DIRECTORATE-GENERAL FOR MOBILITY AND TRANSPORT

D4: The impact of e-safety applications for cyclists on traffic safety

The Intelligent Bicycle Initiative
for safe cycling in Europe

Project Acronym: **SAFECYCLE**

Project Coordinator: **Mobycon (Netherlands)**

Proposal full title: **ICT applications for safe cycling**

Grant Agreement n°: MOVE/D3/SUBV/2010-125/SI2,593924/SAFECYCLE

Document Title: **Impact assessment safety effect of ICT-applications for cycling**

Authors: **Henk Jan Zoer, Angela van der Kloof, Ronald Jorna: Mobycon (the Netherlands) - Antonino Tripodi, Luca Persia: CTL (Italy) - Marjolein de Jong: Hasselt University, IMOB (Belgium) - Zbynek Sperat, Radomira Jordova: CDV (Czech Republic)**

Summary: **Cycling and safety framework for Europe and four European countries and a cost benefit analysis of eleven applications for safer cycling,**

Status: **Rev.0**

Distribution: **All Partners**

Document ID: **D4-1**

Date: **November 5, 2012**

Project start: 1st June 2011 **Duration: 18 Months**

Executive summary

The main objective of SAFECYCLE is to find out if ITS or smart applications can be used to increase the safety of cyclists in Europe. Cycling is becoming more and more popular, and at this moment of all fatalities in the EU-19 traffic, approximately 7% are cyclists.

In this report the bicycle safety situation in four European countries (the Netherlands, Belgium, Italy and Czech Republic) is used as a basis for a Cost Benefit Analysis (CBA). These countries are chosen because these countries are represented in the SAFECYCLE project team as well as that they represent a very good mix of cycling experience.

Table 0.1 gives an overview of the absolute number of fatalities in the four European countries, with an indication of the conditions under which the fatalities occured.

Indicator	Netherlands	Belgium	Italy	Czech Rep.
Bicycle fatalities	138	89	295	84
% fatalities at junction	63%	37%	62%	65%
% fatalities urban area	61%	46%	52%	30%
% fatalities dark/twilight	20%	22%	58%	43%
% bicycle accidents in total accidents	21%	9%	7%	9%

Table 0.1: The absolute number of cyclist fatalities in four European countries in 2009. Source: Safetynet (2011).

Eleven applications were selected for the CBA. The applications range from intelligent lighting to preventing blind spot accidents or the planning of safer routes. The selection was based on a SWOT analysis in WP3. This deliverable can be downloaded from the SAFECYCLE website.

For each of the eleven applications a Cost-Benefit Analysis (CBA) was realised, based on assumptions about:

- costs for implementing the application;
- costs for maintaining the application. The assumption is 10% of the investment costs per year;
- unit to be considered depending on the application (e.g. km of equipped roads, n° of traffic lights equipped, n° of vehicles equipped);
- type of accident (e.g. accident at intersection, accident at night, frontal accident)
- expected duration of the application. The expectation is ten years;
- an interest rate of 10%.

Although the results of the CBA are based on many assumptions and best estimates, the outcomes are hinting towards the following conclusions:

- ITS applications that require installations in all passenger cars, such as SaveCap and ISA, result in a very low Benefit Cost ratio. This is caused by the fact that the systems need to be installed in millions of vehicles and therefore are very costly in total.
- The same applies for ITS applications that need to be installed in trucks, such as Lexguard. On a European-wide basis this requires an investment of hundreds of millions of euros.
- For the systems to be installed at the bicycles, two out of three seem to have a positive Benefit Cost ratio, i.e. bike braking light and the LightLane bike. These are relatively cheap applications. On the other hand the HindSight does not have a positive Benefit Cost ratio.
- The infrastructure-based systems show a mixed picture. The traffic light countdown system has a positive B/C ratio for all four countries, but the Traffic Eye Zurich only seems to have a positive B/C ratio for The Netherlands and Belgium. For the LEDmark system the expected costs are always higher than the expected benefits in all four investigated countries.
- Last but not least it seems that the Internet applications such as the route planner in Ghent and the Citizens Connect have the highest Benefit Cost ratio. With relatively little investment many potential users can be reached, which seems to result in a very positive Benefit Cost ratio.

Table of Contents

List of Terms

Abbreviation	Definition
Bicycle accident	An accident in which at least one bicycle is involved
Bicycles / cycles	Two-wheel push bikes
CBA	Cost Benefit Analysis
CRF	Crash Reduction Factor
Fatality	Any road user who was killed outright or who died within 30 days as a result of the accident
ICT	Information and Computer Technology
ITS	Intelligent Transport Systems are a complex of technologies that are derived from ICT and applied to transport infrastructure and vehicles.
Single-bicycle crash	A fall from the bicycle or obstacle collision
SWOT	Strength Weakness Opportunity Threat
WP	Work Package

1. Introduction

ITS can be used in cycling to provide intelligent systems that assist the cyclist to avoid, prevent, or mitigate accidents. Although isolated ITS applications and services have been developed for cycling, there is no integrated approach to research activities in this domain at a national or international level. To fill this gap, the SAFECYCLE project was proposed in 2010 and accepted in 2011.

The main objectives of SAFECYCLE are:

- to identify e-safety applications that have the potential to enhance the safety of cyclists in Europe;
- to create knowledge and raise awareness about e-safety applications applied to cycling (policy, industry, users);
- to speed up the adoption of (new) e-safety applications in cycling.

In this project e-safety is defined as an intelligent safety system that could improve road safety in terms of exposure, crash avoidance, injury reduction and post-crash phases. A variety of measures are being promoted widely as 'e-safety' measures, though the knowledge about e-safety is slowly evolving, including information on the costs and benefits of measures (EC 2012). This is also what the project team found out while working on the impact assessment of the selected applications.

In Work Package (WP) 2 more than 120 applications for cyclists were found by the project team. Not all of the applications are in definition e-safety applications, but have the potential to increase safety in a smart manner. The search not only included Europe, but also other continents. At the end of WP2 the list of e-safety applications was reduced to 30 applications based on various criteria. These applications were entered into WP3, the SWOT (strength, weakness, opportunity and threat) analysis. Cycling, ITS and road safety experts filled in many SWOTs, resulting in a list of applications from most to less promising in relation to increasing road safety for cyclists. Based on the SWOT[1] the SAFECYCLE project team selected 11 applications out of the 30 applications.

For each of the eleven applications an impact assessment on traffic safety for cyclists is carried out. Safety impacts are expected directly from increasing the safety for cyclists. For instance by increasing the visibility of cyclists, by preventing blind-spot accidents, by preventing red light negation or by planning safer cycling routes.

In the next chapter we zoom in on the road safety situation in Europe. In the third chapter we explain the methodology used for the impact assessment. In chapter four the results of the impact assessment for the eleven applications is presented. The final chapter presents the conclusions and there is room for discussing the results.

[1] The deliverables of WP2 and WP3 can be found on http://www.safecycle.eu/section/deliverables

2. Cycling and safety framework

This chapter describes the cycling and safety framework for the impact assessment of the eleven e-safety applications. It sketches most of the similarities and differences in the use of the bicycle and cycling safety between the countries. These should be taken into account when thinking about the e-safety applications in different circumstances.

First we give an overview of cycling and safety on the European level. This overview shows that there are huge national differences within the EU, so we subsequently zoom in to four different countries: the Netherlands, Belgium, Italy and Czech Republic[2]. Being four countries with differences in cycling rates, cycling culture and safety for cyclists. Also, these four countries are the countries represented in the project team.

When we refer to a 'fatality' it refers to any road user who was killed outright or who died within 30 days as a result of the accident. This chapter addresses fatalities among cyclists and all references to fatalities thus refer to a fatal injury of a cyclist. A 'bicycle accident' refers to an accident in which at least one bicycle is involved. The terms "bicycles" and "cycles" refer only to two-wheel push bikes.

2.1 Overall situation in Europe

Here we give an overview of the diversity in bicycle mode share and cycling policy within the EU and look at safety for cyclists in general. Finally we discuss the problem of underreporting of accidents in which cyclists are involved.

2.1.1 Bicycle mode share and cycling policy

According to the 'Promotion of cycling' note, written by TRT in 2010 for the European Commission, there are no reliable single international or European statistical reports showing modal share of bicycle use per country, related to all journeys. In figure 2.1 the data available in each country (from different sources and years) are presented. The Netherlands has the highest percentage of bicycle use (26%), followed by Denmark and Germany. In this graph Belgium has a percentage of 8%, Italy 4% and Czech Republic 3%.

In many countries a higher percentage of males, compared to females, ride bicycles. Typically, in countries with high cycling rates the balance tends to be equal. "*In cities where a high percentage of bike trips are by women, overall rates of cycling are high, and cycling conditions are safe, convenient, and comfortable. Where few women cycle, overall rates of cycling are low, and cycling conditions are unsafe, inconvenient, uncomfortable, and sometimes outright impossible.*" (www,ecf,com/news/cyclingandwomen, Scientists for Cycling. Interview with John Pucher, 11.06.2012)

[2] It should be noted that the figures in this chapter are not necessarily the same as used in the Cost Benefit Analysis. In the CBA we prefered to use data from the same sources, such as CARE database and Eurostat, and not national statistics with differences in defnititions.

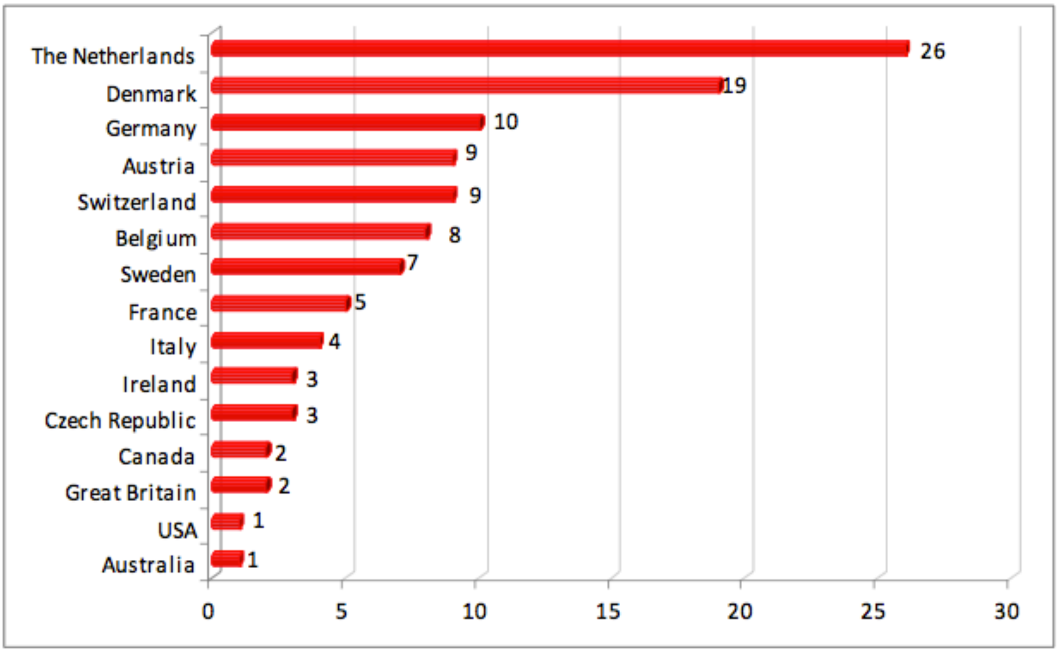


Figure 2.1: Bicycle modal share for all journeys per country

Sources: Australian Bureau of Statistics (2007); Netherlands Ministry of Transport (2006); United States Department of Transportation (2003); Isfort Italian survey 'Audimob' (2006); Annex I: Literature search bicycle use and influencing factors in Europe– ByPad Project (2008), In: 'Promotion of cycling'

Also, the degree in which children and elderly take part in cycling differs between the EU countries (and worldwide). Figure 2.2 illustrates different rates of children cycling to school for several countries.

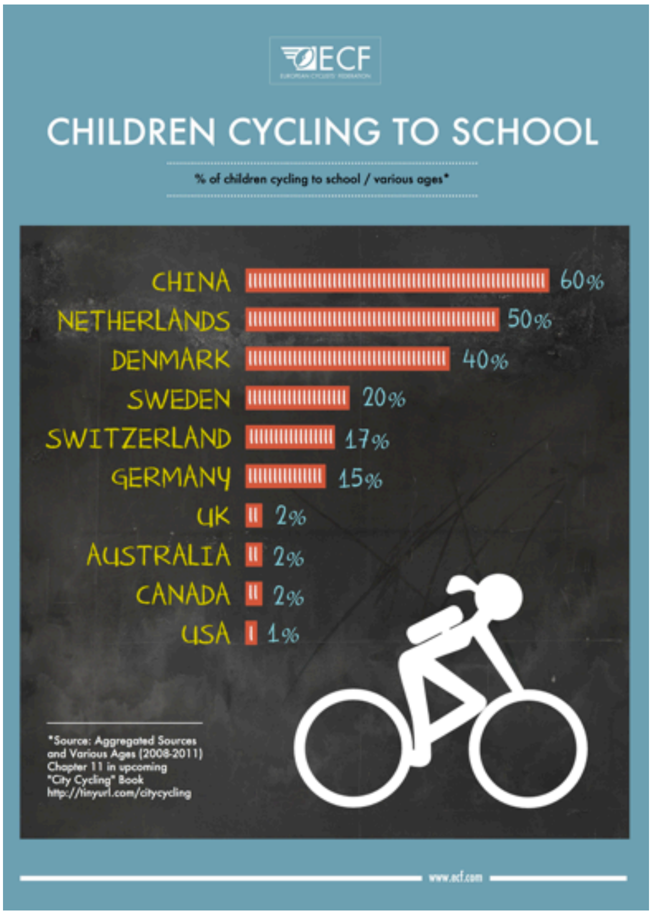


Figure 2.2 Percentages of children cycling to school for several countries worldwide (Source: http://www,ecf,com/press_release/29-06-2012-united-nations-demanded-to-enshrine-global-right-to-cycle-for-children/).

The authors of ‘Promotion of cycling’ note that “*cities that have embraced bicycle-friendly policies are able to achieve significant results, even if the national average bicycle use is low. On the other hand, cities that have not adopted policies to promote cycling have a modal share lower than the national one”* (TRT 2010, p.27).

EU Member States are free to develop national bicycle plans, or not, and there are no compulsory legal or financial frameworks. In some cases cycling policies are regulated in a specific plan for cycling promotion at the national level. In other cases cycling policies are included in more general national transport, environmental and/or health plans. There are also countries where cycling is the responsibility of regional and local authorities.

2.1.2 Safety for cyclists

In many European countries there is not a good road infrastructure network for cyclists. Cycle paths are poorly maintained, dirty and not entirely safe. Often, cyclists are expected to share the road with fast traffic. This makes cyclists feel unsafe and does not encourage them to use the bicycle as a means of transportation. Also, this has an effect on road safety figures for cyclists. During the last years, more cities, regions and national governments start to take cycling as a means of transportation serious and making cycling safer is one of the objectives. Data from Europe suggests (TRT 2010) that countries that have invested the most in cycling tend to have the highest rates of cycling. These countries also have the lowest rates of cycling mortality, expressed as ‘risk in fatalities per billion cycling kilometres’. Due to a higher number of bicycle trips and kilometres cycled, cyclists are perceived and expected in traffic, which makes their coexistence with other road users mutually smoother and accidents are reduced. To improve this safety situation for cyclists (national) road safety policy with attention for infrastructure for cyclists, traffic control measures and training of children and adults (cyclists and non-cyclists) is needed.

Of all fatalities in the EU-19 traffic, approximately 7% are cyclists (SafetyNet 2009). Figure 2.3 shows that in absolute numbers the number of fatalities has decreased with 33% between 2000 and 2009. The proportion of cyclist fatalities increased slightly in the same period.

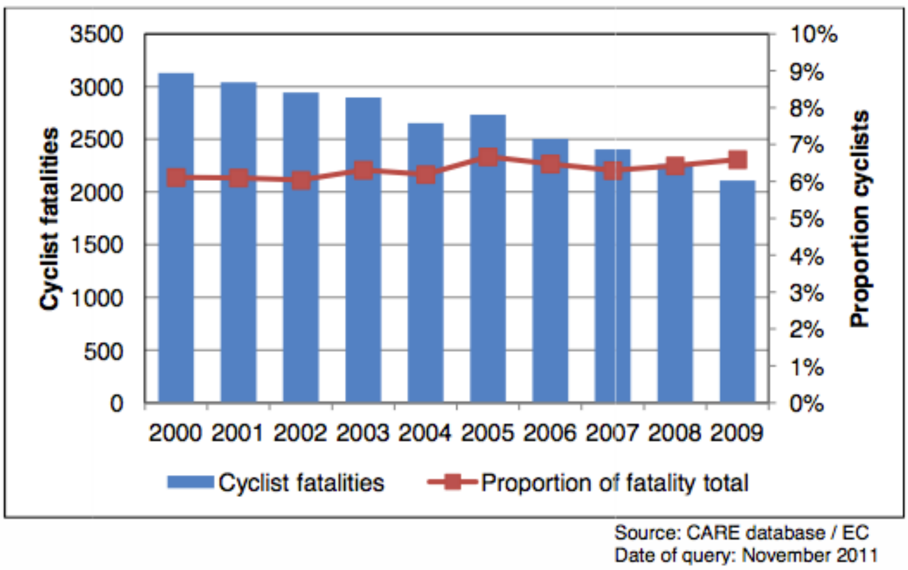


Figure 2.3 Number and proportion of cyclist fatalities in U-19 countries between 2000 and 2009

Figure 2.4 indicates cycling fatalities in traffic accidents (per million inhabitants). It is interesting to note that for example Czech Republic and The Netherlands have almost the same number of fatalities per million inhabitants, but in The Netherlands share of cycling in the modal choice is about nine times higher than in Czech Republic.

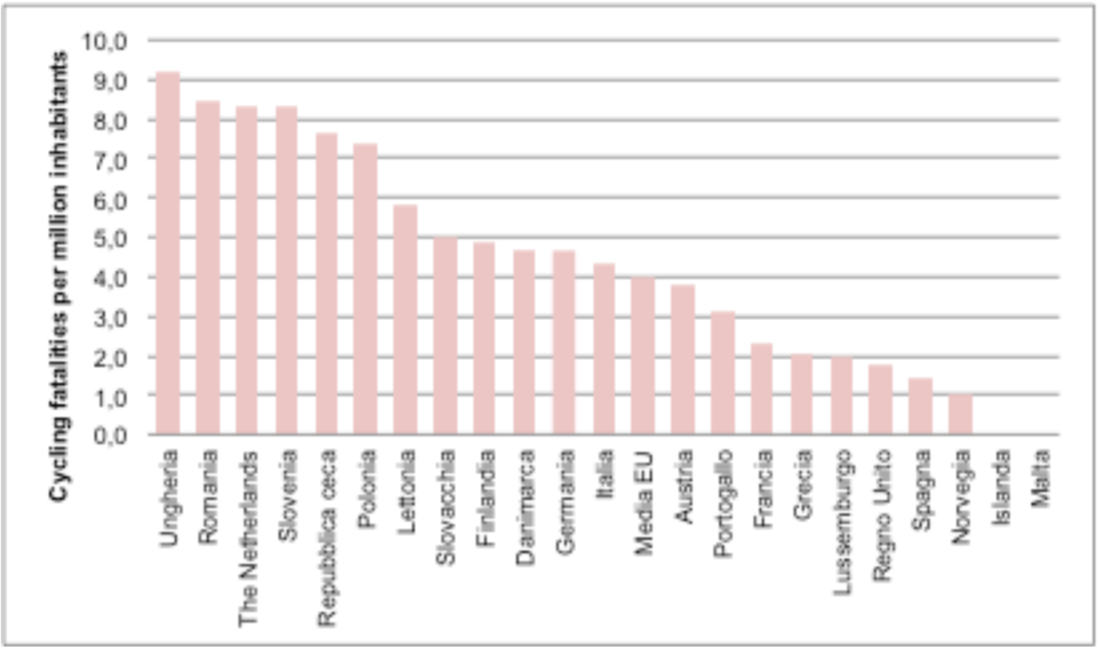


Figure 2.4 Cycling fatalities in traffic accidents (per million inhabitants – 2008) (Statistics The Netherlands from 2009)

Across the EU-23 countries, the majority of cyclist fatalities are males (80%). The Netherlands and Belgium had the highest proportion of female cyclist fatalities (around 30%), while countries like Romania and Portugal had 8% or less female fatalities (Traffic Safety Basic Facts 2011, Cyclists). This corresponds with the general trend that less than one quarter of all fatalities are female (Traffic Safety Basic Facts 2011, Gender) and the notion that in most countries a high percentage of cyclists is male.

Also, across the EU-23 countries, there appears to be a large proportion of cyclists of 60 years and older who die because of an accident (49%). Next to this, there appears to be a peak in fatalities of cyclists aged between 12 and 17. This is the age at which children increasingly undertake independent trips by bicycle and their exposure rate in traffic increases a lot (Traffic Safety Basic Facts 2011, Cyclists).

Almost 60% of the bicycle fatalities in the EU-23 countries were killed in urban areas. Again, there are large differences ranging from over 75% in Spain to 24% in Romania (Traffic Safety Basic Facts 2011, Cyclists).

2.1.3 Underreporting

A problem with all figures on traffic safety for cyclists is underreporting. This means that not all road traffic casualties are reported in the accident database. This is not limited only to slight accidents that are not always notified to the police (and in which police are not bound to intervene), but also happens because admissions to hospital as a consequence of road traffic accidents are not reported properly. Especially minor accidents, where there is no motorized vehicle involved, are not registered in police records. Part of these accidents can be grouped in the category of single-bicycle crashes, which is a fall from the bicycle or obstacle collision. Research from the Netherlands shows that each year 9,000 cyclists are heavily injured and in 60% of the cases the cause was a single-bicycle crash. Next to that every year 46,000 cyclists need to go to the emergency room because of a single-bicycle crash (Grip op enkelvoudige fietsongevallen; samenwerken aan een veilige fietsomgeving, Fietsberaadpublicatie 19a, 2011).

Another issue with the figures can be the fact that the system of information gathering in a country can change. For instance, in the Czech Republic it was no longer possible to report accidents to the police if there was limited or no material damage. The result was that the figures seemed to indicate that traffic had become safer for cyclists, but this was not the case.

Examples of single-bicycle crashes are the cyclist rode off the road, or collided with an obstacle, the bicycle skidded due to a slippery road surface, or the rider was unable to stabilize the bicycle or stay on the bike because of an uneven road surface. About half of the single-bicycle crashes have a crash mechanism related to infrastructure. Figure 2.5 shows some pictures of situations that may typically cause single-bicycle accidents.

Left: Slippery road surface. Right: Obstacle on the road, difficult to see in the dark or in groups.

Left: Big difference in height between the road and the shoulder. Right: Obstacle on the road.

Figure 2.5 Pictures of situations that may typically cause single-bicycle accidents (Grip op enkelvoudige fietsongevallen; samenwerken aan een veilige fietsomgeving, Fietsberaadpublicatie 19a, 2011).

2.2 Situation in four EU-countries

Taking all considerations of the previous paragraph in mind, we will now have a closer look at the bicycle safety situation in four countries: The Netherlands, Belgium, Italy and Czech Republic. These countries are chosen because these countries are represented in the SAFECYCLE project team as well as that they represent a very good mix of cycling experience. Table 2.1 gives an overview of the absolute number of fatalities in the four European countries, with an indication of the conditions under which the fatalities occured.

Indicator	Netherlands	Belgium	Italy	Czech Rep
Bicycle fatalities	138	89	295	84
% fatalities at junction	63%	37%	62%	65%
% fatalities urban area	61%	46%	52%	30%
% fatalities dark/twilight	20%	22%	58%	43%
% bicycle accidents in total accidents	21%	9%	7%	9%

Table 2.1 The absolute number of cyclist fatalities in four European countries in 2009. Source: Safetynet (2011)

2.2.1 The Netherlands

In 2009 the number of trips realised by bicycle in the Netherlands accounted for 26% of all the trips realised.

The fatality rate of the bicycle accidents, in 2010, was equal to 8.33 deaths per milion of inhabitants, which is higher than the European average of 4.0 (Figure 2.1, in paragraph 2.1.1). This is not a surprise, since the number of cyclists and the level of the use of the bicycle in The Netherlands is very high.

Trends

The trend in the last years (from 2001 to 2009) of the traffic accidents with cyclists in The Netherlands is positive. Figure 2.6 shows a significant decrease of the number of bicycle accidents (-33%), as well as of the number of injured (-35%). The number of deaths has decreased with 29%. A table with the number of bicycle accidents, deaths and injured in traffic can be found in appendix D. Trends in numbers of bicycle accidents, deaths and injured.

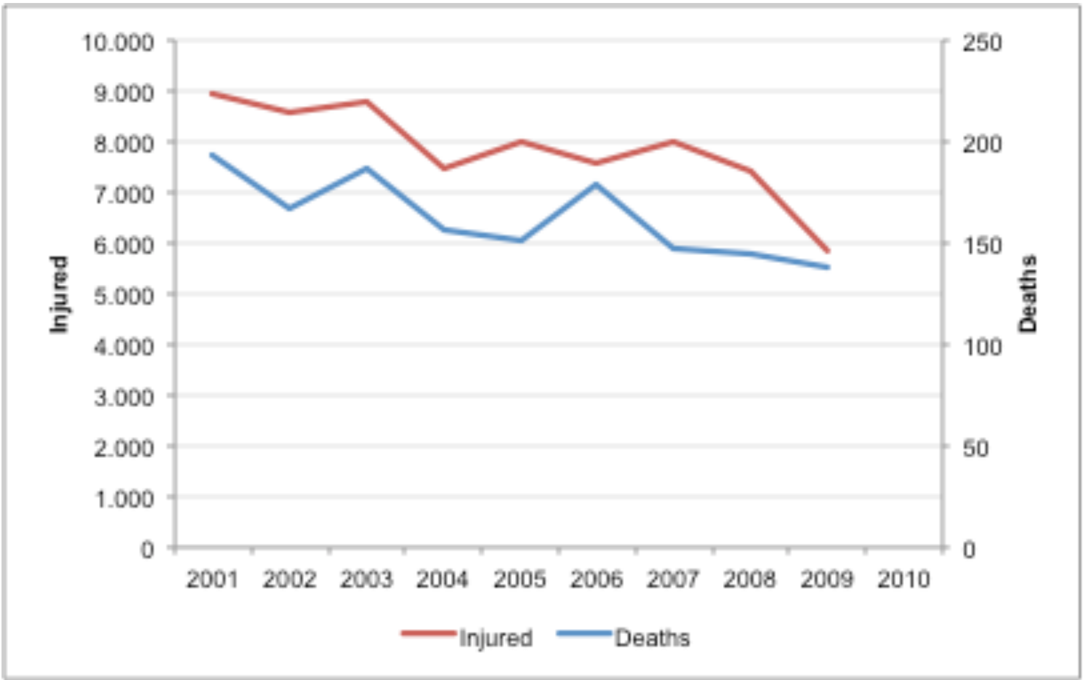


Figure 2.6 Trend of deaths and injured in bicycle accidents

Spatial distribution

The distribution of fatality rate per Province in The Netherlands is shown in figure 2.7. Provinces with higher population densities have less fatalities per 1,000,000 inhabitants (SWOV, Verkennende studie naar regionale verschillen in relatie tot verkeersveiligheid. Drs. S. Houwing e.a., 2012 p.11), The possible causes are under research by SWOV, the Dutch scientific institute for road safety research.

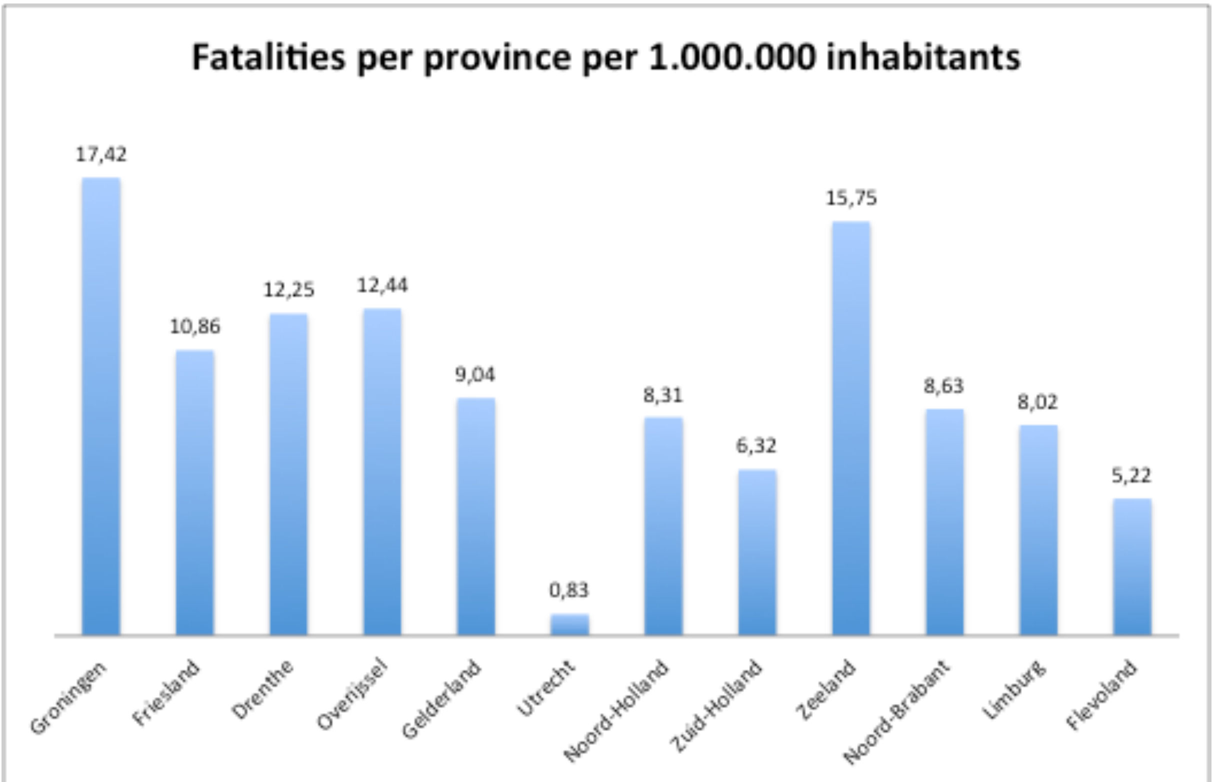


Figure 2.7 Fatality rates per province in The Netherlands – 2009

Accident situations

Comparing the situations of bicycle accidents with those of all accidents in The Netherlands (figure 2,8), a higher percentage of accidents occured at intersections (62% vs 47% of all accidents) and inside urban areas (85% vs 64% of all accidents). This last situation is mainly related to the higher use of bicycle as means of transport in cities.

The higher accident risk at intersections, compared to that of road sections, can highlight a lower protection of cyclists in these areas. Compared to all accidents, a lower percentage of accidents with cyclists occur during the week end. The percentage of accidents with cyclists during night-time is lower than during day-time.

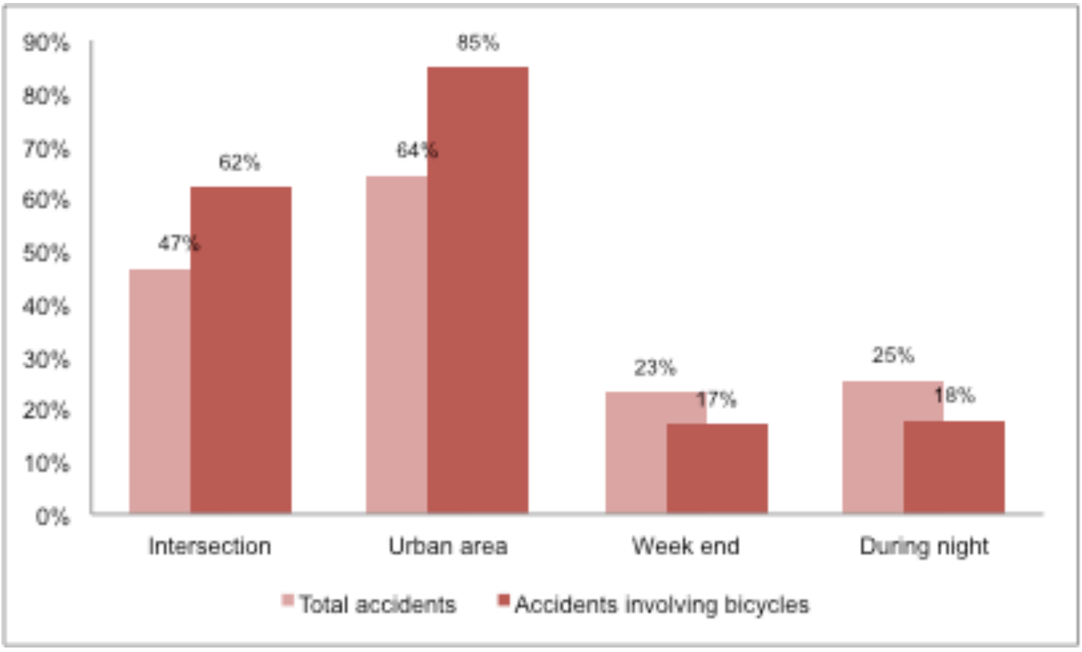


Figure 2.8 Comparison of traffic accidents situations (all accidents vs accidents involving bicycles) – 2010

The data of bicycle accidents per age group (table 2.2) shows that elderly (> 60 years old) represent 49% of cyclist fatalities in The Netherlands. The highest amount of injuries is found in the age group between 25 and 49 years old (26%).

Age group	Fatalities	Injuries
< 17	21	1,427
18-24	11	601
25-49	13	1,526
50-59	15	833
> 60	68	1,378
Unknown	10	85
Total	**138**	**5,850**

Table 2.2 Number of deaths and injured in bicycle accidents per age group – 2009

Collision types

Figure 2.9 shows the main collision type of bicycle accidents in The Netherlands (2009). The majority of collision types (> 60%) are lateral accidents. In appendix E the number of cyclists victims and injured in bicycle accidents in 2009 can be found. More information about the accident circumstances can be found in appendix F.

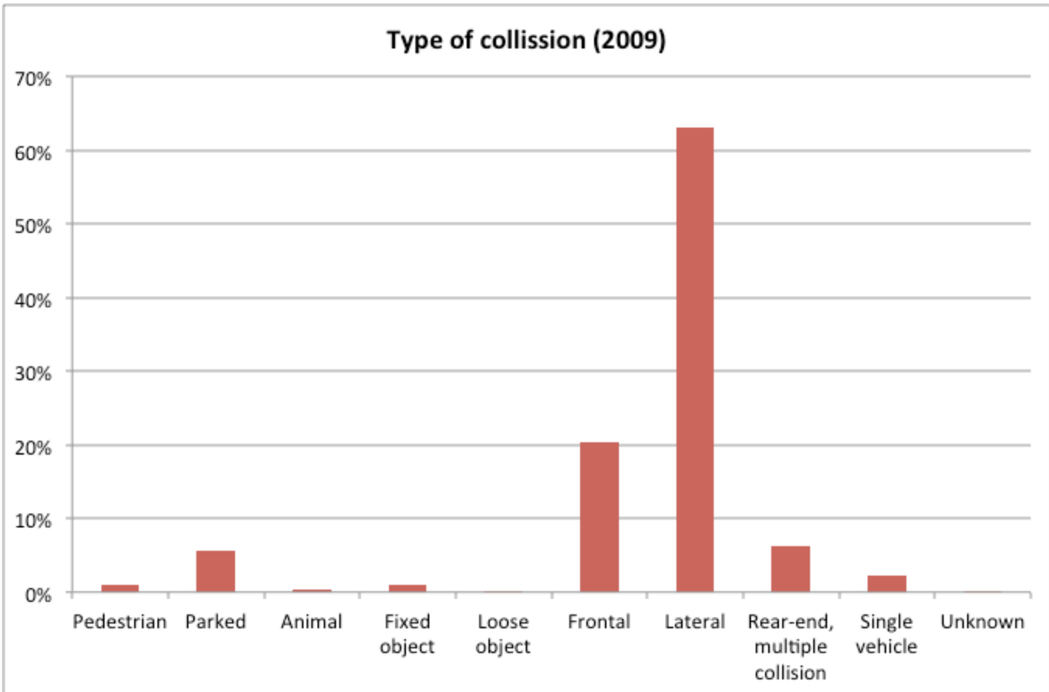


Figure 2.9 Type of collision of accidents with cyclist involved 2009

2.2.2 Belgium

This paragraph deals with the characteristics of cyclist fatalities in Belgium / Flanders. In 2009 the number of trips realised with bicycle accounted for 9% of all the trips realised in Belgium. The share of cyclists/mopeds (together) is the highest in Flanders (12.2%) and the lowest in Wallonie (1.7%). In Brussels 4.2% of all trips is realised per bicycle/moped. The average distance per bicycle/moped in Belgium is 3.76 kilometer (Beldam, Foto van de mobiliteit van de Belgen, 20-12-2011), according to Flemish travel behaviour research from 2009-2010 (Onderzoek Verplaatsingsgedrag 4.2) about 12% of all trips were made by bicycle.

Table 2.1 in paragraph 2.2 shows that the amount of fatalities amongst cyclists in Belgium in 2011 was 89 victims. Table 2.3 shows the distribution of all fatalities in 2009 in different regions. In the course of this paragraph, we focus on the situation in Flanders.

	Fatalities 2009	Inhabitants 2009	Mio vehicle km	Deaths / 10,000 inh	Deaths / mio veh km
Flanders	479	6,208,877	56,399	7,71	8.49
Wallony	434	3,475,671	38,025	12.49	11.41
Brussels	30	1,068,532	3,806	2,81	7.88
Total Belgium	**943**	**10,753,080**	**98,231**	**8.77**	**9.60**

Table 2.3 Deaths in traffic accidents in Belgium and the regions – year 2009

Trends

Over the last ten years there is an increase of accidents with cyclists in Flanders. Between 1997 and 2009 the amount of bicycle accidents increased with 9%, compared to an overall decrease of road accidents of 15%.

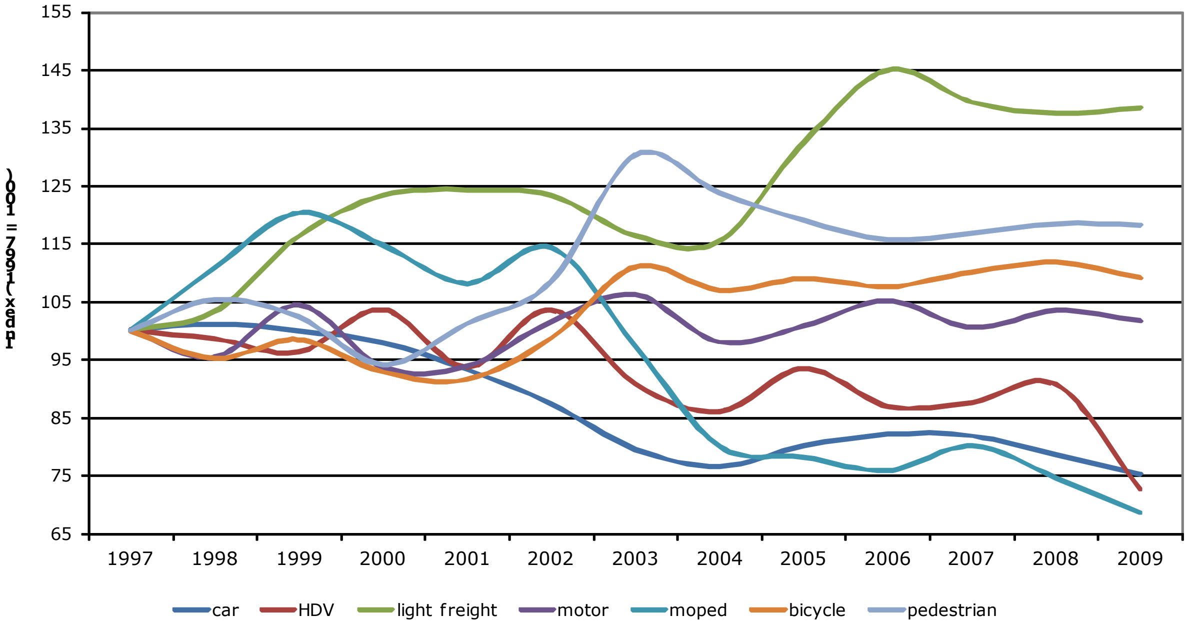


Figure 2.10 Evolution of road safety for different transportation modes

Spatial distribution

The distribution of the fatality rate per Province in Flanders is shown in table 2.4.

Provincie	Fatalities	Accidents	Amount/100,000 inh	
			Deaths + heavily injured	Accidents
Antwerpen	120	8,251	75	477
Limburg	82	3,980	91	478
Oost-Vlaanderen	111	7,782	78	548
Vlaams-Brabant	57	3,956	50	370
West-Vlaanderen	109	6,055	90	524
Flanders	479	30,024	76	484

Table 2.4 Fatality rates per province in Flanders – 2009

Accident situations

It is shown in figure 2.11 that a high percentage of cycling fatalities occur at intersections (32% vs 10% of all accidents).

75% of all accidents with fatalies and severly injured involving a cyclist occur during weekdays compared to 61% for all accidents. Also the weekend days show a slightly higher percentage of cyclist accidents than all accidents (21% vs 20%). During the nights the amount of cyclists involved is lower than for all accidents (about a fifth of the total amount of accidents).

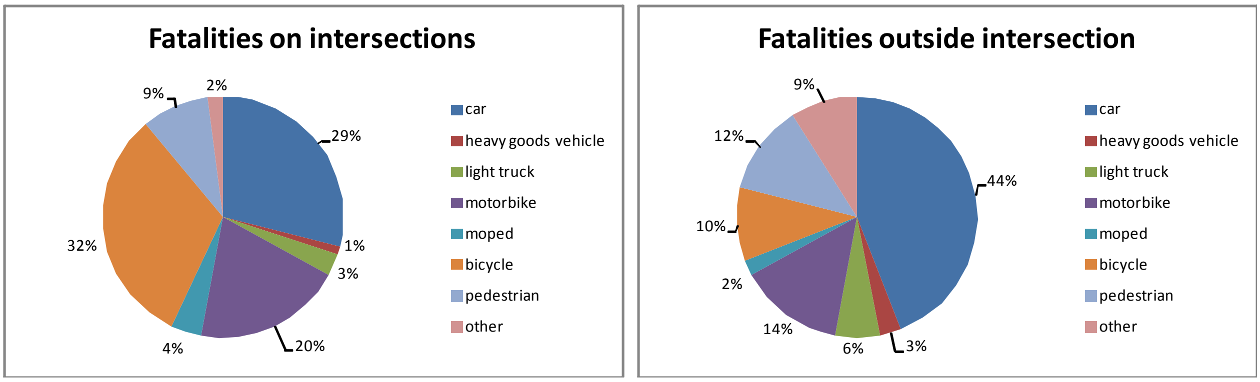


Figure 2.11 Comparison of traffic accidents situations in Flanders (all accidents vs accidents involving bicycles) - 2009

Collision types

Figure 2.12 shows the main collision type of bicycle accidents in Belgium over a period of 10 years. The majority of collision types (> 60%) are lateral accidents. The second most important collision type is where the two road users drive in the same direction and hit each other from the front or from the back.

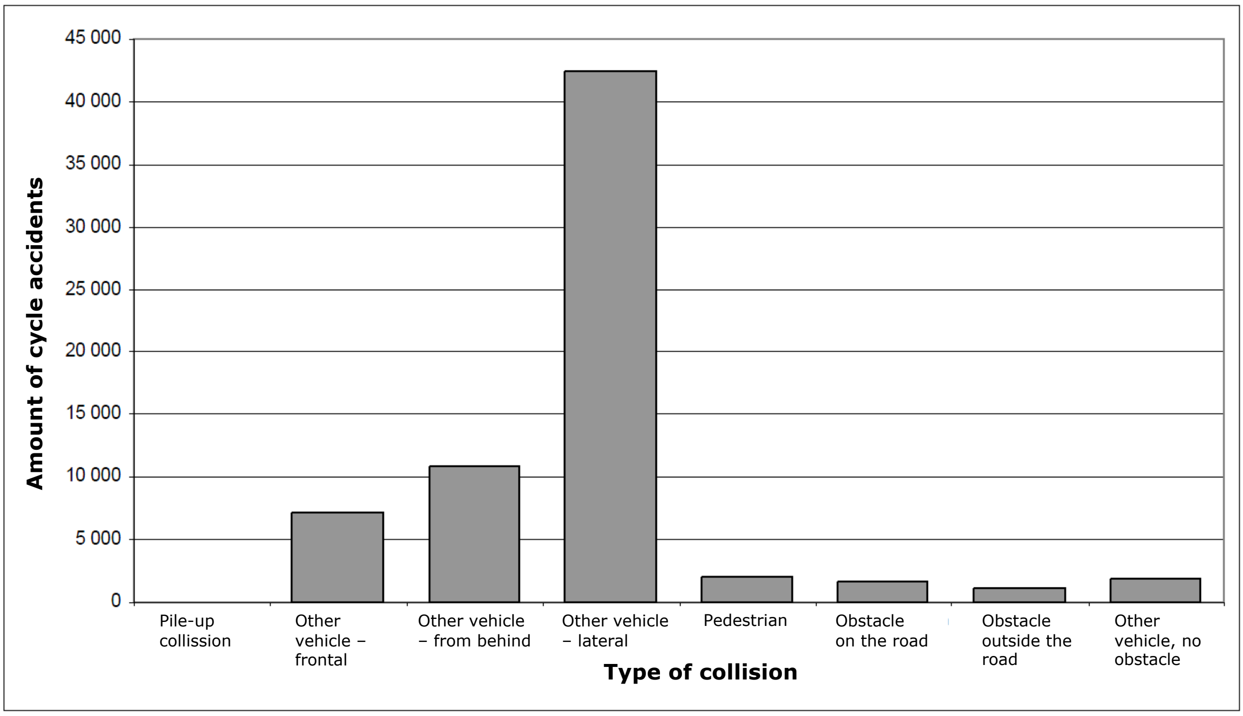


Figure 2.12 Type of collision of accidents with cyclist involved 1991-2001

Age group

The data of bicycle accidents per age group (table 2.5) shows that most fatalities occur in the age group > 65 years old. Most injuries occur in the age group 40 - 54 years old. The first representing 36% of cyclist deaths and heavy injuries in Flanders. In appendix G an overview of the amount of deaths and heavily injured according to age, for different types of transportation in Flanders can be found.

Age group	Fatalities (30days)	Injuries	Evolution Deaths (30days) compared to 1998-2000 and 2007
< 17	9	2,170	-69% (estimate)
18-24	6	825	-18%
25-39	6	1,278	-33%
40-54	10	1,584	-47%
55-64	13	907	-30%
> 65	44	1,180	-10%
Total	88	7,960	-32%

Table 2.5 Number of deaths and injured in bicycle accidents per age group - 2007

Moment of the day

On average 1.1% of all cyclists that are involved in an accident die within 30 days. At night the percentage is higher: 1.7%. On average 11.4% of the cyclists involved are seriously injured. When we look at the accidents during the night, the percentage is higher: 13,4%. During dawn or night-fall this is 12.0%. For slight injuries the pattern is the other way around: during the night the percentage of slight injuries is lower than the average (85% vs 87.5%).

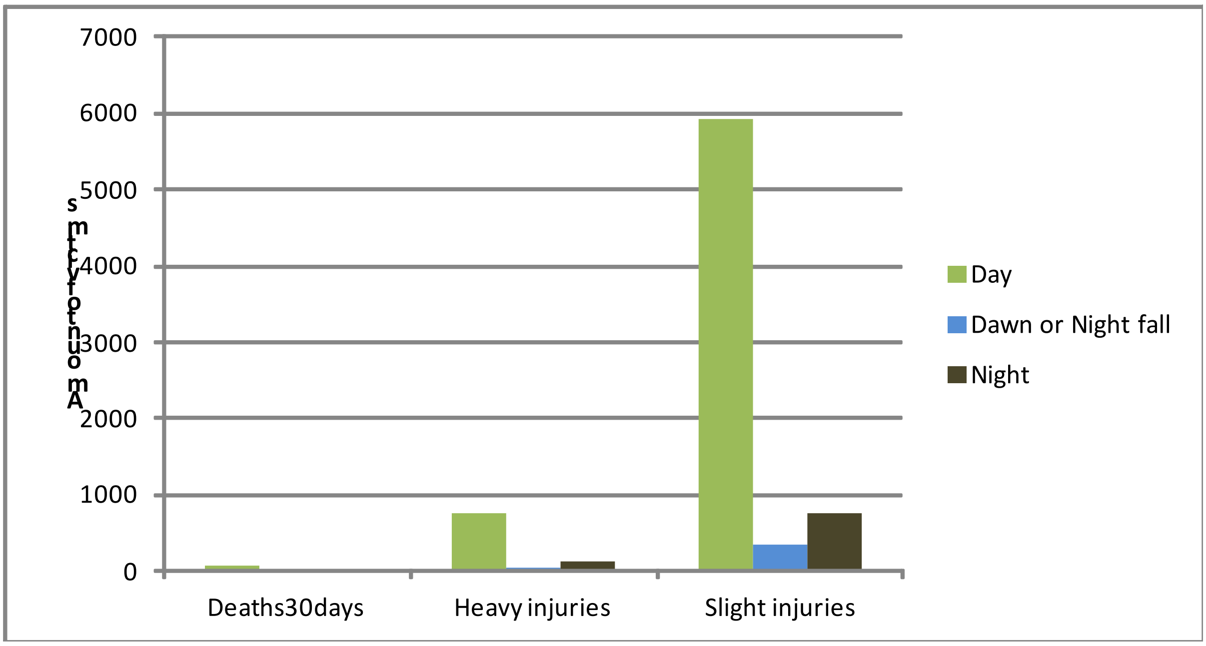


Figure 2.13 Amount of deaths and injured cyclists accoring to moment of the day in Flanders, average 2007

2.2.3 Italy

In 2009 the number of trips realised by bicycle accounted for 3.7% of all the trips realised in Italy. In general the use of non motorised transport modalities (pedestrians and cyclists) has decreased, from 2000 to 2009 with about 17%.

In 2010 a reduction of fatal (-9%) and severe injuries (-3%) compared to 2009 in bicycle accidents occured. Looking only at the cyclists fatalities, the reduction is about 11%. In appendix H a table with a synthesis of the users (fatal or injured) involved in traffic accidents with bicycles for 2009 and 2010 can be found.

The fatality rate of the bicycle accidents in 2010 was equal to 4.36 deaths per milion of inhabitants, very similar to the European average (Figure 2.1. in paragraph 2.1.1). The fatality rate is also similar to that of Germany, where the use of bicycles as a means of transportation is more frequent than in Italy.

Trends

Over the last 10 years (from 2001 to 2010) the trend in traffic accidents with cyclists in Italy is not very positive. Figure 2.14 shows a significant increase in the number of bicycle accidents (+24%), as well as of the number of injured (+31%). The number of fatalities on the contrary decreased with 28%. The corresponding figures can be found in appendix I.

While the amount of injuries seems to have increased, perhaps due to an increase of the number of trips made by bicycle, the consequences of the accidents seem to be less serious than in the past.

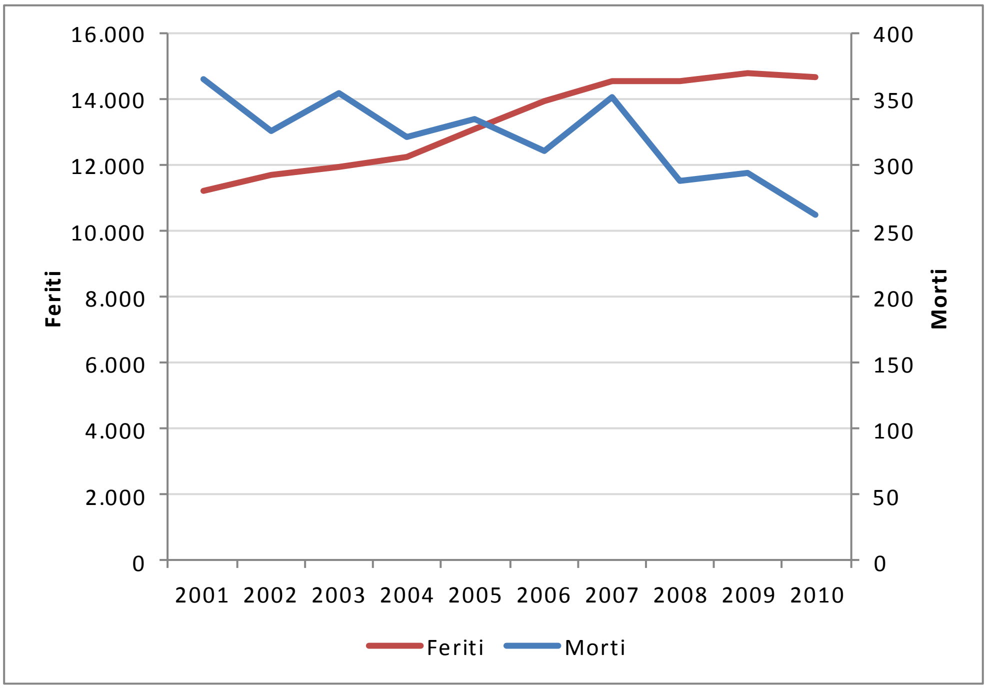


Figure 2.14 Trend of deaths ('Morti') and injured ('Feriti') in bicycle accidents

Spatial distribution

The distribution of fatality rate per Region in Italy is shown in figure 2.15. Higher fatalitiy rates are accounted in the nothern regions, while the southern has lower values. This trend is probably due to a higher use of the bicycle in the nothern regions than in that of the south.

Figure 2.15 Fatality rates per Regions in Italy - 2010

Accident situations

Comparing the situation of bicycle accidents with those of all accidents in Italy (figure 2.16), a higher percentage of accidents occured at junctions (56% vs 48% of all accidents) and inside urban areas (89% vs 77% of all accidents). This last situation is mainly related to the higher use of bicycle as transport mean in cities. The table with exact figures can be found in appendix J Bicycle accident circumstances in 2010 in Italy.

Compared to all accidents, a lower percentage of accidents with cyclists occur during the weekend. The percentage of accidents with cyclists during night is slightly higher than all accidents. This last data, associated with the lower use of bicycle during night, gives an indication of the higher accident rate during this time interval.

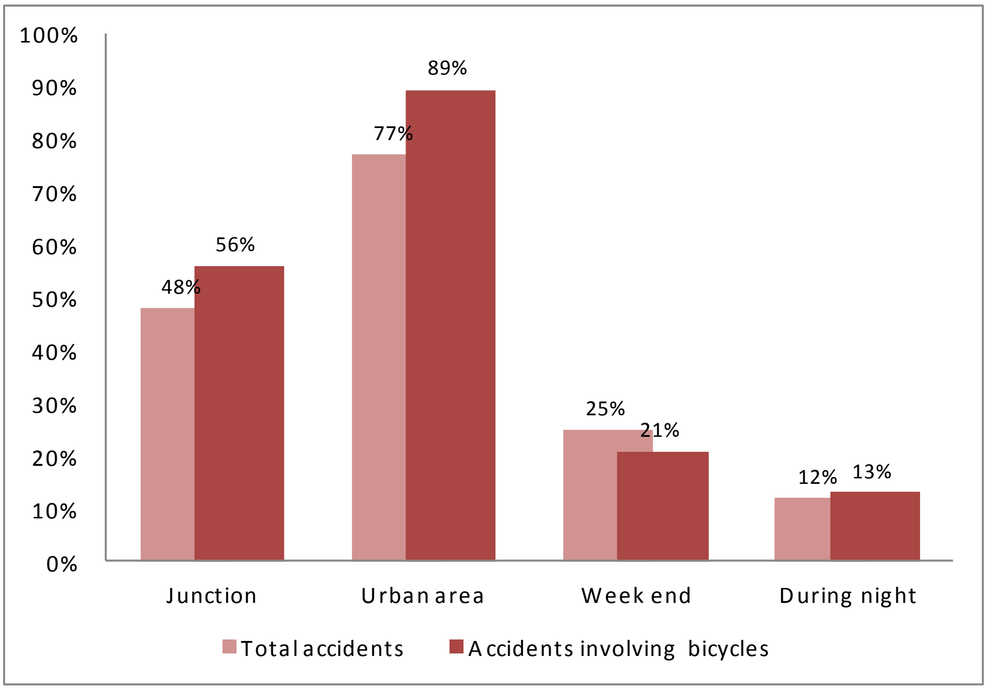


Figure 2.16 Comparison of traffic accidents situations (all accidents vs accidents involving bicycles) - 2010

The data of bicycle accidents per age group (table 2.6) shows that most fatalities occur in the age group > 64 years old), representing 54% of cyclist fatalities in Italy. Most injuries occur in the age group 25 to 49 years old (36%).

Age group	Fatalities	Injuries
< 15	7	1,181
15-17	1	542
18-24	9	1,120
25-49	54	5,342
50-64	47	2,892
> 64	144	3,440
Unknown	1	138
Total	**263**	**14,655**

Table 2.6 Number of deaths and injured in bicycle accidents per age group - 2010

Collision types

Figure 2.17 shows the main collision type of bicycle accidents in Italy from 2008 to 2010. No main differences appear between years. In all cases the majority of collision types (70%) are lateral accidents. All the other types occur in less than 10% of the cases. Lateral collisions seem thus to be the most important type of accidents to be faced in Italy. The corresponding table with exact figures can be found in appendix K Number of deaths and injured in bicycle accidents per collision type in 2010 in Italy.

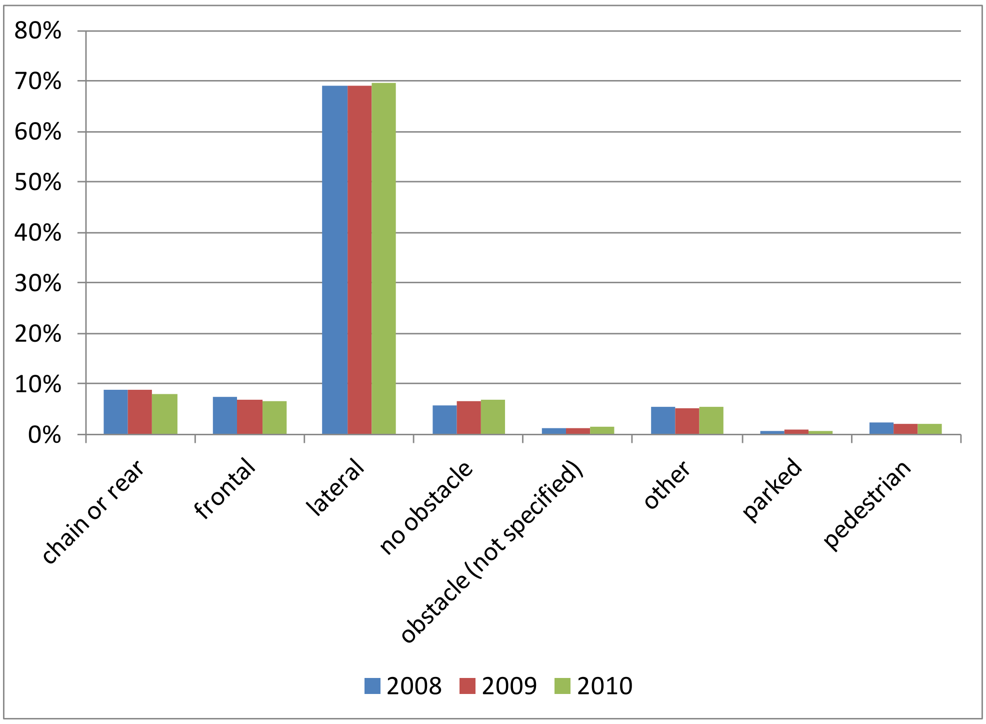


Figure 2.17 Type of collision of accidents with cyclist involved – 2008 – 2009 – 2010

2.2.4 Czech Republic

Of all traffic fatalities in Czech Republic in 2010, cyclist accounted for 9%.

Trends

The trend in traffic accidents with cyclists over the last years (from 2000 to 2010) is quite positive in Czech Republic. Figure 2.18 shows a significant decrease of the number of victims. The number of deaths has decreased with 45%. But many cyclists die due to errors of other road users (47% in 2009, 43% in 2010). In appendix L a table with the corresponding numbers can be found.

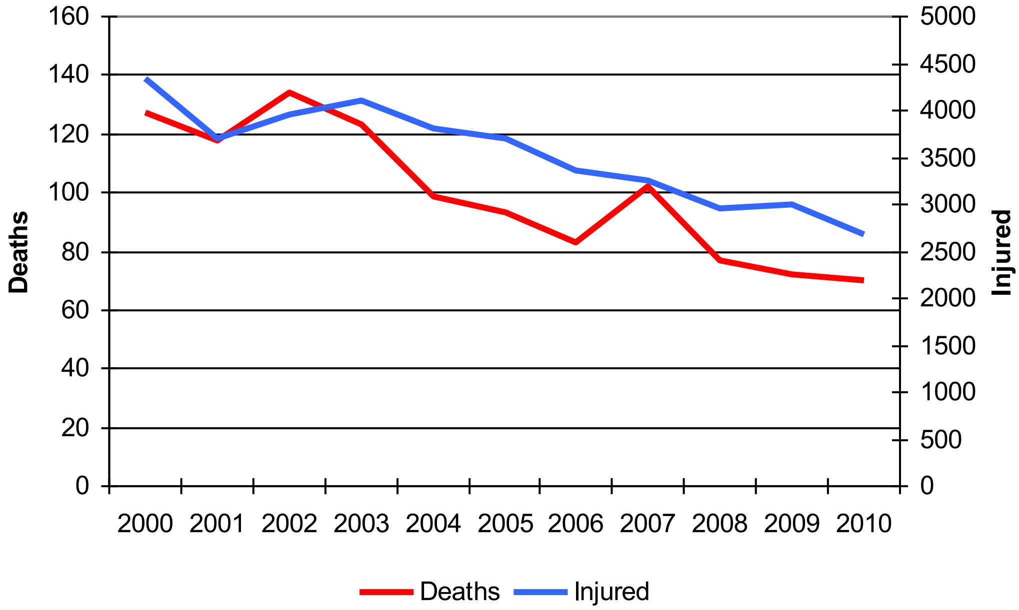


Figure 2.18 Trend of fatalities and injured in bicycle accidents

Spatial distribution

The distribution of fatality rate per region in the Czech Republic is shown in figure 2.19.

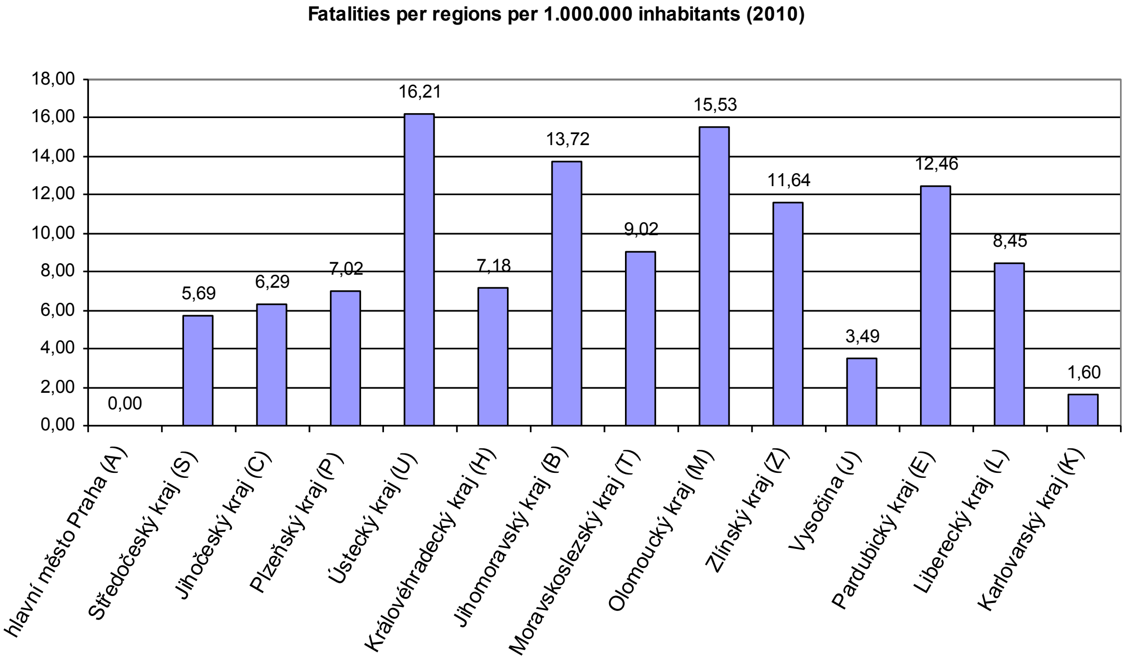


Figure 2.19 Fatality rates per region in Czech Republic - 2010

Accident situations

Comparing the situations of bicycle accidents according to location in Czech Republic, a lower percentage of bicycle accidents occur at intersections (21.22% vs 23.45%) and a higher percentage occurs in urban areas (53% vs 48% of all cyclists accidents) as can be seen in figure 2.20 and 2.21.

Regarding fatal accidents, a higher number of victims are in sections, which is mainly related to missing infrastructure for cycling (figure 2.21). Althoug volumes of cyclists are higher in cities, rural roads are more dangerous for cyclists because of higher speed diferences with car traffic.

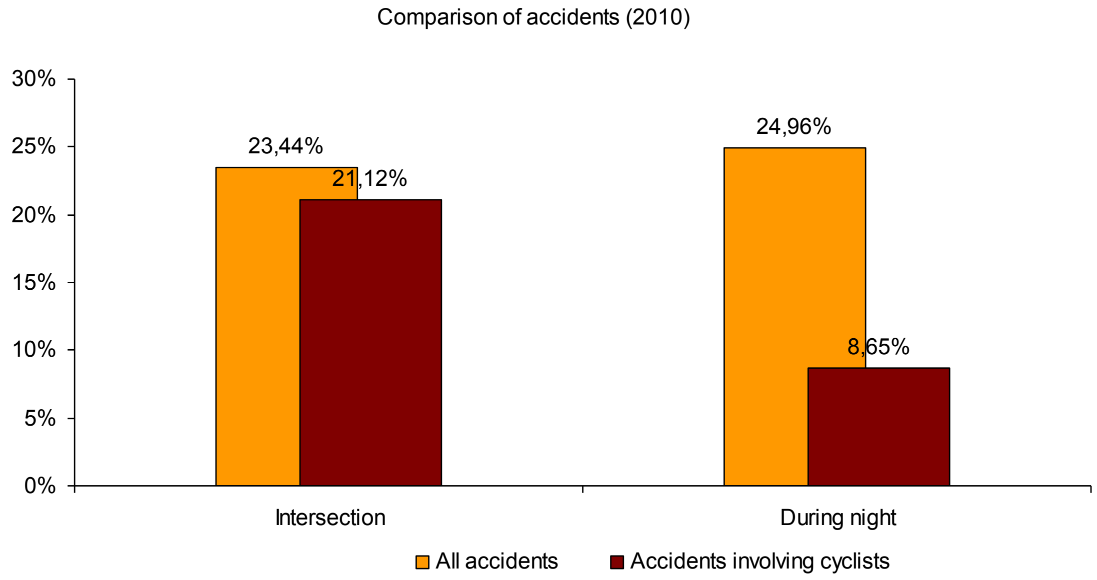


Figure 2.20 Comparison of traffic accidents situations (all accidents vs accidents involving bicycles) – 2010

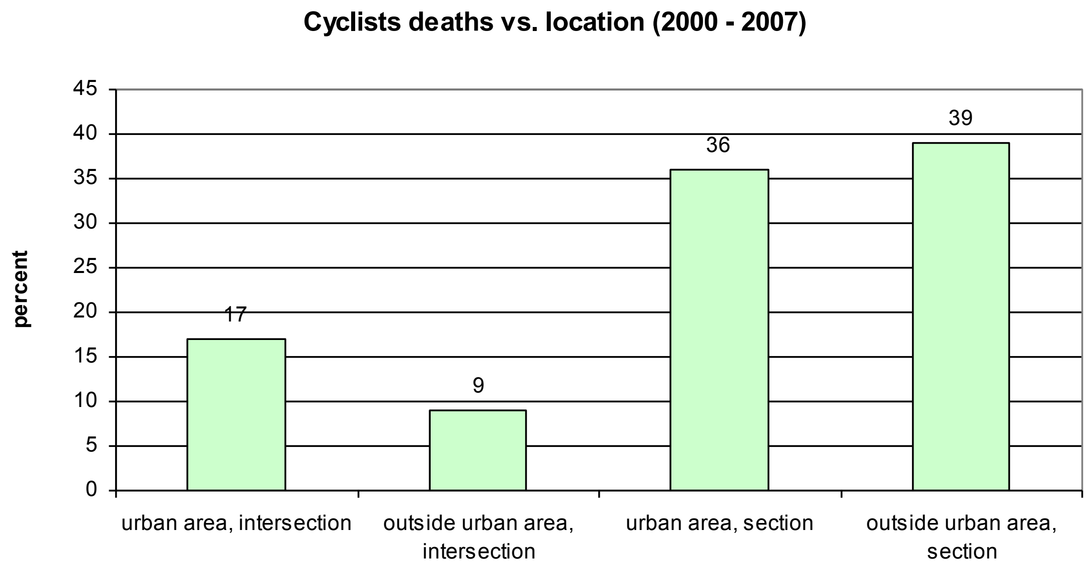


Figure 2.21 Comparison of cyclists fatal accidents according to location

The data of bicycle accidents per age group (table 2.7) show that most fatalities occur in the age group > 59 years old (40%). Looking at injured, most injuries occur in the age group 18 to 24 years old (36%).

Age group	Fatalities	Injuries
< 18	2	388
18-24	3	2,606
25-49	26	2,333
50-59	12	1,212
> 59	29	663
Unknown	0	0
Total	**72**	**7,202**

Table 2.7 Number of deaths and injured in bicycle per age group – 2009

Collision types

Figure 2.22 shows the main collision type of bicycle accidents in Czech Republic (2009 and 2010). The majority of collision types (around 40%) are lateral accidents. The corresponding numbers can be found in appendix M.

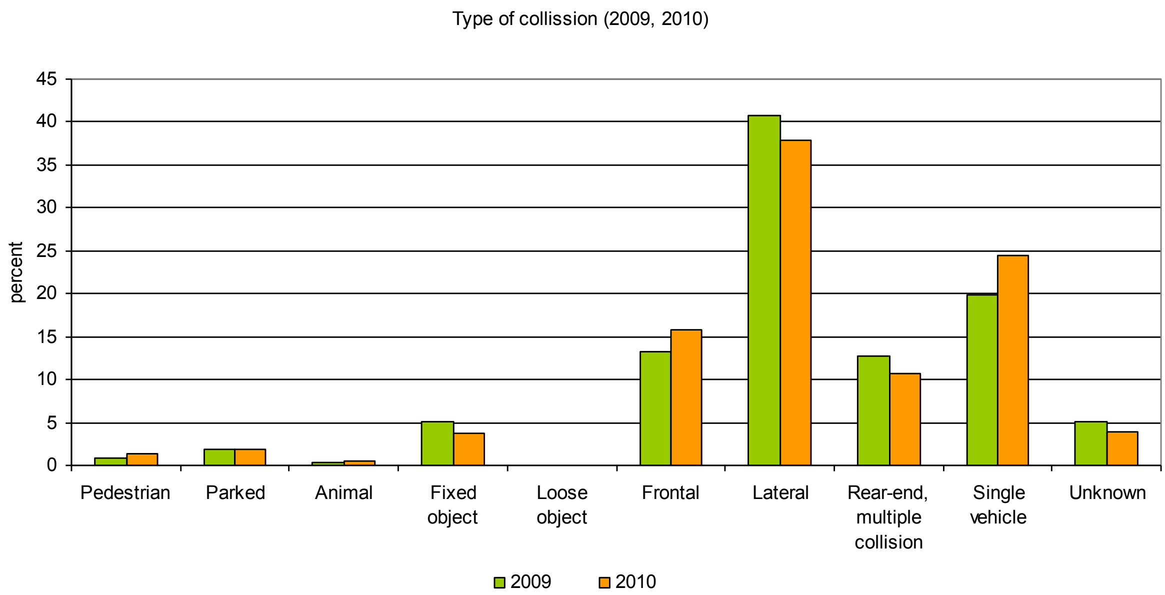


Figure 2.22 Type of collision of accidents with cyclist involved – 2009 and 2010

3. Methodology

The impact assessment of the most promising applications selected as output of the SWOT analysis is mainly based on a literature review of impacts on safety of similar measures (i.e. having similar effects).

The literature review is used to choose the most adequate Crash Reduction Factors (CRF) applied to the applications. This was not an easy task, since there is not much research available about e-safety and smart applications for safer cycling. Therefore CRFs of similar or comparable applications were used. In some cases it was assumed that all applications are installed in year 1, whereas in other cases it was assumed that applications were gradually implemented over time (every year 10% of the fleet). In the first situation the full CRF was applied for every year. In the latter situation (gradual implementation) in the first year 10% of the CRF was applied, in the second year 20% of the CRF etc, until 100% of the CRF in year 10. On average the latter situation results in a crash reduction of (10% + 100%)*CRF/2 = 0.55 CRF.

For each of the eleven applications a Cost-Benefit Analysis (CBA) was realised, based on assumptions about:

- costs for implementing the application;
- costs for maintaining the application, The assumption is 10% of the implementation costs per year;
- unit to be considered depending on the application (e.g. km of equipped roads, n° of traffic lights equipped, n° of vehicles equipped);
- type of accident (e.g. accident at intersection, accident at night, frontal accident)
- expected duration of the application, The expectation is ten years;
- an interest rate of 10%.

The actualised costs[3] are assumed to be the same for all four countries, because of a lack of information. The actualised costs are compared to the actualised social benefits associated to the reduction of cycling accidents, injuries and fatalities. Though one has to keep in mind that there are indications that especially (relatively light) injuries and accidents are underrecorded (Methorst & Schepers, 2011). The SWOV (2012b) indicates that single sided accidents, especially without serious consequences, are very often not registered. Therefore the expected benefits might be higher than predicted in the CBA.

In addition to the above, it should be noted that due the differences in definition, not all indicators are comparable. For example, an 'urban road' in the Netherlands might have a different definition than in Italy. Nevertheless, due to lack of better data, the analysis had to be based on available data, even if this means a certain degree of inaccuracy.

[3] Actualised costs are the costs of current and futuere investments (including annual maintenance costs) for a defined period at current cost level, by 'correcting' future costs with the interest rate,

While the implementation and maintenance costs were assumed to be equal in the four countries considered (Netherlands, Belgium, Italy and Czech Republic), the social costs were differentiated based on the last national figures. This implicates that safety benefits in Czech Republic are much lower compared to the other countries, because of the lower costs of fatalities, injuries and accidents.

The following table shows the social costs considered for the four countries,

Cost (€) *	Netherlands	Belgium	Italy	Czech Rep	Average ***
Accident **	€ 19,000	€ 16,000	€ 14,000	€ 4,800	€ 13,450
Injury	€ 236,000	€ 249,000	€ 183,000	€ 67,100	€ 183,775
Fatality	€ 1,782,000	€ 1,639,000	€ 1,430,000	€ 495,000	€ 1,336,500

* Social costs refer to official national data of 2002 (DaCoTa project)

** Only material damage

*** Average value is a mean value of the values of the four countries

The CRF are considered to be equal in the four selected countries. This assumption is made due to the lack of information and specific studies about the impacts of specific applications like those considered in the SAFECYCLE project,

This procedure allows for assessing the differences, in term of impacts, of the applications between the four selected countries. This especially allows to understand if (potentially) certain applications would be more cost effective to implement than others (i.e. if its benefits are higher than its costs) and in what countries applications could provide the highest benefits.

The results of the CBA and the assumptions and estimations made were successively assessed by international road safety, ITS and cycling experts. They provided opinions about the assumptions and about possible improvements. Finally the experts also contributed to discussions about the benefits of implementing applications and provided the project team with context relevant comments. The list of experts can be found in Annex B. The detailed calculations per application can be found Annex C.

4. Description of applications and the Cost Benefit Analysis

In this chapter the selected applications are described shortly, with a focus on the possible effects on the safety of cyclists[4]. Thereafter the impact assessment and the underlying data are presented per application. Each application is concluded with a discussion about the availability of data and value of the results.

4.1 Blind spot systems - LEXGUARD

The most common incident involving blind spots and lorries occur when the lorry turns right (or left in some EU-countries) without being able to see the cyclist. The cyclist is usually situated in an unsighted area to the side or just in front and to the side. In the accident, the cyclist is knocked off the bike and falls under the lorry as the corner is cut off as the lorry turns and the cyclists goes under the back wheels (ECF, 2012).

Improvements in technology and a better understanding of the causes of blind spot accidents have led the EU to adopt legislation aimed at reducing by means of appropriate devices the number and size of blind spots and consequently the number of accidents and fatalities. Directive 2003/97/EC2 requires all new vehicles put into circulation in the EU as of January 2007 to be equipped with blind spot mirrors (EC, 2012). The downside of mirrors is that these are passive systems. Drivers have to look in the mirrors themselves. That is why the focus of our research is on intelligent blind spot systems, with active warning systems. Directive EG/2003/97 and EG2005/2 created the possibility to replace the front mirror with a camera monitoring system.

Description of the LEXGUARD blind spot system

The active blind spot system is equipped with synthetic sensor strips at the right side of the trailer and at the front and the right side of the truck. These strips 'sense' and 'see' if there is an object in the blind spot. In case of dangerous situations an automatic sound and light warning system is activated inside the truck on the display. The signal becomes more intense when cyclists are close to the truck.

When the distance is less than 40 centimetres an extra sound and light warning is activated, so the truck driver knows he has to stop immediately. The system deactivates when the truck reaches a speed above 30 km/h to prevent unnecessary warning signals. More than thousand vehicles are equipped with LEXGUARD, mainly in Europe (for example in Germany, France and The Netherlands).

[4] For more information about applications, take a look at the deliverables 2 and 3 on the SAFECYCLE website

Impact on safety for cyclists

The literature review about CRFs of this application did not provide precise indications about its effects on road safety. It seems that similar applications have not been studied yet. Some studies about blind spot countermeasures instead exist, even if not specifically referred to ICT applications.

Effects on blind spot accidents are reported in Elvik et al, (2009) with reference to convex mirror, aimed at covering all fields of vision behind cars (blind zones may hide another vehicle, a cyclist or pedestrians). Convex mirrors were also found to reduce cars visibility and lead to an underestimation of the speed of passing cars. Elvik estimated a fatality decrease of 40%. A gradual implementation over ten years results in a fatality decrease of 22% (see explanation in chapter 3). The same percentage is assumed for injuries.

The CRFs assumed for this “blind spot application”, considering that it is an ICT application referred to cyclist’s accidents, are thus:

- Fatal accidents: -22%
- Serious injury accidents: -22%
- Other accidents: 0% (no effects)

First of all, the application was considered to have impacts on the accidents involving cyclists while turning left or right (CARE database, 2012). Second, in the Netherlands 25% of the fatalities and 1.25% of the injuries is a result of blind spot accidents (SWOV, 2008). In Belgium the figures are 15% and 0.25% (Casteels & Godart, 2008). For Italy and Czech Republic the percentages of the Netherlands are used. The figures for lateral blind spot accidents in the four countries, for the last year available (2009) are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	4,237	4,694	10,633	2,142	60,300
Injuries	45	63	130	26	788
Fatalities	20	8	34	10	156

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €2,700 per vehicle and it is assumed that every new truck uses LEXGUARD,

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	2,700	2,700	2,700	2,700	2,700
N° of vehicles*	39,000	56,000	171,000	20,000	1,700,000

* reference to average number of new trucks registered at country level in 2011 – source: EuroStat

The actualised costs and benefits for LEXGUARD are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	712	1,022	3,121	365	31,024
Actualised benefits (mln €)	63	39	97	9	477
B/C ratio	**0.09**	**0.04**	**0.03**	**0.02**	**0.02**

When the results between the countries are compared, the Netherlands shows the most potential. The B/C ratio for the other three countries is comparable. Compared to other applications, an important issue is the costs of LEXGUARD. It is estimated that the costs are €2,700 (based on information from an insurance company). That is why the costs are relatively high compared to the benefits.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	0.18	0.08	0.06	0.05	0.03
Interest rate 5%	0.09	0.04	0.03	0.03	0.02
Impact -50%	0.04	0.02	0.02	0.01	0.01

Decreasing the unit costs with 50% leads to an increase of the B/C ratio with 100%. An interest rate of 5% does not influence the B/C ratio very much. Reducing the impact with 50% (fatalities, injuries and accidents) leads to a decrease of 50% of the B/C ratio.

Discussion

Naturally the assumptions made have influenced the CBA results. The hypothesis was made that all new trucks and trailers will be equipped with LEXGUARD and that all the cyclist accidents due to vehicle turning are influenced. Since not all vehicle-turning accidents happen because of blind spots, the fatal accident reduction could be lower than the estimated amount.

However, it is possible that the potential effect of LEXGUARD is higher than estimated. An Italian expert expects that the effect of LEXGUARD may be greater than the reference used, which is the effect of convex mirrors. The main reason is that LEXGUARD issues a warning sound that activates the driver.

Although the costs seem to outrun the benefits, chances are high that this application does reduce fatalities and injury. It is proven technology and it warns the driver onscreen and with sound in case there is a cyclist in the blind spot.

4.2 Intelligent Speed Adaptation (ISA)

Speed management is an important theme in traffic management, aiming to optimize traffic in terms of safety and efficiency, by reducing speeding and speed differences in traffic. Research indicates that in about 30% of all fatal road accidents excessive speeding is involved, making it one of the crucial factors in road safety (SWOV, 2006).

Intelligent vehicles can perform tasks that conventional measures cannot do at all or less efficiently. The applications are an addition to current speed measures by helping to deploy the favoured speed limit system and increase the compliance with it. In-vehicle technology can support or force the driver to choose an appropriate speed at all times and places, and in highly changing, specific conditions, that cannot be accounted for in speed limits (SWOV, 2006).

Description of ISA

Intelligent Speed Adaptation (ISA) is an Advanced Driving Assistance System (ADAS) that may help the driver to cope with speed limits, ISA can be described as a system that:

1. “knows” the real-time location of a car (with the aid of GPS);
2. “knows” the (posted) speed limit at that specific location (e.g. using in-vehicle speed database);
3. compares the speed with the (posted) speed limit;
4. if the speed is inappropriate intervenes with the driving task.

ISA can use three types of limits: static, variable and dynamic speed limits (Bekiarias et al 2011). For the Cost Benefit Analysis, the mandatory (“dead throttle”) system was chosen.

Level of support	Type of feedback	Definition
Informing	Visual	The speed limit is displayed and the driver is reminded of speed limit changes
Voluntary (warning)	Visual/auditory	Warning when the driver exceeds the speed limit, Driver can ignore the warning
Voluntary (assisting)	Haptic throttle	Driver gets a force feedback through the gas pedal in case of speeding, Overruling the system is possible
Mandatory	Dead throttle	Vehicle speed is automatically limited

Source: Bekiarias et al 2011

Since the 1980s the effects of ISA have been studied using different methodologies, ISA is among the most investigated Intelligent Transport Systems. Many trials with different types of ISA have shown that ISA is an effective application to reduce speed and speeding. However, some investigators mention the acceptance versus effectiveness paradox. The more effective ISA is on road safety (restricting ISA) the less accepted it is by the users. This could be a barrier to implement ISA successfully.

Impact on safety for cyclists

The literature review about CRFs of this application did provide indications about its effects on road safety. Some studies about the effects of ISA exist, such as Carsten & Tate (2005) and the TRACE project.

In deliverable 4.1.4 of the TRACE project references about the effectiveness of mandatory ISA were found. An estimated decrease of 9% for fatalities and accidents and 5% for injuries leads to a decrease of 5% and 2.8% respectively due to a gradual implementation over ten years. The CRFs assumed for this application, considering that it is an ITS application referred to cyclist accidents, are thus:

- Fatal accidents: -5%
- Injury accidents: -2.8%
- Other accidents: -5%

The application was considered to have impacts on the accidents involving cyclists while turning left or right. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	4,237	4,694	10,633	2,142	60,300
Injuries	4,083	4,836	10,367	2,103	63,049
Fatalities	78	51	168	48	779

To estimate the implementation and maintenance costs of mandatory ISA, the following assumptions were made. The costs are estimated at €1,000 per vehicle and it is assumed that every new car uses mandatory ("dead throttle") ISA.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	1,000	1,000	1,000	1,000	1,000
N° of vehicles*	500,000	480,000	2,180,000	170,000	15,320,000

* reference to average number of new vehicles registered at country level in 2011 – source: EuroStat

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	3,380	3,244	14,735	1,149	103,548
Actualised benefits (mln €)	233	256	446	34	2,562
B/C ratio	**0.07**	**0.08**	**0.03**	**0.03**	**0.02**

Mandatory ISA is most effective in Belgium, followed by the Netherlands. The Benefit Cost ratio for Italy and Czech Republic are the same. The relatively high costs of ISA are the reason why the calculated Benefit Cost ratio is low.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	0.14	0.16	0.06	0.06	0.05
Interest rate 5%	0.07	0.08	0.03	0.03	0.03
Impact -50%	0.03	0.04	0.02	0.02	0.01

When unit costs are assumed to be €500 instead of €1,000 the B/C ratio increases with 100%. The B/C ratio remains below 0.17 for all countries. An impact reduction of 50% brings the B/C ratio close to zero.

Discussion

It was estimated that all new cars would be equipped with mandatory ISA. This will only happen if EU or national legislation obliges producers to equip cars with mandatory ISA. What's more, the acceptance of mandatory ISA by car drivers might be a problem. Drivers tend to like the fact that they can directly influence their own speed.

Next to an estimated effect on safety for cyclist ISA also has an effect on the safety of pedestrians. Speeding is not possible anymore, leading to lower speed of motor vehicles. We do not focus on pedestrian safety, but including pedestrians in the CBA might increase the B/C ratio substantially.

A Belgian expert says that contrary to the other applications ISA also has an effect on the environment and liveability of cities. When there is no speeding, the environment benefits because cars drive more environmentally friendly.

4.3 Car airbag for cyclists - SaveCap

In 2009 in the Netherlands, 185 cyclists were killed in road accidents and some 8,000 were hospitalised. There is an upward trend compared to accidents involving other transport modes. Since the bicycle is gaining in popularity as a means of transportation in all countries, this trend is alarming. A Dutch research institute is now investigating the characteristics of these accidents and studying and developing possible measures of protection (SaveCap, 2012). One of the promising applications is SaveCap.

Description

Pedestrians usually bump their heads on the bonnet of a car and the lower part of the windscreen. Cyclists appear to strike the higher part of the windscreen. Therefore, cyclists would benefit less from softening a car's bonnet or a pedestrian airbag. Different measures are required to protect cyclists.

Possible ways of preventing severe injuries to both cyclists and pedestrians can be found in an airbag that covers a larger part of the windscreen and in automatic braking systems. A study was conducted to find out what the effects would be of such systems (SaveCap, 2012).

Impact on safety for cyclists

The literature review about CRFs for airbags on car bonnet did not provide indications about its effects on road safety. Very few experiments have been done yet about this application.

Possible effects on frontal (car hits cyclist) accidents involving cyclists are reported in the website dedicated to this application (http://www,savecap,org/vulnerable-road-user-protection). An estimated decrease of 35% leads to a decrease of 19% due to a gradual implementation over ten years. The CRFs assumed are:

- Fatal accidents: -19%
- Injury accidents: -19%
- Other accidents: 0% (unknown effects)

The application was considered to have impacts on frontal accidents involving cyclists. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	408	452	1,025	206	7,978
Injuries	396	469	1,006	204	9,078
Fatalities	11	7	24	7	208

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €500 per vehicle and it is assumed that every new car is equipped with SaveCap.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€/car)	500	500	500	500	500
N° of vehicles*	500,000	480,000	2,180,000	170,000	15,320,000

* reference to average number of cars registered at country level in 2011 – source: EuroStat

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	1,690	1,622	7,367	575	51,774
Actualised benefits (mln €)	134	152	259	20	2,308
B/C ratio	**0.08**	**0.09**	**0.04**	**0.04**	**0.04**

Belgium and the Netherlands receive the highest benefits from the introduction of SaveCap, though the Benefit Cost ratio is low. The estimated costs of SaveCap are quite high and it was assumed that SaveCap only affects frontal accidents.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	0.16	0.19	0.07	0.07	0.09
Interest rate 5%	0.08	0.10	0.04	0.04	0.05
Impact -50%	0.04	0.05	0.02	0.02	0.02

Lowering unit costs with 50% leads to a maximum B/C ratio of 0.19 (Italy). Decreasing the impact with 50% brings the B/C ratio close to zero.

Discussion

According to an expert from Greece the proportion of cyclist fatalities is about 6% of all fatalities. However, differences between countries are large. In countries like the Netherlands and Denmark, where the bicycle is an important daily means of transport, the proportion of cyclist fatalities is much higher (18% and 13% respectively), whereas in Greece and Spain, the proportion of cyclist fatalities is only 1 or 2%. So the safety effect in the Netherlands is much greater than in Greece.

A Dutch expert thinks that Savecap can negatively influence the risk acceptance of both cyclists and car drivers. When Savecap is implemented on a large scale it is possible that more accidents occur, because Savecap mitigates the consequences of an accident. Another expert states that there are two different impacts, one with the car and one with the ground. Especially with elderly it is questionable what the mitigating effect is.

Another Dutch expert indicates that most cycling victims in the Netherlands are elderly. He questions whether an airbag mitigates the effects in case of accidents with elderly involved, since elderly are much more vulnerable. Therefore, more research is needed.

4.4 Countdown traffic light

This type of traffic light is equipped with a waiting time indicator (before green) together with an algorithm implemented in the traffic light software. The objective is to inform cyclists about the expected waiting time. It is expected that the countdown traffic light prevents cyclists to violate the red light.

Description

There are two types of waiting time indicators:

1. Indicators that predict the waiting time with small lights
2. Indicators that predict the waiting time with figures

The remaining waiting time is equally divided between the small lights. In case the waiting cycle is shortened, for instance at night when there are not many road users, the small lights fade out quicker (or the remaining waiting time decreases quicker).

Rain sensor

The optical rain sensor is shaped like a horseshoe and emits infrared signals. The sensor is heated in order to be able to detect snow as well. When rain or snow interrupts the infrared signal, this is detected and a signal is sent to a device that turns the traffic light for cyclists faster to green. The delay signal is adjustable, At this moment, two types of optical rain sensors are on the market. The first one registers whether it rains or not. The second type of sensor distinguishes between four levels, ranging from drizzle to heavy rain.

A rain sensor cannot be integrated within any existing traffic management system. It can only be applied to modern devices. It cannot be used with traffic lights which are part of a network because in that case, influencing one traffic light would impact on a whole chain of traffic lights, which would undermine the set regulations for that particular.

The rain sensor can be considered as a specific type of countdown system, but can also be connected to a countdown system.

Impact on safety for cyclists

In the Netherlands some research about the countdown traffic light is executed. There is not one general conclusion; research in Tilburg indicates that cyclists violate the red light even more (Gemeente Tilburg, 2008) whereas research in Amsterdam shows that there is a decrease in red light negation (Gemeente Amsterdam, 2006). Therefore, the literature review in The Netherlands about CRFs of this application did not provide useful indications about its effects on road safety.

In the Netherlands 18% of the accidents at intersections happen at traffic controlled intersections (Rijkswaterstaat, 2010). If it is assumed that 5% of all traffic light accidents can be avoided the CRFs assumed for the countdown traffic light are:

- Fatal accidents: -0.9%
- Injury accidents: -0.9%
- Other accidents: -0.9%

The application was considered to have impacts on the accidents involving cyclists on junctions. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	2,347	3,676	6,802	1,899	77,126
Injuries	2,204	3,767	6,480	1,824	80,336
Fatalities	87	41	125	25	650

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €2,500 per traffic light and it is assumed that there are 0.05 traffic light intersections per urban (not provincial or state) road kilometre. It is also assumed that all traffic lights are equipped with the countdown application. We note that the amount of urban roads in Italy seems to be too low, since the country is much bigger than the Netherlands or Belgium. It might be a matter of definition.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	2,500	2,500	2,500	2,500	2,500
N° of traffic lights*	5,900	6,900	3,450	3,750	90,000

* based on km of urban roads per country - assumption of 0,05 traffic light intersection per km urban road in 2011 – source: EuroStat

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	24	28	14	15	363
Actualised benefits (mln €)	40	59	81	8	922
B/C ratio	**1.67**	**2.11**	**5.80**	**0.53**	**2.54**

Italy will benefit most from the countdown traffic light. The Benefit Cost ratio for Italy is much higher than Belgium, the Netherlands and Czech Republic. All Benefit Cost ratios are higher than one, except for Czech Republic, because the amount of traffic lights is quite low and the expected benefits are quite high.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	3.34	4.23	11.60	1.05	5.08
Interest rate 5%	2.45	3.09	8.49	0.77	3.71
Impact -50%	0.84	1.06	2.90	0.26	1.27

In case the unit costs are lowered with 50% the B/C ratio for all countries is higher than one. Changing the interest rate to 5% leads to an increase of the B/C ratio. When we take Italy as an example, the B/C ratio changes from 5.80 to 8.49. If the impact decreases with 50% the B/C ration of the countdown traffic light no longer is above one for the Netherlands.

Discussion

A Dutch expert explains that there is a risk that people start cycling a short period before green. This is called the anticipation effect. In the Netherlands it is questionable whether the countdown traffic light prevents red light negation. It is also possible that the traffic cycle starts again shortly before the red light is supposed to turn green (bus priority). When cyclists anticipate and start cycling just before green the consequences might be enormous.

A rain sensor is beneficial for more comfort, though it is possible that cyclists violate the red light when they see they have to wait relatively long for green.

4.5 LightLane bike

Originally, LightLane was created for a design competition to promote commuting by bicycle. The response was overwhelming, although the concept did not win. On the website of LightLane it is said that this encouraged the inventors to continue development. However, there does not seem to be any activity since 2009. A Chinese company also developed a similar application called the laser taillight and it is in production already.

Description

A green (or red) laser projects a cycle lane behind the bicycle, making the cyclist more visible so that other road users (car drivers) take account of the cyclist’s presence. Specifications of LightLane are: high visibility green (or red) lasers, super-bright red LED’s, and three hour runtime on rechargeable Li-Ion battery. LightLane is also compatible with universal mobile-phone charger standard (LightLane, 2009).

Impact on safety for cyclists

The literature review about CRFs for the light lane bicycle or similar applications did not provide indications about its effects on road safety.

Effects on the use of lights are reported in Elvik et al, (2009) with reference to the use of taillights on all bicycles. The estimated effect is a decrease of accidents with 80%. It is assumed that the effect of the light lane bike is half the effect, leading to the following CRFs for this application:

- Fatal accidents: -40%
- Injury accidents: -40%
- Other accidents: -40%

The application was considered to have impacts on the accidents involving cyclists at night. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	776	866	2,809	648	12,760
Injuries	720	866	2,684	635	13,324
Fatalities	24	15	75	20	418

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €15 per bicycle and it is assumed that all bicycles are equipped with the LightLane Bike.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	15	15	15	15	15
N° of bicycles*	16,000,000	5,500,000	27,000,000	5,200,000	223,800,000

* bicycles per country in 2007 – source: Ministerie van Verkeer en Waterstaat & Fietsberaad (2009)

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	387	133	654	125	5,420
Actualised benefits (mln €)	559	624	1,567	136	7,813
B/C ratio	**1.44**	**4.69**	**2.40**	**1.09**	**1.44**

The Benefit Cost ratio is positive for all countries, but Belgium shows the highest potential. The effect is almost twice as high compared to Italy and three or four times higher than the Netherlands and Czech Republic. This means that night-time accidents in Belgium happen relatively often compared to the other countries. Improved bicycle lighting and claiming the road with light could improve the safety of cyclists in the dark.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	2.89	9.38	4.79	2.17	2.88
Interest rate 5%	2.11	6.86	3.51	1.59	2.11
Impact -50%	0.72	2.34	1.20	0.54	0.72

Reducing the impact of LightLane Bike with 50% leads to a B/C ratio lower than one for the Netherlands, Czech Republic and the EU. It can also be seen that changing the interest rate to 5% leads to a higher B/C ratio (EU from 1.44 to 2.11).

Discussion

With regular lighting at roads, the effect of LightLane Bike might be low. However, for rural areas of countries without well-developed cycling infrastructure the effects of LightLane Bike could be substantial with regard to road safety benefits.

A Dutch expert is curious about what happens when a lot cyclists travel together and all use the light lane bicycle. For other road users, this is distracting and disturbing. The effectiveness also depends on how long the battery lasts.

4.6 HindSight

The idea behind Hindsight is that it is important to be aware of what is happening behind the bicycle. With a camera attached to the seat post and a display on the steering wheel cyclists do not have to take their eyes of the road ahead to see what is happening behind them.

Description

A digital camera is attached to the seat post or seat stay and sends video data to a handlebar-mounted head-unit. The head-unit is a LCD screen and sunlight readable. It also gives information about speed, average speed, trip distance, odometer and more. The video data is recorded to an internal memory card, so it is possible to review what happened behind you in case of an accident (Cerevellum, 2009).

Impact on safety for cyclists

The literature review about CRFs for hindsight or similar applications did not provide indications about its effects on road safety. Also, there are no figures available about cycling accidents due to problems with moving your head.

Effects on the use of car mirrors on the passenger side are reported in Elvik et al, (2009). Although it might not be completely comparable to Hindsight it is assumed that the effect of car mirrors on the passenger side are the same. Therefore, the following CRFs for this application are assumed:

- Fatal accidents: -21%
- Injury accidents: -21%
- Other accidents: -21%

The application was considered to have impacts on rear-end accidents involving cyclists. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	533	591	1338	270	6,755
Injuries	502	595	1275	259	7,224
Fatalities	31	20	66	19	339

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €250 per bicycle and it is assumed that 30% of all bicycles are equipped with HindSight.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	250	250	250	250	250
N° of bicycles*	4,800,000	1,650,000	8,100,000	1,560,000	67,147,000

* 30% of all bicycles in 2007 – source: Ministerie van Verkeer en Waterstaat & Fietsberaad (2009)

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	1,937	666	3,269	630	27,101
Actualised benefits (mln €)	237	246	447	36	2,415
B/C ratio	**0.12**	**0.37**	**0.14**	**0.06**	**0.09**

The result of the CBA is not very positive for HindSight. In Belgium the potential of this application is relatively high compared to the other countries. This is because rear-end accidents happen more often in Belgium.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	0.24	0.74	0.27	0.12	0.18
Interest rate 5%	0.18	0.54	0.20	0.08	0.13
Impact -50%	0.06	0.18	0.07	0.03	0.04

When unit costs are reduced with 50% the B/C ratio for Belgium is the highest with 0.74. If it is assumed that the impact is reduced with 50%, than the B/C ratio is close to zero.

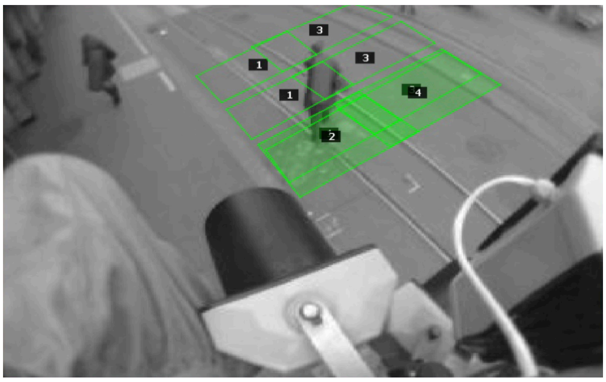
Discussion

A Dutch road safety expert mentions that an application with a display that assist the driver or cyclist, possibly distracts the driver or cyclist from the driving task. And distraction is an important cause of accidents. Another Dutch expert is worried about vandalism and what happens when the system fails. Other questions are if Hindsight is only beneficial for cyclists with stability problems or not. More research is needed to answer these questions.

4.7 Traffic Eye Zurich

In 2011 in Zurich (Switzerland) a new traffic regime called Traffic Eye was implemented. This is a new cyclist detection system at a tram stop, where TraffiCam is combined with a metal detector. Traffic Eye prevents conflicts between trams and cyclists sharing the same road. Three different measures for cyclists were necessary: regulation of lighting signals, on road marking, and signalization (Stadt Zurich, 2011).

Description



The idea behind Traffic Eye is as follows. When a tram is approaching it instantly gets the green light, In case a tram and a cyclist are approaching at the same time, it depends on the situation who gets priority. In one direction the cyclist gets a head start of ten seconds, to prevent conflicts with trams. It is also possible to do this with other types of traffic, such as cars.

Several signalization changes were needed to implement Traffic Eye:

1. Common road use by pedestrians and cyclists (two times)
2. No entry, except cyclists (two times)
3. No priority for cyclists (one time)
4. One way street/oncoming cyclists (one time)

The first results are that the system is functioning as expected and there are no technical problems reported. However, 47% of the cyclists are violating the new traffic regime (they might not want to wait too long before green). This raises questions about the acceptance of Traffic Eye by cyclists (Stadt Zurich, 2011).

Impact on safety for cyclists

The literature review about CRFs for Traffic Eye Zurich or similar applications did not provide indications about its effects on road safety.

Effects on the vehicle actuated phase change are reported in Elvik et al, (2009). Elvik estimates a decrease in accidents of 25%. Although it might not be completely comparable to Traffic Eye it is assumed as a reference value. It is assumed that 10% of the most dangerous intersections are equipped with Traffic Eye, leading to an effect of 50% of the reference value. Therefore, the following CRFs for this application are assumed:

- Fatal accidents: -12.5%
- Injury accidents: -12.5%
- Other accidents: -12.5%

The application was considered to have impacts on blind spot accidents involving cyclists on junctions equipped with traffic lights. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	5	8	15	4	174
Injuries	5	8	15	4	181
Fatalities	3	1	5	1	23

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €2,500 per traffic light and it is assumed that there are 0,05 traffic light intersections per urban (not provincial or state) road kilometre. It is also assumed that 10% of all traffic lights use the Traffic Eye.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	2,500	2,500	2,500	2,500	2,500
N° of traffic lights*	590	690	3,450	375	9,000

* based on km of urban roads per country - assumption of 3 traffic lights per km in 2011 and that 10% is equipped with Traffic Eye – source: EuroStat

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	2,4	2,8	14,0	1,5	36
Actualised benefits (mln €)	5,3	3,6	7,2	0,6	51
B/C ratio	**2.21**	**1.29**	**0.51**	**0.38**	**1.41**

The Benefit Cost ratio for the Netherlands and Belgium are higher than one. The estimated benefits in Italy and Czech Republic are four to six times lower than in the Netherlands. In the Netherlands accidents happen relatively often at intersections and that is why the Benefit Cost ratio is higher than in the other countries.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	4.42	2.57	1.03	0.75	2.83
Interest rate 5%	3.23	1.88	0.75	0.55	2.07
Impact -50%	1.06	0.62	0.25	0.18	0.68

Lowering the unit costs with 50% leads to a B/C ratio higher than one for Italy. For Czech Republic the B/C ratio remains lower than one. When the impact of Traffic Eye is reduced with 50%, only the B/C ratio for the Netherlands remains higher than one.

Discussion

One of the most important preconditions for predicted benefits of Traffic Eye is that several types of road users are using one lane in front of a traffic light. When for instance cyclists and motorized vehicles use different lanes and have separate traffic lights, the Traffic Eye does not have any effect. In countries like the Netherlands this is more and more often the case. The estimated Benefit Cost ratio might be too high. For countries like Italy and Czech Republic the estimated effect might be too low, because there are fewer separate cycling lanes.

4.8 Bicycle braking light

Imagine as a cyclist decelerates by putting on the brakes and a bright brake light lights up just like on a car, with the difference that the braking light is not wired to anything. It is attached to the bicycle seat post. This application is called LucidBrake. The difference with other braking lights is that the application does not need mechanical interfacing with the braking system (LucidBrake, 2012).

Currently, the developers are in the middle of a intellectual property discussion with manufacturers and legal people. When the discussion is finished, more information will become available.

Description

The LucidBrake application is situated on the bicycle seat post and automatically adjusts to the angle of mount. It is an awareness beacon when braking is not being signalled by other road users. The braking light can be seen for more than 50 yards at night. When braking is being signalled, the 16 LED's flash until the cyclist stops. The bicycle does not have to be modified, adapted or customized in any possible way (LucidBrake, 2012).

Impact on safety for cyclists

The literature review about CRFs for the bicycle braking light or similar applications did not provide indications about its effects on road safety. Therefore the following CRFs for this application are assumed:

- Fatal accidents: -20%
- Injury accidents: -20%
- Other accidents: -20%

The application was considered to have impacts on rear-end accidents involving cyclists. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	533	591	1338	270	6,755
Injuries	502	595	1275	259	7,224
Fatalities	31	20	66	19	339

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €30 per bicycle and it is assumed that 30% of all bicycles are equipped with Bicycle braking light.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	30	30	30	30	30
N° of bicycles*	4,800,000	1,650,000	8,100,000	1,560,000	67,147,000

* 30% of the amount of bicycles per inhabitants in 2007 – source: Ministerie van Verkeer en Waterstaat & Fietsberaad (2009)

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	232	80	392	76	3,252
Actualised benefits (mln €)	226	234	426	35	2,300
B/C ratio	**0.97**	**2.93**	**1.09**	**0.46**	**0.71**

The Benefit Cost ratio is highest in Belgium, followed by Italy and the Netherlands. This is caused by the fact that in Belgium there are relatively many rear-end accidents involving cyclists.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	1.94	5.86	2.17	0.91	1.41
Interest rate 5%	1.42	4.29	1.59	0.67	1.04
Impact -50%	0.49	1.46	0.54	0.23	0.35

If unit cost are reduced with 50% than the B/C ratio is higher than one for all countries, except Czech Republic. Changing the interest rate to 5% has the same effect. When the impact is reduced with 50% than the B/C ratio is positive for Belgium only.

Discussion

An important question is whether the bicycle braking light affects all rear-end accidents involving cyclists. When cycling in larger groups and close to each other the effect seems rather low.

A Dutch cycling policy developer expects a lot from the bike braking light, but only when it is made obligatory by the government. Than it can lead to a decrease of the bicycle-bicycle and bicycle-moped accidents.

A problem however might arise if some cyclists do have a bicycle braking light and others don't. Then car drivers might count on the bicycle braking light, which then could create dangerous situations.

4.9 Routeplanner Gent

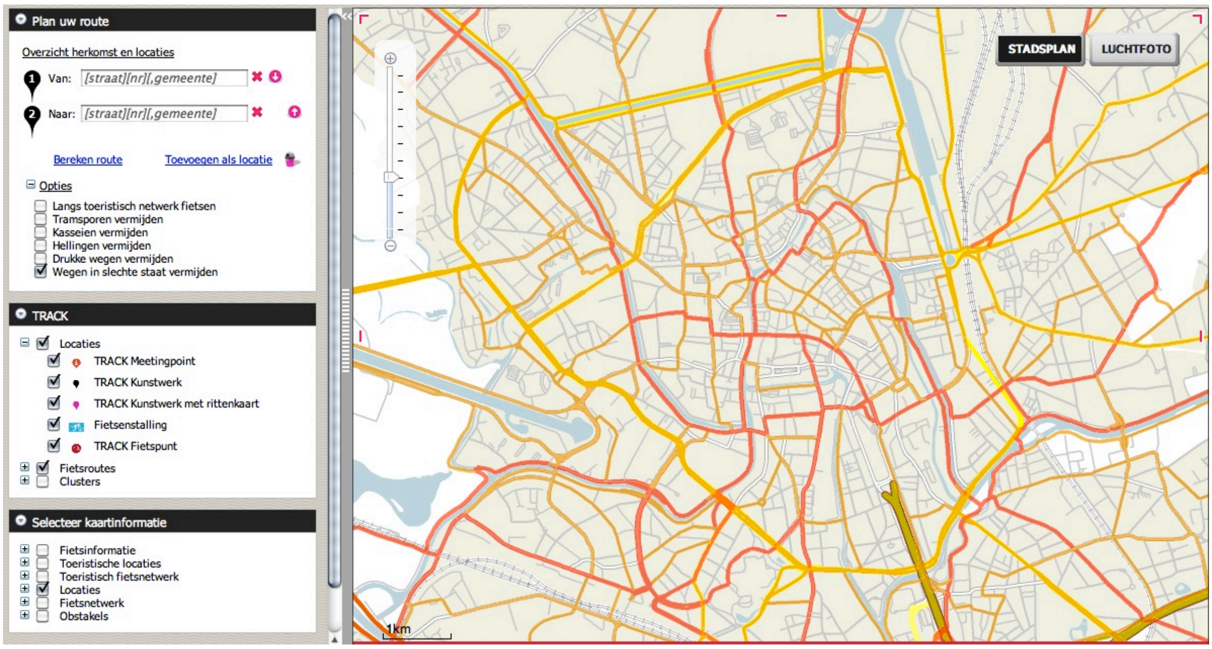
With this application it is easier for cyclists to plan safer routes in the City of Gent (Belgium). It is possible to avoid:

- tram tracks;
- cobblestones;
- gradients;
- roads with lots of traffic;
- roads in a poor state of repair.

Next to safer routes information it is possible to select more information: bike information, tourist locations, tourist cycle network, locations, cycle network and obstacles (Fietsrouteplanner Gent, 2012).

From September 2010 until May 2012 more than 36,000 people visited the Routeplanner Gent website (more than 22,000 unique visitors) resulting in 46,000 planned routes.

Description



The Fietsrouteplanner Gent web application is accessible by the public through a standard Internet browser as part of the website www.fietsrouteplanner.gentfietst.be. The application is based on Mapplate, extended with custom developed functionality. The web application focuses on an interactive graphical user interface and an intuitive user experience. Routes can be downloaded on a GPS device.

The web application relies on a variety of web services for a broad range of server-side functionality. The application calls map services on the GIS server to generate map images for basemaps and thematic map overlays. The GIS server uses locally stored cached map tiles, as well as thematic spatial datasets. It hosts a routing service for optimized bicycle route calculations, using an enriched roads network spatial dataset. The Geolocator server hosts geocoding and reverse geocoding web services. Geocoding functionality is used to decide on a location of an address (address to location). Reverse geocoding functionality is used to find an address that matches a certain location (location to address). The SharePoint server hosts feedback registration web services. With this functionality, the user feedback, entered by the user in the contact form, is registered within SharePoint, and made accessible to city staff for follow up.

Impact on safety for cyclists

The literature review about CRFs for safer routes did not provide indications about its effects on road safety. One of the reasons for this result is that cycling routeplanners with safer routes are quite a new phenomenon.

Effects on the use of dynamic route guidance are reported in Elvik et al, (2009) with reference to road safety effects. If 100% of the cyclists uses the safer routes application, the following CRFs are assumed:

- Fatal accidents: -1.5%
- Injury accidents: -1.5%
- Other accidents: -1.5%

The application was considered to have impacts on all accidents. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	6,130	6,792	15,385	3,100	159,740
Injuries	5,831	6,906	14,804	3,003	168,539
Fatalities	138	89	295	84	2,353

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs of building a routeplannner are estimated at €1,000,000 per country, except for Italy because the country is much bigger. Further, it is assumed that all cyclists use the routeplanner.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	1,000,000	1,000,000	2,000,000	1,000,000	27,000,000

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	1.6	1.6	3.2	1.6	44
Actualised benefits (mln €)	160	182	308	24	3,342
B/C ratio	**99.25**	**112.70**	**95.52**	**14.73**	**76.68**

The Benefit Cost ratio is very high for all countries. The estimated costs are relatively low compared to the benefits. It is assumed that all cyclists use safer routes, but that the safety effect is low (1,5% decrease of fatalities, injuries and accidents). Even if a safety effect of 0.1% is assumed, the Benefit Cost ratio is higher than one for the Netherlands, Belgium and Italy.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	198.50	225.40	191.04	29.45	153.37
Interest rate 5%	145.28	164.97	139.82	21.56	112.24
Impact -50%	72.64	82.48	69.91	10.78	56.12
Impact* 0.01%	0.97	1.10	0.93	0.14	0.75

**Fatalities, injuries and accidents reduced with 0.01%*

The assumption that the Routeplanner has an impact of 0.01% is added to this table. With an impact of 0.01 the B/C ratio is close to one for the Netherlands, Belgium and Italy.

Discussion

The assumption that every cyclist uses a routeplanner for safer routes is unrealistic. First of all, not all cyclists have access to internet. Second, that all cyclists know a routeplanner for safer routes is also not very realistic. However, there is no data available about the use of routeplanners and it is also hard to make a solid assumption about the use of routeplanners.

Some experts think that this application can be useful to plan safe routes to school for children. It also raises awareness about safe route choices.

A Belgian expert expects that the impact will be higher if the routeplanner is combined with on street signing. Another option that might increase the safety effect is to allow people to download tracks for GPS or smartphones.

4.10 LED-Mark

The LED-Mark was initially about 10 years ago an idea of a Danish inventor, who wanted to increase the effect of road marking lines, by installing solar powered road studs in the thermoplastic lines. A private company (Geveko ITS) partnered up with this inventor, and took over the rights to the product 5-6 years ago. Since then the product has undergone further development. Compared to other technologies and products LED-Mark is a feasible way of increasing the security feeling of the cyclists.

Description

LED-Mark is used as additional road marking, where there are risks or needs for making roads or paths more visible (Geveko ITS, 2012):

- Black spots
- Roundabouts
- Cycle paths
- Pedestrian crossings
- School roads
- Spots of road prone to frost

The LED-Mark has been sold for cycle paths in Denmark, Germany and Holland. The total number of produced LED-Mark is approximately 4,000 pieces, and they have been used for both cycle paths and roads. The number of kilometres cycle path with LED-Mark installed is approximately 25 to 30 kilometres. One of the benefits is that it withstands extreme conditions such as snow ploughs and other vehicles used for road maintenance.

The installation costs are approximately 1/10 of wire based technologies and the operation costs approximately 1/3. Mounting is done by gluing and there is no need for additional mounting. The mounting time is short, so it does not disturb cycling commuters. The budget price is approximately € 4,700 EUR per km cycle path depending on the specifics of the cycle path (Geveko ITS, 2012).

Impact on safety for cyclists

Academic research has not yet been done as to the effects of LED-Mark, but very recently an evaluation from Fureso Municipality in Denmark was received, who have installed the product and evaluated the effect. Cyclists are positive about the LED-Mark, stating that the lighting is more efficient (Geveko ITS, 2012). More specific figures are not available,

Effects on the use of improved road lighting are reported in Elvik et al, (2009). A decrease in fatal and injury accidents of 8% and a decrease of 1% in other accidents is estimated by Elvik. These figures are assumed as reference values. It is assumed that 10% of the most dangerous roads are equipped with LED-Mark, leading to an effect of 50% of the reference value. Therefore, the following CRFs for this application are assumed:

- Fatal accidents: -4%
- Injury accidents: -4%
- Other accidents: -0.5%

The application was considered to have impacts on the accidents involving cyclists at night. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	411	459	1,489	343	6,763
Injuries	382	459	1,423	337	7,062
Fatalities	13	8	39	11	222

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs are estimated at €4,700 per kilometre and it is also assumed that 10% of all roads are equipped with LED-Mark.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	4,700	4,700	4,700	4,700	4,700
N° of road km*	12,900	15,200	24,600	13,000	410,000

* 10% of all road kilometres in 2011 – source: Eurostat

The actualised costs and benefits are shown in the next table,

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	98	115	187	99	3,111
Actualised benefits (mln €)	28	32	78	7	397
B/C ratio	**0.29**	**0.27**	**0.42**	**0.07**	**0.13**

The Benefit Cost ratio for LED-Mark is lower than one for all four countries. The highest ratio is estimated for Italy and the lowest for Czech Republic. Since there are many accidents in the dark in Italy compared to the other countries, the absence of lighting or low quality lighting could be an important explanation. The amount of road kilometres is much higher in Italy than in the other countries. It might be that this also plays a role here.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	0.57	0.55	0.84	0.14	0.26
Interest rate 5%	0.42	0.40	0.61	0.10	0.19
Impact -50%	0.14	0.14	0.21	0.03	0.06

Reducing the unit cost of LED-Mark with 50% does not lead to a B/C ratio higher than one. When the impact is reduced with 50% than the B/C ratio is close to zero for Czech Republic.

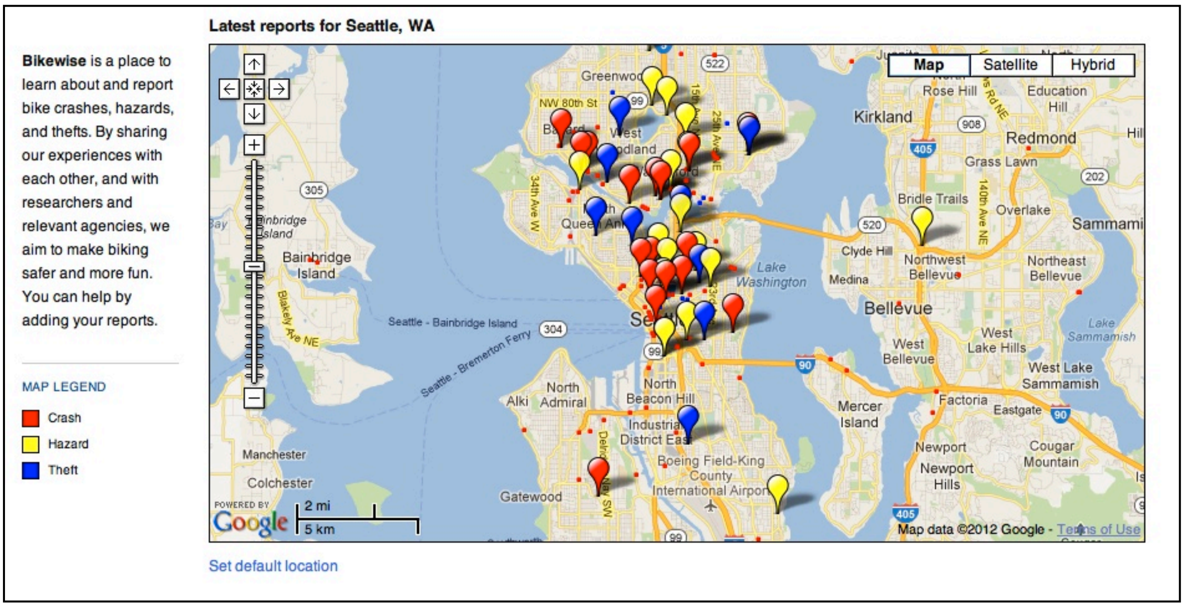
Discussion

It is hard to predict what the difference is between improved lighting and placing LED (instead of regular lighting) at places where there was no lighting before. Further, it is impossible to estimate what kind of accidents is related to poor 'regular' lighting.

4.11 Bikewise / Citizens Connekt

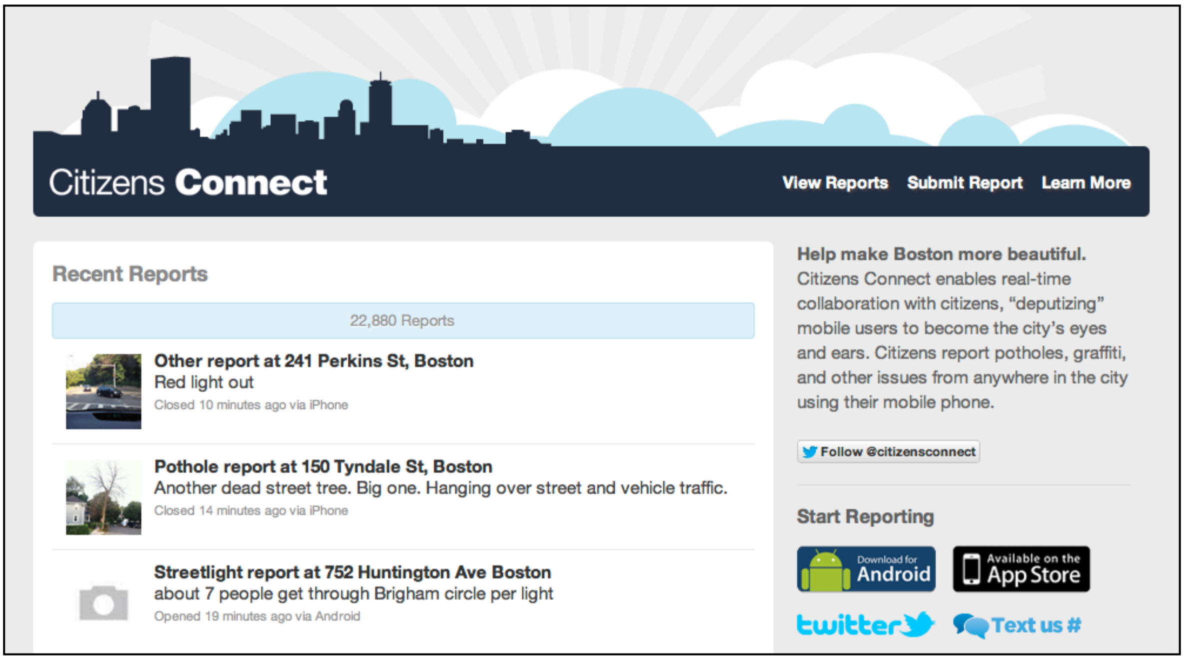
Bikewise and Citizens Connekt are applications to mobilize citizens. The interactive nature of the applications is very interesting, especially in relation to cycling and road safety. Bikewise is a place to learn about and report bike crashes, hazards, and thefts. By sharing experiences with each other, and with researchers and relevant agencies, the aim is to make cycling safer and more fun. Bikewise is run by the Cascade Cycling Club, Citizens Connekt is developed by the City of Boston. Citizens can inform the city by smartphone about potholes and other issues.

Description



Bikewise is currently used as a tool to collect crash, hazard and theft data in a way that can be utilized by local agencies. For example, if someone submits a bicycle hazard report using Bikewise in Seattle, this report is automatically forwarded to the Seattle Department of Transportation so they can respond to the issue. Many of the hazard reports that have been submitted in Seattle have been reported as fixed.

It is estimated that 75% or more of all crashes go unreported. Bikewise believes that by gathering detailed information on how and why crashes happen, cyclists are able to ride smarter. Knowledge about where crash hotspots are will help Bikewise to identify issues with traffic behaviour and road design (Cascade Bicycle Club, 2012).



Citizens Connect enables real-time collaboration with citizens, "deputizing" mobile users to become the eyes and ears of the city. Citizens report potholes, graffiti, and other issues from anywhere in the city using their mobile phone (City of Boston, 2012).

Impact on safety for cyclists

At this point research evaluating the level of impact that applications like Bikewise have on bicycle safety is not conducted. However it is anecdotally known that this application is helping to improve safety by facilitating data collection, exchange, and ultimately a response to specific safety issues. It is known that approximately 4,000 potholes were filled because of constituents using the Citizens Connekt application.

Bikewise and Citizens Connekt can be used to inform governments and other cyclists about dangerous situations, but it does not suggest safer routes as Routeplanner Gent. It is assumed that 10% of the effects of Routeplanner Gent can be achieved, leading to the following CRFs:

- Fatal accidents: -0.15%
- Injury accidents: -0.15%
- Other accidents: -0.15%

The application was considered to have impacts on all accidents. The figures for these accidents in the four countries, for the last year available (2009) are shown in the next table (CARE database, 2012).

	Netherlands	Belgium	Italy	Czech Rep	EU
Accidents	6,130	6,792	15,385	3,100	159,740
Injuries	5,831	6,906	14,804	3,003	168,539
Fatalities	138	89	295	84	2353

To estimate the implementation and maintenance costs of this system, the following assumptions were made. The costs of building an application similar to Citizens Connect are estimated at €1,000,000 per country, except for Italy because the country is much bigger. Further, it is assumed that all cyclists use the application.

	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost (€)	1,000,000	1,000,000	2,000,000	1,000,000	27,000,000

The actualised costs and benefits are shown in the next table.

	Netherlands	Belgium	Italy	Czech Rep	EU
Actualised costs (mln €)	1.6	1.6	3.2	1.6	44
Actualised benefits (mln €)	16	18	31	2	334
B/C ratio	**9.93**	**11.27**	**9.55**	**1.47**	**7.67**

The Benefit Cost ratio is higher than one for all countries. The highest effect is estimated for Belgium, followed by the Netherlands, Italy and Czech Republic. It is assumed that Bikewise has an effect on all accidents, which is probably not the case. Therefore the Benefit Cost ratio might be too high.

The next table shows the effect of changed assumptions in the B/C ratio.

Changed in B/C ratio	Netherlands	Belgium	Italy	Czech Rep	EU
Unit cost -50%	19.85	22.54	19.10	2.95	15.34
Interest rate 5%	14.53	16.50	13.98	2.16	11.22
Impact -50%	4.96	5.64	4.78	0.74	3.83
Impact* 1.5%	99.25	112.70	95.52	14.73	76.68
Impact 0.01%**	0.66	0.75	0.64	0.10	0.51

** Fatalities, injuries and accidents reduced with 1.5%*

***Fatalities, injuries and accidents reduced with 0.01%*

When the impact is reduced to 0.01% the B/C ratio is higher than 0.5 for the Netherlands, Belgium, Italy and the EU. Reducing the impact with 50% leads to a B/C ratio higher than one for all countries except Czech Republic.

Discussion

The application potentially provides a lot of information against relatively low costs. For road maintenance and infrastructure measures it is vital that public authorities use the gathered information.

The assumption that every cyclist uses Bikewise is unrealistic. First of all, not all cyclists have access to a smartphone or are willing to go to a website to fill in dangerous situations. Second, that all cyclists know the application is also not very realistic. However, there is no data available about this kind of application and it is also hard to make a solid assumption about the use.

5. Conclusion and discussion

5.1 Conclusion impact assessment

The CBA in this deliverable is based on many assumptions. There has not been a lot of research carried out about ITS and cycling. Comparable national statistics between countries - in this deliverable The Netherlands, Belgium, Italy and Czech Republic – are hard to find. However, on a European level there are some comparable statistics, although not in depth, such as the CARE database and Eurostat. Furthermore, many of the applications in our research are in the development or prototype stage, which makes it hard to make an estimation of the price or the costs of an application.

When looking at the different components of the CBA there are differences in the social costs of accidents, injuries and fatalities. The social costs in the Czech Republic are much lower than in The Netherlands, Italy and Belgium. This influences the CBA heavily. What's more, especially (light) injuries and accidents where only non-motorized transport modes are involved are underreported. As a result the expected benefits might be higher than predicted in the CBA.

Although the results of the CBA are based on many assumptions and best estimates, the outcomes are hinting towards some conclusions:

- ITS applications that require installations in all passenger cars, such as SaveCap and ISA, result in a very low Benefit Cost ratio. This is caused by the fact that the systems need to be installed in millions of vehicles and therefore are very costly in total.
- The same applies for ITS applications that need to be installed in trucks, such as Lexguard. On a European-wide basis this requires an investment of hundreds of millions of euros.
- For the systems to be installed at the bicycles, two out of three seem to have a positive Benefit Cost ratio higher than 1, i.e. bike braking light and the LightLane bike. These are relatively cheap applications. On the other hand the HindSight has a Benefit Cost ratio lower than 1.
- The infrastructure-based systems show a mixed picture. The traffic light countdown system has a positive B/C ratio for all four countries, but the Traffic Eye Zurich only seems to have a positive B/C ratio for The Netherlands and Belgium. For the LEDmark system the expected costs are always higher than the expected benefits in all four investigated countries.
- Last but not least it seems that the Internet applications such as the route planner in Ghent and the Citizens Connect have the highest Benefit Cost ratio. With relatively little investment many potential users can be reached, which seems to result in a very positive Benefit Cost ratio.

It should be stressed that the conclusions are based on the data available and on generalisation of impacts of safety measures with similar objectives. To draw firm conclusions on the safety impacts of ITS applications for cyclists it will be necessary to carry out demonstrations and measure the observed impacts in large-scale Field Operational Tests. It is also necessary to conduct in-depth analyses of accidents to develop better estimations of safety effects of applications.

Annex A – Literature

BELDAM (2011), Tweede nationale enquête over de dagelijkse mobiliteit van de Belgen BELDAM: BELgian DAily Mobility – oplevering van de resultaten.

BIVV (2009), *Observatorium voor de verkeersveiligheid*. Themarapport fietsers, Verkeersongevallen met fietsers.

Boggelen, O. van, Schepers P., Kroeze P. and M. van der Voet (2011), *Grip op enkelvoudige fietsongevallen; samenwerken aan een veilige fietsomgeving*. Available from:

http://www.fietsberaad.nl/library/repository/bestanden/Fietberaadpublicatie%2019a_printversie.pdf

CARE database (2012), CARE database. Available from:

https://webgate.ec.europa.eu/care_boxi/InfoViewApp/logon.jsp

Cascade Bicycle Club (2012), Bikewise. Available from: http://www,bikewise,org/

Casteels, Y. & B. Godart (2008), "Dagelijks doen zich 7 lesteselongevallen met een vrachtwagen voor, vrachtwagenongevallen onder de loep". Via Secura (78).

Carsten, O, and F, Tate (2005), Intelligent speed adaptation: accident savings and cost-benefit analysis. Accident Analysis and Prevention 37(3), p.407–416.

Cerevellum (2009), Hindsight. Available from: http://www.cerevellum.com

City of Boston (2012), Citizens Connekt. Available from:

https://mayors24.cityofboston.gov:4443/.

European Commission (EC) (2012), Report from the commission to the European Parliament and the council on the implementation of Directive 2007/38/EC on the retrofitting of mirrors to heavy goods vehicles registered in the Community. Brussels: European Commission.

European Cyclists' Federation (ECF) (2012), Factsheet Lorry/Cyclist Blind Spot Accidents. Available from:

http://www,ecf.com/wp-content/uploads/ECF_FACTSHEET5_V3_cterreeBlindSpots.pdf

Eurostat (2012), Available from:

http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/

Fietsrouteplanner Gent (2012), Fietsrouteplanner Gent. Available from:

http://fietsrouteplanner.gentfietst.be

Gemeente Amsterdam (2006), Evaluatie wachttijdmelder. Amsterdam: Dienst Ruimtelijke Ordening.

Gemeente Tilburg (2008), Evaluatie wachttijdvoorspeller. Tilburg: gemeente Tilburg.

Geveko ITS (2012), The Glowing cycle path. Rudkobing: Geveko ITS.

Hout, K. van (2007), *De risico's van fietsen, Feiten, cijfers en vaststellingen.* Steunpunt verkeersveiligheid.

Houwing, S., Aarts L.T., Reurings M.C.B. and C.A. Bax (2012), *Verkennende studie naar regionale verschillen in relatie tot verkeersveiligheid*. Available from:

http://www.swov.nl/rapport/R-2012-10.pdf

It's All About 'High Heels on Wheels' - 'City Cycling' Talk With John Pucher (11.06.2012), Scientists for Cycling. Interview with John Pucher. Available from: www.ecf.com/news/cyclingandwomen

LucidBrake (2012), LucidBrake. Available from: http://www.lucidbrake.com/

Martino, A., Maffii S. and Raganato P. (2010) (Trasporti e Territorio, Milan, Italy), *The promotion of cycling, Note for DG Internal policies, transport and tourism.* Available from: http://www.ecf.com/wp-content/uploads/European-Parliament-2010_Promotion-of-Cycling.pdf

Methorst, R. and P. Schepers (2011), Letselongevallen van voetgangers en fietsers. Available from:

http://www,crow,nl/Downloads/Congressen/Nationaal%20verkeerskundecongres/2011/Bijdragen%202011/Bijdrage49.pdf

Ministerie van Verkeer en Waterstaat & Fietsberaad (2009), Cycling in the Netherlands. Den Haag: Ministerie van Verkeer en Waterstaat.

Rijkswaterstaat (2010), Oversteekongevallen met fietsers. Den Haag: Rijkswaterstaat.

Stadt Zurich (2011), Kontrolle des Versuchs Velodurchfahrt Haltestelle Opernhaus. Zurich: Stadt Zurich, Dienstabteilung Verkehr.

SWOV (2006), Speed support through the intelligent vehicle. Leidschendam: SWOV.

SWOV (2008), De toedracht van dodehoekongevallen en maatregelen voor de korte en lange termijn. Leidschendam: SWOV.

SWOV (2012), Cognos PowerPlay Web. Available from: http://www,swov,nl/cognos/cgi-bin/ppdscgi,exe?toc=%2FNederlands%2FOngevallen,%20bestuurders%20en%20slachtoffers

SWOV (2012b), Van fietsongeval naar maatregelen: kennis en hiaten. Leidschendam: SWOV.

TNO (2011), Crash friendlier cars for cyclists. Available from:

http://media.fietsersbond.nl/botsvriendelijkeautos/presentation_english_ECF.pdf

Traffic Safety Basic Facts – Cyclists (2011). Available from:

http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011_dacota-swov-cyclists.pdf)

Traffic Safety Basic Facts – Gender (2011). Available from:

http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2011-dacota-ntua-gender.pdf

United Nations Demanded to Enshrine Global “Right to Cycle” for Children (29,06,2012). Available from http://www.ecf.com/press_release/29-06-2012-united-nations-demanded-to-enshrine-global-right-to-cycle-for-children/

Wilmots B., Van Hout K., Hermans E., Brijs T. and S. Daniels (2011), *Verkeersonveiligheid in Vlaanderen, Probleemanalyse tot en met 2009*. Steunpunt Mobiliteit & Openbare Werken, Spoor Verkeersveiligheid.

Annex B – List of experts

Name	Organization	Country
Davide Shingo Usami	CTL	Italy
Hans Vergeer	ROV Zuid-Holland	The Netherlands
Marco Wigbers	ROV Overijssel	The Netherlands
Ewoud Wesselingh	Provincie Flevoland	The Netherlands
Evangelos Bekiaris	Centre for Research and Technology Hellas	Greece
Giulio Piccinini	ISEC/Universitas	Italy
Martien Panneman	Veiligheid NL	The Netherlands
Vincent Meerschaert	Traject Mobility Management	Belgium

Annex C – CBA per application

Lexguard					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 2.700	€ 2.700	€ 2.700	€ 2.700	€ 2.700
Unit project	39.000	56.000	171.000	20.000	1.700.000
Implementation cost per year	€ 105.300.000	€ 151.200.000	€ 461.700.000	€ 54.000.000	€ 4.590.000.000
Maintenance (€/Km/yr) = 10%	€ 10.530.000	€ 15.120.000	€ 46.170.000	€ 5.400.000	€ 459.000.000
Actualized **impl + maintenance** costs	€ 711.725.208	€ 1.021.964.401	€ 3.120.641.296	€ 364.987.286	€ 31.023.919.317
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	20	8	34	10	156
Injuries	45	63	130	26	788
Accidents	4237	4694	10633	2142	60300
CRF					
Fatalities	22%	22%	22%	22%	22%
Injuries	22%	22%	22%	22%	22%
Accidents	0%	0%	0%	0%	0%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 10.177.200	€ 6.335.780	€ 15.787.753	€ 1.433.496	€ 77.673.656
Actualization of costs & benefits					
Total costs actualized	€ 711.725.208	€ 1.021.964.401	€ 3.120.641.296	€ 364.987.286	€ 31.023.919.317
Total benefits actualized	€ 62.534.488	€ 38.930.625	€ 97.008.906	€ 8.808.213	€ 477.270.994
BC ratio	**0,09**	**0,04**	**0,03**	**0,02**	**0,02**

Individual Speed Adaptation	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 1.000	€ 1.000	€ 1.000	€ 1.000	€ 1.000
Unit project	500.000	480.000	2.180.000	170.000	15.320.000
Implementation cost per year	€ 500.000.000	€ 480.000.000	€ 2.180.000.000	€ 170.000.000	€ 15.320.000.000
Maintenance (€/Km/yr) = 10%	€ 50.000.000	€ 48.000.000	€ 218.000.000	€ 17.000.000	€ 1.532.000.000
Actualized **implementation + maintenance** costs	€ 3.379.511.908	€ 3.244.331.432	€ 14.734.671.919	€ 1.149.034.049	€ 103.548.244.865
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	78	51	168	48	779
Injuries	4083	4836	10367	2103	63049
Accidents	4237	4694	10633	2142	60300
CRF					
Fatalities	5,0%	5,0%	5,0%	5,0%	5,0%
Injuries	2,8%	2,8%	2,8%	2,8%	2,8%
Accidents	5,0%	5,0%	5,0%	5,0%	5,0%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 37.955.414	€ 41.651.242	€ 72.575.608	€ 5.653.196	€ 417.039.664
Actualization of costs & benefits					
Total costs actualized	€ 3.379.511.908	€ 3.244.331.432	€ 14.734.671.919	€ 1.149.034.049	€ 103.548.244.865
Total benefits actualized	€ 233.219.588	€ 255.928.852	€ 445.945.694	€ 34.736.445	€ 2.562.528.203
BC ratio	**0,07**	**0,08**	**0,03**	**0,03**	**0,02**

SaveCap					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 500	€ 500	€ 500	€ 500	€ 500
Unit project	500.000	480.000	2.180.000	170.000	15.320.000
Implementation cost per year	€ 250.000.000	€ 240.000.000	€ 1.090.000.000	€ 85.000.000	€ 7.660.000.000
Maintenance (€/Km/yr) = 10%	€ 25.000.000	€ 24.000.000	€ 109.000.000	€ 8.500.000	€ 766.000.000
Actualized **implementation + maintenance** costs	€ 1.689.755.954	€ 1.622.165.716	€ 7.367.335.960	€ 574.517.024	€ 51.774.122.433
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	11	7	24	7	208
Injuries	396	469	1006	204	9078
Accidents	408	452	1025	206	7978
CRF					
Fatalities	19,3%	19,3%	19,3%	19,3%	19,3%
Injuries	19,3%	19,3%	19,3%	19,3%	19,3%
Accidents	0,0%	0,0%	0,0%	0,0%	0,0%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 21.820.194	€ 24.753.022	€ 42.154.674	€ 3.310.606	€ 375.636.180
Actualization of costs & benefits					
Total costs actualized	€ 1.689.755.954	€ 1.622.165.716	€ 7.367.335.960	€ 574.517.024	€ 51.774.122.433
Total benefits actualized	€ 134.075.646	€ 152.096.605	€ 259.022.223	€ 20.342.242	€ 2.308.121.714
BC ratio	**0,08**	**0,09**	**0,04**	**0,04**	**0,04**

Countdown traffic light					
	NL	BE	IT	CZ	CZ
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 2.500	€ 2.500	€ 2.500	€ 2.500	€ 2.500
Unit project	5.900	6.900	3.450	3.750	90.000
Implementation cost	€ 14.750.000	€ 17.250.000	€ 8.625.000	€ 9.375.000	€ 225.000.000
Maintenance (€/Km/yr) - 10%	€ 1.475.000	€ 1.725.000	€ 862.500	€ 937.500	€ 22.500.000
Actualized maintenance costs	€ 9.063.236	€ 10.599.378	€ 5.299.689	€ 5.760.532	€ 138.252.760
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	87	41	125	25	650
Injuries	2204	3767	6480	1824	80336
Accidents	2347	3676	6802	1899	77126
CRF					
Fatalities	1%	1%	1%	1%	1%
Injuries	1%	1%	1%	1%	1%
Accidents	1%	1%	1%	1%	1%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 6.477.939	€ 9.575.982	€ 13.138.362	€ 1.294.925	€ 150.028.363
Actualization of costs & benefits					
Total costs actualized	€ 23.813.236	€ 27.849.378	€ 13.924.689	€ 15.135.532	€ 363.252.760
Total benefits actualized	€ 39.804.131	€ 58.840.264	€ 80.729.547	€ 7.956.756	€ 921.859.344
BC ratio	**1,67**	**2,11**	**5,80**	**0,53**	**2,54**

Light lane bike					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 15	€ 15	€ 15	€ 15	€ 15
Unit project	16.000.000	5.500.000	27.000.000	5.200.000	223.821.815
Implementation cost	€ 240.000.000	€ 82.500.000	€ 405.000.000	€ 78.000.000	€ 3.357.327.222
Maintenance (€/Km/yr) - 10%	€ 24.000.000	€ 8.250.000	€ 40.500.000	€ 7.800.000	€ 335.732.722
Actualized maintenance costs	€ 147.469.611	€ 50.692.679	€ 248.854.968	€ 47.927.623	€ 2.062.932.241
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	24	15	75	20	418
Injuries	720	866	2684	635	13324
Accidents	776	866	2809	648	12760
CRF					
Fatalities	40%	40%	40%	40%	40%
Injuries	40%	40%	40%	40%	40%
Accidents	40%	40%	40%	40%	40%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 90.972.800	€ 101.630.000	€ 255.099.200	€ 22.247.560	€ 1.271.558.840
Actualization of costs & benefits					
Total costs actualized	€ 387.469.611	€ 133.192.679	€ 653.854.968	€ 125.927.623	€ 5.420.259.464
Total benefits actualized	€ 558.988.474	€ 624.472.355	€ 1.567.474.153	€ 136.701.625	€ 7.813.178.621
BC ratio	**1,44**	**4,69**	**2,40**	**1,09**	**1,44**

Hindsight	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 250	€ 250	€ 250	€ 250	€ 250
Unit project	4.800.000	1.650.000	8.100.000	1.560.000	67.146.544
Implementation cost	€ 1.200.000.000	€ 412.500.000	€ 2.025.000.000	€ 390.000.000	€ 16.786.636.050
Maintenance (€/Km/yr) - 10%	€ 120.000.000	€ 41.250.000	€ 202.500.000	€ 39.000.000	€ 1.678.663.605
Actualized maintenance costs	€ 737.348.053	€ 253.463.393	€ 1.244.274.839	€ 239.638.117	€ 10.314.661.169
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	31	20	66	19	339
Injuries	502	595	1275	259	7224
Accidents	533	591	1338	270	6755
CRF					
Fatalities	21%	21%	21%	21%	21%
Injuries	21%	21%	21%	21%	21%
Accidents	21%	21%	21%	21%	21%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 38.606.610	€ 39.982.110	€ 72.751.770	€ 5.896.779	€ 393.018.959
Actualization of costs & benefits					
Total costs actualized	€ 1.937.348.053	€ 665.963.393	€ 3.269.274.839	€ 629.638.117	€ 27.101.297.219
Total benefits actualized	€ 237.220.906	€ 245.672.758	€ 447.028.133	€ 36.233.154	€ 2.414.931.364
BC ratio	**0,12**	**0,37**	**0,14**	**0,06**	**0,09**

Traffic eye Zurich					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 2.500	€ 2.500	€ 2.500	€ 2.500	€ 2.500
Unit project	590	690	3.450	375	9.000
Implementation cost	€ 1.475.000	€ 1.725.000	€ 8.625.013	€ 937.500	€ 22.500.000
Maintenance (€/Km/yr)	€ 147.500	€ 172.500	€ 862.501	€ 93.750	€ 2.250.000
Actualized maintenance costs	€ 906.324	€ 1.059.938	€ 5.299.697	€ 576.053	€ 13.825.276
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	3	1	5	1	23
Injuries	5	8	15	4	181
Accidents	5	8	15	4	174
CRF					
Fatalities	12,5%	12,5%	12,5%	12,5%	12,5%
Injuries	12,5%	12,5%	12,5%	12,5%	12,5%
Accidents	12,5%	12,5%	12,5%	12,5%	12,5%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 856.485	€ 582.745	€ 1.164.675	€ 92.673	€ 8.353.320
Actualization of costs & benefits					
Total costs actualized	€ 2.381.324	€ 2.784.938	€ 13.924.709	€ 1.513.553	€ 36.325.276
Total benefits actualized	€ 5.262.731	€ 3.580.717	€ 7.156.426	€ 569.438	€ 51.327.535
BC ratio	**2,21**	**1,29**	**0,51**	**0,38**	**1,41**

bike braking light	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 30	€ 30	€ 30	€ 30	€ 30
Unit project	4.800.000	1.650.000	8.100.000	1.560.000	67.146.544
Implementation cost	€ 144.000.000	€ 49.500.000	€ 243.000.000	€ 46.800.000	€ 2.014.396.326
Maintenance (€/Km/yr)	€ 14.400.000	€ 4.950.000	€ 24.300.000	€ 4.680.000	€ 201.439.633
Actualized maintenance costs	€ 88.481.766	€ 30.415.607	€ 149.312.981	€ 28.756.574	€ 1.237.759.340
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	31	20	66	19	339
Injuries	502	595	1275	259	7224
Accidents	533	591	1338	270	6755
CRF					
Fatalities	20%	20%	20%	20%	20%
Injuries	20%	20%	20%	20%	20%
Accidents	20%	20%	20%	20%	20%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 36.768.200	€ 38.078.200	€ 69.287.400	€ 5.615.980	€ 374.303.770
Actualization of costs & benefits					
Total costs actualized	€ 232.481.766	€ 79.915.607	€ 392.312.981	€ 75.556.574	€ 3.252.155.666
Total benefits actualized	€ 225.924.672	€ 233.974.055	€ 425.741.079	€ 34.507.766	€ 2.299.934.633
BC ratio	**0,97**	**2,93**	**1,09**	**0,46**	**0,71**

Route Planner Gent					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 1.000.000	€ 1.000.000	€ 2.000.000	€ 1.000.000	€ 1.000.000
Unit project	1	1	1	1	27
Implementation cost	€ 1.000.000	€ 1.000.000	€ 2.000.000	€ 1.000.000	€ 27.000.000
Maintenance (€/Km/yr) = 10%	€ 100.000	€ 100.000	€ 200.000	€ 100.000	€ 2.700.000
Actualized maintenance costs	€ 614.457	€ 614.457	€ 1.228.913	€ 614.457	€ 16.590.331
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	138	89	295	84	2353
Injuries	5831	6906	14804	3003	168539
Accidents	6130	6792	15385	3100	159740
CRF					
Fatalities	1,5%	1,5%	1,5%	1,5%	1,5%
Injuries	1,5%	1,5%	1,5%	1,5%	1,5%
Accidents	1,5%	1,5%	1,5%	1,5%	1,5%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 26.077.530	€ 29.612.055	€ 50.195.580	€ 3.869.420	€ 543.998.133
Actualization of costs & benefits					
Total costs actualized	€ 1.614.457	€ 1.614.457	€ 3.228.913	€ 1.614.457	€ 43.590.331
Total benefits actualized	€ 160.235.133	€ 181.953.259	€ 308.430.110	€ 23.775.908	€ 3.342.633.036
BC ratio	**99,25**	**112,70**	**95,52**	**14,73**	**76,68**

LED mark					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 4.700	€ 4.700	€ 4.700	€ 4.700	€ 4.700
Unit project	12.900	15.200	24.600	13.000	410.000
Implementation cost	€ 60.630.000	€ 71.440.000	€ 115.620.000	€ 61.100.000	€ 1.927.000.000
Maintenance (€/Km/yr)	€ 6.063.000	€ 7.144.000	€ 11.562.000	€ 6.110.000	€ 192.700.000
Actualized maintenance costs	€ 37.254.510	€ 43.896.787	€ 71.043.485	€ 37.543.305	€ 1.184.058.081
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	13	8	39	11	222
Injuries	382	459	1.423	337	7062
Accidents	411	459	1.489	343	6763
CRF					
Fatalities	4,0%	4,0%	4,0%	4,0%	4,0%
Injuries	4,0%	4,0%	4,0%	4,0%	4,0%
Accidents	0,5%	0,5%	0,5%	0,5%	0,5%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 4.548.057	€ 5.129.361	€ 12.760.444	€ 1.121.423	€ 64.209.030
Actualization of costs & benefits					
Total costs actualized	€ 97.884.510	€ 115.336.787	€ 186.663.485	€ 98.643.305	€ 3.111.058.081
Total benefits actualized	€ 27.945.843	€ 31.517.704	€ 78.407.406	€ 6.890.657	€ 394.536.696
BC ratio	**0,29**	**0,27**	**0,42**	**0,07**	**0,13**

Bike Wise					
	NL	BE	IT	CZ	EU
Duration (year)	10	10	10	10	10
Interest rate	10%	10%	10%	10%	10%
	0,1	0,1	0,1	0,1	0,1
Realization costs estimation					
Unit cost	€ 1.000.000	€ 1.000.000	€ 2.000.000	€ 1.000.000	€ 1.000.000
Unit project	1	1	1	1	27
Implementation cost	€ 1.000.000	€ 1.000.000	€ 2.000.000	€ 1.000.000	€ 27.000.000
Maintenance (€/Km/yr) = 20%	€ 100.000	€ 100.000	€ 200.000	€ 100.000	€ 2.700.000
Actualized maintenance costs	€ 614.457	€ 614.457	€ 1.228.913	€ 614.457	€ 16.590.331
Equivalent uniform factor	6,1	6,1	6,1	6,1	6,1
Effectiveness estimation					
Fatalities	138	89	295	84	2353
Injuries	5831	6906	14804	3003	168539
Accidents	6130	6792	15385	3100	159740
CRF					
Fatalities	0,15%	0,15%	0,15%	0,15%	0,15%
Injuries	0,15%	0,15%	0,15%	0,15%	0,15%
Accidents	0,15%	0,15%	0,15%	0,15%	0,15%
Social cost accidents					
Fatality	€ 1.782.000	€ 1.639.000	€ 1.430.000	€ 495.000	€ 1.336.500
Injury	€ 236.000	€ 249.000	€ 183.000	€ 67.100	€ 183.775
Accidents	€ 19.000	€ 16.000	€ 14.000	€ 4.800	€ 13.450
ICT benefit estimation					
Average annual benefit	€ 2.607.753	€ 2.961.206	€ 5.019.558	€ 386.942	€ 54.399.813
Actualization of costs & benefits					
Total costs actualized	€ 1.614.457	€ 1.614.457	€ 3.228.913	€ 1.614.457	€ 43.590.331
Total benefits actualized	€ 16.023.513	€ 18.195.326	€ 30.843.011	€ 2.377.591	€ 334.263.304
BC ratio	**9,93**	**11,27**	**9,55**	**1,47**	**7,67**

Appendix D Trends in numbers of bicycle accidents, deaths and injured

Trend in numbers of bicycle accidents, deaths and injured in the Netherlands

Year	Bicycle accidents	Deaths	Injured
2001	9,201	194	8,935
2002	8,812	167	8,570
2003	8,986	187	8,801
2004	7,679	157	7,460
2005	8,208	151	7,988
2006	7,794	179	7,565
2007	8,148	147	7,995
2008	7,593	145	7,418
2009	6,130	138	5,850

Appendix E Numbers of deaths and injured in bicycle accidents in 2009 can be found

Number of deaths and injured in bicycle accidents per collision type – 2009 in the Netherlands

Collision type	Victims	Injured
Pedestrian	0	54
Parked	4	330
Animal	0	20
Fixed object	6	56
Loose object	0	2
Frontal	10	1,214
Lateral	98	3,682
Rear-end, multiple collision	13	362
Single vehicle	7	129
Unknown	0	1
Total	**138**	**5,850**

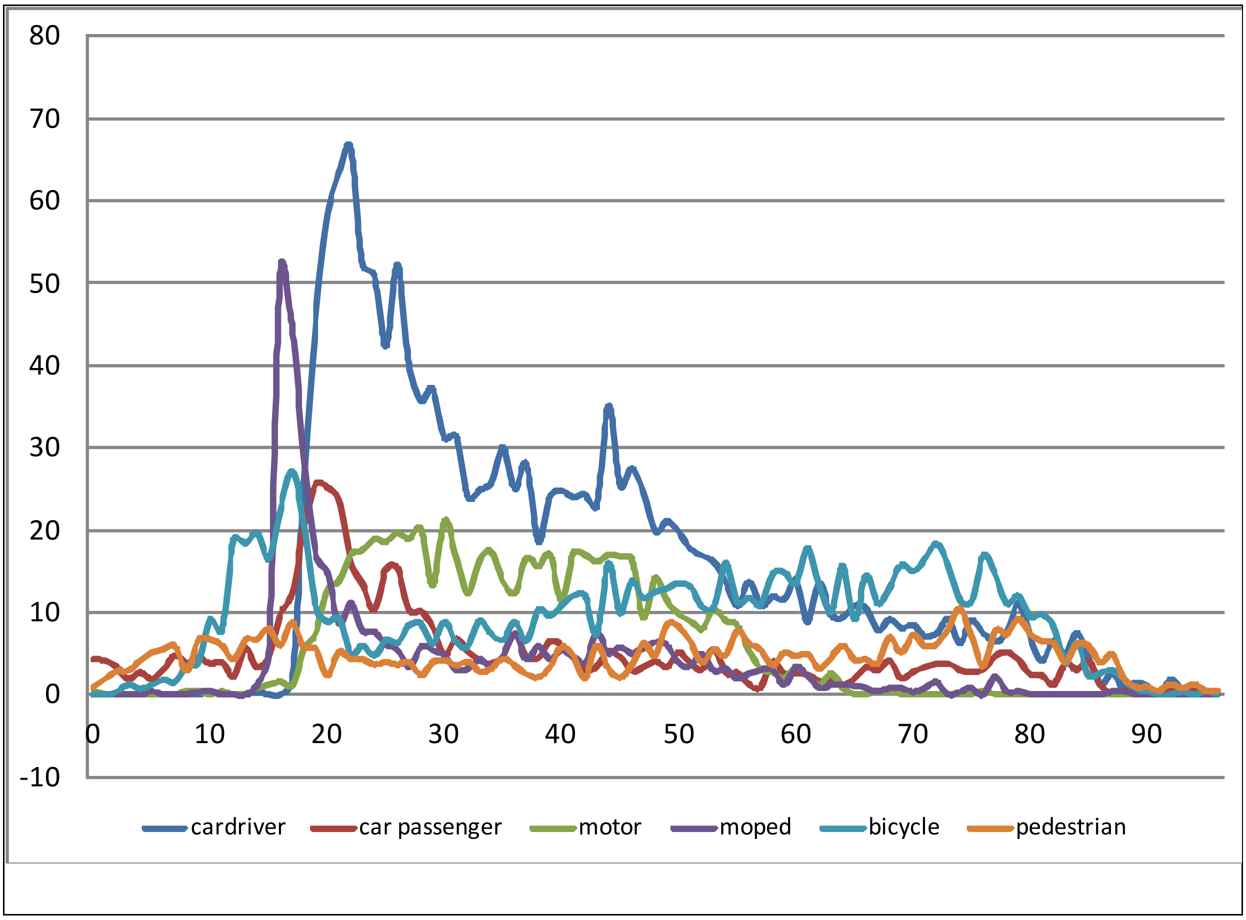
Appendix F Accident circumstances

Number of accidents, victims and injured in bicycle accidents per circumstances – 2009 in the Netherlands

Manouvre	Deaths	Injuries
Into water	2	2
Not off the road	5	114
Other single vehicle	0	13
Parked vehicle hit at the rear	1	27
Parked vehicle - hit at the front	2	228
Other crashes with parked vehicle	1	75
Animals crossing	0	20
Crash into tree or other stationary objects	5	35
Crash into lamppost	0	2
Crash into other infrastructural elements	1	19
Crash into object on the road	0	2
Pedestrian at level crossing	0	0
Pedestrian at pedestrian crossing	0	1
Pedestrian - other crossing	0	0
Pedestrian at bus / tramstop	0	4
Pedestrian on carriageway	0	8
Pedestrian on cycle lane	0	6
Pedestrian on pavement / shoulder	0	30
Pedestrian - Crossing over suddenly	0	3
Other crash into pedestrian	0	2
On railway crossing with train	2	0
Other crashes with train or tram	1	17
On intersection - side impact	44	1,205
On intersection - side impact with vehicle standing still	0	11
On intersection = side impact while changing lane	0	13
Front - rear while overtaking	1	8
Front - rear while join /exit	0	0
Front - rear without turning	7	198
Front - rear with vehicle standing still	0	21
Front - rear while changing lane to the left	0	0
Front - rear while changing lane to the right	0	1
Other crashed - same direction, no turning	3	29
Frontal impact - join / exit	0	7
Frontal impact - one vehicle changing lane	0	34
Frontal impact - both vehicles changing lane	0	0
Frontal impact without changing lane	6	600
Frontal impact - other	2	58
Front - rear while turning right	0	2

Front - rear while turning left	1	11
Rigth side while turning right	6	126
Left side while turning right	0	80
Left side while turning left	12	264
Right side while turning left	4	120
Left side while U-turn left	0	4
Right side while U-turn left	0	5
Right side - crossing vehicle	4	167
Both turning right	0	10
Both turning left	1	32
Grazed	10	409
Other side impacts	15	1,221
Other	2	606
Manoeuvre	**138**	**5,850**

Appendix G The amount of deaths and heavily injured according to age, for different types of transportation in Flanders,



Amount of deaths and heavily injured according to age of the road user in Flanders, average 2007-2009

Appendix H Deaths and injures in bicycle accidents – years 2009-2010 in Italy

Deaths and injured in bicycle accidents – years 2009-2010

User	Deads 2010	Deads 2009	Change Deads 2009-2010	Injured 2010	Injured 2009	Change Injured 2009-2010
Cyclists	263	295	-10,8%	14,655	14,804	-1,0%
Other users involved						
- heavy good vehicles	2	0	-	34	40	-15,0%
- cars	0	2	-100,0%	388	541	-28,3%
- mopeds	0	0	-	182	290	-37,2%
- motorcycles	7	4	75,0%	526	550	-4,4%
- others	0	0	-	15	56	-73,2%
Pedestrians	3	2	50,0%	324	312	3,8%
Total	**275**	**303**	**-9,2%**	**16,124**	**16,593**	**-2,8%**

Appendix I Trend of number of accidents, deaths and injured in bicycle accidents in Italy from 2001 – 2010

Trend of number of accidents, deaths and injured in bicycle accidents

Year	Bicycle accidents	Deaths	Injured
2001	12,227	366	11,223
2002	12,425	326	11,737
2003	12,516	355	11,941
2004	12,915	322	12,284
2005	13,760	335	13,087
2006	14,575	311	13,956
2007	15,286	352	14,535
2008	15,199	288	14,533
2009	15,385	295	14,804
2010	15,117	263	14,655

Appendix J Bicycle accident circumstances in 2010 in Italy

Number of accidents, victims and injured in bicycle accidents per circumstances – 2010 in Italy

Situation	Vehicle A behaviour	Vehicle B behaviour	Accidents	Victims	Injured
Inside junction between vehicles	Yield sign	Driving normally	907	952	5
Inside junction between vehicles	Stop	Driving normally	600	640	5
Inside junction between vehicles	Priority to vehicle from right	Driving normally	579	604	5
Outside junction between vehicles	Distracted	Driving normally	522	579	11
Inside junction between vehicles	Driving normally	Yield sign	507	529	7
Inside junction between vehicles	Distracted	Driving normally	444	468	6
Inside junction between vehicles	Driving normally	Distracted	430	465	10
Inside junction between vehicles	Driving normally	Stop	420	453	6
Outside junction between vehicles	Driving normally	Distracted	414	447	11
Outside junction between vehicles	Entering flow	Driving normally	347	368	2
Inside junction between vehicles	Driving normally	Priority to vehicle from right	333	356	2
Accident with stopped vehicle	Distracted	Vehicle stopped regularly	327	344	1
Outside junction between vehicles	Safety distance	Driving normally	324	364	12
Outside junction between vehicles	Driving normally	Entering flow	321	346	3
Accident with stopped vehicle	Driving normally	Vehicle stopped irregularly	271	276	3
Inside junction between vehicles	Distracted	Distracted	253	273	0
Outside junction between vehicles	Distracted	Distracted	213	236	2
Inside junction between vehicles	Turn left irregular	Driving normally	204	215	3
Inside junction between vehicles	Turn right irregular	Driving normally	192	195	3
Inside junction between vehicles	Driving	Turn left	175	193	8

Situation	Vehicle A behaviour	Vehicle B behaviour	Accidents	Victims	Injured
	normally	irregular			
Inside junction between vehicles	Safety distance	Driving normally	172	193	4
Inside junction between vehicles	Driving normally	Wrong way	165	175	5
Outside junction between vehicles	Driving normally	Safety distance	152	151	8
Accident without hit	Fall of person from vehicle due to going outside from moving vehicle	Without obstacle or other	143	144	4
Accident without hit	Fall of person from vehicle due to cling	Without obstacle or other	138	142	1
Accident with stopped vehicle	Driving normally	Casual obstacle	137	140	0
Outside junction between vehicles	High speed	Driving normally	135	158	9
Outside junction between vehicles	Reverse motion to turn left	Driving normally	134	140	2
Outside junction between vehicles	Overtaking on right without looking at ban signalgnale di divieto	Driving normally	120	128	1
Outside junction between vehicles	Driving normally	Reverse motion to turn left	115	133	2
Inside junction between vehicles	Driving normally	Safety distance	104	109	2
Outside junction between vehicles	Placing beside 2 wheels vehicle	Driving normally	104	109	2
Accident without hit	Skid with road exit to avoid obstacle	Vehicle	102	101	2
Inside junction between vehicles	Wrong way	Driving normally	100	107	0
Accident without hit	Skid with road exit because distracted	Without obstacle or other	99	95	5
Outside junction between vehicles	Driving normally	Wrong way	96	102	1
Inside junction between vehicles	Driving normally	Turn right irregular	83	86	1

Situation	Vehicle A behaviour	Vehicle B behaviour	Accidents	Victims	Injured
Outside junction between vehicles	Driving normally	Close to right side of carriageway	82	89	2
Outside junction between vehicles	Reverse motion to stop irregularly	Driving normally	81	83	0
Outside junction between vehicles	Wrong way	Driving normally	78	82	3
Inside junction between vehicles	Driving normally	Traffic lights	77	85	1
Inside junction between vehicles	High speed	Driving normally	73	88	3
Outside junction between vehicles	Driving normally	High speed	71	81	1

Appendix K Number of deaths and injured in bicycle accidents per collision type in 2010 in Italy

Number of deaths and injured in bicycle accidents per collision type - 2010

Collision type	Victims	Injured
Chain or rear	54	1,157
Frontal	24	951
Lateral	150	10,349
No obstacle	27	1,009
Obstacle (not specified)	2	224
Other	5	783
Parked	0	100
Pedestrian	1	82
Total	**263**	**14,655**

Appendix L Trend in numbers of accidents, deaths and injured in bicycle accidents from 2000 – 2010 in Czech Republic

Trend of number of accidents, deaths and injured in bicycle accidents

Year	Bicycle accidents	Deaths	Injured
2000	5,586	127	4,336
2001	4,628	118	3,704
2002	5,004	134	3,955
2003	5,073	123	4,109
2004	4,769	99	3,819
2005	4,534	93	3,706
2006	4,107	83	3,355
2007	4,151	102	3,260
2008	3,694	77	2,947
2009	3,066	72	2,994
2010	3,174	70	2,689

Appendix M Number of deaths and injured in bicycle accidents per collision type – 2009 – 2010 in Czech Republic

Number of deaths and injured in bicycle accidents per collision type – 2009, 2010

Collision type	Victims 2010	Injured 2010	Victims 2009	Injured 2009
Pedestrian	1	32	0	55
Parked	0	101	0	116
Animal	0	24	0	23
Fixed object	3	89	5	98
Loose object	not in evidence	not in evidence	not in evidence	not in evidence
Frontal	15	272	12	295
Lateral	23	1,154	26	1,359
Rear-end, multiple collision	10	188	13	218
Single vehicle	16	697	12	691
Unknown	2	132	4	139
Total	**70**	**2,689**	**72**	**2,994**