route in both directions on the street and the other six bus lines that are operating on the street link only have traffic in the direction towards Pärnu mnt. The total number of busses that pass the street during the rush hour (16.00-17.00) at working days is 39 in the direction towards Pärnu mnt and 13 in the direction towards Narva mnt. The total number of trams that passes the street during the same time is 21 in each direction (Tallinn homepage, 2007 b).

3.2.4 Accidents

The number of pedestrian accidents, which are relevant to the study, is five during the last years. The number of accidents is based on accidents that have been registered at the police. Many accidents that occur are very likely not to be reported to the police, which mean that the number of accidents is very likely to be higher than the presented figures indicate. Smaller accidents with less extensive consequences might be ignored by the involved and thereby not reported to the police. These sorts of accidents are difficult to survey and the number of accidents that are not reported to the police might be high. Those accidents that have occurred between 2002 and 2005 at the studied street link and been reported to the police can be seen in figure 24.

Figure 24. Location and number of pedestrian accidents 2002-2005. The dot symbolizes one accident which occurred in 2002 and each cross symbolizes two accidents which occurred in 2002 and 2003 (Eniro, 2007)

The accident symbolized with a dot occurred in 2002 at the unprotected pedestrian crossing. The accidents symbolized with the cross in the middle occurred in 2002 and the other in 2003. These accidents occurred between the signal controlled pedestrian crossing and the unprotected pedestrian crossing, in connection to the tram stop. The two accidents symbolized with the cross to the right occurred in 2002 and 2003 in connection to the signal controlled pedestrian crossing (Stratum, 2005 a).

4. Empirical study

To analyse the traffic situation at the street link of Pärnu mnt various observational methods have been used in the field study. The methods that have been used are:

- Document the use of the street and problems that pedestrians face in the traffic by ocular inspection
- Speed measuring
- Count flow of pedestrians
- Count flow of cars
- Queue length
- Time to cross the unprotected pedestrian crossing
- Interviews
- Behavioural studies

4.1 Ocular inspection

To analyse how the street is used and problems that pedestrians face in connection to the street an ocular inspection was done. These observations resulted in a picture of aspects that influence the pedestrians' situation in traffic, constituting a base for the preparation of the consecutive observational studies. The ocular inspection was carried out during the evening rush hours, 16.00 to 18.00, between Tuesday the 17th and Friday the 20th of April 2007.

4.2 Speed measuring

Speeds measuring with a radar gun were done to find out about the speed of the motorized vehicles at Pärnu mnt. Only cars that could choose speed themselves and cars that were driving without being disturbed were measured. This means that cars coming in a column of vehicles or cars that were disturbed by pedestrians that was waiting to cross the street were not measured. The speed measuring was made in both directions at the unprotected pedestrian crossing and at the signal controlled pedestrian crossing within the studied street link. The speed was measured about 10 meters before the crossing and the total number of measured vehicles was 60 per direction. The measuring was made between 08.00 and 12.00 in the morning at Wednesday the 11th and Thursday the 12th of April 2007.

4.3 Flow of pedestrians

Flow of pedestrians was counted at the signal controlled pedestrian crossing and at the unprotected pedestrian crossing. In both cases the flow was counted during the evening rush hour, 16.00-17.00. The counting at the signal controlled pedestrian crossing was done at Wednesday the 11th of April and the counting at the unprotected pedestrian crossing was done at Friday the 13th of April 2007. Because of the high flow of pedestrians at the signal controlled pedestrian crossing the flow was counted in one direction at the time in intervals of 15 minutes. This means that the flow was counted for 30 minutes in each direction and the result was therefore multiplied with two to get the hourly flow.

4.4 Flow of cars

Flow of cars was counted between the signal controlled pedestrian crossing and the unprotected pedestrian crossing. There are no options to turn off from the street before the crossings and the flow can thereby be supposed to be the same at the pedestrian crossings. The counting was done during the evening rush hour, 16.00-17.00 at Thursday the 12th of April 2007. Because of the high flow of cars the traffic was counted in one direction at the time in intervals of 15 minutes. This means that the flow was counted for 30 minutes in each direction and the result was therefore multiplied with two to get the hourly flow.

4.5 Queue length

The queue length of cars was counted during the evening rush hour at the signal controlled pedestrian crossing. Only cars that was standing still at the time when the signal turned green was counted. Cars that reached the queue just after the signal turned green and had to stop because the queue was not wound up was not counted. The queue length was counted in one direction at the time and in intervals of 15 minutes between 16.00 and 17.30 at Tuesday the 17th of April 2007.

4.6 Time to cross the unprotected pedestrian crossing

The time it takes for pedestrians to cross the street at the unprotected pedestrian crossing, including waiting time was measured. Every fifth pedestrian was measured and the time was divided into waiting time and time to cross the street. Waiting time was considered as the time it took from that the pedestrian reached the crossing until he/she started to cross the street. The measuring was done at Monday the 16th of April between 15.30 and 17.20 and the total number of pedestrians that was observed was 150.

4.7 Interviews

To get a better picture of what the pedestrians think about the street link and its surroundings a number of interviews was made. The total number of interviewed pedestrians was 100. The interviews were made during four days, Saturday and Sunday the14-15th and Thursday and Friday the 19-20th of April. Half of the interviews were made in connection to the signal controlled pedestrian crossing and the other half in connection to the unprotected pedestrian crossing. The last question was specific for the crossing where the interview was made. This means that 50 pedestrians were asked about the signal controlled pedestrian crossing and the other 50 were asked about the unprotected pedestrian crossing. The interview consisted of five questions and four of them were standardised questions. Three of the four standardised questions also had an open complementing question. The interviews were made in Estonian and all interviews started with an explanation of which area the interview is about and also a short explanation of the aim of the study. The interview form can be seen in appendix 1.

4.8 Behavioural studies

Behavioural studies were made at the signal controlled pedestrian crossing and at the unprotected pedestrian crossing. The studies aimed to elucidate:

- How many car drivers that drive against yellow and red light
- The interaction between pedestrians and vehicles at the unprotected pedestrian crossing
- If the pedestrians cross the street at other places than marked out pedestrian crossings

The behavioural studies were carried out on Friday the 13th, Monday the 16th and Wednesday the 18th of April 2007. All the observations were made during the morning and lunch time, between 09.00 and 13.00. The weather was clear and sunny all days and the light situations were good as the observations were carried out during day light in good weather conditions.

5. Results

All results from the empirical study are presented in this chapter.

5.1 Ocular inspection

The ocular inspection of the street link and its surroundings showed that it is a very heterogenic group of pedestrians that are using the street. There is a mix of males and females in all ages, children, youths, middle aged and elderly. There are also some pedestrians with reduced ability that use the street and elderly with impaired mobility is the dominating group among them.

The surface evenness varies along the street link and there are holes and cracks at some places on the pavement, see figure 25. The holes and cracks result in an uneven surface that can cause problems for some pedestrians.

Figur 25. Cracks and holes on the pavement

There are also some trees in the park along the street that are placed in the middle of the footpath, see figure 26. These trees can be difficult to notice for pedestrians with impaired vision and could thereby result in inconvenience for them. Another factor that might complicate for pedestrians with impaired vision is the lack of guide lines at both pedestrian crossings.

Figure 26. Trees in the middle of the pavement

Both pedestrian crossings are provided with lighting, which make pedestrians more visible and easier to recognize. The kerbs are also dropped at both pedestrian crossings, which make it easier for pedestrians to cross the street. The dropped kerbs facilitate especially for pedestrians with impaired mobility, impaired vision and pedestrians that use any sort of equipment.

5.1.1 Signal controlled pedestrian crossing

The traffic signal is time regulated and the total cycle length is 75 seconds. Pedestrians have green light for 22 seconds and then there is a clearance period of 6 seconds. The motorized vehicles then have green light for 42 seconds, followed by yellow light for 3 seconds and then a clearance period of 2 seconds before the pedestrians get green light again. The signal is also equipped with a sound signal so pedestrians with impaired vision know when they can walk and when they can not. When the flow of pedestrians was observed it was very obvious that the time pedestrians have green light is too short. Some pedestrians do not have time to cross the street during the green light period, but thanks to the long clearance period they get to the other side of the street before the signal turns green for the cars. Only pedestrians arriving before the green light have time to cross the street during the green light. Others, who arrive during green light have to run over the street to be able to cross it before the signal turns red.

Another thing that causes problems for the pedestrians is the fact that the tram stop is in front of the signal, in direction towards Narva mnt, and that there is no platform to stand on. All cars have to stop behind the tram when it stops so tram travellers can cross the two lanes and get on and off the tram. The car drivers follow this rule but when they have green light in the signal they are more anxious to get away and that often result in that elderly getting of the tram do not have time to walk to the side of the street. They thereby have to wait for green light in the middle of the street on the tram tracks, see figure 27.

Figure 27. To the left: A couple who did not have time to cross the street after they got of the tram are walking on the tram tracks. To the right: Same couple have found a place to wait until the traffic signal turns green.

There are also some car drivers who cross the painted refuge island in front of the pedestrian crossing to overtake the queue. This results in that the two lanes become three.

5.1.2 Unprotected pedestrian crossing

When cars in the first lane stop at the unprotected pedestrian crossing it is very common that cars in the second lane do not. This results in that many pedestrians have to wait in the street for cars in the second lane to stop. The same scenario is also very common when the pedestrians have crossed the lanes in one direction. Cars in the other direction do not stop and the pedestrians thereby have to wait in the middle of the street.

The bus lane is used 50 meters before the unprotected pedestrian crossing but the full width of it is still left at the unprotected pedestrian crossing. This results in that some car drivers use this lane to overtake the queue in front of the unprotected pedestrian crossing or when they turn right, into the parking lot a few meters after the unprotected pedestrian crossing. Practically, the two lanes often become three.

There is a tram stop in front of the unprotected pedestrian crossing in the direction towards Pärnu mnt. The cars have to stop behind the tram when it stops and the car drivers always follow this rule, see figure 28. The car drivers are not anxious to get away in the same way as they are at the signal controlled crossing, which give the pedestrians a good opportunity to cross the street at the same time as the tram stops.

Figure 28. Tram travellers get off the tram while car drivers wait behind the tram

There is also a garbage bin at the unprotected pedestrian crossing that blocks the view for the pedestrians and it also makes it more difficult for car drivers to catch sight of the pedestrian, see figure 29.

Figure 29. A rubbish bin blocks the view at the unprotected pedestrian crossing

5.2 Vehicle speeds

Curves of speed distribution in both directions at the signal controlled pedestrian crossing and at the unprotected pedestrian crossing can be seen in figures 30-33. Number of measured vehicles, mean speed and standard deviation can be seen in table 2.

Table 2. Results from the speed measuring

	Signal controlled pedestrian crossing		Unprotected pedestrian crossing	
	Towards Narva mnt	Towards Pärnu mnt	Towards Narva mnt	Towards Pärnu mnt
Number of measured vehicles	60	60	60	60
Mean (km/h)	46.6	47.6	50	50.6
Standard deviation (km/h)	8	7.7	7.2	5.6

Table 2 shows that the mean speed is higher at the unprotected pedestrian crossing than it is at the signal controlled pedestrian crossing. Table 2 also indicates that the speed is very similar in both directions at both pedestrian crossings.

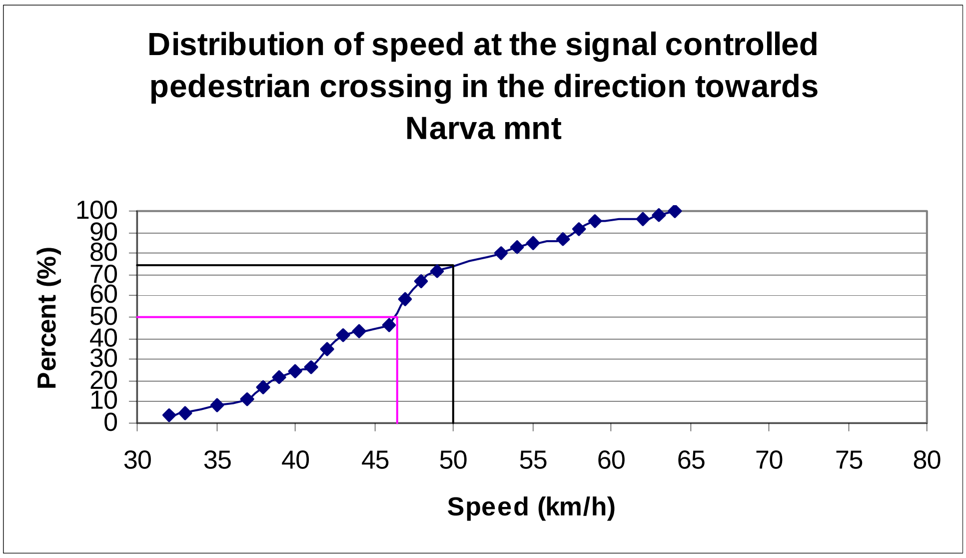

Figure 30. Distribution of speed at the signal controlled pedestrian crossing in the direction towards Narva mnt.

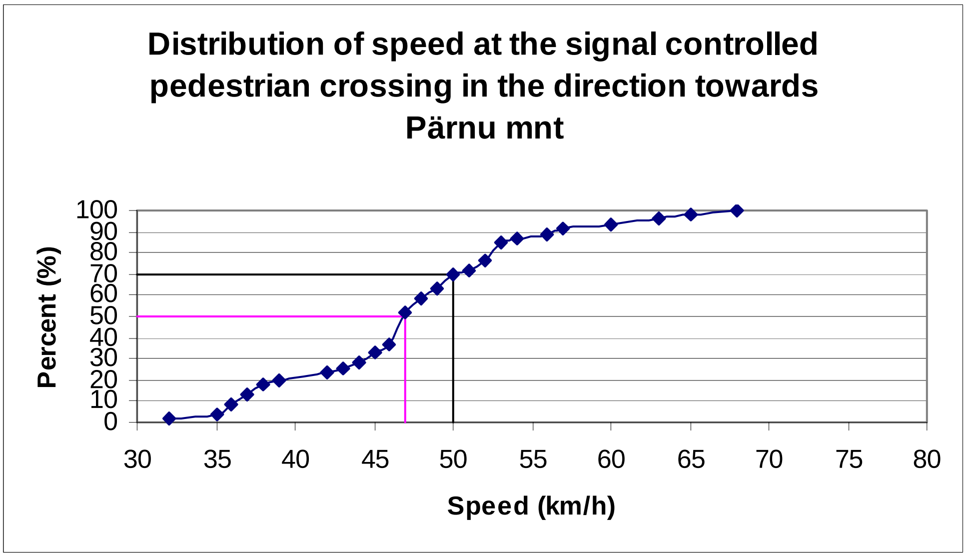

Figure 31. Distribution of speed at the signal controlled pedestrian crossing in the direction towards Pärnu mnt.

Figure 30 shows that the speed varied between 32 km/h and 64 km/h in the direction towards Narva mnt. The mean speed in the same direction was 46.6 km/h. Figure 31 shows that the speed varied between 32 km/h and 68 km/h in the direction towards Pärnu mnt and the mean speed was 47.6 km/h in this direction as well. Figure 30 and 31 also indicate that between 20 and 30 % of the car drivers are driving above the speed limit at the signal controlled pedestrian crossing. The 50-percentile is also marked in the figures and it is 46 km/h in the direction towards Narva mnt and 47 km/h in the opposite direction.

Distribution of speed at the unprotected pedestrian crossing can be seen in figures 32 and 33.

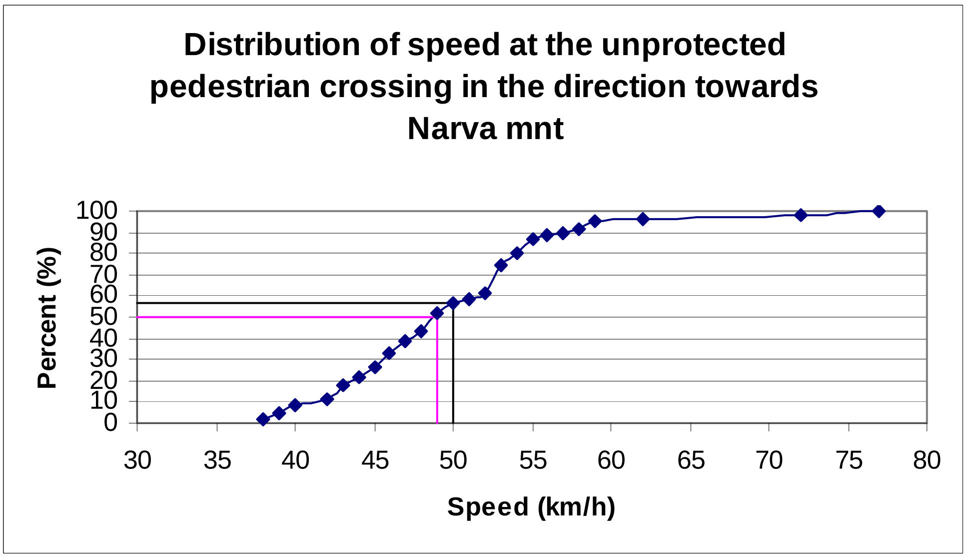

Figure 32. Distribution of speed at the unprotected pedestrian crossing in the direction towards Narva mnt.

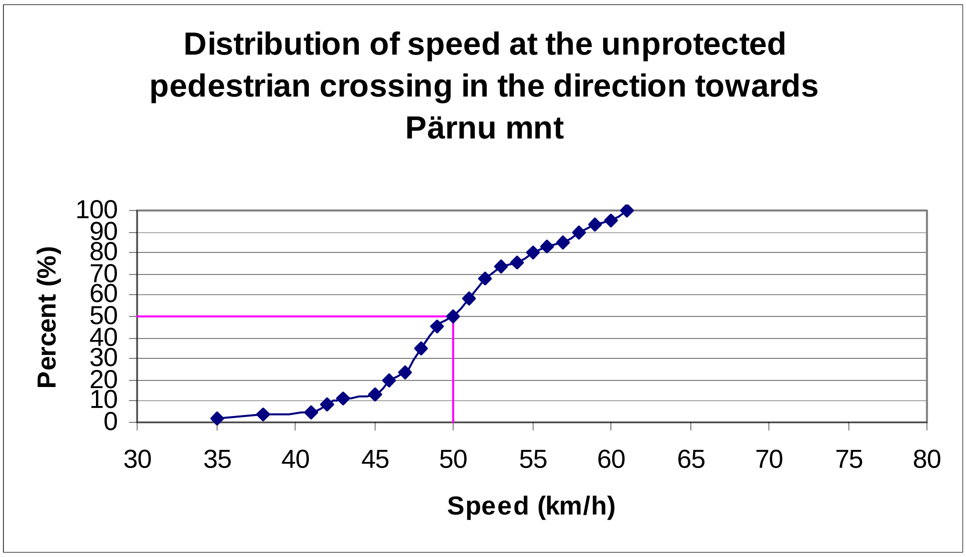

Figure 33. Distribution of speed at the unprotected pedestrian crossing in the direction towards Pärnu mnt.

Figure 32 shows that the speed varied between 38 km/h and 77 km/h at the unprotected pedestrian crossing in the direction towards Narva mnt. The mean speed was 50 km/h. In the opposite direction the speed varied between 35 km/h and 61 km/h and the mean speed was 50.6 km/h. Figures 32 and 33 shows that between 40 and 50 % of the car drivers are driving above the speed limit at the unprotected pedestrian crossing. Further, the figures show that the 50-percentile in the direction towards Narva mnt is 49 km/h and in the opposite direction the 50-percentile coincide with the speed limit, 50 km/h.

5.3 Flow of pedestrians

Counted in hourly flow, the total number of pedestrians that crossed the street at the signal controlled pedestrian crossing was 1514 in one direction and 1334 in the other. The total flow of pedestrians at the signal controlled pedestrian crossing was 2848 pedestrians per hour. Number of pedestrians that crossed the street each time interval can be seen in table 3.

Table 3. Number of pedestrians that crossed the street each time interval.

Time interval	Direction	
	Towards old city	Towards park
16.00-16.15	382	
16.15-16.30		341
16.30-16.45	375	
16.45-17.00		326

The flow of pedestrians at the unprotected pedestrian crossing was counted between 16.00 and 17.00 and because of the lower number of pedestrians at this crossing the pedestrians was counted in both directions at the same time. The number of pedestrians who crossed the unprotected pedestrian crossing in the direction towards the old city was 247 and the number of pedestrians in the other direction was 227, which result in a total number of 474 pedestrians during the evening rush hour.

5.4 Flow of cars

The hourly traffic flow on the studied street link was 1012 cars per hour in the direction towards Narva mnt and 1230 cars per hour in the opposite direction. Number of cars that passed the street link each time interval can be seen in table 4.

Table 4. Number of cars that passed the street link each time interval.

Time interval	Direction	
	Towards Narva mnt	Towards Pärnu mnt
16.00-16.15	241	
16.15-16.30		314
16.30-16.45	365	
16.45-17.00		301

5.5 Queue length

The average number of cars in queue in each lane at the time when the traffic signal turned green can be seen in table 5.

Table 5. Average number of cars in queue at the time when the signal turned green.

Time	Towards Pärnu mnt		Towards Narva mnt	
	Lane 1	Lane 2	Lane 1	Lane 2
16.00-16.15	7.4	5.1		
16.15-16.30			4.5	5.1
16.30-16.45	9.2	8.3		
16.45-17.00			3.5	4.3
17.00-17.15	10.3	8.1		
17.15-17.30			4.7	4.9
Average	9	7.2	4.2	4.8

Table 5 shows that the number of cars in queue is larger in the direction towards Pärnu mnt. During the time queue lengths were counted the queue always wound up during the green time.

5.6 Time to cross the unprotected pedestrian crossing

The time it takes for pedestrians to cross the unprotected pedestrian crossing was measured for 150 pedestrians. The waiting time varied between 0 and 46 seconds and the average waiting time was 5.6 seconds. The walking time varied between 8 and 25 seconds and the average time was 13.4 seconds. The average total time to cross the street was 19 seconds.
73 % of the pedestrians had to wait at the unprotected pedestrian crossing and the average waiting time among them was 7.6 seconds.

5.7 Interviews

The results from the interviews are presented in figures 34-42 below. The answers are divided in how men and women answered the question and the total number of men respectively women was 34 respectively 66.

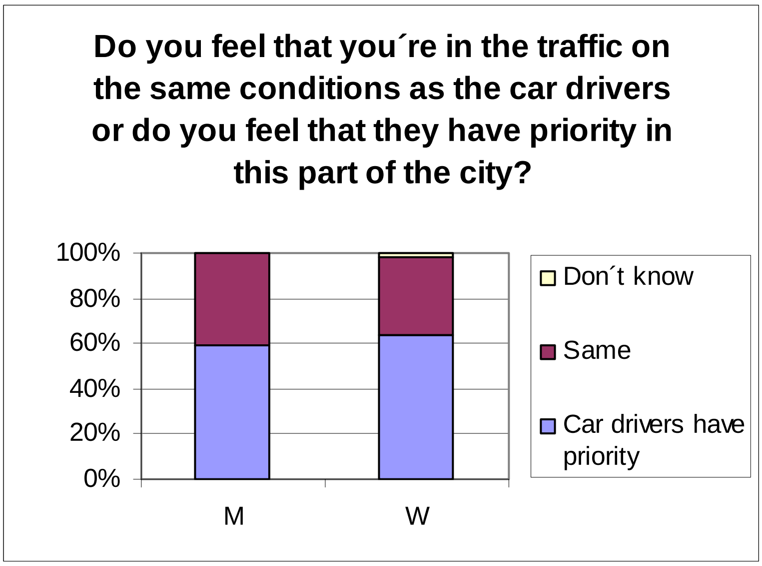

Figure 34. Result of the question concerning pedestrians' feeling if car drivers have priority

Figure 34 shows that the majority of the pedestrians feel that car drivers have priority in the referred part of the city. Further, the figure also indicates that men and women share the same opinion but women answered in a little higher extent that car drivers have priority.

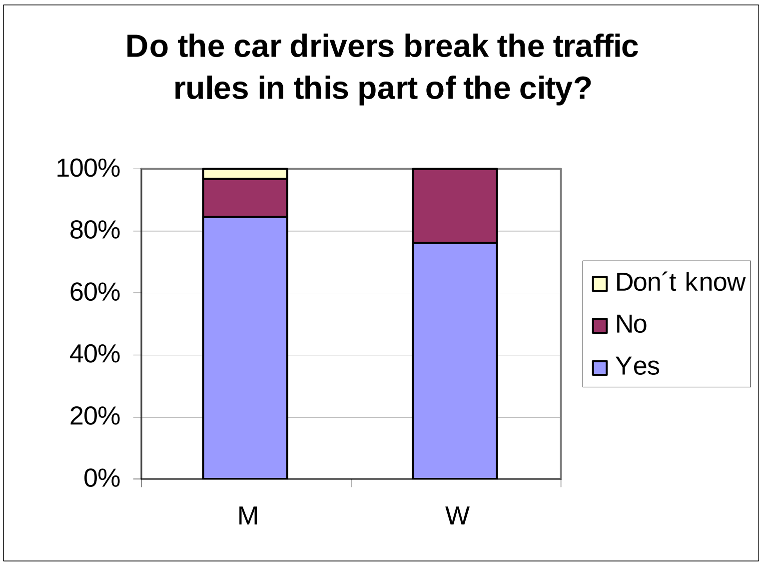

Figure 35. Result of the question concerning if car drivers break traffic rules.

Figure 35 shows that the majority of the pedestrians think that car drivers break the traffic rules in the referred part of the city. Men and women agreed on this question as well but men answered in a higher extent that car drivers break the traffic rules. 84 % of the men and 76 % of the women answered that car drivers break the traffic rules.

Those who answered yes to the question above were also asked what rules the car drivers break. This question was open and they could give as many answers they wanted to. The result of the question can be seen in figure 36.

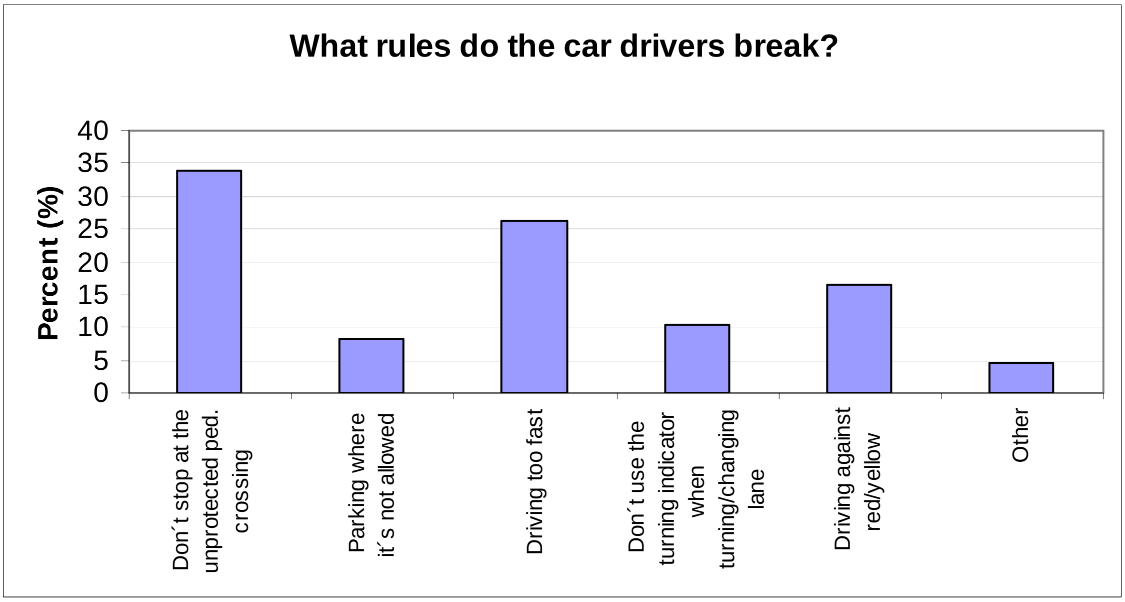

Figure 36. The result of the question concerning what rules the car drivers break.

The dominating answer to this question was that car drivers do not stop at the unprotected pedestrian crossing and let pedestrians cross the street. Thereafter, speeding and driving against red/yellow light were the most frequent answers. Answers belonging to the group “other” consist of occasional answers like two lanes become three, car drivers drinking and driving, cars do not stop at tram stops and car drivers talk in mobile phone while driving.

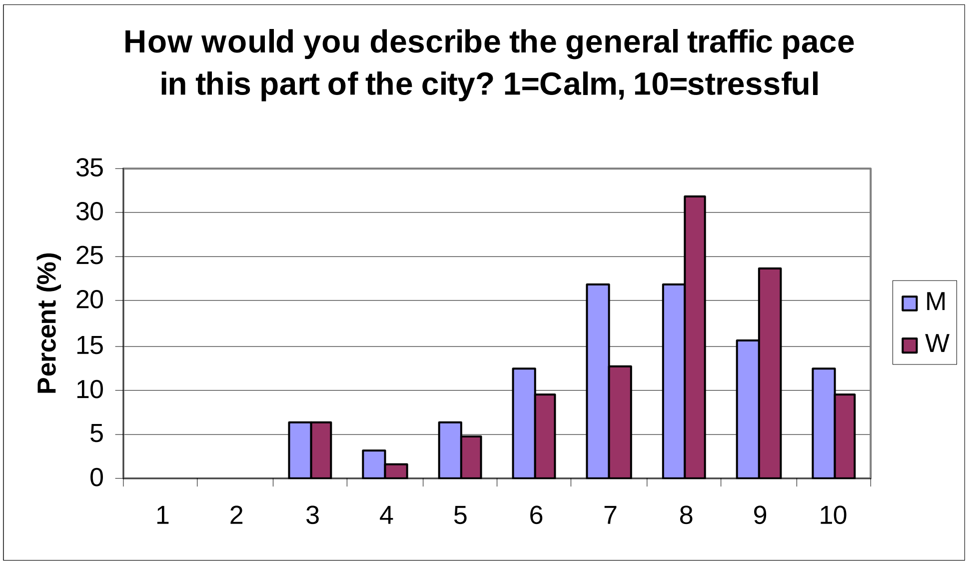

Figure 37. Description of the general traffic pace

Figure 37 shows that the pedestrians refer to the traffic as stressful rather than calm in the mentioned part of the city. The average description of the traffic pace among women was 7.6 and 7.3 out of ten among men.

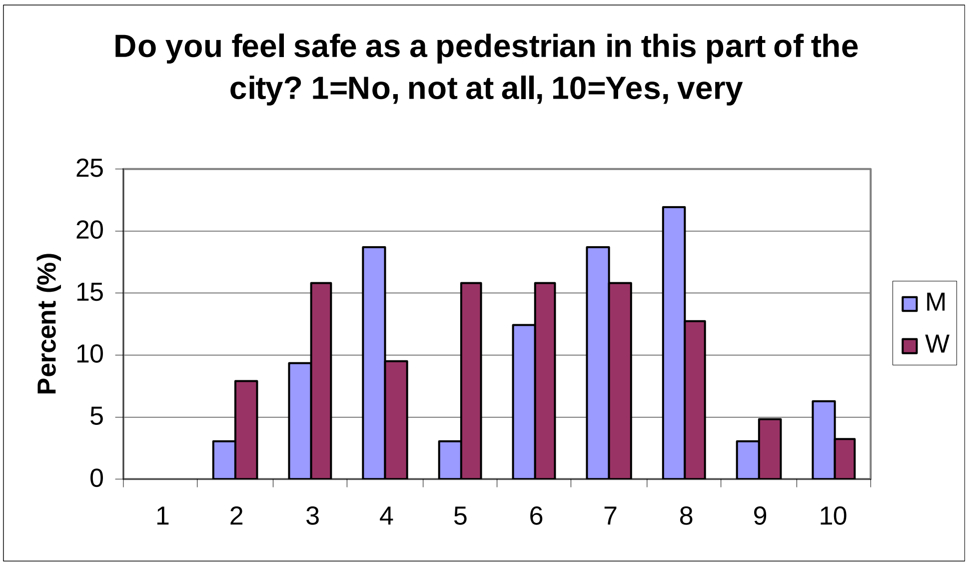

Figure 38. Result of the question concerning the pedestrians' feeling of safety

The answer to this question differed a bit and it is hard to notice a trend in the answers. About half of the pedestrians (45 %) answered within the interval 1-5 and the other half (55 %) in the interval 6-10 which can be understood as half of them feel safe and the other half feel more unsafe. The average among men is 5.9 and 5.6 out of ten among women, which indicate that there is no difference between how men and women feel.

Half of the interviews were made at the unprotected pedestrian crossing and the result with answers frequency to the question can be seen in figure 39 and 40.

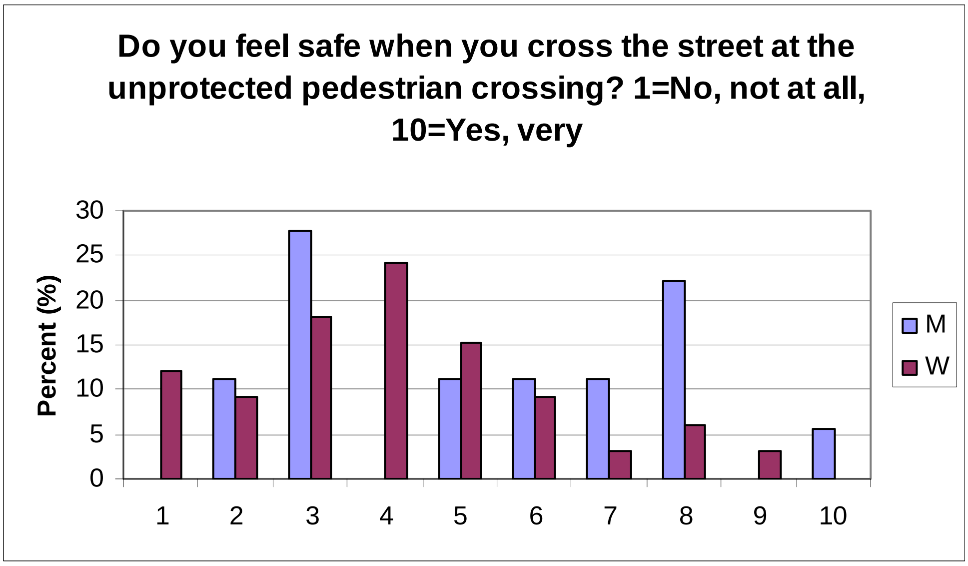

Figure 39. Feeling of safety when crossing the unprotected pedestrian crossing.

Figure 39 shows that 69 % of the asked answered five or lower and 31 % answered 6 or higher. This means that about 70 % of the pedestrians who cross the street at the unprotected pedestrian crossing feel more unsafe than safe. There is a small variation in the answers between men and women. Men feel generally safer than the women when crossing the unprotected pedestrian crossing. The average among men is 5.4 and the average among women is 4 out of ten.

Those who answered in the interval 1-5 were also asked an additional question concerning why they feel unsafe when crossing the unprotected pedestrian crossing. The result of the question can be seen in figure 40.

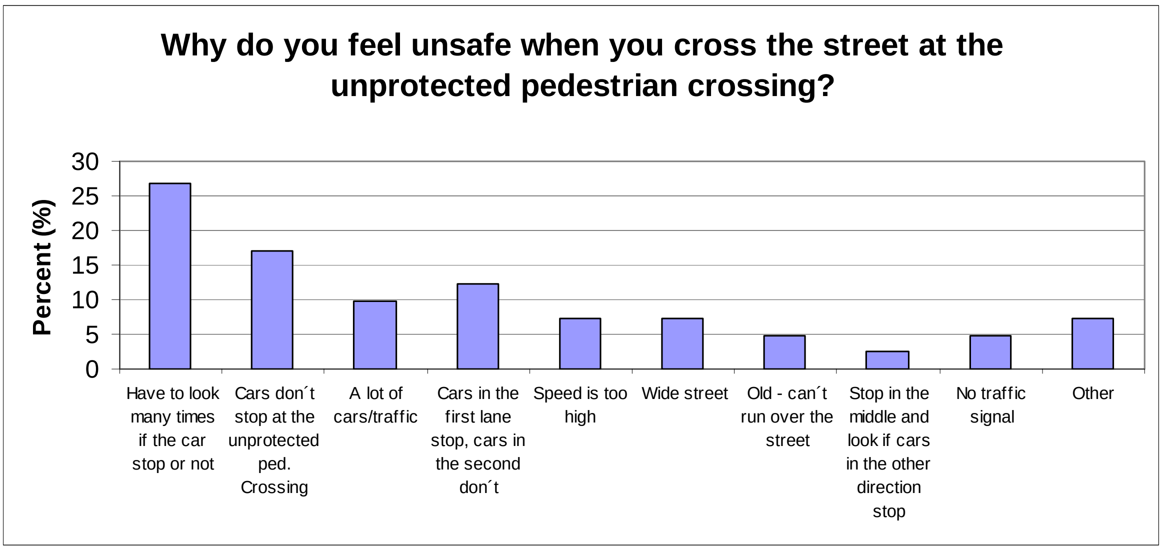

Figure 40. The reason for the unsafe feeling at the unprotected pedestrian crossing

As seen in figure 40 the most frequent answer why pedestrians feel unsafe was that they were unsure if cars would stop or not while they were crossing the street. Thereafter, the most common reason was that cars in the second lane keep driving while cars in the first lane stop.

Among the category "other" was for example drink driving and poor visibility due to objects that blocks the view mentioned.

The second half of the interviews were made in connection to the signal controlled pedestrian crossing. The result with answers frequency to the question can be seen in figures 41 and 42.

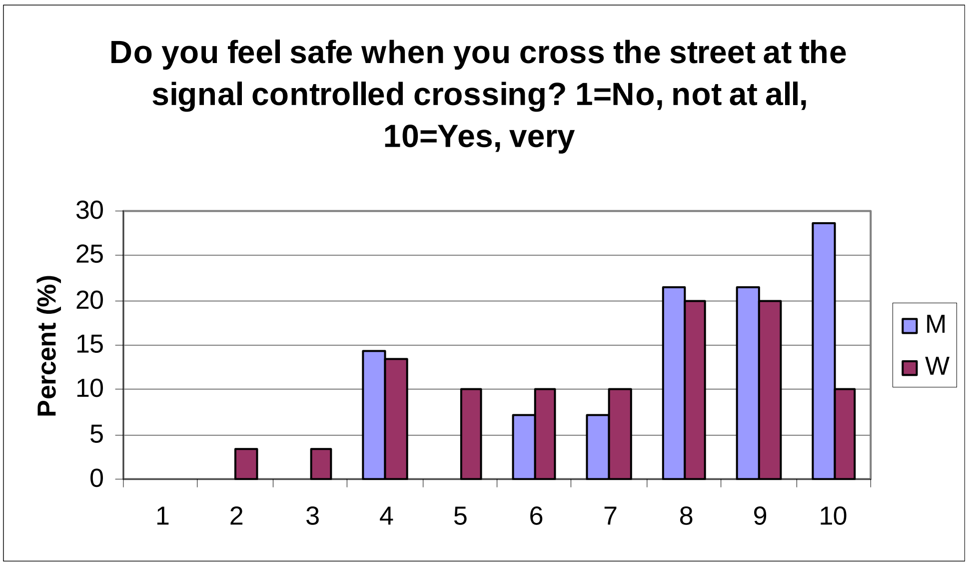

Figure 41. Feeling of safety when crossing the signal controlled crossing.

Figure 41 shows that the majority of the pedestrians feel safe while crossing the street at the signal controlled crossing. Both men and women are of the same opinion but men feel safer in a higher extent. The average among men was 8 while it was 6.9 out of ten for women. Almost all of those who answered that they feel safe answered that it was because of the traffic signal. Those who answered in the interval 1-5 were asked why they feel unsafe when they cross the street at the signal controlled crossing. The result can be seen in figure 42.

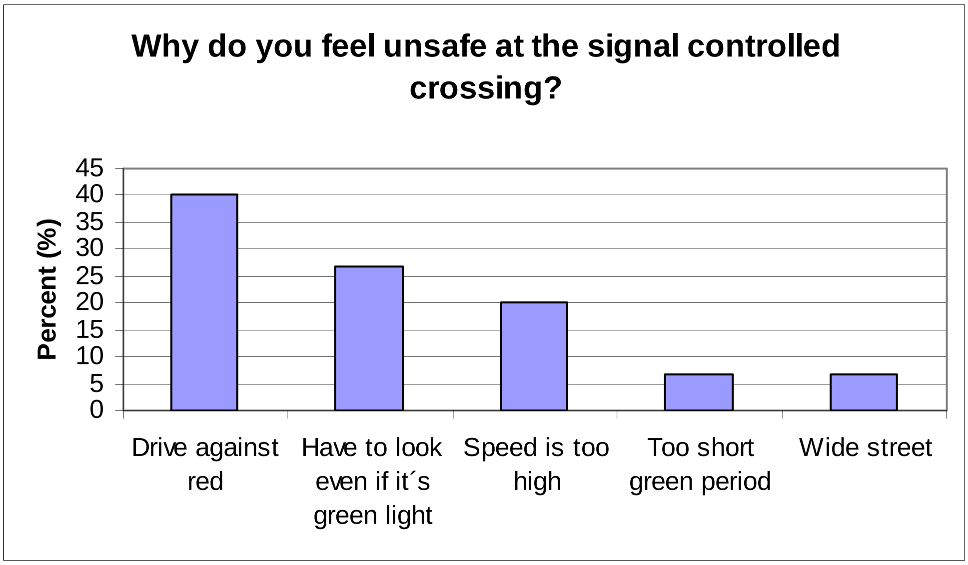

Figure 42. The reason for why some feel unsafe at the signal controlled crossing.

As seen in figure 42, the most common answer was that car drivers drive against red and that the pedestrians have to look even if they have green light in the signal.

5.8 Behavioural studies

5.8.1 Share of cars that drive against red light

The total number of cars arriving after the green/yellow change that was counted was 110 in the direction towards Pärnu mnt and 121 in the direction towards Narva mnt. The time that the traffic signal turned yellow was marked as 0 and then the signal turned red after 3 seconds. The first vehicle that arrived to the traffic signal in each lane was counted. The share of car drivers that keeps driving respectively stops at each time slot can be seen in figures 43 and 44. See observation protocol in appendix 2.

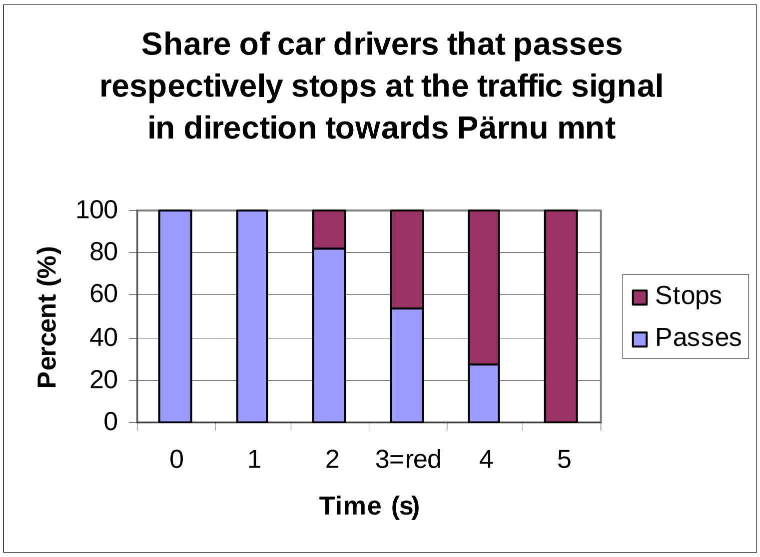

Figure 43. Share that drive against yellow and red

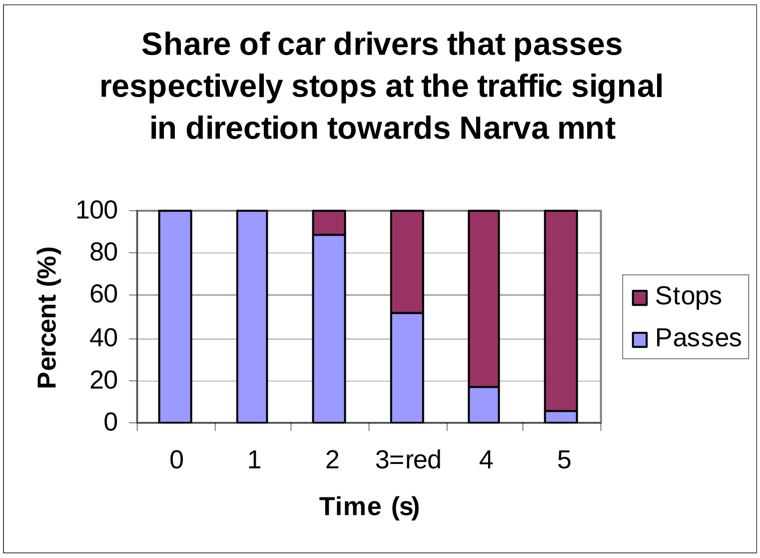

Figure 44. Share that drives against yellow and red

The results are very similar in both directions. The car drivers use the whole time it is yellow light and about 50 % drives at the time the signal turns red as well. Thereafter, the majority stops but it is still 27 % respective 17 % that drives one second after the signal turned red.

5.8.2 Interaction between pedestrians and vehicles at the unprotected pedestrian crossing

The interaction between pedestrians and vehicles was studied at the unprotected pedestrian crossing. The result can be seen in table 6. See observation protocol in appendix 3.

Table 6. Share of car drivers that gives respectively doesn't give priority.

Car driver			
Gives priority in good time	Gives priority late	Drives first	
		Below 30 km/h	Over 30 km/h
8,6 %	10,6 %	3,9 %	76,9%

Table 6 shows that the majority of the car drivers drive first and only about 20 % give priority to the pedestrian. It is also obvious that the speed is over 30 km/h in almost all of the cases when the driver drives first. When the car driver gave priority late to the pedestrians, the case was often that the pedestrian started to cross the street and the car driver had to stop quickly.

5.8.3 Pedestrians' route choice

All pedestrians crossed the street at the unprotected pedestrian crossing or at the signal controlled crossing. The high flow of traffic made it impossible for pedestrians to cross the street at other places than the marked crossings.

5.9 Summary of the results

The results of the empirical study indicate that there are various factors that affect the pedestrians' situation at the studied street link. The present situation at the studied street link result in various problems for the pedestrians and a summary of them can be seen below.

5.9.1 Signal controlled pedestrian crossing

- The speed level is too high for the situation
- Car drivers are driving against yellow and red light to a large extent
- Pedestrians do not have time to cross the street during the green time because of the short green time period related to the width of the carriageway
- Car drivers pass the prohibited area in front of the pedestrian crossing to overtake the queue
- There is no platform for tram travelers at the tram stop
- High flow of cars and high flow of pedestrians

5.9.2 Unprotected pedestrian crossing

- The speed level is too high for the situation
- Few car drivers stop to let pedestrians cross the carriageway
- Cars in other lanes than the one the pedestrian is crossing for the moment pass the stopping car
- Car drivers are using the bus lane as an ordinary lane
- The visibility is limited because of a rubbish bin in connection to the crossing
- Pedestrians feel unsafe while crossing the street
- There is no platform for tram travelers at the tram stop

6. Proposals of changes in the design

The purpose of this chapter is to present changes in the physical design of the street. The changes aim to make the studied street link safer and more accessible for pedestrians and to prevent the unintended use of the street. The proposals of changes are made with the presumption that the width of the street is not changed and that the tram tracks are not moved.

6.1 Proposals of changes and their purpose

A sketch of the street link after the proposed changes can be seen in figure 45.

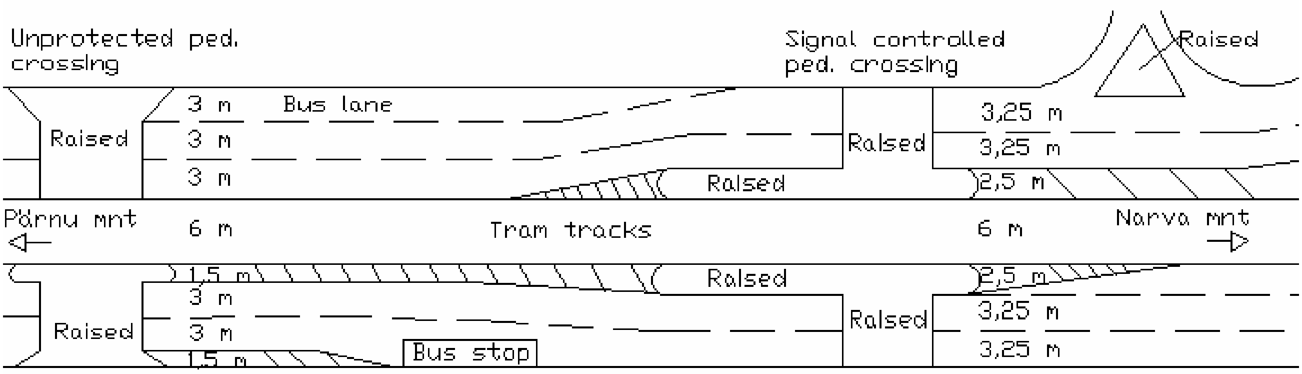

Figure 45. Sketch of the street link after the proposed changes.

Holes and cracks in pavements and footpaths along the street link need to be repaired to receive a more even surface. There were also some trees in the middle of the footpath that need to be removed in order to facilitate for pedestrians with impaired vision. Both pedestrian crossings should be provided with guide lines in order to make it easier to cross the street for pedestrians with impaired vision. The signal controlled pedestrian crossing is provided with a sound signal and it should remain the same after the reconstruction. Both pedestrian crossings are also provided with lighting and that should also remain the same as it contributes to make pedestrians more visible and thereby easier to recognize for car drivers.

The painted refuge island in front of the signal controlled pedestrian crossing is raised to prevent car drivers from overtaking the queue in front of the pedestrian crossing.

The pedestrian crossing is raised and there are also raised refuge islands in connection to the signal controlled pedestrian crossing. The refuge islands are intended to be used as platforms for tram travellers and also for pedestrians who do not have time to cross the street during the green light period. The tram tracks are on ground level and the kerbs thereby have to be dropped to make sure there is not a high step for the pedestrians. The refuge islands contribute to narrow the street, which combined with the raised pedestrian crossing should prevent car drivers from speeding and driving against red and yellow.

Along the street link between the pedestrian crossings the lanes are narrowed by prohibited areas and the refuge islands at the signal controlled pedestrian crossing. The bus lane is also marked out in a clear way and it disappears before the unprotected pedestrian crossing to prevent cars from using it to overtake the queue.

The unprotected pedestrian crossing is raised and the street is narrowed to force the car drivers to lower the speed and make it easier for pedestrians to cross the street. The lower speed will hopefully result in that car drivers stop at the unprotected pedestrian crossing in a higher extent than they do today and that cars in all lanes will stop at the unprotected pedestrian crossing and not only cars in the lane the pedestrian is crossing for the moment. The narrowed street will prevent car drivers from using the bus lane to overtake the queue in front of the unprotected pedestrian crossing and it will also make pedestrians more visible and thereby easier to recognize. There is also a refuge island on one side of the tram tracks to facilitate for pedestrians to cross the street. The refuge island will make it possible for pedestrians to take a break in the middle of the street and it will also result in that pedestrians do not have to wait on the tram tracks for cars to stop. The crossing can also be made in a deviant material or colour to make the car drivers more attentive. The tram stop at the unprotected pedestrian crossing is also removed to the signal controlled pedestrian crossing where the tram travellers can use the refuge island as a platform.

As the tram tracks are on ground level and both pedestrian crossings are proposed to be raised above the carriageway it is of great importance that the kerbs are dropped. The dropped kerbs make it possible for pedestrians with impaired mobility, impaired vision and those who use equipment to cross the street in a safe way. The dropped kerbs can be made by a gradual lowering of the raised area until it is on ground level, see figure 46.

Figure 46. Example of dropped kerb

6.2 Plan for evaluation of the effects of the measures

If the proposed changes are implemented it is of great importance to evaluate the effects of them. To follow up if the results of the changes correspond to the intended result, a similar study should be done after the changes are carried through. This study should be done under similar conditions to this study and is therefore suggested to take place one year after the changes are carried out. If the evaluation of the effects should be reliable it is also important that the street has been in use for a while so the actual use of it reflects in the result. The follow up study should include the same elements as this study and the results can thereafter be compared to find out if the intended results are achieved. Results concerning speed at both the unprotected pedestrian crossing and the signal controlled pedestrian crossing, share of cars driving against red and share of car drivers that give priority to the pedestrians at the unprotected pedestrian crossing is especially interesting to compare before and after the changes. It is also of great interest to find out if the pedestrians' opinions about the street link have changed or not. To do that, the same interview can be made and the results can be compared or the questions can be modified. See suggestion of modified interview form in appendix 4.

7. Discussion and conclusions

The result of the empirical study shows that there are various factors that affect the pedestrians' possibility to walk freely in the studied part of the city and some of the results are quite deplorable. Interviews with pedestrians and their answers describe the pedestrians' situation from their own point of view. By following up the interviews with behavioural studies and other observations their description of the situation can be compared with the results of the behavioural studies. Many of the received answers from the interviews were confirmed with the behavioural studies and the other observations. The questions pedestrians were asked mainly touched what they think and how they feel. These kinds of questions give a picture of how the pedestrians generally experience the traffic. The majority of the pedestrians feel that car drivers have priority at the studied street link and about 80 % of the pedestrians answered that car drivers break traffic rules within the same area. When the pedestrians were asked what traffic rules the car drivers break the most common answers were that car drivers do not stop at the unprotected pedestrian crossing to let pedestrians cross the street, they are driving above the speed limit and that they drive against red and yellow light. These answers are all confirmed with the behavioural study and other observations. The interaction between car drivers and pedestrians were observed and it clearly showed that the majority of car drivers do not stop at the unprotected pedestrian crossing. About 80 % of the car drivers ignored the fact that they by law have to stop at the unprotected pedestrian crossing to let pedestrians cross the street. About half of the car drivers who gave priority to the pedestrian did it in good time and the others gave late priority. When the car driver gave late priority to the pedestrian the case was often that the pedestrian started to cross the street and the car driver had to stop quickly to avoid running over the pedestrian. The speed measuring also confirmed the statement that many car drivers drive above the speed limit. Depending on the crossing and direction the share of car drivers who were speeding varied between 20 and 50 %. The problem was especially big at the unprotected pedestrian crossing, where 40-50 percent of the car drivers were driving above the speed limit. One reason to the high speed might be the straight and wide street which encourage to high speed. Finally, many of the interviewed also mentioned that car drivers are driving against red and yellow light. This was also confirmed by the behavioural study that showed that almost all car drivers were driving through the signal at yellow light and about 50 % were driving through the signal at the time it turned red. One second after the signal turned red there were still about 20 % of the car drivers who passed the signal. These results strengthen the impression pedestrians have that the car drivers have priority on the studied street link.

Further, the pedestrians referred to the traffic pace at the street link as stressful rather than calm and about half of the pedestrians answered that they feel more unsafe than they feel safe as a pedestrian at the studied street link. The high traffic volume on the street combined with the speed might contribute to the feeling of a high traffic pace. The reason that many pedestrians feel unsafe is probably a combination of all things mentioned above, a lot of traffic combined with that traffic rules are followed in a low extent.

About 70 % of the interviewed answered that they feel more unsafe than they feel safe when crossing the unprotected pedestrian crossing and the most common reason for feeling unsafe was due to if the car stops or not. Other factors mentioned were that cars in the first lane stops while cars in the second lane keeps driving, the high traffic volume, speed and width of the street. These are all factors that are confirmed by the behavioural studies and the other observations. Many pedestrians mentioned that cars in the second lane keeps driving when cars in the first lane stops. This result in that pedestrians have to wait in the middle of the street in front of a car. It was also common that the pedestrian crossed the lanes in one direction and then had to wait on the tram tracks for cars in the other direction to stop. Both situations result in that the crossing time is increased and the pedestrian is exposed a longer time than necessary in the traffic. This behaviour contributes to make the crossing procedure more difficult as the pedestrian have to focus on many contemporary happenings. While standing in front of a waiting car the pedestrian have to make sure it does not start to drive on the same time as he/she has to follow the traffic in the next lane to be able to cross it. It is even worse for those who have to wait on the tram tracks. They have to look in both directions to make sure there is no tram coming at the same time as the cars are driving on each side of the pedestrian.

The result at the signal controlled pedestrian crossing was the opposite compared with the unprotected pedestrian crossing. The pedestrians feel considerably safe when crossing the signal controlled crossing. This result is quite interesting as the behavioural studies showed that many car drivers ignored the red light and many pedestrians did not have time to cross the street during the green light period. One reason to the fact that pedestrians feel safe when crossing the signal controlled pedestrian crossing might be that the clearance period after the green light period for the cars is 2 seconds and then the pedestrians receive green light. This means that the pedestrians have still red light when the car drivers who drives against red are driving. There is also a long clearance period (6 seconds) after the green light period for pedestrians and this result in that the pedestrians that do not have time to cross the street during the green light period have another 6 seconds before the cars receive green light. When car drivers are using the whole clearance period and pedestrians do the same to have time to cross the street it results in that there are no margins between them.

The counting of traffic flow showed that there are high flows of both motorized vehicles and pedestrians. Totally 2225 cars passed the street link during the rush hour when the counting was done. The total number of pedestrians that crossed the street link was 3322 during the rush hour. 2848 crossed the street at the signal controlled pedestrian crossing and the other 474 crossed the street at the unprotected pedestrian crossing. Thulin and Obrenovic (2001) showed that the pedestrians' waiting time at the unprotected pedestrian crossing is decreased with increased flows of pedestrians. With an hourly flow of 300-500 pedestrians they presented an average waiting time of two to three seconds among those who had to wait. The flow of pedestrians at the observed unprotected pedestrian crossing is within the above mentioned interval (474) and the average waiting time among the ones who had to wait was more than the double, 7.6 seconds. Further, Thulin and Obrenovic (2001) showed that about 70 % of the car drivers stopped or decreased the speed to let pedestrians cross the street at the unprotected pedestrian crossing when the hourly flow of pedestrians was between 300 and 500. The unprotected pedestrian crossing that was observed in this study showed considerably worse results again, only about 20 % of the car drivers gave priority to the pedestrian.

A more extensive investigation concerning car drivers attitude to give way at unprotected pedestrian crossings and car drivers speed choice in Estonia have been made by Antov (2006). In this report he shows that between 60 and 65 percent of the car drivers ignore giving the pedestrian priority at unprotected pedestrian crossings in urban areas. The figures Antov presents shows that car drivers generally give priority to the pedestrian in a little higher extent than the case was at the studied street link. This deviation can depend on various factors, such as street width, traffic flow of cars respectively pedestrians, speed and whether there is a refuge island in the middle of the street or not. It is though clear that the share of car drivers that gives priority to the pedestrians is very low and this problem needs immediate attention.

In the same report Antov (2006) also present results concerning car drivers choice of speed in vicinity of unprotected pedestrian crossings. According to Antov (2006) almost 60 % of the observed vehicles' speed was above the speed limit. On streets with a speed limit of 50 km/h the average speed at the unprotected pedestrian crossing was 44.6 km/h. The speed measuring carried out in this study resulted in an average speed of 50.3 km/h at the unprotected pedestrian crossing and that between 40 and 50 % of the car drivers drive above the speed limit. Again, the difference between the results might depend on factors mentioned above. Both results points to the same direction though, car drivers are driving above the speed limit to a very high extent.

There are plans of constructing a by-pass route around central Tallinn and that would probably reduce the load factor on the streets that are running throw the city centre. With a decreased traffic volume in the city there are better possibilities to give the pedestrians higher priority in the city centre without affecting the motorized vehicles' level of service in a high extent. If the by-pass route will be constructed it is possible that the proposed changes should be more drastic to improve the pedestrians' situation even more. A decreased load factor in the city centre would probably improve the pedestrians' situation but the main problem is still left. To really make a change the car drivers' behaviour need to change. Behaviour that is most urgent to influence at the studied street link is choice of speed, observance of the obligation to give pedestrians priority at the unprotected pedestrian crossing and observance of the red light in the signal. The most effective way to influence the car drivers' behaviour is to adapt the road environment to human limitations (Antov, 2006).

As mentioned before in this report, Estonia belongs to the group of countries within the EU that show the worst statistics concerning pedestrians' safety. This study only touches the pedestrians' safety- and accessibility aspects on a local level but the results presented in this report strengthen the statistics. The people of Estonia also seems to be aware of the situation and Antov (2006) showed that Estonian drivers' attitude towards pedestrian safety development is very positive. This positive attitude might make it easier to implement changes that are needed in order to improve the pedestrians' situation. To find out what changes that are needed to carry out there is a need of extensive investigations and surveys of the road network and the specific shortcomings at each street link.

It would also be interesting if further studies of how to improve the pedestrians' situation at the studied street link would be done. If the by-pass route around central Tallinn becomes true and the effect of it is reduced traffic volumes in the city centre, then will further studies of the street link be very interesting to follow.

8. References

8.1 Literature

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8.3 Figures

All figures and photos without a reference are made or photographed by Urban Nordh.

Appendix 1 Interview form

Date: Time: Intersection:

Weather: Sunny Cloudy Rainy

Surface: Dry Wet

Questions

Age: 18-35 36-50 51-65 >65 Sex:_____

1. Do you feel that you are in the traffic on the same conditions as the car drivers or do they have priority in this part of the city?

2. Do the car drivers break the traffic rules in this part of the city?
Yes No Don't know

If yes;
What rules do they break?

3. How would you describe the traffic pace in this part of the city?
Calm Stressful
1 2 3 4 5 6 7 8 9 10

4. Do you feel safe as a pedestrian in this part of the city?

No, not at all Yes, very
1 2 3 4 5 6 7 8 9 10

If less than 5;
Why do you feel unsafe?

5. Do you feel safe when you cross the street here (unprotected/signal)?
No, not at all Yes, very
1 2 3 4 5 6 7 8 9 10

If less than 5;
Why do you feel unsafe?

Appendix 2 Protocol Cars driving against red

Date: Time: Intersection:

Weather: Sunny Cloudy Rainy

Surface: Dry Wet

Y - Yellow
R – Red (to be filled out at the starting time)
P – Passes
S – Stops

Nr	Seconds					
	0	1	2	3	4	5
	Yellow	….	….	….	….	….
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Appendix 3 Protocol Interaction between pedestrians and vehicles

Date:	Time:	Intersection:	
Weather:	Sunny	Cloudy	Rainy
Surface:	Dry	Wet	

Car driver			
Gives priority in good time	Gives priority late	Drives first	
		Below 30 km/h	Over 30 km/h

Appendix 4 Interview form for the follow up study

Date: Time: Intersection:

Weather: Sunny Cloudy Rainy

Surface: Dry Wet

Questions

Age: 18-35 36-50 51-65 >65 Sex:_____

1. Do you feel that you are in the traffic on the same conditions as the car drivers or do they have priority in this part of the city?

2. Do the car drivers break the traffic rules in this part of the city in a higher or lower extent after the reconstruction of the street?
Higher Lower No change

If higher or no change;
What rules do they break?

3. Is the traffic pace higher or lower in this part of the city after the reconstruction of the street?
Higher Lower No change

4. How do you feel as a pedestrian in this part of the city after the reconstruction of the street?
Safer More unsafe No change

5. How do you feel when you cross the street here (unprotected/signal) after the reconstruction compared with before?
Safer More unsafe No change