Universiteit Hasselt | Campus Diepenbeek | Agoralaan Gebouw D | BE-3590 Diepenbeek
Universiteit Hasselt | Campus Hasselt | Martelarenlaan 42 | BE-3500 Hasselt

2011
2012

BEDRIJFSECONOMISCHE WETENSCHAPPEN

master in de verkeerskunde: verkeersveiligheid
(Interfacultaire opleiding)

Masterproef

Amenability to treatment for various traffic safety problems

Promotor :
Prof. dr. Gerhard WETS

Copromotor :
dr. Stijn DANIELS

Caroline Kopmanis

Masterproef voorgedragen tot het bekomen van de graad van master in de verkeerskunde , afstudeerrichting verkeersveiligheid

2011
2012

BEDRIJFSECONOMISCHE WETENSCHAPPEN

master in de verkeerskunde: verkeersveiligheid
(Interfacultaire opleiding)

Masterproef

Amenability to treatment for various traffic safety problems

Promotor :
Prof. dr. Gerhard WETS

Copromotor :
dr. Stijn DANIELS

Caroline Kopmanis

Masterproef voorgedragen tot het bekomen van de graad van master in de verkeerskunde , afstudeerrichting verkeersveiligheid

universiteit hasselt
KNOWLEDGE IN ACTION

Foreword

As final part of the Master of Traffic Science at the University of Hasselt, students are expected to write a Master thesis. This thesis will be written with the knowledge which was gained through the courses.

The topic I chose in June 2011 was 'Amenability to treatment for various traffic safety problems'. A major reason for this choice is that this topic really interests me and that it is related with my specialization in the Master of Traffic Science, namely traffic safety. Road safety has attracted me throughout all the courses in the Traffic education. This subject is therefore a good choice for finishing my study.

Through this research I gained more insight into the traffic problems that our country and other countries are dealing with and which measures are the most promise to resolve or reduce these problems.

I would like to express my gratitude to several persons who helped me with the realization of this Master thesis. First and foremost I would like to thank my co-promoter Dr. D. Daniels and my mentor Mrs. E. De Pauw for their help, time, dedication and expert advice. Secondly I would like to thank my parents for all the support and encouragement during this thesis process.

Caroline Kopmanis

August, 2012

Summary

This thesis investigated the amenability to treatment for different traffic safety problems and examined how this could be measured. Amenability to treatment means all the prospects of implementing measures that will reduce the size of a road safety problem or at best eliminate the problem. Through the examination of the amenability to treatment of a certain traffic safety problem, the best measures to resolve or reduce a traffic safety problem can be determined. This thesis thoroughly examined the different dimensions of amenability to treatment by means of a literature study. Subsequently, the amenability to treatment of three important traffic safety problems in Belgium were investigated, namely speeding, driving under influence of alcohol and seat belt use. The amenability to treatment was applied on the safety problem as on the measures which could be taken to resolve this problem. The problem can be studied through three main criteria, that are the magnitude, the public support and the costs of the problem. The magnitude of the problem is expressed in the population attributable risk (PAR). The PAR gives the size of the reduction in the number of accidents or injuries when the risk factor would be removed. The public support for the problem is expressed in the percentage of the population that supports stronger policy interventions. This support can for example be found by means of an attitude measurement. The costs can be split up in material and non-materials costs. In order to investigate the amenability to treatment of the three problems, the first two criteria were thoroughly examined. The cost aspect was not discussed, because it was not evident to represent the costs in a correct way and the magnitude of the problem already gives a sufficient image of the problem itself. The analysis showed that speeding is the largest problem of the three, followed by seat belt use and driving under influence of alcohol. The public support for the three problems is lying close together. There was found the most public support for the problem driving under influence of alcohol (59%), a slightly less public support for speeding (56%) and the lowest public support for the policy interventions for seat belt use (44%). Here can be concluded that only just half of the respondents support the stronger policy interventions for the problem speeding, while this problem needs more attention than is currently present in the population. For the policy interventions for seat belt use was found a small support. For the problem drunk driving the highest public support was found. This can be due to the fact that more people realize that drinking and driving at the same time is a problem, while they don’t feel the same about speeding or wearing a seat belt. Speeding is not seen as a problem by a major part of the population, but is rather socially accepted. It is important that more attention to the problem speeding is given.

Next to the investigation of the traffic safety problems, also the amenability to treatment of different traffic safety measures that can be taken to resolve problems was analyzed. These measures were classified into three major groups, namely the three E's (education, environment and enforcement). Per measure three different factors were discussed, that are the public support, the effectiveness and the cost of the measure. The public support can for example be measured by means of an attitude measurement. The effectiveness is expressed in a final outcome, namely the reduction in the number of accidents. The costs of the measure are divided into two main groups. At first the maintenance costs. These are the costs for the material of the measure itself (e.g. ISA-system, the camera) and are expressed in fixed costs per kilometer. Secondly the maintenance and personnel costs. The maintenance costs are the costs per year to maintain the system. The personnel costs are the costs for processing the police reports and the costs per year for one police man to control for example the speed at location. The next step was to find out how to weigh the different measures to each other, in order to find the best measure per traffic safety problem. For this the 'analytical hierarchy process' was found a suitable method. This method can convert a complex problem into a hierarchy consisting of several (sub) criteria with one overall goal, in this case solving traffic safety problems. Therefore each measure got a score on each of the three criteria, that is the public support, the effectiveness and the costs of measure. However, as in some cases certain criteria will be found as more important, compared to other criteria, there were assigned weights in order to weigh the various measures to each other. For this purpose four different scenarios were built. In the first scenario the three criteria received all equal weights to compare the different measures to each other. In the next three scenarios each of the criteria received alternately a twice as higher score than the other criteria. For the problem speeding the three highest ranked measures were ISA, fixed cameras and section control. However, ISA scored by the four scenarios with the different weights three times the best in the overall score. This can be explained by the fact that there was found the second highest percentage on effectiveness by the five discussed measures, the second best score for the costs and the third best score on public support. The results for the problem drunk driving were more ambiguous. Public campaigns scored in the four scenarios three times the best in the overall score. This is mainly due to the very high cost of the AIID and the low public support for this system. Alcohol controls could count on more public support, but scored very low on effectiveness. Finally the measures for seat belt use were weighed against each other. The seat belt reminder achieved three times the best overall score in the scenarios. This is due to the higher effectiveness and public support in comparison with the other measures, but the seat belt reminder did not scored well for the costs. Generally there can be concluded that there is not one category of the three E's that emerges to be the best. For one problem educational measures are preferred, for the other problems there should be given more attention to environmental or enforcement measures. In reality it is often the combination of the three which can provide the desired effect.

Samenvatting

In deze thesis werd de 'amenability to treatment' onderzocht van verschillende verkeersveiligheidsproblemen en werd gezocht hoe deze gemeten kon worden. Amenability to treatment betekent het zoeken naar maatregelen die de grootte van het verkeersveiligheidsprobleem kunnen verminderen of beter nog wegwerken. Door het onderzoeken van de amenability to treatment van een bepaald verkeersveiligheidsprobleem, konden de beste maatregelen gevonden worden om een verkeersveiligheidsprobleem op te lossen of te reduceren. Deze thesis onderzocht grondig de verschillende dimensies van amenability to treatment door middel van een literatuurstudie. Vervolgens werd deze amenability to treatment toegepast op drie belangrijke verkeersveiligheidsproblemen in België, namelijk te snel rijden, rijden onder invloed van alcohol en het niet dragen van een veiligheidsgordel. De amenability to treatment werd zowel toegepast op het veiligheidsprobleem zelf als op de maatregelen die kunnen genomen worden om dit probleem weg te werken. Het probleem zelf kan bestudeerd worden door middel van drie belangrijke factoren, dat is de grootte, de publieke draagkracht en de kost van het probleem. De grootte van het probleem is uitgedrukt in het aan de populatie toe te schrijven risico, hier afgekort als PAR. De PAR geeft de grootte van de reductie in het aantal ongevallen of gewonden weer wanneer de risico factor zou verwijderd worden. De publieke draagkracht van het probleem is uitgedrukt in het percentage populatie dat strengere beleidsinterventies ondersteund. Deze draagkracht kan bijvoorbeeld gevonden worden door middel van een attitude meting. De kosten kunnen opgedeeld worden in materiële en niet materiële kosten. Enkel deze eerste twee factoren werden grondig onderzocht in deze thesis om de verschillende problemen tegenover elkaar te kunnen afzetten. Het aspect kosten werd niet nader besproken gezien het niet evident was om de kosten op een correct manier weer te geven en aangezien de grootte van het probleem een voldoende beeld geeft over het probleem zelf. Uit analyse kwam voort dat te snel rijden het grootste probleem van de drie is, gevolgd door gordeldracht en rijden onder invloed van alcohol. De publieke ondersteuning lag voor de drie problemen dicht bij elkaar. Er werd het meeste draagvlak gevonden voor het probleem rijden onder invloed van alcohol (59%), iets minder voor te snel rijden (56%) en het laagste draagvlak voor de beleidsinterventies voor gordeldracht (44%). Hieruit kan besloten worden dat maar net iets meer dan de helft van de respondenten draagvlak voor strengere beleidsinterventies voor het probleem snelheidsgedrag vertroont, terwijl dit probleem om veel meer aandacht vraagt dan er momenteel aanwezig is bij de bevolking. Voor de beleidsinterventies voor gordeldracht is weinig draagvlak. Voor het probleem rijden onder invloed van alcohol wordt het meeste draagvlak vertoond. Dit kan te maken hebben met het feit dat mensen hierbij meer

inzien dat drinken en rijden een probleem is, terwijl ze dat van te snel rijden of hun gordel niet dragen niet vinden. Te snel rijden wordt door een groot deel van bevolking niet als een probleem gezien, maar wordt eerder sociaal aanvaard. Hierbij is het belangrijk dat het probleem snelheid extra in het daglicht wordt gezet.

Naast het onderzoeken van de verschillende verkeersveiligheidsproblemen, werd ook de amenability to treatment geanalyseerd van verschillende verkeersveiligheidsmaatregelen die het probleem kunnen wegwerken. Deze maatregelen werden opgedeeld in drie grote groepen, namelijk de drie E's (education (educatie), environment (omgeving) en enforcement (handhaving)). Per maatregel werden telkens drie verschillende factoren besproken, dat is de publieke draagkracht, de effectiviteit en de kost van de maatregel. De publieke draagkracht kan bijvoorbeeld gemeten worden door middel van een attitude meting. De effectiviteit van een maatregel werd uitgedrukt in een finale uitkomst, namelijk de reductie in het aantal ongevallen. De kosten van de maatregel werden opgedeeld in twee grote groepen. Eerst en vooral de implementatiekosten, welke de kosten zijn voor het materiaal van de maatregel (bv. ISA-systeem, de camera). Dit zijn vaste kosten per kilometer. Vervolgens zijn er onderhoud –en personeelskosten. De onderhoudskosten zijn de jaarlijkse kosten om het systeem te onderhouden. De personeelskosten zijn de jaarlijkse kosten voor het verwerken van de politierapporten en de jaarlijkse kosten van één politieagent om bijvoorbeeld de snelheid op locatie te controleren. Vervolgens werd nagegaan hoe deze verschillende elementen ten opzichte van elkaar kunnen afgezet worden om vervolgens de beste maatregel per probleem te vinden. Hiervoor werd in de literatuur 'analytical hierarchy process' als geschikte methode gevonden. Deze methode kan een complex probleem omzetten in een hiërarchie bestaande uit verschillende (sub) criteria met een algeheel doel, in dit geval het oplossen van verkeersveiligheidsproblemen. Hiervoor kreeg elke maatregel een score op elk van de drie criteria, namelijk een score voor de publieke draagkracht, de effectiviteit en de kost van de maatregel. Omdat in sommige gevallen een bepaald criterium belangrijker zal zijn dan een ander criterium, worden er gewichten toegekend zodat de verschillende maatregelen kunnen afgewogen worden ten opzichte van elkaar. Hiervoor werden vier verschillende scenario's opgesteld. Eerst en vooral een scenario waarbij alle criteria gelijke waarden kregen om de verschillende maatregelen met elkaar te vergelijken. Vervolgens drie scenario's waarbij telkens één van de criteria een dubbel zo hoge score kreeg dan de andere criteria. Voor het probleem snelheid kwamen er drie goedscorende maatregelen naar voren, namelijk ISA, onbemande camera's en trajectcontrole. Toch scoorde ISA bij de vier scenario's met de verschillende gewichten drie keer het beste bij de totale score. Dit kan verklaard worden door het feit dat ISA zowel als tweede meest effectieve maatregel uitkwam bij de vijf maatregelen, alsook tweede goedkoopste maatregel en een derde plaats behaalde bij het criterium publieke draagkracht. Voor het probleem rijden onder invloed van alcohol waren de resultaten eenduidiger. De maatregel publieke campagnes behaalde in de vier scenario's drie keer de hoogste totale score. Dit is te wijten aan de zeer hoge kosten voor het alcoholslot en de lage draagkracht bij de populatie voor dit systeem. Alcohol controles konden op meer publieke draagkracht rekenen, maar scoorden zeer laag op het criterium effectiviteit. Tenslotte werden ook de maatregelen voor gordeldracht tegenover elkaar afgewogen. De gordelverklikker behaalde drie keer de hoogste totale score in de scenario's. Dit is te wijten aan de hoge effectiviteit en hoge publieke draagkracht voor de maatregel. Op het criterium kosten scoort deze maatregel dan weer slecht. Algemeen kan er besloten worden dat er niet één bepaalde groep van de drie E's naar voren springt bij het kiezen van maatregelen. Voor het ene probleem is er een grotere voorkeur aan educatieve maatregelen, terwijl er voor de andere problemen meer ingezet zou moeten worden op omgeving –of handhavingmaatregelen. In realiteit is het vaak de combinatie van de drie dat het gewenste effect zou kunnen bereiken.

Table of contents

Foreword ... i
Summary ... iii
Samenvatting ... vi
List of figures ... xii
List of tables ... xiii
INTRODUCTION ... 1
PART 1: THEORETICAL INTRODUCTION ... 3
1. Dimensions of road safety problems ... 4
2. Research questions ... 5
  2.1 Traffic safety problems ... 5
  2.2 Traffic safety measures ... 6
3. Description of traffic safety problems with all their dimensions ... 6
  3.1 The current traffic safety problems ... 6
  3.2 Magnitude ... 8
  3.3 Public support ... 9
  3.4 Costs ... 10
4. Traffic safety measures ... 12
  4.1 Types of safety measures ... 12
  4.2 Public support ... 13
  4.3 Effectiveness ... 14
  4.4 Costs ... 15
5. The weight of different elements ... 16
  5.1 Traffic safety problems ... 16
  5.2 Traffic safety measures ... 17
    5.2.1 Possible weighting methods ... 17
    5.2.2 The analytical hierarchy process ... 17
Part 2: Practical Application of the amenability to treatment ... 27
1. Speeding ... 27
  1.1 Safety problem ... 27
    1.1.1 Magnitude ... 27
    1.1.2 Public support ... 31

1.1.3 Conclusions for the safety problem speeding 33
1.2 Safety measures 34
1.2.1 Education 34
1.2.2 Environment 36
1.2.3 Enforcement 40
1.2.4 Conclusions for safety measures of speeding 46
1.3 Multicriteria analysis speeding 47
1.3.1 Traffic safety problem 47
1.3.2 Traffic safety measures 48
2. Driving under influence of alcohol 59
2.1 Safety problem 59
2.1.1 Magnitude 59
2.1.2 Public support 64
2.1.3 Conclusions for the safety problem driving under influence of alcohol 65
2.2 Safety measures 66
2.2.1 Education 66
2.2.2 Environment 67
2.2.3 Enforcement 69
2.2.4 Conclusions for the safety measures driving under influence of alcohol 71
2.3 Multicriteria analysis driving under influence of alcohol 72
2.3.1 Traffic safety problem 72
2.3.2 Traffic safety measures 73
3. Seat belt use 81
3.1 Safety problem 81
3.1.1 Magnitude 81
3.1.2 Public support 83
3.1.3 Conclusions for the safety problem seat belt use 85
3.2 Safety measures 86
3.2.1 Education 86
3.2.2 Environment 87
3.2.3 Enforcement 89
3.2.4 Conclusions for the safety measures of seat belt use 91
3.3 Multicriteria analysis seat belt use 92
3.3.1 Traffic safety problem 92
3.3.2 Traffic safety measures 93

PART 3: DISCUSSION 99
1. Summary results 99
1.1 Traffic safety problems 99
1.2 Traffic safety measures..100
2. Limitations..102
3. Recommendations 103
Bibliography..105
Attachments 111

List of figures

Figure 1 Accident causes in the field of the human, vehicle and environment (Van Malderen & Macharis, 2009)... 7

Figure 2 Relationship between support for stronger policy interventions and risk attributable to various traffic safety problems in Norway (Elvik, 2008) 17

Figure 3 Hierarchical three..18

Figure 4 V85 on 30km/h.-, 50km/h.-, 70km/h.- and 90km/h.- roads in Belgium (Vlaamse Stichting Verkeerskunde, 2010a)..28

Figure 5 V85 on 30km/h.-, 50km/h.-, 70km/h.- and 90km/h.- roads in Belgium (Vlaamse Stichting Verkeerskunde, 2010a)..30

Figure 6 The general opinion about implementation of ISA (Vlassenroot & De Mol, 2005) 37

Figure 7 Relationship between support for stronger policy interventions and risk at different road categories attributable to the traffic safety problem speeding.................48

Figure 8 Results scenario 1 56

Figure 9 Results scenario 2 56

Figure 10 Results scenario 3 57

Figure 11 Results scenario 4 57

Figure 12 The relative risk indicates the risk at a certain alcohol concentration in comparison with the risk of a sober driver (with 50mg/dl=0,5g/l) (BRSI, 2010) 61

Figure 13 Relationship between support for stronger policy interventions and attributable to the traffic safety problem driving under influence of alcohol 73

Figure 14 Results scenario 1 78

Figure 15 Results scenario 2 79

Figure 16 Results scenario 3 79

Figure 17 Results scenario 4 80

Figure 18 Relationship between support for stronger policy interventions and risk for different effectiveness's of seat belt use attributable to the traffic safety problem seat belt use...92

Figure 19 Results scenario 1 97

Figure 20 Results scenario 2 97

Figure 21 Results scenario 3 98

Figure 22 Results scenario 4 98

List of tables

Table 1 Total costs of traffic accidents in 2002 (in Euro, based on the price level of 2004) (De Brabander & Vereeck, 2005) 11

Table 2 Equal weights 20

Table 3 Equal weights converted into decimals 20

Table 4 Calculation of the eigenvector for scenario 1 20

Table 5 Eigenvectors of the four weighting scenarios 21

Table 6 Weighting public support 23

Table 7 Weighting public support converted into decimals 23

Table 8 Calculating eigenvector for the public support of different measures (iteration 1) 23

Table 9 Calculating eigenvector for the public support of different measures (iteration 2) 23

Table 10 Calculating eigenvector for the public support of different measures (iteration 3) 24

Table 11 The eigenvectors for the public support, effectiveness and costs for different measures 24

Table 12 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios 25

Table 13 Final result of the weighting process 26

Table 14 Percentage of respondents who are saying to obey the speed limits (within a margin of 5km/h) (Silverans et al., 2005) 28

Table 15 Calculation of the PAR following the method of Nilsson (2004) for different speed limits (based on the V85) 30

Table 16 Distribution of different types of accidents in the built-up area and the outside the built-up area (Wilmots et al., 2009) 31

Table 17 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009) 31

Table 18 Attitudes towards speeding (BRSI, 2009) 32

Table 19 Effectiveness fixed cameras. A comparison between Belgium and international studies (Nuyts, 2006) 41

Table 20 Summary table traffic safety measures for speeding 47

Table 21 Eigenvectors for the four weighting scenarios 49

Table 22 Summary table traffic safety measures for speeding 49

Table 23 Allocation of ranking scores for the public support of traffic safety measures for speeding 50

Table 24 Calculating eigenvector for the public support of different measures for speeding 50

Table 25 Allocation of ranking scores for the effectiveness of traffic safety measures for speeding 50

Table 26 Calculating eigenvector for the effectiveness of different measures for speeding 51

Table 27 Allocation of ranking scores for the implementation costs of traffic safety measures for speeding 51

Table 28 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for speeding...51

Table 29 Weights for costs 1 and costs 2 for speeding 52

Table 30 Calculation the eigenvector for the two costs factors for speeding..................52

Table 31 Allocation of ranking scores for the costs of traffic safety measures for speeding 52

Table 32 Calculating eigenvector for the effectiveness of different measures for speeding 52

Table 33 The eigenvectors for the public support, effectiveness and costs for the different measures for speeding 53

Table 34 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios 54

Table 35 Final results of the weighting process for speeding 55

Table 36 Results of breath testing, expressed in BAC (Vanlaar, 2005) 60

Table 37 Results of drink drivers (Vanlaar, 2005) 60

Table 38 Relative risk of getting seriously injured in an accident for different BAC limits (Bernhoft, 2011) 62

Table 39 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009) 64

Table 40 Calculation for the total cost of all breathalyzers in Flanders 71

Table 41 Summary table traffic safety measures for driving under influence of alcohol ..72

Table 42 Summary table traffic safety measures for driving under influence of alcohol ..74

Table 43 Allocation of ranking scores for the public support of traffic safety measures for driving under influence of alcohol 74

Table 44 Calculating eigenvector for the public support of different measures for driving under influence of alcohol 74

Table 45 Allocation of ranking scores for the effectiveness of traffic safety measures for driving under influence of alcohol 75

Table 46 Calculating eigenvector for the effectiveness of different measures for driving under influence of alcohol 75

Table 47 Allocation of ranking scores for the implementation costs of traffic safety measures for driving under influence of alcohol 75

Table 48 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for driving under influence of alcohol...75

Table 49 Calculation of the eigenvector for the two cost factors for driving under influence of alcohol 76

Table 50 Calculating eigenvector for the costs of different measures for driving under influence of alcohol 76

Table 51 The eigenvectors for the public support, effectiveness and costs for the different measures for driving under influence of alcohol 76

Table 52 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios 77

Table 53 Final results of the weighting process for driving under influence of alcohol 77

Table 54 Self reported behavior seat belt use (BRSI, 2009) 82

Table 55 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009) 84

Table 56 Summary table traffic safety measures for seat belt use....92

Table 57 Summary table traffic safety measures for seat belt use....93

Table 58 Allocation of ranking scores for the public support of traffic safety measures for seat belt use 93

Table 59 Calculating eigenvector for the public support of different measures for seat belt use 93

Table 60 Allocation of ranking scores for the effectiveness of traffic safety measures for seat belt use 94

Table 61 Calculating eigenvector for the effectiveness of different measures for seat belt use 94

Table 62 Allocation of ranking scores for the implementation costs of traffic safety measures for seat belt use....94

Table 63 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for seat belt use 94

Table 64 Calculation of the eigenvector for the two costs factors for seat belt use....95

Table 65 Calculating eigenvector for the costs of different measures for seat belt use ...95

Table 66 The eigenvectors for the public support, effectiveness and costs for the different measures for seat belt use....95

Table 67 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios 96

Table 68 Final results of the weighting process for seat belt use 96

INTRODUCTION

In 2010 about 760 road fatalities, 4600 accidents with seriously injured people and 39.400 accidents with slightly injured people occurred in Belgium (Belgian Federal Government, 2010). Traffic safety remains an important challenge for the Belgian policy makers. The goal is to gain the highest effects with at least means as possible, which is not an easy task. Traffic safety problems are multidimensional, from which the severity and the magnitude of the problem are two examples. Even if the problem makes a large contribution to the number of accidents and injuries, it does not make it easier to solve the problem (Elvik, 2008). This can be expressed as the amenability to treatment. Elvik (2008) describes the amenability to treatment as "all the prospects of implementing measures that will reduce the size of a road safety problem or at best eliminate the problem". Through the examination of the amenability to treatment of a certain traffic safety problem, the best measures to resolve or reduce a traffic safety problem can be determined. This thesis thoroughly examines the different dimensions of amenability to treatment, through a literature study. Secondly the amenability to treatment will be applied to various traffic safety problems in Belgium, that is speeding, driving under the influence of alcohol and seat belt use.

Amenability to treatment can be applied on the traffic safety problem, as on the measures to resolve this problem. An examination of the amenability to treatment of a traffic safety problem can give more information regarding the impact and the necessity to treat the problem. This can be determined through three important factors, at first the magnitude of the problem, which is the size of contribution a problem makes to the total number of accidents or killed or injured road users (Elvik, 2008), secondly through the public support for the problem and thirdly through the costs of the problem. Only the first two factors will be used in this thesis to examine the amenability to treatment for these problems. This is because it is too difficult to give an estimation of the costs in terms of money. On the other hand, amenability to treatment can be applied on traffic safety measures, which can help to determine which measures are the best to solve or eliminate the problem. Therefore three factors can be used. The first factor is effectiveness: How effective is the treatment to resolve the traffic safety problem. This can be expressed in the final outcome, which is the reduction of the number of crashes, and in an intermediate outcome, such as changes in attitudes regarding the problem and the traffic behavior. The second factor is public support: The support of the population for the introduction of a measure and the willingness to accept this measure. And the third factor is the cost of the measure.

The amenability to treatment for various traffic safety problems in Belgium will be gathered trough a fully literature based study. The first part of this thesis consists of an exploratory literature study which is necessary to get a first impression of the existing literature and which is also essential to define the scope and the research questions of this thesis. This first part forms a theoretical introduction. In the second part three traffic safety problems will be discussed. These three traffic safety problems are speeding, driving under influence of alcohol and seat belt use. Throughout this thesis the best measures to resolve or reduce traffic safety problems will be searched.

PART 1: THEORETICAL INTRODUCTION

This theoretical introduction consists out of five parts. At first an introduction will be given in the amenability to treatment: What is amenability to treatment and how can amenability to treatment be measured. A distinction will be made between the traffic safety problem on the one hand and the measures which could be taken in order to reduce or resolve the problem on the other hand. Secondly the research questions will be represented. Subsequently a description of traffic safety problem with all its dimensions will be given followed by a description of traffic safety measures. At last will be searched for a good method to weigh the investigated elements to each other, in order to recommend the best measures which can resolve/reduce the discussed traffic safety problems.

Elvik (2010) stated that not all traffic safety problems are easy to reduce or resolve. This is an important statement in the research of amenability to treatment of traffic safety problems. Elvik (2010) gives four important reasons why certain safety problems are more difficult to solve then others.

1) The problem is widely tolerated and not regarded as a problem

It may occur that a road safety problem continues to exist, because no attempt is made to solve it. This can be explained by two possible reasons, namely the problem is regarded as very difficult to solve or the problem may be tolerated and not regarded as a serious problem.

2) Solving the problem involves overcoming social dilemmas, which means overcoming opposition to effective but unpopular measures

Some problems are difficult to solve because of social dilemmas. A social dilemma (e.g. the setting of speed limits, speed enforcement) exist whenever the costs and benefits of a measure as regarded from the perspective of a road user differs from the costs and benefits as seen from the societal perspective.

3) The problem is to certain extent caused by biological factors or factors related to human development that are difficult to influence

Some problems can be difficult to solve because the problem may be caused by biological factors that are very difficult to influence. It is likely that the high accident involvement of young drivers is to some extent the result of factors related to biology and human development.

4) The physics of kinetic energy involved in accident are such that they make the problem difficult to solve.

Some problems are difficult to solve because the outcome of accidents may be closely linked to the physical dimensions of vehicles and the kinetic energy they produce. The physics of kinetic energy can be modified both by reducing speed and by reducing the mass of vehicles. But it is not clear that any of these options would help much in reducing the problems caused by incompatibility between vehicles and lack of protection in the case of an accident.

1. Dimensions of road safety problems

Worldwide many traffic safety problems exist. Treating these problems is not easy because traffic safety problems can be regarded from different points of view and are not always easy to resolve or to reduce (Elvik, 2010). Solving traffic safety problems in an objective way is not an easy task.

Selecting problems for treatment usually cannot be done on the basis of a single dimension, it is moreover a mix of characteristics that determine the prospects for successfully treating a problem. It is proposed that amenability to treatment is a function of complexity, perceived urgency and the availability of cost-effective treatments. Road safety problems are multidimensional and may therefore be viewed from different perspectives, emphasizing different dimensions. Elvik (2008) gives therefore nine dimensions for measuring road safety problems. These dimensions are:

- Magnitude = the size of contribution a problem makes to the total number of accidents or killed or injured road users
- Severity = the gradient of attributable risk associated with a problem with respect to levels of injury severity
- Externality = the fact that travel performed by one group of road users imposes an additional risk on other groups of road users
- Inequity = the size of contribution to risk made by a lack of proportionality between the benefits of transport and risk run
- Complexity = the extent to which the specific contributions of individual risk factors to the overall risk represented by a problem can be identified
- Spatial dispersion = the degree to which an accident problem is concentrated geographically
- Temporal stability = changes over time with respect to the magnitude of a road safety problem
- Perceived urgency = the strength of the support in the population for stronger action or regulations designed to solve the problem
- Amenability to treatment = the prospects of implementing effective safety treatments, that will reduce a problem (in particular its magnitude)

Elvik (2008, p. 1) describes the amenability to treatment as: "The prospects of implementing measures that will reduce the size of a road safety problem, or at best eliminate the problem". Furthermore Elvik (2006) quotes in Eksler (2007, p. 2) that there is no correct way of defining a road safety problem, though he defines it as follows; "A road safety problem is any factor that contributes to the occurrence of accidents or the severity of injuries, that includes traffic volume as risk factor".

According to Elvik (2008) the amenability to treatment can be found by searching for the relationship between the support for stronger policy interventions and the risk attributable to the road safety problems. These dimensions are more extensively described in chapter 3 and 4 of this theoretical introduction. In this Master thesis this method shall be applied on various traffic safety problems.

2. Research questions

The central question of this Master thesis can be formulated as follows: **"What is the amenability to treatment of the most important traffic safety problems and how can they be measured"?** The ultimate goal of this Master thesis is to find the amenability to treatment for various traffic safety problems. Through examination of the amenability to treatment, can be determined how the best measures to resolve or reduce traffic safety problems can be chosen. This thesis will try to find the answers on the research questions. The research questions are divided in two main parts. The first part deals with questions concerning the traffic safety problem. The second part deals with questions concerning traffic safety measures which could be taken in order to resolve or reduce the problem. These answers to these questions must provide an answer to the central question of this Master thesis.

2.1 Traffic safety problems

- Which are the current traffic safety problems?
- What is the magnitude of the problem?
    - How can the magnitude of a problem be measured?
- What is the public support for the problem?
    - How can public support be measured?
- How can the different elements (magnitude and public support) be weighed against each other?

2.2 Traffic safety measures

- Which measures can be taken to resolve/reduce the problem?
- Is there a public support for the measures?
    - How can this public support be measured?
- How effective are the measures?
    - How can this effectiveness be measured?
    - Is there a reduction in accidents?
- Is there a reduction in the severity of crashes?
- How large are the costs to execute the measure?
- How can the different elements (effectiveness, public support and costs) be weighed against each other?

3. Description of traffic safety problems with all their dimensions

At first it can be examined to what extent a certain traffic safety problem is amenable to treatment. When a certain traffic safety problem is examined, this can be viewed from different perspectives. As described by Elvik (2008) three important elements can be examined, that is the magnitude of the problem, the public support to resolve the problem and the costs of the problem. These aspects will be explained in the next paragraph. First an introduction of the current traffic safety problems in Belgium will be given.

3.1 The current traffic safety problems

The appearance of traffic safety problems can be determined by three main factors, these factors are the human, the physical environment and the vehicle. Van Malderen & Macharis (2009) are giving in figure 1 a visual overview of the contribution of these factors to a traffic safety problem. This figure shows that about 94% of the accidents are caused by the human, that about 18% of the accidents are caused by the environment and that about 5% of the accidents are due to technical issues of the vehicle. Next to these three factors, other factors such as time of the day, weather circumstances, light condition, emotional state of the driver may also play a role, even though less direct.

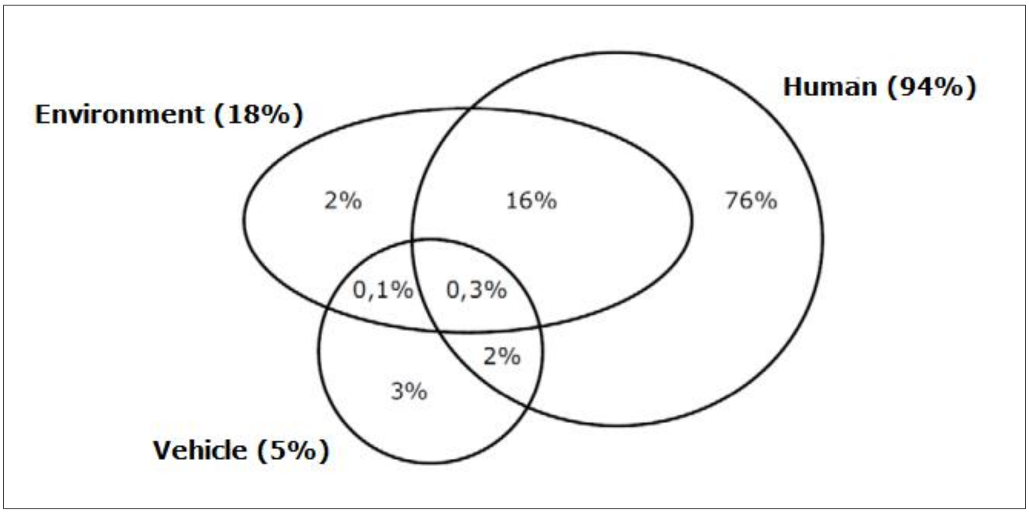


Figure 1 Accident causes in the field of the human, vehicle and environment (Van Malderen & Macharis, 2009)

Elvik & Vaa (2004) made an enumeration of the existing traffic safety problems in the Handbook of road safety measures:

- Poor road standards
- Roadside obstacles
- Poor vehicle crashworthiness
- Erroneous highway signs
- Heavy vehicles
- High risk junctions
- Bad system design
- Risk at night
- Risk in winter
- Risk of animal crashes
- Environmental risk
- Children's traffic risks
- Unprotected road users
- Young driver traffic risks
- Older road users traffic risk
- Vulnerable road users
- Speed limit violations
- Drinking and driving
- Not wearing seat belts
- Other violations of traffic law
- Excessive driving in towns
- Unsafe behavior
- Standard of medical services

The purpose is to discuss only some of these problems for Belgium. Therefore we need to know which traffic safety problems are the most common ones in our country, in order to select and examine the highest threats. First of all the Belgian Federal Government (2011) indicates that the three most common problems in Belgium are speeding, driving under the influence of alcohol and seat belt use. According to the Belgian Federal Government there were in 2008 in Belgium about 300 deaths in which speed violations played an important role, about 200 deaths where drinking and driving was the problem and about 100 deaths because the car occupants did not wear a seat belt when the accident occurred. Subsequently the BRSI (2009) executed her attitude measurement around four traffic safety problems, including the traffic safety problems speeding, driving under the influence of alcohol and seat belt use. In the second part of this Master thesis, each of these three traffic safety problems will be extensively illustrated.

3.2 Magnitude

Elvik (2008, p. 2) described the magnitude of traffic safety problems as follows: "The size of contribution a problem makes to the total number of accidents or killed or injured road users". Through the examination of the magnitude, the severity of a traffic problem can be compared with the severity of another traffic safety problem. Thereby can be concluded which problem appeals for more help than other problems. For the purpose of comparing the magnitude of different road safety problems, population attributable risk is perhaps the best indicator. The term population should not be taken literally; it refers to the contribution a factor makes to the total number of cases (i.e. all accidents) rather than a subset of cases.

The population attributable risk can be estimated through next formula (Elvik, 2008):

$$PAR = \frac{PE\ (RR - 1)}{(PE\ (RR - 1\ )) + 1}$$

PE = the proportion of exposure in the presence of the risk factor
RR = relative risk associated with the PE

Attributable risk is the fraction of accidents or injuries that is attributable to a certain risk factor, that is, the size of the reduction in the number of accidents or injuries that could be achieved by removing the risk factor. The attributable risk is generally expressed as a fraction and assumes values in the range from 0 to 1 (Evans, 2004). The population attributable risk (PAR) is the contribution that their enhanced risk level makes to the total number of people killed or injured.
However several notes of caution with respect to the use of attributable risk as a measure of the importance of various road safety problems are relevant. First of all, there are many important risk factors for which no meaningful estimate of attributable risk is possible. Trying to quantify the contribution of this risk factor to accidents is very difficult because exposure to it is virtually impossible to measure (e.g. what is the proportion of kilometers driven by inattentive driver). Secondly it is possible that risk factors tend to be correlated but these correlations are not very well known. Thirdly some road safety problems are not adequately described in terms of enhanced risk. A last

possible shortcoming is that accidents and injuries are not fully reported in official accident statistics. If the level of reporting is associated with a risk factor, an estimate of the risk attributable to that factor will be biased. Despite these limitations, the concept of attributable risk is fruitful when trying to assess the importance of various road safety problems (Evans, 2004).

3.3 Public support

Next to the magnitude also the attitude of the population towards different traffic safety problems is an important factor. This will reveal the populations view on the magnitude of the problem. Does the population recognize the different traffic safety problems in our society? What is their point of view on resolving the problem?

A possible method to measure the public support of a traffic safety problem is to execute an attitude measurement. The BRSI executed in 2003, 2006 and 2009 a measurement with questions concerning important traffic safety themes such as driving under influence, speeding and seat belt use. This attitude measurement was executed with respectively 1063, 972 and 1500 car drivers. This attitude measurement was personally administered and was only performed with Belgian car drivers of personal cars and vans who drove at least 1500km at the last six months. Attitude can be defined as all relevant opinions, judgments and preferences towards all possible aspects of traffic safety (BRSI, 2009). The attitude measurement of the BRSI (2009) deals with following categories:

- Perception of road accidents
- Attitudes towards traffic safety measures
- Subjective probability of being caught and subjective probability on punishment
- Attitudes towards driving under influence
- Attitudes towards speeding
- Attitudes towards seat belt use and child seat restraints
- Self-reported accidents, controls and punishments

This attitude measurement consists out of closed ended questions with a number of respond options from which the respondent can choose.

Also AXA executed an attitude measurement in 2009 in 10 European countries, including Belgium. AXA (2009) posed questions about traffic safety related problems concerning dangerous driving behavior, the perception of traffic safety on the road, fines and the importance of the prevention of road accidents. The traffic safety problems such as speeding and driving under influence are also included in the AXA study.

The purpose of those attitude measurements is to measure the public support of the society about traffic safety problems, traffic safety measures, concerns about traffic, … which can make a contribution to the traffic safety policy.

3.4 Costs

Traffic accidents cause all kinds of social costs. In the first place, there are costs such as material damage, production loss and medical expenses. Secondly, there are non – material damage costs. These costs involve the loss of quality of life for the victims and their families, which is the result of suffer, pain and loss of enjoyment of life. Several studies indicate that the immaterial damage caused by accidents, both with traffic deaths and injured victims, make up a substantial part of the costs of road safety. Therefore research about immaterial costs is of major importance to the policy. In the Netherlands a research regarding the magnitude of immaterial damage of fatal accidents was executed. The value of a statistical life (VOSL), which exists for the major part out of immaterial damage, is estimated at €2,2 million. If taken into account the inflation, the VOSL in 2009 equals to €2,6 million (SWOV, 2012).

In 2002 1353 people in Belgium died due to traffic. The table below gives a resume of the total costs which are the result of the traffic accidents in Belgium in 2002. The numbers are representing the costs of all the accidents with injuries which were included in the statistics of 2002, and are also representing the costs for traffic accidents with only material damage. The total cost of the traffic accidents in 2002 appears to be €12,5 billion (De Brabander & Vereeck, 2005).

Costs related to victims	
Medical costs	240.061.022
Visiting costs	6.070.595
Early funeral costs	2.106.621
Temporary production loss	
* Victims with the age of 22 to 58	46.857.982
Permanent production loss	
* Victims younger than 22	1.215.429.017
* Victims with the age of 22 to 58	2.160.076.469
Human costs	6.238.425.017
Total costs related to victims	9.909.026.723
Costs related to accidents	
Private property and public domain	2.335.411.636
Administrative costs insurance	81.467.656
Private costs juridical treatment	86.780.764
Juridical organization costs	6.832.342
Police intervention costs	21.872.295
Fire brigade costs	69.566.040
Congestion costs	13.318.191
Total costs related to accidents	2.615.248.924
Total costs	**12.524.401.474**

Table 1 Total costs of traffic accidents in 2002 (in Euro, based on the price level of 2004) (De Brabander & Vereeck, 2005)

From the table above can be concluded that the costs related to victims are way higher than the costs related to accidents. Remarkable is that the numbers for production losses are forming the second most important category in the total costs. On the other hand it is remarkable that the medical costs are relatively low compared with other costs. But thereby it is important to realize that costs for medical care and revalidation only arise when victims which are involved in accidents have physical injuries. While this review also deals with accidents without victims. If we only consider the accidents with injuries but without material damage only, the part of medical costs will obvious increase. But if only the accidents without victims are considered (only material damage), the number of damage to private and public properties will increase and will present a larger part of the total costs (De Brabander & Vereeck, 2005).

In the second part of this thesis, where the amenability to treatment will be applied on different traffic safety problems, the costs for the traffic safety problems will not be discussed. This is because it is difficult to give an estimation of the costs in terms of money. To make a good estimation, a thorough research is necessary. This was not possible within this thesis. This thesis only examines the magnitude and the public support regarding the traffic safety problem.

4. Traffic safety measures

When there is a good sight on the traffic safety problems, the next step is to examine the possible traffic safety measure that can help to reduce or solve the problems. When discussing the amenability of treatment of traffic safety measures, three important categories per measure can be discussed, that is the effectiveness, the public support and the costs of the measure. The purpose of this study about the amenability to treatment of traffic safety measures is to provide policymakers useful and objective information in order to select the most promising measures, to resolve and reduce traffic safety problems. First of all, it is important to get a sight on possible traffic safety measures, before the effectiveness, the public support and the costs can be measured.

4.1 Types of safety measures

There are three general types of safety measures which may resolve or reduce the problem. These are known as the 3 E's: Engineering, Education and Enforcement. Below, these 3 E's will be discussed briefly (Van Malderen & Macharis, 2009).

Engineering includes all measures that relate to the vehicle on one hand and to the road infrastructure on the other hand. Any measure that is implemented with attempt to positively influence the road infrastructure or vehicle safety modifications, we refer to as engineering measures (Van Malderen & Macharis, 2009).

In **education** or traffic- and mobility education a closer look is given to the human factor, and more specific to human behavior. Through education it is possible to improve knowledge, skills, insight, and/ or attitude of the various road users. There are two ways to improve the behavior of the road user, that is through sensitization and training. Sensitization can be achieved through campaigns, which are launched in the various media and which are broadcasted on road safety programs on television. Training is mainly implemented in schools. The course 'traffic science' is part of the annual school program for primary and secondary schools. This training is not only for youth, but is also indented to reach adults. Beside schools, there is for example the Flemish Foundation Traffic Engineering, which gives both workshops in schools as for adults. Education can include various themes such as speed, toxicology, fatigue, environment, protection instruments, courtesy, etc. (Van Malderen & Macharis, 2009).

Enforcement covers legislations and regulations, which form an important process in road safety. It should be ensured that road users obey the traffic legislations and regulations, in order to be able to comply with traffic safety and viability in the society. Not all citizens are willing to exert desired behavior spontaneously, which necessitates control and enforcement. These measures try to intervene preventative to avoid unwanted and dangerous behavior of road users. The ultimate goal is to reduce or even prevent traffic accidents and, such as education, influence the human behavior (Van Malderen & Macharis, 2009).

4.2 Public support

From the perspective of policy makers, public support is an important necessity to achieve success. It is assumed that more acceptance by the public results in even more support in political and administrative circuits and behavioral changes in the public (Goldenbeld, 2002). Goldenbeld (2002) describes public support as a positive appreciation of road safety measures which can ultimately improve road safety. Under favorable conditions, these positive evaluations lead to an increased willingness to accept a measure and can even lead to an active support. If a citizen not support a proposed measure, it will be very difficult to achieve the intended effect. It is important to realize that public support is not something static, but that it is a dynamic state of opinions and emotions of citizens and organizations. It appears that participation in decision making, knowledge of the contents of plans and perceived effectiveness positively influence the accomplishment of public support for the treatment of a problem.

Based on behavioral analyses of Goldenbeld (2002), four types of problems regarding the cooperation of the public for a given measure are expected. The four kinds of troubles are presented below:

1) Uncertainty about the importance and the goal of the measure for the people who are involved directly and others
2) Unbelief or doubt in the effectiveness of the measure
3) Unfavorable influencing of co-operational behavior from others
4) Restriction of freedom

We refer to the acceptation of a measure, when there are no attempts to counteract it. Active support can be distinguished in two distinct forms, that is adaptation of own traffic behavior to the new measure and support of the measure in its political form (Goldenbeld, 2002).

Rienstra et al. (1999) conclude that public support for policy measures can be influenced by several factors. First of all, the support for measures can be influenced by personal traits of the respondent, which are factors such as age and educational level. Personal mobility patterns may also influence the support. Secondly, the support of policy measures can also be influenced by the perception of problems. Thirdly the perception of the effectiveness of a measure will also influence the support one has for that measure, because the higher the effectiveness of a problem solving measure, the more attractive it will be. The perception of the effectiveness on its turn will be influenced by the personal traits and the mobility pattern of the respondent.

If we want to know if there is public support for a measure, it is necessary to examine the opinions and attitudes about this measure (Goldenbeld, 2002). This is the best method of visualization of support for a measure. We can distinguish different kinds of opinions and attitudes amongst the population:

- Ideas concerning the overall traffic safety problem
- Ideas about a specific traffic problem
- Ideas about general types of solutions for general traffic safety, as for effectiveness, fairness and proportionality of the solutions
- Ideas about ones expected behavior and the behavior of others, by implementations of a measure or policy

Through the measurement of public support, we can obtain the underlying thoughts on the severity and the magnitude of a problem, expected effectiveness and views on alternatives can be visualized. (Goldenbeld, 2002).

4.3 Effectiveness

Another important factor to decide whether or not to implement a certain measure is to examine the effectiveness of the measure. The ultimate goal of traffic safety measures is to provide a decrease in the number of traffic accidents, injuries and deaths, which are caused by traffic. Next to this final goal of traffic crashes, it can also be examined which effect the measure had on intermediate goals. This is for example the behavior and attitudes of drivers. Examples are the attitude towards drunk driving, the actual behavior concerning speeding… .

During the courses of Transportation Science there was seen that many different methods to investigate the effectiveness of various measures could be used. These different methods are before-after studies, cross-sectional studies and time series studies. In traffic safety research the most commonly used method are before-after studies. Cross-sectional and time series studies are less used in traffic safety research and will not be explained here. In before-after studies a distinction can be made between two movements. A first movement is the conventional approach that involves a simple before-after comparison of accident counts or rates with or without a control group. The expected number of accidents can be determined based on a control ratio or by means of a statistic model. This method does not take into account changes in traffic volume and next to this, regression to the mean might give a biased result. If the accident numbers are large enough, the effect of regression to the mean can be accounted by considering before and after periods that are long enough to carry out analysis (Moons, 2009). A second movement to evaluate the effectiveness of measures is the Empirical Bayesian approach. A major advantage of the correct use of this method entails the fact of controlling for confounding factors, such as regression to the mean and changes in traffic volume. The major disadvantages are the complexity of the evaluation method itself next to the enormous amount of date required for the analysis. Conditioning on the availability of the data and on a correct application of the method, this way of evaluating is preferred (Moons, 2009; Persaud & Lyon, 2006).

4.4 Costs

Public support and effectiveness are two important elements. However it is also important to take into account possible costs when implementing traffic safety measures. On the one hand there are costs for implementing the measure (education-environment-enforcement costs). On the other hand there will be costs which can be avoided by carrying out a measure (costs related to victims and accidents). Thereby it is more evident to find costs for implementing the measures than costs which can be avoided by carrying out the measure. Under costs of the measure there can be made a distinction between implementation costs on the one hand and operational and personnel costs on the other hand.

5. The weight of different elements

The overall goal of this thesis is to find a method that can help to select the best measures for treating a specific traffic safety problem, so that the largest effects in reducing traffic accidents can be reached. This can be explained as the amenability to treatment. In the theoretical introduction the different elements when measuring amenability to treatment were extensively described. On the one hand the elements were described, which visualize the traffic safety problem, on the other hand more information is given about the elements which play an important role in executing measures to counteract the traffic safety problem. This brings us to the next question: "How can those different elements be weighed up against each other, in order to choose the best traffic safety measure"?

In determining the importance of the different elements, a distinction will be made between the traffic safety problem on the one hand and traffic safety measures on the other hand.

5.1 Traffic safety problems

The elements which give an indication about the traffic safety problem are the magnitude of the problem and the public support for the problem. Per problem those elements can be weighed up against each other, in order to compare those different problems. Figure 2 (Elvik, 2008) shows an example of how different problems can be displayed. In this graph the magnitude is displayed at the y-axis, the public support on the x-axis. The magnitude presents the fatality attributable risk to each problem and indicates the importance of the problem. The public support is expressed in the percentage of the public who support stronger policy interventions for a particular problem. It is thought that the higher the public support is, the easier that a measure can be implemented and the higher the chance to reach favorable effects. The figure of Elvik (2008) shows that there is a high population attributable risk for speeding, but that there is a small public support for policy interventions to reduce speeding. For the problem drinking and driving was found a lower effectiveness then for speeding, but a higher public support. In this Master thesis three traffic safety problems will be discussed that is speeding, driving under influence of alcohol and seat belt use. These three problems will be presented in a graph, such as the example below (figure 2). Afterwards the three problems will be presented in one graph, in order to compare those problems.

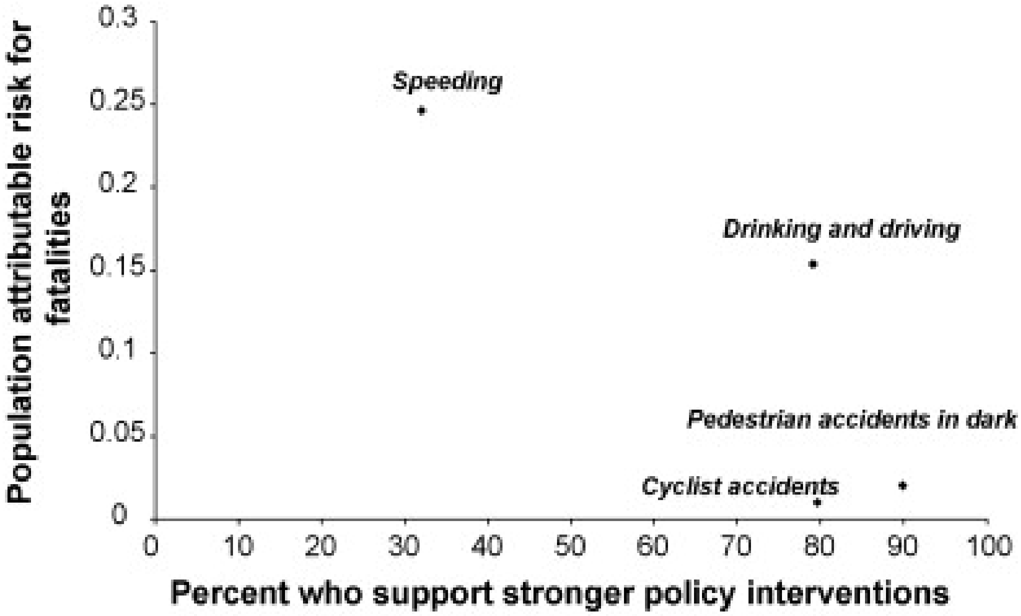


Figure 2 Relationship between support for stronger policy interventions and risk attributable to various traffic safety problems in Norway (Elvik, 2008)

5.2 Traffic safety measures

5.2.1 Possible weighting methods

In order to weigh traffic safety measures, different methods can be used. A study of Hermans et al. (2008) presents different weighting methods which can be useful for policymakers to help them in their decisions. These different methods are factor analysis, analytical hierarchy process, budget allocation, data envelopment analysis and equal weighting. In the context of this Master thesis it appears that the analytical hierarchy process could be a good method to make the analyses. Factors which predominated the decision of this method are: the small number of criteria and sufficiently different criteria that is needed (in this case public support, effectiveness and costs) and the possibility to incorporate as well quantitative and qualitative information.

5.2.2 The analytical hierarchy process

The analytical hierarchy process translates a complex problem into a hierarchy consisting of an overall goal. There can be several (sub) criteria contributing to this goal and a number of alternatives of which the best has to be selected. The goal in this situation is enhancing road safety. Both quantitative and qualitative data can be handled with this method. In the context of this thesis the relative contribution of each criteria to road safety must compared to another criteria (Hermans et al., 2008). The next questions have to be answered: Which criteria of the two is more contributing to the overall goal? How large is the intensity of the difference? Haas & Meixner (2006) propose to give values on a scale from 1 to 9, where equal contribution results in value 1, value 3 indicates a slightly higher contribution, value 5 a strongly higher contribution, value 7 a very strongly higher contribution and value 9 an absolutely higher contribution of one criteria compared to another. In this process it is advisable to keep the number of criteria small and to define sufficiently different criteria in each level of the hierarchy.

5.2.2.1 Hierarchy tree

The first step in the process is to build a hierarchy tree. The overall goal of the hierarchy tree is to help policy makers to make decisions. To compare the different traffic safety measures, a multicriteria analysis will be handled, through which the elements public support, effectiveness and costs will be weighed against each other. The public support will take into account the percentage of acceptation of the public for a certain measure. The effectiveness assumes the reduction of accidents due to the measure. The costs present the price (in terms of money) that needs to be paid for implementing the measure.

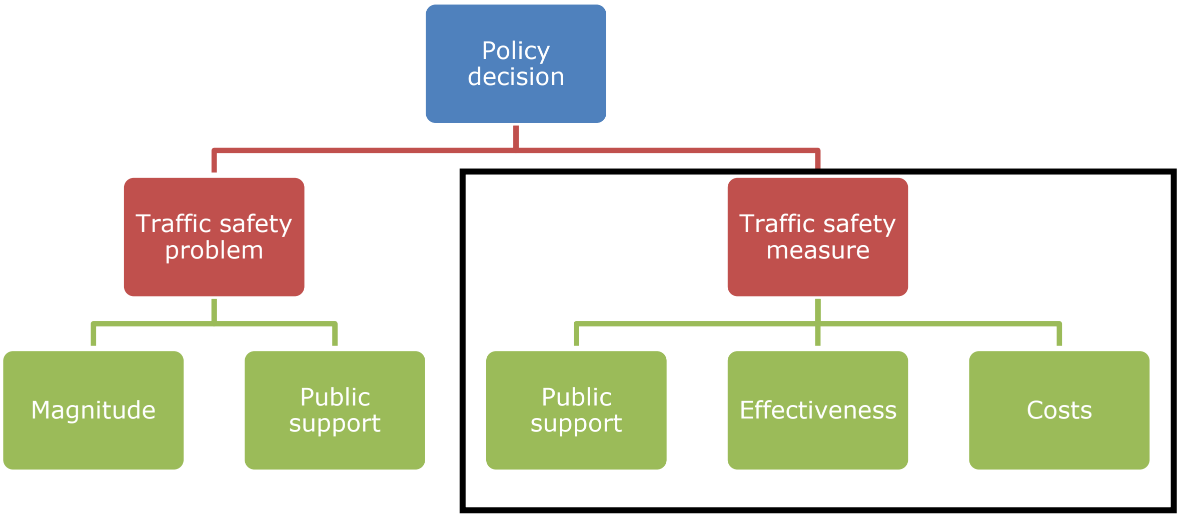


Figure 3 Hierarchical three

5.2.2.2 Setting priorities

The second step in the analytical hierarchy process is to set priorities. This step consists out of three parts. First of all the different criteria public support, effectiveness and costs will be given a weight. This weight determines the importance of each criterion. Secondly all possible alternatives, which are the different traffic safety measures per problem, will be compared to each other on the basis of the different criteria. Subsequently those two calculations will be combined into one score.

A) Giving weights to the different criteria

First it is important to determine the weight of the main criteria, which are in this research the public support, effectiveness and costs. This determination of weights can be executed through a pair wise comparison. The pair wise comparisons for the different criteria public support, effectiveness and costs will be done following the method proposed by Haas & Meixner (2006). In practice the pair wise comparisons can be made by experts. Thereby the average or the median of the answers can be calculated or the group of experts could vote or reach consensus after a debate. Because I did not had the opportunity to work with a team of experts, I suggest four scenarios with for each scenario different weights to examine variability in the results. All four scenarios will undergo the same calculations. Therefore only the first scenario will be explained in detail here and the other calculations can be found in attachment 1. The most important results of the other three scenarios will be presented in a summary table after the explanation of the first scenario (see table 5 on page 21).

The four chosen scenarios are:

- Equal weights for each of the three criteria
- Public support as two times important as the other criteria
- Effectiveness as two times important as the other criteria
- Costs as two times important as the other criteria

The first scenario with equal weights is a scenario where all the criteria (public support, effectiveness and costs) receive an equal weight in the analysis. This means that every criteria, public support, effectiveness and costs plays an equal role in determining the best measure to resolve or reduce a traffic safety problem. Next to this first scenario three other, but very similar scenarios are chosen, for which each of the elements gets a two times higher important than the other two elements. For example; in the second scenario the public support is as two times important as effectiveness and costs. In order to clarify what is meant by these scenarios and how there can be dealt with these scenarios, the first scenario will be explained in detail. The results of the other scenarios will be summarized in table 5 on page 21.

The first step in this scenario is to build a matrix where weights are given to the different criteria. The results of this first step are given in table 2. Because all weights are equal in this first scenario, each cell will have an equal value. If for example the public support is two times more important than the costs, the value in column three, cell one would be 2/1. Haas & Meixner (2006) recommend to turn the values of the basic matrix into decimals, because in the second step the matrix (table 3) needs to be squared. This process should eventually lead to the calculation of the eigenvector, which is the final value that determines the importance of each criterion when choosing measures.

	Public support	Effectiveness	Costs
Public support	1/1	1/1	1/1
Effectiveness	1/1	1/1	1/1
Costs	1/1	1/1	1/1

Table 2 Equal weights

	Public support	Effectiveness	Costs
Public support	1,0000	1,0000	1,0000
Effectiveness	1,0000	1,0000	1,0000
Costs	1,0000	1,0000	1,0000

Table 3 Equal weights converted into decimals

In table 4 the results of the squared matrix are presented. To clarify this calculation, the results of the first row in the first column will be explained. The calculation is as follows: r1c1 = (r1c1 * r1c1) + (r1c2*r2c1) + (r1c3 * r3c1) where the first number indicates the number of the row and the second number indicates the number of the column. So cell 'r1c1' is the value in column one, row one. The number 3,000 is obtained as follows: (1,000*1,000) + (1,000*1,000) + (1,000*1,000). Through this method, the value of each cell can be determined. The squared matrix forms the base to find the eigenvector. The sum of each row for each element need to be calculated and subsequently each row total must be divided by the sum of the three row totals. In this example the sum of the rows for public support, is 9; which needs to be divided by the overall sum 27. The eigenvector for public support is equal to 0,3333. The sum of the calculated eigenvectors is always 1. In some cases this matrix need to be squared again and the eigenvector needs to be recalculated. The calculation needs to be repeated, until the eigenvector of the last column of each row is equal until four decimal places, to the eigenvector of the previous calculation. In case when the eigenvector differs significantly from the before calculated eigenvector, the process needs to be executed again, until there are no significant differences left.

	Public support	Effectiveness	Costs		
Public support	3,0000	3,0000	3,0000	9,0000	0,3333
Effectiveness	3,0000	3,0000	3,0000	9,0000	0,3333
Costs	3,0000	3,0000	3,0000	9,0000	0,3333
				27,0000	1
					Eigenvector (1)

Table 4 Calculation of the eigenvector for scenario 1

For this first scenario a new calculation shows an equal eigenvector. In choosing measures there will be equal attention for the public support of the measure, the effectiveness of the measure and the costs of the measure. Each criterion will have a weight of 33%.

These calculations as ascribed above need to be made for the other three scenarios (double weight for public support, effectiveness and costs) too. Each of these scenarios will also end in an eigenvector for each of the three elements public support, effectiveness and costs. The results of these calculations can be found in table 5.

	Equal weights	Public support x2	Effectiveness x2	Costs x2
Public support	0,3333	0,5000	0,2500	0,2500
Effectiveness	0,3333	0,2500	0,5000	0,2500
Costs	0,3333	0,2500	0,2500	0,5000

Table 5 Eigenvectors of the four weighting scenarios

B) Comparison of each measure through the different criteria

After assigning weights to the criteria, the possible traffic safety measures have to be compared in terms of those different criteria. Therefore per traffic safety problem, a hierarchy of the different measures has to be made. For example for seat belt use the effectiveness of public campaigns, education and enforcement will be compared, and hierarchically classified. The same will be done for public support and costs. When comparing the different elements to each other, it is important that these are expressed in the same terms. The public support is expressed in the percentage of persons who support a certain measure. The effectiveness is expressed in a percentage of the number of decreasing accidents due to a certain measure and the costs are expressed in terms of expenses which need to be made to implement and maintain the measures. Specific attention is necessary for the comparison of costs. The scale to which this is implemented need to be taken into account. For example, the single cost for a lane control system will be much higher than the cost for an intelligent speed adaptation system. Thereby it is important that these costs could be compared to each other. The paper of Vermote et al. (2012) gives therefore a good example. The costs can be divided in two main groups, namely the implementation costs and the maintenance and personnel costs. The implementation costs are the costs of the material itself (e.g. the camera, the ISA system) and are fixed cost per kilometer. These costs could be calculated in function of one maintained kilometer road. The length of the regional road in Flanders counts 6055km (Van Geirt, 2004). The maintenance costs are the costs to maintain the system. The personnel costs are the costs for processing the police reports and the costs per year for one police man to control e.g. speed at location. The maintenance and personnel costs can differ each year depending on the maintenance that needs to be done. In this way the different measures can be compared more correctly to each other. This division in costs will be applied to the three discussed traffic safety problems in this thesis.

In order to make a comparison possible, per criteria scores will be assigned to each of the measures. For a particular criteria (public support, effectiveness or costs) this means that a higher percentage for one measure will receive a higher score then a measure with a lower percentage for that criteria. If there are for example three different measures discussed, three scores must be assigned. The measure with for example the highest public support will receive score 3, the measure with the second highest public support will receive score 2, and the measure with the lowest public support receives score 1. If there are for example two measures with the same value (e.g. two measures with the highest value), the scores for the highest and second highest measures need to be summated (3+2) and dived by two (5/2), so each of these measures receive the same score (2,5) in the ranking process. The procedure to compare methods will be explained now in detail.

For each measure that can be taken to resolve a traffic safety problem, certain results will be found for public support, effectiveness and cost. For one measure the public support will be for example higher than the public support for another measure. Therefore the alternatives will be ranked according the results of each criterion. For example; for problem X there are three possible measures (O, P and Q). For public support a score of 50% is found for measure O, for measure P there is a public support of 40% and for measure Q there is a public support of 70%. The ranking can be made as follows:

Measure Q > Measure O > Measure P (in terms of public support)

Given that there are three measures, three scores will be assigned. A score of 3 will be given for the measure with the highest public support, a score of 2 for the second highest public support and score 1 for the measure with the lowest public support. These scores can be allocated to the matrix in table 6. This is the same method which is used to determine the weights to the different criteria (public support, effectiveness and costs). Also these values need to be turned into decimals and the matrix needs to be squared in order to determine the eigenvector.

Measure Q (3) > Measure O (2) > Measure P (1) (in terms of public support)

	Measure Q	Measure O	Measure P
Measure Q	3/3	3/2	3/1
Measure O	2/3	2/2	2/1
Measure P	1/3	1/2	1/1

Table 6 Weighting public support

	Measure O	Measure P	Measure Q
Measure O	1,0000	1,5000	3,0000
Measure P	0,6667	1,0000	0,5000
Measure Q	0,3333	0,5000	1,0000

Table 7 Weighting public support converted into decimals

As mentioned before, the eigenvector needs to be recalculated until the eigenvectors of the last calculation are the same at four decimal places than the eigenvectors of the previous calculation. Each last calculated table with the new eigenvector need therefore be squared. This is the same procedure which was executed to determine the eigenvectors for the different scenarios as explained in step a. When two times next to each other the same eigenvectors arises, there are no more iterations needed and so the definitive eigenvector is found. In table 8 the first eigenvector of the first iteration can be found.

	Measure O	Measure P	Measure Q		
Measure O	3,0000	4,5000	6,7500	14,2500	0,5534
Measure P	1,5000	2,2500	3,0000	6,7500	0,2621
Measure Q	1,0000	1,5000	2,2500	4,7500	0,1845
				25,7500	1
					Eigenvector (1)

Table 8 Calculating eigenvector for the public support of different measures (iteration 1)

A second iteration need to be made in order to control if the first eigenvector is already a definitive one.

	Measure O	Measure P	Measure Q		
Measure O	22,5000	33,7500	48,9375	105,1875	0,5505
Measure P	10,8750	16,3125	23,6250	50,8125	0,2659
Measure Q	7,5000	11,2500	16,3125	35,0625	0,1835
				191,0625	1
					Eigenvector (2)

Table 9 Calculating eigenvector for the public support of different measures (iteration 2)

From two iterations appears that the two eigenvectors differ too much from each other. In this case a third iteration need to be made and need to be compared with the second iteration out of table 9.

	Measure O	Measure P	Measure Q		
Measure O	1240,3125	1860,4688	2696,7305	5797,5117	0,5505
Measure P	599,2734	898,9102	1302,9609	2801,1445	0,2660
Measure Q	413,4375	620,1563	898,9102	1932,5039	0,1835
				10531,1602	1
					Eigenvector (3)

Table 10 Calculating eigenvector for the public support of different measures (iteration 3)

After three iterations it appears that there are no more iterations needed and that the eigenvectors for each of the measures are determined. These three eigenvectors for the public support for measure O, P and Q are required in the last part of this step of setting priorities. The example described above, only showed the calculations for the public support of the different measures of a certain traffic safety problem. When comparing measures also the effectiveness and the costs need to be taken into account. Therefore the same calculation process is required. For each of the three criteria an eigenvector need be calculated. This means that there will be an eigenvector for public support, effectiveness and costs for each different measure. Because the eigenvectors for effectiveness and costs are not calculated here and a full table is needed for the description of the last part of this process, there will be assumed that the values for effectiveness and costs are the same, in order to give a clear demonstration of the process. The final result of this step B would look as follows:

	Public support	Effectiveness	Costs
Measure O	0,5505	0,5505	0,5505
Measure P	0,2659	0,2659	0,2659
Measure Q	0,1835	0,1835	0,1835

Table 11 The eigenvectors for the public support, effectiveness and costs for different measures

C) Combining part A and B

The final step of this procedure is to combine the outcomes of the first two parts (A and B) in this step, in which priorities will be set. At first weights were given to the different criteria, public support, effectiveness and costs. Here four scenarios were chosen. Subsequently the possible traffic safety measures were compared through the different criteria. For both steps eigenvectors were calculated. To examine which effect the assignment of the different weights has on the final score, each scenario needs to be multiplied with the results of part B. Because there are four scenarios, this means that there are in total four outcomes possible (see table 12).Table 13 shows the outcomes of the calculations of the previous described example.

The calculation of scenario 1 will be explained as example. The result of scenario 1 (see table 13), row 1 column 1 (0,1835) is the result of multiplying the value for the public support of measure O (0,5505) with the value for public support of weighting scenario 1 (0,3333). The result in row 1 column 2 (0,1835) is the result of multiplying the value for effectiveness of measure O (0,5505) with the weighting scenario 1 (0,3333). The overall value can be calculated by taking the average of the sum for each of the three criteria for each measure. The overall value in scenario 1 for measure O is the result of summating the results for public support (0,1835), the effectiveness (0,1835) and the costs of that measure (0,1835) and dividing the total by 3.

	Public support	Effectiveness	Costs
Measure O	0,5505	0,5505	0,5505
Measure P	0,2659	0,2659	0,2659
Measure Q	0,1835	0,1835	0,1835

X

	Weighting Scenario 1
Public support	0,3333
Effectiveness	0,3333
Costs	0,3333

	Public support	Effectiveness	Costs
Measure O	0,5505	0,5505	0,5505
Measure P	0,2659	0,2659	0,2659
Measure Q	0,1835	0,1835	0,1835

X

	Weighting Scenario 2
Public support	0,5000
Effectiveness	0,2500
Costs	0,2500

	Public support	Effectiveness	Costs
Measure O	0,5505	0,5505	0,5505
Measure P	0,2659	0,2659	0,2659
Measure Q	0,1835	0,1835	0,1835

X

	Weighting Scenario 3
Public support	0,2500
Effectiveness	0,5000
Costs	0,2500

	Public support	Effectiveness	Costs
Measure O	0,5505	0,5505	0,5505
Measure P	0,2659	0,2659	0,2659
Measure Q	0,1835	0,1835	0,1835

X

	Weighting Scenario 4
Public support	0,2500
Effectiveness	0,2500
Costs	0,5000

Table 12 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios

Scenario 1	Public support	Effectiveness	Costs	OVERALL
Measure O	0,1835	0,1835	0,1835	0,1835
Measure P	0,3333	0,0886	0,0886	0,1702
Measure Q	0,3333	0,0612	0,0612	0,1519

Scenario 2	Public support	Effectiveness	Costs	OVERALL
Measure O	0,2753	0,1376	0,1376	0,1835
Measure P	0,1330	0,0665	0,0665	0,0886
Measure Q	0,0918	0,0459	0,0459	0,0612

Scenario 3	Public support	Effectiveness	Costs	OVERALL
Measure O	0,1376	€ 0,2753	€ 0,1376	0,1835
Measure P	0,0665	€ 0,1330	€ 0,0665	0,0886
Measure Q	0,0459	€ 0,0918	€ 0,0459	0,0612

Scenario 4	Public support	Effectiveness	Costs	OVERALL
Measure O	0,1376	0,1376	0,2753	0,1835
Measure P	0,0665	0,0665	0,1330	0,0886
Measure Q	0,1376	0,0459	0,0918	0,0918

Table 13 Final result of the weighting process

The traffic safety measure with the highest overall score in a scenario appears to be the best measure in that particular scenario. The highest score in each scenario is marked in table 13. From these calculations for the four different scenarios appears that measure O always has the best score.

This calculation was only an example of the method that will be used in this thesis to compare the different measures of traffic safety problems speeding, driving under influence of alcohol and seat belt use. Through this, the different results can be compared, in order to choose the measure with the best score. If one measure has the best or a good total score in each of the four scenarios, there might be concluded that this will be a good measure to counteract that particular traffic safety problem.

Part 2: Practical Application of the amenability to treatment

In this part, three traffic safety problems, namely speeding, driving under influence of alcohol and seat belt use will be analyzed. For each of these problems the magnitude and the public support will be examined and presented. Subsequently a selection of possible measures to solve these problems will be discussed. For these measures the effectiveness, public support and costs will be examined.

1. Speeding

1.1 Safety problem

One of the major road safety problems is speeding (Elvik, 2008)*. This problem will be extensively researched, through analysis of the magnitude and attitudes towards the problem.*

1.1.1 Magnitude

Excessive and inappropriate speed still remains a major problem on our roads. Yet, excessive speed is often seen as an innocent infringement. According to Elvik (2010) it is fair to say that speeding is widely tolerated. When road users are asked which they think the most important road safety problems are, speeding is hardly the first problem mentioned. The risks involved in speeding tend to be underestimated and few drivers see any reasons to change their speed behavior (Elvik, 2010).

According to the Belgian Road Safety Institute more than 300 fatal accidents occur each year in Belgium due to speeding (BRSI, 2011a). According to various studies excessive or inappropriate speed causes 20 to 35% of the traffic accidents (States-General of traffic safety, 2002). In 2005 31.423 crashes with injuries occurred in Flanders. This means that in approximately 6300 to 11.000 accidents excessive or inappropriate speed had an influence (Policy Research Centre for Traffic Safety, 2008).

A survey of Silverans et al. (2005) asked 1500 Belgian respondents if they respected the speed limits for each road category (accurate to 5km). Forty-three percent of the respondents affirm respecting the speeding rules in general. Regarding the percentage for each speed regime there can be seen that the higher the speed limit the lower the compliance with the speed rules. The lower the speed limits, the higher number of respondents who are saying that they obey the speeding rules.

Respecting the speed limits (%)	
30km/h	66,70%
50km/h	54,70%
70 km/h	49,70%
90 km/h	47,80%
120 km/h	38,40%
General	43,70%

Table 14 Percentage of respondents who are saying to obey the speed limits (within a margin of 5km/h) (Silverans et al., 2005)

The BRSI (Vlaamse Stichting Verkeerskunde, 2010a) measured for different years the average speed and the V85 on different road categories. The V85 is the speed that is not exceeded by 85% of the drivers on a road with a normal flow and normal traffic conditions. It is the speed that is considered by the majority of the drivers as safe and reasonable. Therefore the V85 may be a better indicator to calculate the population attributable risk compared to the average driven speed. On figure 4 can be seen that the V85 at each road category is higher than the maximum allowed speed on that category.

Figure 4 V85 on 30km/h.-, 50km/h.-, 70km/h.- and 90km/h.- roads in Belgium (Vlaamse Stichting Verkeerskunde, 2010a)

A good way to visualize the magnitude is through the calculation of the population attributable risk (PAR) (Elvik, 2008). The PAR refers to the contribution a factor makes to the total number of cases (i.e. all accidents). According to Nilsson (2004) and Elvik (2008) the relationship between speed changes and changes in the number of crashes and injuries can be described as a power function. The exponent of the power function differs according to the crash/injury severity.

Nilsson (2004) showed that a speed change may result in many direct effects related to the drivers or the road users which are important for the safety situation. A first effect is the change in braking distance of the motor vehicle. A second effect caused by a change in speed is the possible change in reaction time. Also the collision speed will change due to a modification in speed. The probability for pedestrians/cyclist to avoid an accident with a motor vehicle will change and the force or violence to the human organs in an accident changes due to an adjustment in speed. Nilsson (2004) stated that the number of injury accidents will change as an exponent of the relative speed change. Therefore Nilsson defines three different exponents: First of all an exponent of 2, which presents the number of injury accidents. Subsequently an exponent of 3, which represents the number of serious injury accidents and finally an exponent of 4, which presents the number of fatal accidents.
Also Elvik (2008) examined the relationship between speeding and the traffic safety risk, through a power model The model of Elvik (2008) describes also three power functions, one for slight injuries, one for serious injuries and one for the fatality risk attributable to speeding. Therefore he gives respectively the exponents: 1,5; 3 and 4,5.

The main differences between the formulas of Nilsson (2004) and Elvik (2008) is that the formula of Nilsson the number of accidents calculates, while the formula of Elvik the proportion calculates, but not the number of accidents. Beside there is also a difference between the exponents in the two formulas, but the reasoning remains the same. Namely comparing the allowed speed limit with the actual driven speed limited, multiplied with an exponent to determine the difference in accidents. Here is chosen to work with the formula of Nilsson (2004), because the actual number of accidents is calculated and because the study of Nilsson was more expanded than the study of Elvik (2008).

Power model by Nilsson:

Number of *(kind of injury)* accidents $_{after}$

$$= \text{Number of } \textit{(kind of injury)} \text{ accidents}_{before} * \left(\frac{v_{after}}{v_{before}} \right)^X$$

With ‘v’ is the average speed and ‘X’ is the power according to the severity of the crash

The PAR can be calculated for different speed limits. For this calculation the V85 values of the BRSI presented in Figure 5 can be used. For these calculations, the V85 on the Belgian roads in 2007 will be used. The Belgian roads can be divided in five main speed categories, namely 30km/h-, 50km/h-, 70 km/h-, 90km/h- and 120km/h roads. In the table below, the results for the first four road categories can be found, for the road category of 120km/h other data will be used from the Policy Research Centre for Traffic Safety. The data for the V85 was measured on six different measurement locations on the E40 in Boutersem in 2011 where the V85 on these locations was 132km/h.

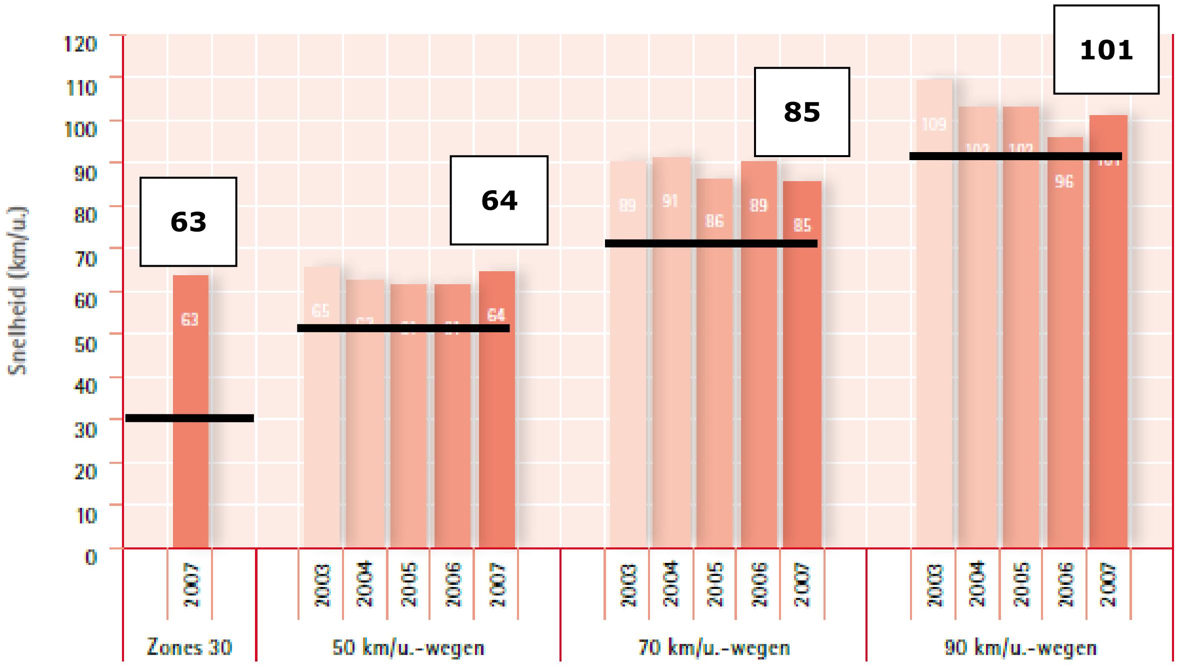


Figure 5 V85 on 30km/h.-, 50km/h.-, 70km/h.- and 90km/h.- roads in Belgium (Vlaamse Stichting Verkeerskunde, 2010a)

Table 15 presents the results of the applied data of the BRSI on the Power function of Nilsson (2004). The results are expressed in the reduction of accidents per road category and per type of accident.

	Population Attributable Risk (PAR)		
	Injuries	Serious injuries	Fatal accidents
Road categorie			
30km/h	0,77	0,89	0,95
50 km/h	0,39	0,52	0,63
70 km/h	0,32	0,44	0,54
90 km/h	0,21	0,29	0,37
120 km/h	0,17	0,25	0,32

Table 15 Calculation of the PAR following the method of Nilsson (2004) for different speed limits (based on the V85)

If the V85, namely the speed that is exceeded by 15% of the drivers, would coincide with the maximum allowed speed limit, then could the following results be found. The fatal accidents could be reduced on 30km/h roads with 95% and on 120km/h up to 32%. For injuries these percentages are lying lower. The accidents with injuries could be reduced with 77% on 30km/h roads and up to 17% on 120km/h roads. It is remarkable that the higher the allowed speed limit, the lower the chance to reduce the number of injuries and fatal accidents. The highest reduction can be reached by the fatal accidents on 30km/h roads. A study of Wilmots et al. (2009) found that the type and amount of accidents differ according to the type of road. In the paper a distinction is made between roads inside the built-up area (roads where maximal 50km/h is allowed) and roads outside the built-up area (roads where more than 50km/h is allowed). In the paper also a division was made according to the severity of the crashes. Table 16 shows the distribution of the different types of accidents over the two different road areas. Remarkable is that the number of accidents (with seriously injured) are more or less the same in the two areas, but the number of fatal accidents is significantly higher outside the built-up area compared to the built-up area.

	In the built-up area	Outside the built-up area
Accidents	51%	49%
Accidents with seriously injured	40%	60%
Fatal accidents	22%	78%

Table 16 Distribution of different types of accidents in the built-up area and the outside the built-up area (Wilmots et al., 2009)

1.1.2 Public support

The BRSI conducted a survey on the attitude towards the most common traffic safety problems in Belgium in the year 2003, 2006 and 2009 (BRSI, 2009). In the survey of 2009, about 1500 respondents had to indicate whether they agreed with some traffic related statements. Here the most important results of this measurement related to speeding will be presented. First of all a general view for the public support of the most common traffic safety problems will be given, so that the public support for speeding can be compared to the public support for other traffic safety problems.

	Speeding	Alcohol	Seat belt use
The rules should be stronger	35%	63%	42%
It is difficult to respect the rules	33%	12%	11%
The rules are unclear	30%	18%	14%
The public support for the enforcement of traffic rules	56%	59%	44%
Too heavy punishment	35%	11%	30%

Table 17 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009)

Out of this results a few conclusions concerning the public support for speeding regulations can be made. First of all it is remarkable that only 35% of the respondents think that the rules for speeding should be stronger. This result is sufficiently lower, compared to the results for alcohol and seat belt use. From this can be concluded that the respondents think that the rules for speeding are strong enough. Thirty – three percent of the respondents have difficulties with respecting the rules. Also this percentage is remarkably different compared with the other traffic safety problems. The reason why it could be difficult to respect the rules could point to the problem of the signalization of speed limits, but could also point to illogical speed limits on certain locations (BRSI, 2009). In the results of the next question there is again a clear difference between the safety problems in the answers. Thirty percent indicated that the rules for speeding are unclear. The rules for the other subjects seem to be more clear. The answers on the fourth question, which asked about the support for the enforcement of traffic rules, are approximately equal for each subject. The public support for the enforcement of traffic rules of speeding is 56%. Regarding the heaviness of the punishments, it appears that 35% of the respondents find that there are too strong punishments for speeding. Also 30% said that the punishments for not wearing a seat belt are too strong. The punishments for drunk driving are more accepted.

BRSI (2009) also posed questions specific for speeding. In the table below the percentage of agreement is given for three research years (2003, 2006 and 2009). The States-General in Belgium formulated in 2002 a few objectives for the statements. Through the attitude measurement of the BRSI (2009), the results can be compared with the given objectives.

Percentage of agreement	2003	Goal 2004	2006	Goal 2006	Goal 2008	2009
Speeding is a way to save time for you	38,20%	max. 20%	21,64%	max. 15%	max. 8%	23,84%
Speeding is socially unacceptable for you	69,70%	min. 60%	63,14%	min. 70%	min. 80%	61,77%
Speeding is risking your own life and the life of others	83,80%	min. 60%	76,62%	min. 70%	min. 80%	80,32%

Table 18 Attitudes towards speeding (BRSI, 2009)

From the table above there can be concluded that only one goal of the States-General according to speeding is achieved. Namely about 80% realizes that speeding is dangerous for yourself and others. Nevertheless, the majority of offenses are due to speeding (BRSI, 2009).

Next to the attitude measurement of the BRSI (2009), AXA (2009) also performed an attitude measurement concerning traffic safety problems with 802 Belgian respondents. The questions and answers concerning speeding were the following:

- Which forms of driving behavior you think are dangerous?
  - Driving 65km/h in the urban area
  - Driving in between 150 to 160km/h on the highway (maximum permitted speed in Belgium is 120km/h)

- Are you doing the following things very often/often/sometimes or never?
  - Driving 65km/h in the urban area
  - Driving in between 150 to 160km/h on the highway (maximum permitted speed in Belgium is 120km/h)

Sixty-six percent of the respondents indicated that driving 65km/h in the urban area is dangerous and 43% said that they drive 65km/h in the urban area (very) often to sometimes. Sixty-five percent of the respondents indicated that they find it dangerous to drive 150 to 160 km/h on highways. Thirty percent said that they drive more than 150 km/h on highways (very) often to sometimes.

1.1.3 Conclusions for the safety problem speeding

The two most important parameters to understand the traffic safety problem are the magnitude of the problem and the attitudes towards the traffic safety problem. Both these parameters were discussed for the problem speeding. The magnitude for this problem was determined by the Power function of Nilsson (2004). A first important conclusion that could be made is that stronger speed measures are necessary on 30km/h-, 50km/h-, and 70km/h-roads in Belgium. Certainly on 30km/h roads the number of fatal accidents can be decreased with 95% if all road users would adjust their speed limit. The average decrease for all types of accidents for the different speed limits is equal to 87% on 30km/h-, 51% on 50km/h-, 43% on 70km/h-, 29% on 90km/h- and 25% on 120km/h-roads. To determine the public support of the safety problem speeding the attitude measurement of the BRSI (2009) is used. Fifty-six percent supports the enforcement for the traffic rules for speeding.

In the next part different measures to counteract speeding will be investigated, to eventually select the best measure(s) to reduce or resolve the problem.

1.2 Safety measures

For the safety problem 'speeding', different safety measures can be taken in order to resolve or reduce the problem. As could be expected, each safety measure will have a different public support, effectiveness and cost. The measures that will be discussed are those that are most used in Flanders. For every domain of the three E's (education, environment and enforcement) at least one measure was selected. Per measure the three dimensions of amenability to treatment are discussed: effectiveness, public support and costs. At the end of each of these dimensions a conclusion will be made. This conclusion contains the most important information which will be used in the weight of the different elements at the end of this part speeding.

Driving at an inappropriate speed contributes significantly to the occurrence and the severity of accidents (Paris, 2007). Therefore, the Flemish government spends properly attention to speed behavior as a means to reduce the number of traffic victims and to improve road safety. Below, all the different measures which can be taken to counteract speeding will be analyzed using those three categories.

1.2.1 Education

The States General of Road Safety (SGVV) (2002) is giving three concrete education measures which can be applied in order to raise more awareness for traffic safety. In first instance it can be useful to introduce traffic courses in the last year of the third grade of the secondary education (age of 18). These courses should inform and sensitize the students about the high involvement of young people in road accidents. The effect of speeding should be extensively described. A second measure proposed by the SGVV (2002) is the restriction of the public campaigns of car manufacturers. Their campaigns must be approved by FEBIAC (defender of manufacturers and importers) before they can be publicly shown. Campaigns that encourage speeding will not be approved. A last method presented by the SGVV (2002) is informing road users about the consequences of speeding by means of campaigns. These campaigns fight against the positive image that still exists about speeding. This strategy would rely on mass media and communication actions aimed at population that is guilty of excessive speeding (young people, professional drivers). In order to achieve a maximum effectiveness, sensitization measures will be supplemented with a stronger enforcement. Those public campaigns will be closely discussed here.

A) Public campaigns

In Belgium the BRSI executes each year a national campaign in the context of the compliance with the speed limits and safety distances. Also provinces, regional and local institutions perform campaigns (SGVV, 2002). It was hard to find specific results concerning the effectiveness of speeding campaigns executed by the BRSI. Instead results were found for public support and effectiveness from more general studies. The costs on the other hand were found for campaigns which were performed by the BRSI.

Public support

Scheers (2006) executed a research where she examined 1219 persons and asked them how they felt against public campaigns and measures against speeding. The survey showed that 63% had positive feelings towards public campaigns. In the attitude measurement of the BRSI in 2009 was asked which measures would help to drive safer. Almost 61% of the respondents indicated that sensitization campaigns would help to drive safer.

Effectiveness

Different results concerning the effectiveness of public campaigns were found in Rutten & Van den Bulck (2007). Elder et al. (2004) found that mass media campaigns could reduce the number of accidents with 13%. Most of these campaigns were executed in combination with enforcement and this study was generally focused on reducing drunk driving. Elliot (1993) found that each kind of public campaign produces a positive effect, but that public campaigns in combination with enforcement results in the largest effect, that is a reduction of the number of accidents with 8,9%. Delaney et al. (2004) found the same results. Delhomme et al. (1999) found a non significant effect of 5,4% for the reduction of accidents due to public campaigns without enforcement. The combination of public campaigns in combination with enforcement would lead to a reduction of 6,9%. Elvik & Vaa (2004) concluded that campaigns could reduce accidents up to 49%, depending on the type of campaign. Hagenziker et al. (1997) also investigated the results of campaigns with a reward system. The effect on short term of these campaigns would result in an accident reduction of 12%. The effect on long term would result in a reduction of 9,6%. Phillips et al. (2011) executed a systematic summary of 119 individual road safety campaign effects. The results of this study suggests that road safety campaigns have an overall significant accident-reducing effect of 9%. The meta-regression analysis suggests that road safety campaigns should use personal communication, roadside and/or enforcement strategies to deliver their message. This would lead to higher accident reductions.

Costs

According to the BRSI (2008) the price of a public campaign depends on the theme, the period and the chosen media. The cost of an average campaign (all in) is estimated at €150.000 to €500.000 euro. These campaigns are partly financed by the BRSI and are partly sponsored by externals. It was not found in the literature how many people can be reached with one public campaign. It depends mainly on the type of campaigns and the medium that is used to spread the campaign.

Conclusions education measures

Concerning education, only one measure was discussed, that is public campaigns. For the public support for public campaigns two main results were found (BRSI, 2009; Scheers, 2006). These results, respectively 63%, which gives an indication about positive feelings towards public campaigns and 61%, which gives an indication of the number of respondents who said that sensitization campaigns would help to drive safer, are very close to each other and are giving both a good indication of the public support for public campaigns. Therefore the average of these two, which is 62%, will be used in the overall analysis. To determine the effectiveness of public campaigns different studies were examined. The study of Phillips et al. (2011) seemed the most extended study, as they examined the overall effect of 199 individual studies. The results of this study suggested that road safety campaigns have an overall significant accident-reducing effect of 9%. Concerning the costs of public campaigns, the BRSI (2008) indicated that an average campaign costs about €150.000 to €500.000. Because one value is needed for the analysis, the average of these two prices will be taken, that is €325.000.

1.2.2 Environment

A) ISA

Intelligent speed Assistance (ISA) is a device that gives comfort and safety and provides interaction with the driver when the maximum allowed speed is exceeded. Most ISA-devices are categorized into different types and differ in their intervention. Vlassenroot & De Mol (2011) handle four different types of ISA. An informative (open) system displays the speed limit and the driver will be reminded of changes in the speed limit. The warning (open) visual or auditory system warns the drivers when exceeding the posted speed limit at a given location. The drivers decide whether to use or ignore the information. The assisting (half-open) system gives a force feedback through the gas pedal if the drivers try to exceed the speed limit. In this case it is still possible to overrule the system. A limited or restricted system prevents the driver of exceeding the maximal speed limit. The driver cannot overrule the system. In general, ISA systems establish the position of a vehicle, compare the speed of the vehicle with the posted speed limit at a given location, and then gives feedback the driver or even restricts the vehicle's speed in force (SWOV, 2010a).

Public support

Vlassenroot & De Mol (2005) indicate that defining the public support of ISA depends on the personalities, attitudes and social context of individuals which determine their (safe) traffic behavior as well as the motivational aspects when using the device.

In 1998 a questionnaire was executed with 2507 Belgium respondents. The aim of the questionnaire was to reveal if there could be an acceptance for the ISA-system. One of the posed questions was: "Should ISA be implemented?" (Vlassenroot & De Mol, 2005).

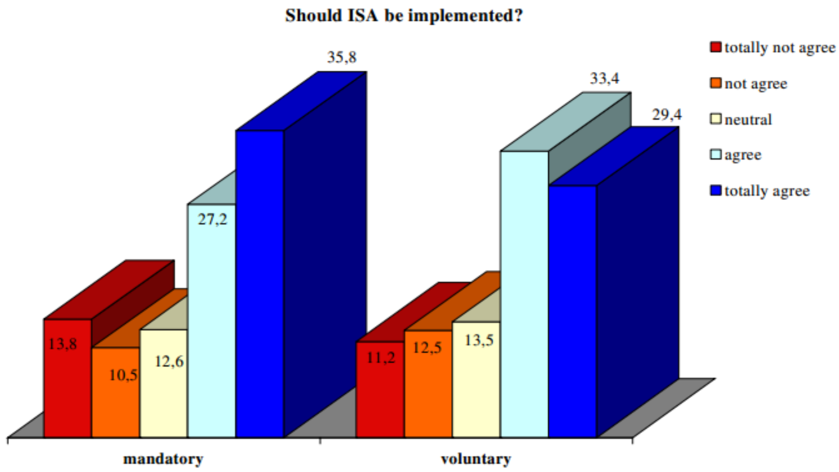


Figure 6 The general opinion about implementation of ISA (Vlassenroot & De Mol, 2005)

As the results in figure 6 shows, 63% of the respondents agreed to totally agreed with the implementation of a mandatory ISA-system and 62% percent of the respondents agreed to totally agreed with the installation of a voluntary ISA-system. Nevertheless the mandatory system encounters most resistance (13,8%) while for the voluntary system a resistance was found of 11,2%. More people were in favor (35,8%) of a mandatory system than a voluntary system (29,4%). From this can be concluded that ISA is accepted by the general public (Vlassenroot & De Mol, 2005). Out of the study of Vlassenroot en De Mol (2005) some conclusions could be made concerning the public support for the ISA-system. All the drivers who were tested accepted the active accelerator pedal. After the trial, they experienced the active pedal as being even more satisfying. In the study the drivers had also the choice when they would use/activate the system. From this can be concluded that the test-drivers used the system voluntary on highways and outside urban areas. This gives a first indication of their acceptance of the active accelerator pedal. The drivers also experienced that the system is satisfying and useful. After the trial almost 50% of the respondents said they wanted the keep the system in the vehicle after the test-period. This is also an indication that there is an acceptance of the active accelerator pedal. The drivers also noticed that the system provided comfortable and relaxed driving, although certain technical issues could have been better (Vlassenroot et al., 2006).

Paris (2007) examined the psychological determinants of speeding behavior by 1000 randomly chosen Flemish car drivers. The results of the study showed that driving with ISA does not give a motivation to a more positive attitude towards traffic safety behavior, but the driver will pay more attention to unconscious and unintentional violations. If there is a positive attitude by the drivers towards traffic safety behavior, ISA could contribute to a more appropriate behavior towards speed (Paris, 2007). Out of a mobility survey of the Flemish minister H. Crevits in Belgium in 2010 appeared that 20,5% of the respondents don’t feel comfortable with this measure. However, 55% does agree with this measure (Kabinet van H. Crevits, 2011).

Effectiveness

Out of the ISA-system study of Vlassenroot et al. (2006) appeared that 60% of the respondents declared that driving with ISA is more comfortable and relaxing. Also 30% declared that they had more attention for the other road users. Out of the study also appeared that most drivers did not notice any difference while driving with or without the active accelerator pedal with respect to looking at the speed signs, recognition of involvement in certain traffic situations or keeping distance with other cars. Fifty percent of the respondents declared that they overtook less while using ISA and fifty percent found it easier to keep a constant speed with ISA. The ISA-system assisted them to maintain the right speed. This was certainly useful for upholding the 30km/h speed limit of which they noted that it was difficult not to violate without the assistance of ISA (Vlassenroot et al., 2006). Driving with ISA changed the respondents’ behavior on speeding: during the project, most of the drivers declared that they never drove faster on highways, outside urban areas, in urban areas and 30-zones.

The study from Vlassenroot et al. (2006) investigated the effectiveness of the active ISA-system in terms of speed reduction. The percentage of the total amount of speed violations of the test-drivers decreased when the active gas pedal was operational. The effects were the largest on 90km/h roads and lower on 50km/h roads. On the 90km/h roads the average speed decreased with almost 10%. At lower speed limits the effects were smaller, although speeding was more frequent. Speeding remained the largest in the 30km/h zones. The effect of ISA on 30km/h roads was minimal. Despite, the counterforce of the pedal was not strong enough to discourage the drivers not to speed (Vlassenroot et al., 2006).

Since the early 1980's, the effects of ISA on driving and traffic safety have increasingly been examined. This was done through different methods and data collection techniques among which micro-simulation, driving simulators, instrumented vehicles and field trials. All those results point in the same direction, which all show the positive effects of ISA systems: an average speed reduction of approximately 2 to 7 km/h, a reduction in speed variance and a reduction in speed violations. The size of these reductions depends on the type of ISA, with more controlling ISA types being more effective (SWOV, 2010a).

The effects of ISA on traffic crashes are not simple to determine. In order to measure the effect on traffic crashes, a substantial number of ISA vehicles is required. Therefore, driving simulator and traffic simulation studies are used to examine this effectiveness. Based on the reductions of mean speed, speed distribution and the percentage of speed violations that ISA systems bring about, these systems are assumed to achieve substantial reductions in the incidence and severity of road crashes (SWOV, 2010a). Carsten & Tate (2005) found a good prediction of reduction in accidents with the use of a limited or restrictive system. This implementation of the system could save 20% of the injury accidents and 37% of the fatal accidents. A more complex version of the limited system, including a capability to respond to current network and weather conditions, would result in a reduction of 36% in injury accidents and 59% in fatal accidents.

Costs

The costs of the ISA-system depend on the chosen system variant (Goldenbeld, 2004). In research from Carsten & Tate (2005) appeared that the cost for a mandatory ISA system in Flanders would be €440 per vehicle. In 2010 the total number of motorized vehicles in Flanders amounted to 3,7 million (Vlaamse Stichting Verkeerskunde, 2010b). If the system would be implemented in 3,7 million cars, this would lead to a total cost of €162,8 million. The maintenance costs for ISA are estimated by Carsten & Tate (2005) at €2,81 million per year plus €1,25 extra per vehicle. The costs of the measure could be a barrier to take ISA in the car (Goldenbeld, 2004).

Conclusions environment measures

For safety measures within the category of the environment, one measure was discussed, namely intelligent speed adaptation (ISA). Different studies investigated the public support for the ISA-system (Kabinet van H. Crevits, 2011; Paris, 2007; Vlassenroot et al., 2006; Vlassenroot & De Mol, 2005). Because the study of Vlassenroot & De Mol (2005) was the most extensive study, these results will be used. Out of this study appeared that 63% of 2507 respondents agreed with the implementation of a mandatory ISA-system. Following Carsten & Tate (2005) the ISA-system could provide a reduction in injury accidents of 20% and a reduction in fatal accidents with 37%. The costs for the implementation of the ISA-system were also given by Carsten & Tate (2005). The cost for an ISA system in Flanders would be €440/vehicle if the system would be implemented in 3.700.000 cars. The maintenance costs for ISA are estimated by Carsten & Tate (2005) at €2,81 million per year plus €1,25 extra per vehicle.

1.2.3 Enforcement

Enforcement covers legislations and regulations, which form an important process in road safety. For the road safety problem 'speeding' there exist a lot of enforcement measures in order to maintain the speed limits. Three different measures will be discussed here, that is fixed cameras, section control and mobile cameras.

A) Fixed cameras

The unmanned or fixed camera is a collective name of unmanned automatic devices which can record traffic violations (e.g. speeding, red light negation) through photographic recordings (SWOV, 2011). Three different types of cameras exist, that are cameras which can only detect the speed of the vehicle, cameras which can only detect red light negation and at last there are cameras which can combine the detection of speeding and red light negation. In Belgium two types are used, that are speed cameras which only measure speed and red light cameras which measure as well red light negation and speed. In most other countries especially speed cameras which only measure speed and red light cameras which only measure red light negation are used (Nuyts, 2006). Here only the speed cameras will be discussed, because red light cameras focus often on red light negation, and it is difficult to distinguish both effects. Speed cameras register speeding offences and indentify the vehicle registration number. The cameras are usually linked to radar or induction loop detectors in the road surfaces which measure the speed of the vehicles. Speed cameras can be installed on roadside areas (fixed position speed cameras) or can be installed in police cars (mobile speed cameras). In this part only the fixed speed cameras will be discussed (SWOV, 2011). When a violation is detected, the registration number of that particular vehicle is photographed (SWOV, 2011). These unmanned speed cameras are often used on road sections with a high accident rate. The fixed camera is in most cases clearly visible, so that drivers can notice the speed camera while driving. A disadvantage of this fixed camera is that the speed is only controlled at one particular location (Vermote, Van Malderen, & Macharis, 2012).

Public support

Scheers (2006) executed a research where she examined 1219 persons about measures against speeding. Out of this research appeared that 74,8% of this research sample is pro fixed cameras. In the attitude measurement of the BRSI in 2009 the respondents were asked which measures would help them to drive safer. Almost 62% of the respondents indicated that fixed cameras would help them to drive safer. To examine the public support of fixed cameras, different international studies were analyzed, from which a study in Canada and one in The Netherlands are discussed here. At the end of 2000 until the beginning of 2001 a survey with 2214 respondents was executed in Canada. The goal of this survey was to explore which percentage of the population agreed with the speed enforcement measures. The survey focused on different types of roads. A high public support was found for fixed cameras in school zones. About 65% was pro fixed cameras, only 9% was against cameras in school zones. The fixed cameras on motorways had a smaller public support: 32% was negative towards enforcement by fixed cameras and only 39% agreed with this form of control on motorways (Delaney, Ward, & Cameron, 2005). A survey by means of self reported behavior with 6.000 respondents was executed in the Netherlands in 2008. Here was found that 80% of the respondents are supporting speed cameras. In 2006 and 2007 these results were respectively 67% and 72% (Openbaar Ministerie, 2009).

Effectiveness

Nuyts (2006) investigated the effectiveness of fixed cameras on a select number of locations in Belgium and examined the effectiveness of fixed cameras in international studies. Table 19 gives an international comparison of the effectiveness (in percentage) of fixed cameras. Nuyts (2006) made a difference between accident reduction with injuries and material damage and accident reductions with only injuries. The results from Elvik and Vaa (2004) are replaced by more recent results of Elvik et al. (2009).

Effectiveness fixed cameras		
		Speed cameras
Belgium	Reduction in accidents (injuries + material dammage)	20-21%
	Reduction in accidents (injuries)	7-9%
International	Reduction in accidents (injuries + material dammage)	16% (12-29%)
	Reduction in accidents (injuries)	16% (-4-28%)

Table 19 Effectiveness fixed cameras. A comparison between Belgium and international studies (Nuyts, 2006)

The best estimation of the effectiveness of the Flemish fixed cameras is a significant reduction of all accidents, including accident with property damage only, with 20 to 21%. International studies show that speed cameras could reduce accidents by 12 to 29% (Elvik et al., 2009; Ha, Kang, & Park, 2003). Nuyts (2006) indicated that the most reliable number of this international study was given by the meta-analysis of Elvik & Vaa (2009), which showed a reduction of 16%. International studies show that fixed cameras could reduce the accidents with injuries with about -4 to 28%. This means that in a study was found that fixed cameras could also increase the number of accidents with injuries (Elvik et al., 2009; ICBC, 2004; Keenan, 2004). Again Elvik et al. (2009) are giving the best estimation of 16% reduction in accidents with only injuries.

Costs

Research by Vermote et al. (2012) showed that the investment costs for a fixed camera are about €90.000. These investment costs depend on the type of technology that is used. In this research is also mentioned that fixed cameras could detect vehicles with an inappropriate speed in the range of 0.5 to 1km. The maintenance costs for fixed cameras are estimated at about €3000 per year, but can for example increase due to vandalism. The personnel costs for the processing of police reports are estimated at €1651 for the year 2010 based on one camera (De Brabander, 2007).

B) Section control

Section control uses several digital cameras on portals, which can measure the speed of vehicles over a longer distance. These cameras photograph every vehicle passing underneath. When a vehicle has passed the last portal, a computer calculates the average driving speed. If the average speed of the vehicle is higher than the speed limit, a fine will be sent to the address of the driver. Section control will not replace speed cameras, but will be used as an additional means for enforcing speed limits. Section control works 24 hours a day, 7 days a week. When section control is in use, there is a 100% chance that the offenders will be caught. (Openbaar Ministerie, 2008; Van Moerkerke, 2011a).

The system is judged as a fair system. This is because you are immediately caught by a normal fixed camera when you excess the speed limits (e.g. inattention, bad luck). In section control the terms inattention and bad luck are playing a smaller role, because section control controls the average speed over a longer distance. A second advantage of the system is that it decreases the differences in speed between the vehicles reciprocally. This gives positive effects for traffic safety and the flow. The section control system also resolves the problem of slowing down right in front of a fixed camera and accelerating right behind the fixed camera. Section control is a complementary system on the traditional speed controls (Van Moerkerke, 2011a). In Belgium there are already a few section controls available. Since June 2012 the section control in Ghentbrugge performs speed controls. The Netherlands have already 15 year experience with section control. The section controls is always announced with large traffic signs and the majority of these systems is installed on highways or in the environment of big cities (Van Moerkerke, 2011a).

Public support

The advantage of section control is that speed limits are not measured on one single point, but over a longer road distance. People feel that section control is a more honest method of enforcement compared to speed cameras (Openbaar Ministerie, 2008). Out of research in 2008 in The Netherlands appeared that 77% out of 6.000 respondents found section controls very acceptable (Openbaar Ministerie, 2009).

Effectiveness

Because the system is in full development in Belgium, the effectiveness of section controls in other countries will also be examined. Since June 2009 a test period started at the section control in Gentbrugge E17 in Belgium. In general there can be concluded that the majority of the drivers comply with the authorized speed limit. On an average weekday about 60.000 vehicles pass the section. On a weekend day about 40.000 vehicles a day are passing. The percentage of violations is around 5 to 6%, which are about 3000 to 4000 vehicles a day. Remarkable is that less vehicles are offending the speed limit at section controls then at fixed cameras (Van Moerkerke, 2011b).

Although the system is already 15 years active in The Netherlands, there remains to be very few information about the effects of section control. But it is already showed that speed differences between the vehicles on roads with section control are smaller than on places where there are no section controls (Van Moerkerke, 2011a). It also appeared that 99% of the drivers comply with the speed limits on the controlled sections. A study in the Netherlands found that section control could reduce the number in accidents with 47% (Kennisplatvorm verkeers en vervoer, 2007). Next to the Netherlands, also Italy has a wide experience with section controls, especially on 130km/h roads. The choice of the section control places is based on the number of traffic deaths, namely at places where the number of deaths is higher than the average. Out of the results of the Italian section controls appeared that the average speed on motorways decreased with 15% and that the maximum driven speed decreased with 25%. The number of traffic deaths on these sections decreased with 51%, the number of accidents decreased with 19% and the number of injuries with 27% (Van Moerkerke, 2011a).

Costs

Following the research of Vermote et al., (2012) the implementation costs for section control are estimated at €150.000 to €250.000 per maintained kilometer. The costs for the section control system in Gentbrugge are about €800.000. In comparison with the installation costs of a fixed camera €50.000 this is a huge installation cost (Ysebaert, 2009). The maintenance costs for the section control system are estimated at €60.000 per year (Stefan, 2006) and the personnel costs (costs for processing the police reports) are estimated at €1651 for the year 2010 for fixed cameras (De Brabander, 2007), but this value can also be used to give an indication for the personnel costs for section control.

C) Mobile speed cameras

Mobile speed cameras can do the same controls as fixed cameras. The only difference between a fixed camera and a mobile speed camera is that the driver usually does not have notice of the place of the speed camera in advance.

Public support

Scheers (2006) found in her research that 74,3% of the 1219 research persons is pro manned cameras. Out of Dutch research appeared that there is a lower public support for mobile speed cameras, than for visible fixed cameras (SWOV, 2011). From a Dutch research in 2008 appeared that 58% of 6000 respondents found speed controls from a mobile speed camera very acceptable (Openbaar Ministerie, 2009).

Effectiveness

Next to fixed cameras, mobile speed cameras have also a positive effect on speed reductions. Elvik & Vaa (2004) found a reduction in speed from 5 to 6% (Elvik & Vaa, 2004). A study of Kallberg et al. (2008) found that the effects concerning accident reduction are negligible. These cameras have strong tendencies of accident-reducing effects. The study found an insignificant effect of a 5% reduction in accidents.

Costs

The cost for a manned camera is estimated at €50.000 (Vermote et al., 2012). Such as The maintenance costs for manned cameras are estimated at €3000 per year (Vermote et al., 2012). The personnel costs per year are estimated at about € 50.000 for direct personnel (Wijnen, Mesken, & Vis, 2010). The same personnel costs that are used for fixed cameras and section control for processing the police reports will also be used here, that is €1651.

Conclusions for the enforcement measures

Three different enforcement measures were discussed for counteracting the traffic safety problem speeding. These measures were fixed cameras, section control and mobile speed cameras. Here the most important results will be given for each measure, which will be used for the overall weighing process of the safety measures for speeding.

For the public support of fixed cameras four important studies were found from three different countries. The Dutch results from the 'Openbaar Ministerie (2009)' will be used as reference for the public support for fixed cameras, because this study took into account a large sample. Thereby was found that 80% supports speed cameras. For the effectiveness of fixed cameras a lot of studies were found. From these studies the study of Elvik (2009) appeared to be the most reliable one. Therefore the reduction of 16% in the number of injury crashes will be used for the overall analysis. The costs for fixed cameras are given in a study by Vermote et al. (2012), namely an implementation cost of €90.000, maintenance costs of €3000 per camera per year and personnel costs of €1651 per year.

Section control is a relatively new system to counteract speeding. Therefore little data was available for the different elements public support, effectiveness and cost. However, there was found a public support in The Netherlands of 77% for section control (Openbaar Ministerie, 2009). The best results for the effectiveness were found in a study of the Netherlands, that is a reduction in accidents of 47%. The implementation costs for section control are estimated at €150.000 to €250.000 euro per maintained kilometer road (Vermote et al., 2012). The value of the average of this cost, namely €200.000 will be used as reference value for the implementation costs for the section control system. The maintenance costs for the system are estimated at €60.000 per year and the personnel costs at €1651 per year.

For the public support of mobile speed cameras, public support studies for Belgium and for The Netherlands were found. As the study in the Netherlands seems to be more representative because of the larger number of respondents, the public support of 58%, which was measured in 2008, will be used in the overall analysis. Kallberg et al. (2008) found an insignificant accident reduction of 5%. In Belgium there was no data found regarding effectiveness. The costs for manned cameras can be estimated at €50.000 for the implementation costs, €3000 per camera per year for the maintenance costs, €50.000 per year for personnel costs and €1651 for personnel costs for processing the police reports (Vermote et al. 2012) .

1.2.4 Conclusions for safety measures of speeding

In total five different possible measures were discussed to intervene in speeding behavior. These different measures are public campaigns, intelligent speed adaptation, fixed cameras, section control and mobile speed cameras. These are measures frequently applied in Flanders for every domain of the three E's (education, environment and enforcement) was tried to select at least one measure.

As already mentioned in chapter 5.2 of the theoretical introduction, the percentages for public support, effectiveness and the money values for costs are necessary for executing the weighting process for each traffic safety problem. In this theoretical introduction was also explained that the costs for the different measures will be split up in implementation costs on the one hand and in operational and personnel costs on the other hand. The costs are expressed on the one hand in function of each maintained kilometer regional road and on the other hand in costs per year. The length of the regional road in Flanders counts 6055km (Van Geirt, 2004).

Implementation costs (per maintained kilometer regional road):

- Public campaigns = €325.000/6055 = €54
- ISA = (€440 * 3.700.000)/6055 = €268.869
- Fixed cameras = €90.000
- Section control = €200.000
- Mobile speed cameras = €50.000

There is assumed that a fixed camera, a section control system and a mobile speed camera can exert an effect at a distance of one kilometer.

Operational + personnel costs (per year per maintained kilometer regional road):

- Public campaigns = €0 (the operational and personnel costs are already included in the implementation costs)
- ISA = (€2,81 million + €1,25 * 3.700.000)/6055 = €1.228
- Fixed cameras = €3000 + €1651 = €4651
- Section control = €60.000 + € 1651 = €61.651
- Mobile speed cameras = €50.000 + €1651 = €101.651

The results are summarized in the table below and are expressed in the average cost per kilometer regional road.

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public support	62%	63%	80%	77%	58%
Effectiveness	9%	20%	16%	47%	5%
Implementation costs	€ 54	€ 268.869	€ 90.000	€ 200.000	€ 50.000
Operational + personnel costs	€ 0	€ 1.228	€ 4.651	€ 61.651	€ 51.651

Table 20 Summary table traffic safety measures for speeding

1.3 Multicriteria analysis speeding

In the study of the traffic safety problem speeding as many answers as possible were tried to give on the research questions which were formulated at the beginning of the theoretical introduction. On the one hand the traffic safety problem itself was examined and on the other hand different measures which could be taken in order to reduce or resolve the traffic safety problem were analyzed. The next goal is to find the measures which are the best for treating this safety problem. Chapter 5 in the theoretical introduction of this thesis gave a description of the method that will be used to determine the importance of the traffic safety problem and to weigh the different measures of a specific problem.

1.3.1 Traffic safety problem

To get a good sight on the problem speeding, the magnitude of the problem and the attitudes of the population towards the problem were examined. Figure 7 shows the relationship between public support, which is expressed as the percentage of the public who support for stronger policy interventions (x-axis), and the population attributable risk for accidents with injuries (y-axis). For the population attributable risk, five different values were calculated by means of the formula of Nilsson (2004), one for every established speed limit in Belgium (30, 50, 70, 90 and 120km/h). If the V85 would coincide with the average speed, then would the number of fatal accidents decrease with 95% on 30km/h-, with 63% on 50km/h-, with 54% on 70km/h-, with 37% on 90km/h- and with 32% on 120km/h-roads. Knowing the average PAR is necessary to compare the PAR of the two other traffic safety problems at the end of this thesis. The average of these five values is equal to 56%. For the public support was found that 56% supports the enforcement of the traffic rules for speeding (BRSI,2009).

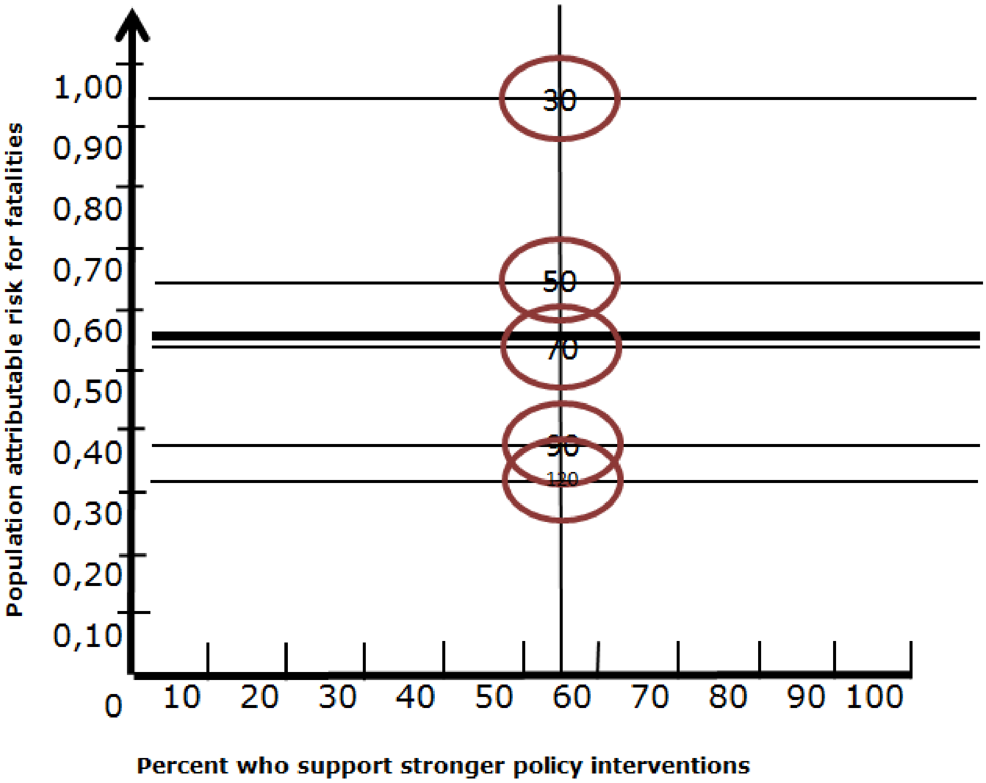


Figure 7 Relationship between support for stronger policy interventions and risk at different road categories attributable to the traffic safety problem speeding

1.3.2 Traffic safety measures

In this part, the different measures will be weighed against each other, taking three variables into account: public support, effectiveness, costs. See chapter 5.2 for an extensive description of the method. The measures that will undergo the analysis for speeding are public campaigns, ISA, fixed cameras, section control and mobile speed cameras. Three important steps need to be carried out in this part, that are:

A) Giving weights to the different criteria
B) Comparison of each measure through the different criteria
C) Combining part A and B

A) Giving weights to the different criteria

Step A, the elaboration of the different scenario's, was already fully explained in chapter 5.2 of the theoretical introduction. This step is the same for all three traffic safety problems. The results of part A, with the four different scenarios are given here in table 21. The first scenario presents all equal weights. In the second scenario the public support is as two times important as the other criteria. In the third scenario the effectiveness is two times more important than and in fourth scenario the costs are two times more important than the other criteria.

	Scenario1	Scenario 2	Scenario 3	Scenario 4
	Equal weights	Public support x2	Effectiveness x2	Costs x2
Public support	0,3333	0,5000	0,2500	0,2500
Effectiveness	0,3333	0,2500	0,5000	0,2500
Costs	0,3333	0,2500	0,2500	0,5000

Table 21 Eigenvectors for the four weighting scenarios

B) Comparison of each measure through the different criteria

In order to execute this analysis the values for public support, effectiveness and costs for the five different measures will be compared The most important results which will be used for this analysis are presented in table 22. The explanation of these results can be found in the conclusions per type (1.2.1 to 1.2.3).

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public support	62%	63%	80%	77%	58%
Effectiveness	9%	20%	16%	47%	5%
Implementation costs	€ 54	€ 268.869	€ 90.000	€ 200.000	€ 50.000
Operational + personnel costs	€ 0	€ 1.228	€ 4.651	€ 61.651	€ 51.651

Table 22 Summary table traffic safety measures for speeding

The next step is to compare the values of the different measures for each criterion (public support, effectiveness and costs). According to the size of their value, the traffic safety measures will be ranked per criterion. Afterwards the eigenvector of each criterion will be calculated. The method is fully discussed in chapter 5.2 in the theoretical introduction. The eigenvectors for public support, effectiveness and costs for the different measures for speeding are summarized in table 32 on page 52. The full calculation of these eigenvectors can be found in attachment 2 of this thesis.

<u>Public support</u>

As can be seen in table 23, the highest public support can be found for section control, which receives a score of 5. The measure with the lowest public support is mobile speed cameras. This measure will receive score 1. The scores for public campaigns, ISA and mobile speed cameras are lying very close to each other.

	Public support	Score
Public campaigns	62%	2
ISA	63%	3
Fixed cameras	80%	5
Section control	77%	4
Mobile speed cameras	58%	1

Table 23 Allocation of ranking scores for the public support of traffic safety measures for speeding

According to the public support, the measures could therefore be ranked as follows: Fixed cameras (5) > Section control (4) > ISA (3) > Public campaigns (2) > Mobile speed cameras (1)

Now that the scores for public support are known, the eigenvector can be calculated. The explanation of the method to calculate this eigenvector can be found in chapter 5.2. The full process of all calculated eigenvectors in this chapter for speeding can be found in attachment 2. In table 24 the main result of this calculation is presented. There were needed two iterations to become the same eigenvectors at four decimal places.

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	83,3333	50,0000	62,5000	250,0000	570,8333	0,1333
ISA	187,5000	125,0000	75,0000	93,7500	375,0000	856,2500	0,2000
Fixed cameras	312,5000	208,3333	125,0000	156,2500	625,0000	1427,0833	0,3333
Section control	250,0000	166,6667	100,0000	125,0000	500,0000	1141,6667	0,2667
Mobile speed cameras	62,5000	41,6667	25,0000	31,2500	125,0000	285,4167	0,0667
						4281,2500	1
							Eigenvector (2)

Table 24 Calculating eigenvector for the public support of different measures for speeding

Effectiveness

The numbers of effectiveness, expressed as the number in reduction of crashes for each of the discussed speeding measures, and their ranking are presented in table 25. As can be seen, the highest effectiveness is found for section control. The measure with the lowest effectiveness is mobile speed cameras.

	Effectiveness	Score
Public campaigns	9%	2
ISA	20%	4
Fixed cameras	16%	3
Section control	47%	5
Mobile speed cameras	5%	1

Table 25 Allocation of ranking scores for the effectiveness of traffic safety measures for speeding

The measures could therefore be ranked as follows: Section control (5) > ISA (4) > Fixed cameras (3) > Public campaigns (2) > Mobile speed cameras (1)

Also here the eigenvectors need to be calculated. In table 26 can the final obtained eigenvectors be found. Also here were the eigenvectors found after two iterations.

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	62,5000	83,3333	50,0000	250,0000	570,8333	0,1333
ISA	250,0000	125,0000	166,6667	100,0000	500,0000	1141,6667	0,2667
Fixed cameras	187,5000	93,7500	125,0000	75,0000	375,0000	856,2500	0,2000
Section control	312,5000	156,2500	208,3333	125,0000	625,0000	1427,0833	0,3333
Mobile speed cameras	62,5000	31,2500	41,6667	25,0000	125,0000	285,4167	0,0667
						4281,2500	1
							Eigenvector (2)

Table 26 Calculating eigenvector for the effectiveness of different measures for speeding

<u>Costs</u>

For the costs of speeding measures a distinction is made between implementation costs and maintenance + personnel costs. These costs were calculated in 1.2.4 (conclusions for safety measures of speeding) and represent the costs per maintained kilometer regional road. Before there can be made a total ranking score for the costs, these two cost need to be aggregated. Both costs will first be ranked, as can be seen from table 27, which shows the ranking of the implementation costs, and table 28, which shows the maintenance and personnel costs.

	Costs 1	Score
Public campaigns	€ 54	5
ISA	€ 268.869	1
Fixed cameras	€ 90.000	3
Section control	€ 200.000	2
Mobile speed cameras	€ 50.000	4

Table 27 Allocation of ranking scores for the implementation costs of traffic safety measures for speeding

	Costs 2	Score
Public campaigns	€ 0	5
ISA	€ 1.228	4
Fixed cameras	€ 4.651	3
Section control	€ 61.651	1
Mobile speed cameras	€ 51.651	2

Table 28 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for speeding

These two tables need to be translated in two matrices following the same principle that was earlier applied for the public support and effectiveness of measures. One matrix for 'costs 1' and one matrix for 'costs 2'. Subsequently these two matrices need to be multiplied with each other. The result can be found in table 30. By calculating the eigenvector for the combination of the two different costs, an overall cost for all the safety measures for speeding can be found. The higher the value of the eigenvector the better the measure and the higher the ranking score.

Costs 1	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5/5	5/1	5/2	5/3	5/4
ISA	1/5	1/1	1/2	1/3	1/4
Fixed cameras	2/5	2/1	2/2	2/3	2/4
Section control	3/5	3/1	3/2	3/3	3/4
Mobile speed cameras	4/5	4/1	4/2	4/3	4/4

Costs 2	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5/5	5/4	5/3	5/1	5/2
ISA	4/5	4/4	4/3	4/1	4/2
Fixed cameras	3/5	3/4	3/3	3/1	3/2
Section control	1/5	1/4	1/3	1/1	1/2
Mobile speed cameras	2/5	2/4	2/3	2/1	2/2

Table 29 Weights for costs 1 and costs 2 for speeding

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	6,9167	34,5833	17,2917	11,5278	8,6458	78,9653	0,3343
ISA	5,5333	27,6667	13,8333	9,2222	6,9167	63,1722	0,2674
Fixed cameras	4,1500	20,7500	10,3750	6,9167	5,1875	47,3792	0,2006
Section control	0,7300	6,9167	3,4583	2,3056	1,7292	15,1397	0,0641
Mobile speed cameras	2,7667	13,8333	6,9167	4,6111	3,4583	31,5861	0,1337
						236,2425	

Table 30 Calculation the eigenvector for the two costs factors for speeding

	Total score costs
Public campaigns	5
ISA	4
Fixed cameras	3
Section control	1
Mobile speed cameras	2

Table 31 Allocation of ranking scores for the costs of traffic safety measures for speeding

After the combination of the two costs, the measures could be ranked as follows: Public campaigns (5) > ISA (4) > Fixed cameras (3) > Mobile speed cameras (2) > Section control (1)

The eigenvectors based on the total costs scores are the following:

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	156,2500	208,3333	625,0000	312,5000	1427,0833	0,3333
ISA	100,0000	125,0000	166,6667	500,0000	250,0000	1141,6667	0,2667
Fixed cameras	75,0000	93,7500	125,0000	375,0000	187,5000	856,2500	0,2000
Section control	25,0000	31,2500	41,6667	125,0000	62,5000	285,4167	0,0667
Mobile speed cameras	50,0000	62,5000	83,3333	250,0000	125,0000	570,8333	0,1333
						4281,2500	1
							Eigenvector (2)

Table 32 Calculating eigenvector for the effectiveness of different measures for speeding

Conclusion part B

In the table below (see table 33) the eigenvectors for the three criteria public support, effectiveness and costs are presented for all the discussed measures for the traffic safety problem speeding. These results and the results from part A will be used to determine the best measure which can be taken in order to resolve or reduce the traffic safety problem speeding in part C.

	Public support	Effectiveness	Costs
Public campaigns	0,1333	0,1333	0,3333
ISA	0,2000	0,2667	0,2667
Fixed cameras	0,3333	0,2000	0,2000
Section control	0,2667	0,3333	0,0667
Mobile speed cameras	0,0667	0,0667	0,1333

Table 33 The eigenvectors for the public support, effectiveness and costs for the different measures for speeding

C) Combining part A and B

The results of part B (see table 33) need to be multiplied with each scenario of part A (see table 22 on page 49). These calculations can be found in table 34 and the results of these calculations can be found in table 35. The calculation for scenario 1 is done as follows: the value of each cell in the column for public support for the measures needs to be multiplied with the eigenvector for public support in scenario 1. So the eigenvector for public support for public campaigns (0,1333) needs to be multiplied with the eigenvector for public support in weighting scenario 1 (0,3333). This equals in a value for the total public support for campaigns, namely 0,0444 as can be seen in the first row from the first column in table 35. This calculation needs to be done for all the data in table 34.

	Public support	Effectiveness	Costs
Public campaigns	0,1333	0,1333	0,3333
ISA	0,2000	0,2667	0,2667
Fixed cameras	0,3333	0,2000	0,2000
Section control	0,2667	0,3333	0,0667
Mobile speed cameras	0,0667	0,0667	0,1333

X

	Weighting Scenario 1
Public support	0,3333
Effectiveness	0,3333
Costs	0,3333

	Public support	Effectiveness	Costs
Public campaigns	0,1333	0,1333	0,3333
ISA	0,2000	0,2667	0,2667
Fixed cameras	0,3333	0,2000	0,2000
Section control	0,2667	0,3333	0,0667
Mobile speed cameras	0,0667	0,0667	0,1333

X

	Weighting Scenario 2
Public support	0,5000
Effectiveness	0,2500
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,1333	0,1333	0,3333
ISA	0,2000	0,2667	0,2667
Fixed cameras	0,3333	0,2000	0,2000
Section control	0,2667	0,3333	0,0667
Mobile speed cameras	0,0667	0,0667	0,1333

X

	Weighting Scenario 3
Public support	0,2500
Effectiveness	0,5000
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,1333	0,1333	0,3333
ISA	0,2000	0,2667	0,2667
Fixed cameras	0,3333	0,2000	0,2000
Section control	0,2667	0,3333	0,0667
Mobile speed cameras	0,0667	0,0667	0,1333

X

	Weighting Scenario 4
Public support	0,2500
Effectiveness	0,2500
Costs	0,5000

Table 34 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios

When each eigenvector for the measures is multiplied with the associated values from the scenarios, the row averages for each measure need to be calculated. This results in an overall value for each traffic safety measure for the safety problem speeding. The highest value in this column demonstrates the best measure in that particular scenario. In scenario 1 (all weights equal), two measures came out as the best to resolve or reduce the traffic safety problem speeding, these are ISA and fixed cameras. In scenario 2 was chosen to give the public support a two times higher weight then the other two criteria (effectiveness and costs). In this scenario fixed cameras showed to be the best measure. In scenario 3 was chosen to give the effectiveness of a measure a two times higher value then the other criteria. Here have ISA and section control the highest overall score. In scenario 4 where the costs received a two times higher value, the ISA-system appears to be the measure with the highest score. The speeding measure mobile speed cameras receive in each scenario the lowest score. This is normal because there is a low public support, low effectiveness and high cost for this measure.

Scenario 1	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0444	0,0444	0,1111	0,0667
ISA	0,0667	0,0889	0,0889	0,0815
Fixed cameras	0,1111	0,0667	0,0667	0,0815
Section control	0,0889	0,1111	0,0222	0,0741
Mobile speed cameras	0,0222	0,0222	0,0444	0,0296

Scenario 2	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0667	0,0333	0,0833	0,0611
ISA	0,1000	0,0667	0,0667	0,0778
Fixed cameras	0,1667	0,0500	0,0500	0,0889
Section control	0,1333	0,0833	0,0167	0,0778
Mobile speed cameras	0,0333	0,0167	0,0333	0,0278

Scenario 3	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0333	0,0667	0,0833	0,0611
ISA	0,0500	0,1333	0,0667	0,0833
Fixed cameras	0,0833	0,1000	0,0500	0,0778
Section control	0,0667	0,1667	0,0167	0,0833
Mobile speed cameras	0,0167	0,0333	0,0333	0,0278

Scenario 4	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0333	0,0333	0,1667	0,0778
ISA	0,0500	0,0667	0,1333	0,0833
Fixed cameras	0,0833	0,0500	0,1000	0,0778
Section control	0,0667	0,0833	0,0333	0,0611
Mobile speed cameras	0,0167	0,0167	0,0667	0,0333

Table 35 Final results of the weighting process for speeding

These above results are visualized in the graphs below. These are giving a clear image of all the results and the weakness and strength of each measure can be easily found. Some measures score well for each of the three criteria (e.g. ISA in scenario 1), while some measures always score low (e.g. mobile speed cameras).

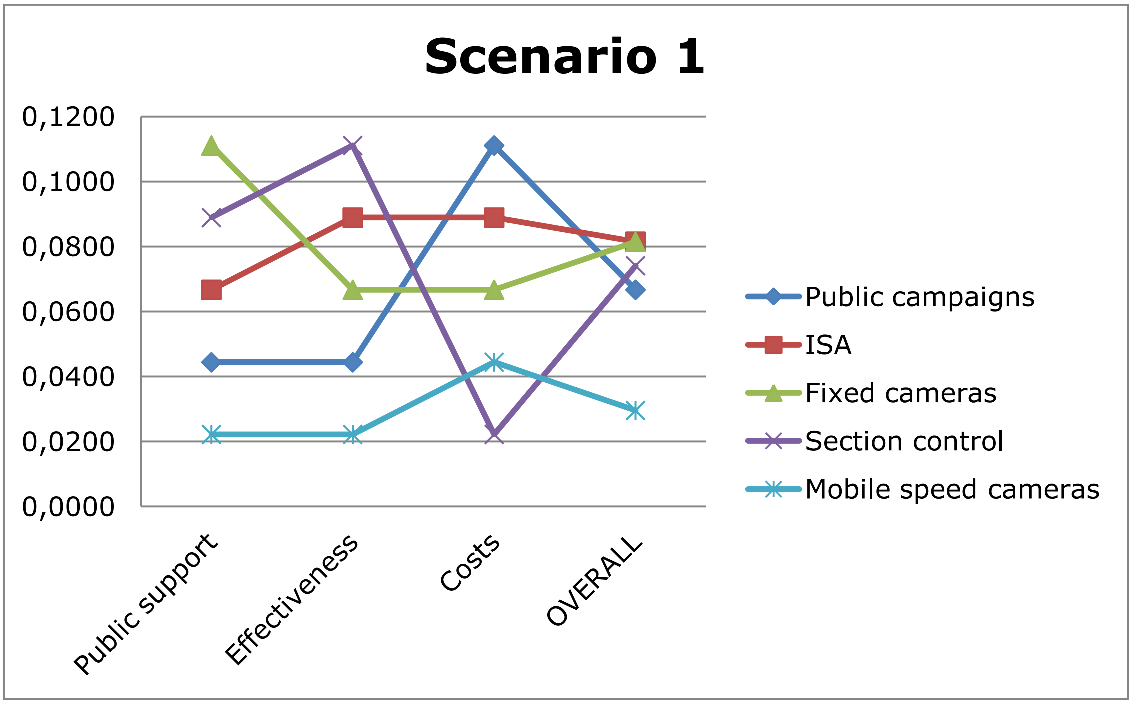


Figure 8 Results scenario 1

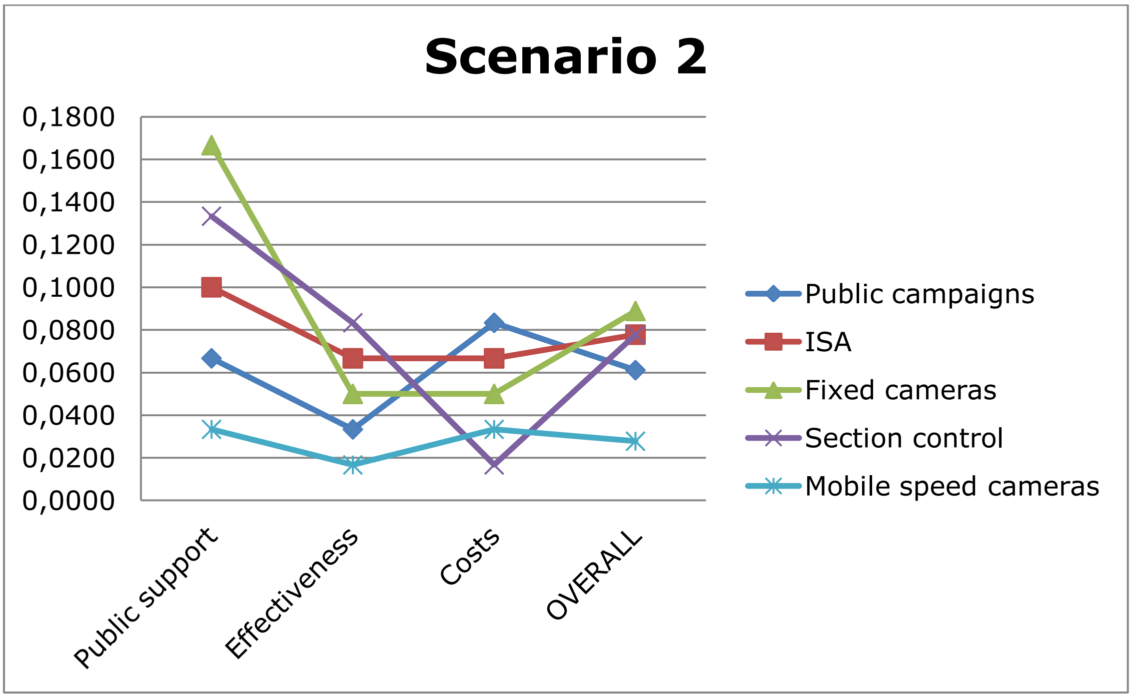


Figure 9 Results scenario 2

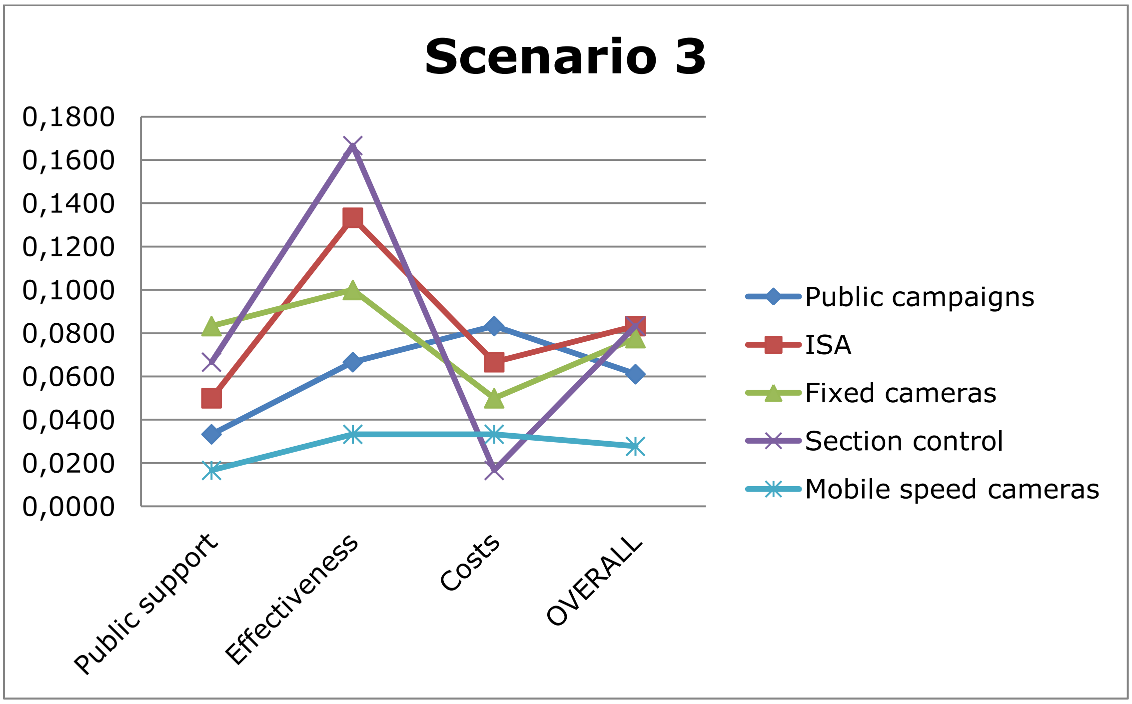


Figure 10 Results scenario 3

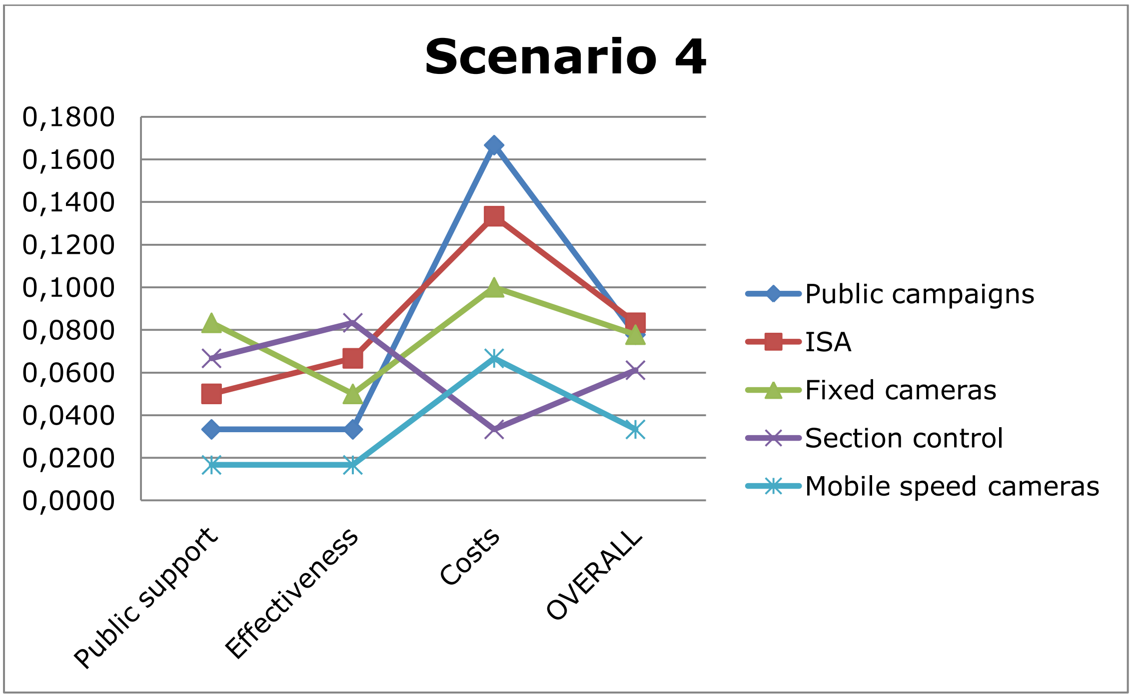


Figure 11 Results scenario 4

2. Driving under influence of alcohol

2.1 Safety problem

Drinking alcohol reduces the ability to drive (Van Vlierden, Vesentini, & Cuyvers, 2004). Alcohol has a large impact on more complex tasks, which greatly increases the reaction time (Policy Research Centre for Traffic Safety, 2008). In addition to decreasing driver performance, there is an overestimation of their own driving performances and an underestimation of difficult traffic situations. The risk to get involved in an accident significantly increases when the driver has a blood alcohol content (BAC) between 0,5 and 0,8%. For younger drivers the accident risk already increases from a BAC between 0,1 and 0,5% (Van Vlierden, 2005). Driving with a BAC at or above the legal limit is illegal in Belgium. This is called driving under influence of alcohol (Vanlaar, 2005).

2.1.1 Magnitude

According to BRSI (2011b) about 230 road users were killed in 2011 due to accidents where alcohol was one of the main causes. This is about 30% of all traffic deaths in Belgium. Driving under influence is primarily a problem that occurs during night, which mostly takes place in the weekend nights. In 2009 the police registered that during weekend nights 13,1% of the drivers were under influence of alcohol compared to 6,7% during week nights. Important to notice is that accident figures are always an underestimation of the real dimensions of the problem, because not all accidents are taken into account and the persons that were involved were not always tested for alcohol (e.g. when they were taken to the hospital) (Vanlaar, 2005).

Vanlaar (2005) executed in 2003 a study to estimate the proportion of drunk drivers on Belgian roads. Therefore during October and November 2003 12.891 drivers from personal cars were stopped by the police to perform an alcohol breath test. The tests were performed on 449 road sites, stratified per region. Each of these sites was randomly linked to one of four possible time spans, namely weekdays (Monday, Tuesday, Wednesday, Thursday and Friday from 8 am – 10 pm, n=4.709), weekday nights (Monday, Tuesday, Wednesday, Thursday from 10 pm – 8 am, n=2.164), weekend days (Saturday, Sunday from 8 am – 10 pm, n=3249) and weekend nights (Friday, Saturday, Sunday from 10 pm – 8 am, n=2702). In this way the sample design is stratified both in space and time. During the research there were 10 drivers which refused to do the alcohol test and 57 drivers were not able to provide a breath sample. These drivers are not included into the results. From the breath test result of the 12.824 drivers appeared that 96,69% had a BAC lower than the legal limit of 0,5. Three point thirty-one percent of all the researched drivers had a BAC at or above the legal limit. The largest part of the offenders, namely 2,26% had even a BAC at or above 0,8g/l. This is a significantly higher percentage of the drink drivers which have a BAC between 0,5 and 0,8g/l, namely 1,05% of the drivers. The results of the sample are presented in table 36.

	Frequency	Percentage
BAC < 0,5g/l	12400	96,69
0,5g/l ≤ BAC < 0,8g/l	134	1,05
BAC ≥ 0,8g/l	290	2,26
Total	12824	100

Table 36 Results of breath testing, expressed in BAC (Vanlaar, 2005)

Table 37 shows the results of the BAC at the different time periods. As can be seen the percentage of drunk drivers with a BAC at or above 0,8g/l was higher in each time span compared to the percentage of drunk drivers with a BAC between 0,5g/l and 0,8g/l, with an exception for weekday nights. This is logical because there can occur more cases in the open-end category than in the closed category.

Time Span	Frequency	Percentage
Weekday		
0,5g/l ≤ BAC < 0,8g/l	18	0,42
BAC ≥ 0,8g/l	54	1,33
Weekday night		
0,5g/l ≤ BAC < 0,8g/l	35	1,06
BAC ≥ 0,8g/l	51	1,93
Weekend day		
0,5g/l ≤ BAC < 0,8g/l	25	0,86
BAC ≥ 0,8g/l	54	2,11
Weekend night		
0,5g/l ≤ BAC < 0,8g/l	52	2,46
BAC ≥ 0,8g/l	113	5,22
Saturday nights		
0,5g/l ≤ BAC < 0,8g/l	21	1,73
BAC ≥ 0,8g/l	39	3,67

Table 37 Results of drink drivers (Vanlaar, 2005)

To make a weighing of the magnitude of a traffic safety problem possible, together with the public support, it is necessary that this is clearly visualized. According to Elvik (2008) the best way to do this, is through the calculation of the PAR. The PAR refers to the contribution a factor makes to the total number of cases (i.e. all accidents) rather than a subset of cases. The population attributable risk for driving under the influence of alcohol can be estimated through next formula (Elvik, 2008):

$$\frac{PE\ (RR - 1)}{(PE\ (RR - 1)) + 1}$$

PE = the proportion of exposure in the presence of the risk factor

RR = relative risk associated with the PE

In this case the PE equals to the average drivers that drive under influence of alcohol. From the study of Vanlaar (2005) appeared that 3,31% of the drivers drove under the influence of alcohol. The relative risk to die in an accident related to a BAC value is presented in figure 12. The graph is the result from a research of Keall et al. (2004) in New Zealand. He examined the risk of dying in a car crash in coherence with the BAC. The risk for a sober driver is equal to one. The x-axis on the graph presents the level of BAC. The y-axis presents the relative risk to die in an accident. As can be seen on figure 12, the relative risk to get involved in an accident with a BAC of 0,5g/l is equal to 6. The relative risk to get involved in an accident with a BAC of 0,8g/l is equal to 16. The study focused on the effect of low alcohol percentages (0-0,8 g/l). Figure 12 shows that the chance on a deadly crash already increases when the BAC is under the current legal limit. Even when a driver has a BAC of 0,2g/l, he has a two times higher chance on a deadly crash then a sober driver. This curve was estimated for the general population.

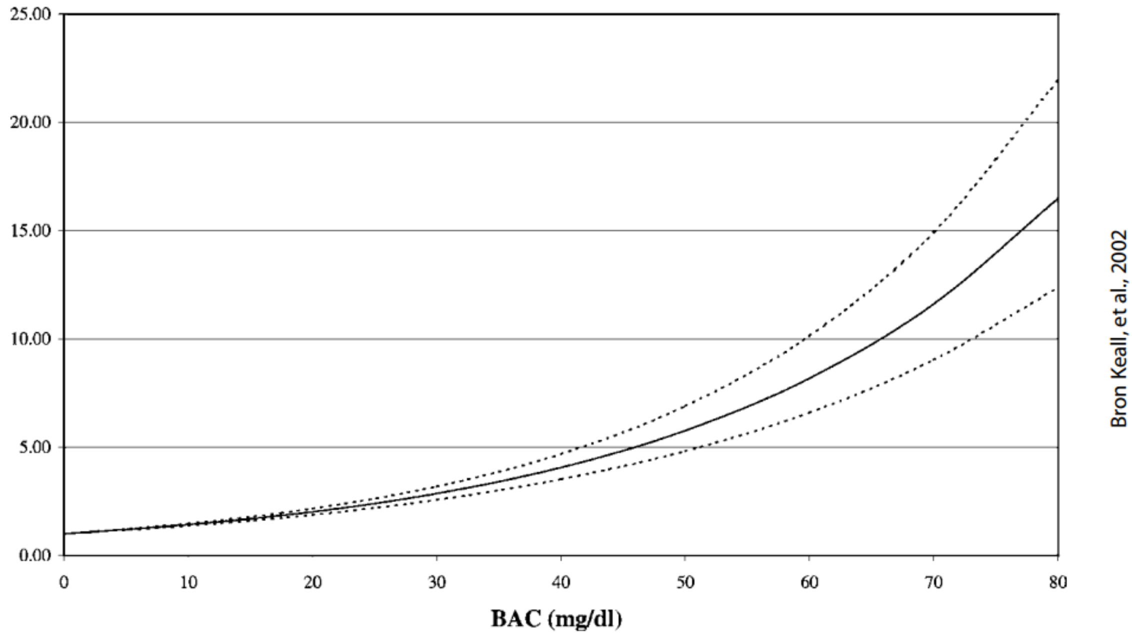


Figure 12 The relative risk indicates the risk at a certain alcohol concentration in comparison with the risk of a sober driver (with 50mg/dl=0,5g/l) (BRSI, 2010)

Bernhoft (2011) also executed research towards the influence of the use of psychoactive substances, including alcohol. Bernhoft found in his study the relative risk for a driver of getting seriously injured or killed as a consequence of a car crash, with different alcohol

concentrations. The results for three groups of alcohol concentrations will be presented in table 38, that is a group with a BAC between 0,1g/l and 0,5g/l, a group with a BAC between 0,5g/l and 0,79g/l and drivers with a BAC between 0,8 and 1,19g/l. The study presents the relative risk for different countries in Europe. The higher the BAC, the higher the chance to get involved in a crash. Drivers with a low BAC limit have a lower chance on a serious accident then drivers with a higher BAC. For the relative risk of seriously injured drivers there are values for Belgium available. For fatal accidents there are only values available for Finland, Norway and Portugal. These results are very different from each other and will not be used for the calculation of the PAR for fatal accidents.
For the calculation of the PAR for seriously injured will the results from Bernhoft (2011) be used. For the calculation of the PAR for fatal accidents will the results from Keall et al. (2002) be used.

	Seriously injured drivers
0,1-0,49g/l	0,5-2,2
0,5-0,79g/l	0,9-5,5
0,8-1,19/l	5,6-31,2

Table 38 Relative risk of getting seriously injured in an accident for different BAC limits (Bernhoft, 2011)

The population attributable risk will be calculated following the formula of Elvik (2008). This will be done for two BAC values, namely for a BAC of 0,5 g/l and for a BAC of 0,8g/l. For both BAC values the population attributable risk will calculated as well for fatal accidents as for accidents with seriously injured.
Two factors need to be determined to calculate the population attributable risk for a BAC of 0,5g/l, that is the relative risk and the average of drivers that drive under influence of alcohol. According to Keall et al. (2002), the relative risk for fatal accidents equals to 6. According to Bernhoft (2011) this relative risk is 2,2. Concerning the % of drivers that are exposed to this risk factor, Vanlaar (2005) found that 1,05% drove with a BAC between 0,5g/l and 0,8g/l. This 1,05% can be an overestimation, because only the PAR at a BAC level of 0,5g/l is calculated and not the PAR with a BAC level between 0,5g/l and 0,8g/l.

PAR for fatal accidents (BAC= 0,5g/l):

$$\frac{0,0105 * (6-1)}{(0,0105 * (6-1)) + 1}$$

= 0,05

For a BAC of 0,5g/l was found a PAR of 0,05. This means that if this number of drivers would be reduced to zero, the number of fatal accidents could be reduced with 5%.

PAR for accidents with seriously injured (BAC=0,5g/l):

$$\frac{0,0105 * (2,2-1)}{(0,0105 * (2,2-1)) +1}$$

= 0,01

For a BAC of 0,5g/l was found a PAR of 0,01. This means that if this number of drivers would be reduced to zero, the number of accidents with seriously injured could be reduced with 1%.

The same two factors need to be determined to calculate the population attributable risk for a BAC which is equal or higher than 0,8g/l. The relative risk for a BAC of 0,8g/l for fatal accidents equals following the study of Keall et al. (2002) to 16. The relative risk for accidents with seriously injured equals following the study of Bernhoft to 5,6. In the study of Vanlaar (2005) was found that 2,26% drove with a BAC of 0,8g/l and more. The result of the calculations may give possible an underestimation, because the lowest risk for, namely for a BAC of 0,8g/l, was used in the formulas. These calculations do not take into account the risk for a BAC of more than 0,8g/l, while the 2,26% equals to the drivers with a BAC of 0,8g/l or more.

PAR for fatal accidents (BAC=0,8g/l):

$$\frac{0,0226 * (16-1)}{(0,0226 * (16-1)) + 1}$$

= 0,25

For a BAC of 0,8g/l was found a PAR of 0,25. This means that if this number of drivers would be reduced to zero, the number of fatal accidents could be reduced with 25%.

PAR for accidents with seriously injured (BAC=0,8g/l):

$$\frac{0,0226 * (5,6-1)}{(0,0226 * (5,6-1)) + 1}$$

= 0,09

For a BAC of 0,8g/l was found a PAR of 0,09. This means that if this number of drivers would be reduced to zero, the number of accidents with seriously injured could be reduced with 9%.

Conclusion

If the number of drivers with a BAC of 0,5g/l would be reduced to zero, the number of fatal accidents could be reduced with 5% and the accidents with seriously injured could be reduced with 1%. If all the drivers who had a BAC of 0,8g/l would not drink and drive, the number of fatal accidents could be reduced with 25% and the number of accidents with serious injured could be reduced with 9%.

2.1.2 Public support

The BRSI conducted an attitude measurement in 2003, 2006 and 2009. In table 39 the most recent results, namely for 2009, for the public support of policy interventions for various traffic safety problems are given. Sixty-three percent of the respondent finds that the rules for driving under influence should be stronger. This might indicate that there is a public support for a further reduction of the legally permitted BAC for driving under the influence of alcohol. This percentage is higher for driving under influence of alcohol than for the other problems. Twelve percent thinks it is difficult to respect the rules for driving under influence of alcohol. Compared with the problem speeding, the rules for drunk driving are not difficult to respect. Eighteen percent of the respondents indicate that the rules concerning driving under the influence of alcohol are unclear. This uncertainty could be due to the fact that drivers fixate on the number of glasses they still can or cannot drink, while the general rule says that drinking and driving is not allowed (BRSI, 2006). From the results appeared that there is a high public support for the enforcement of traffic rules. Almost 60% of the respondents agree with the enforcement for alcohol. This percentage is higher than for the other two problems. Also the answer on the last statement is remarkably different and way lower than the two other percentages. Only 11% says that there is too heavy punishment for drunk driving. This gives an indication that the punishment for driving under influence is accepted.

	Alcohol	Seat belt use	Speeding
The rules should be stronger	63%	42%	35%
It is difficult to respect the rules	12%	11%	33%
The rules are unclear	18%	14%	30%
The public support for the enforcement of traffic rules	59%	44%	56%
Too heavy punishment	11%	30%	35%

Table 39 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009)

AXA (2009) performed an attitude measurement concerning traffic safety problems at 802 Belgium respondents. The questions and answers concerning driving under influence were the following:

Which forms of driving behavior you think are dangerous?

- Driving after the consummation of two alcoholic drinks (68%)

Are you doing the following things very often/often/sometimes or never?

- Driving after the consummation of two alcoholic drinks (34%)

Sixty-eight percent of the respondents said that driving after the consummation of two alcoholic drinks is dangerous. Nevertheless 34% of the respondents still drive after consuming two (or more) alcoholic drinks. This means that a part of the respondents who think that it is dangerous to drive after two drinks, however show this dangerous behavior.

2.1.3 Conclusions for the safety problem driving under influence of alcohol

The magnitude of the problem for driving under influence of alcohol was determined by the formula for calculating the population attributable risk, which was proposed by Elvik (2008). The population attributable risk was calculated for two different BAC values (0,5g/l and 0,8g/l) and two types of accidents, namely fatal accidents and accidents with seriously injured. From this could be concluded that if all the drivers who had a BAC of 0,5g/l would be reduced to zero, the number fatal accidents could be reduced with 5% and the number of accidents with seriously injured with 1%. If all the drivers who had a BAC of at least 0,8g/l would be reduced to zero, the number of fatal accidents could reduce with 25% and the number of accidents with seriously injured could be reduced with 9%. For the determination of the public support to handle the problem of drunk driving, the results of attitude measurement of the BRSI in 2009 are chosen. Here was found that 59% of the respondents support the enforcement of the traffic rules for driving under influence of alcohol.

2.2 Safety measures

For the safety problem 'driving under influence of alcohol' will be used the same structure as for the description of the safety measures for speeding. For each of the three E's (education, environment and enforcement) was again at least one measure selected.

2.2.1 Education

A) Public campaigns

As already mentioned by the education measures for speeding, the BRSI executes each year a national campaign in Belgium for speeding, but also for driving under influence of alcohol. Also here it was hard to find specific results in the literature for drunk driving campaigns executed by the BRSI. Instead there were found results for public support and effectiveness from more general studies. Here will the same general costs of public campaigns of the BRSI be used to give a general view due to lack of better findings.

Public support

In the attitude measurement of the BRSI in 2009 was found that 61% of 1500 respondents would see sensitization campaigns as means to drive safer. In 2006 68% of the respondents said that sensitization campaigns would help them to drive safer (BRSI, 2009).

Effectiveness

The study from Elder et al. (2004) was a systematic review of the effectiveness of mass media campaigns which was executed for reducing alcohol, found that public campaigns could decrease the alcohol-related crashes with 13%. Most of these campaigns were executed in combination with enforcement.

Costs

Following the BRSI (2008) the price of a public campaign depends on the theme, on the period and on the chosen media. The cost of an average campaign is estimated at €150.000 to €500.000. These campaigns are partly financed by the BRSI and are partly sponsored by externals.

Conclusions education measures

Only one measure in the group education was discussed for the traffic safety problem driving under influence of alcohol, namely public campaigns. Out of the attitude measurement of the BRSI in 2009 appeared that 61% of the respondents found that public campaigns would help them to drive safer. This can be a good indicator for the public support of drunk driving campaigns. To determine the effectiveness of public campaigns, different studies have been examined. The study of Elder et al. (2004) seemed the most relevant study for the effectiveness of drunk driving campaigns, because this study was generally focused on the theme driving under influence. The results of this study found that road safety campaigns concerning drunk driving could decrease alcohol related-crashes with 13%. The BRSI (2008) indicates that an average campaign costs about €150.000 to €500.000. Because one value is needed for the analysis, the average of these two prices will be taken, that is €325.000.

2.2.2 Environment

A) Alcohol Ignition Interlock Device (AIID)

An Alcohol Ignition Interlock Device (AIID) or a Breath Alcohol Ignition Interlock device (BRAIDD) can be used for preventing drunk driving. An alcohol lock prevents the vehicle from starting when the BAC of the driver is too high (>0,5g/l). Once the vehicle is started, the driver must blow in the AIID. If during the driving the alcohol concentration is higher than 0,5g/l, the vehicle will be stopped immediately. This test data is digitally recorded in the car. When the driver does not comply, the prosecutor will be informed (Wegcode vzw, 2011). When this technology will be applied, there are not only technical aspects which need to be considered. The application of an AIID needs to be embedded in a broader program that also takes into account behavioral and legal aspects. The AIID is installed in vehicles of drivers who were caught by driving under influence of alcohol (Verlaak, 2004). To approach recidivists and serious offenders of driving under the influence of alcohol, an installation of an ignition interlock device is recommended (Policy Research Centre for Traffic Safety, 2008). This AIID should be incorporated in an all over program to fight against driving under the influence of alcohol where all involved cooperate (Verlaak, 2004). Since October 2010 the court has the possibility to obligate a suspect of driving under influence of the use and installation of an AIID. The possibility of conviction is not limited to merely recidivists, but can also be applied by a first conviction due to alcohol related offenses (Wegcode vzw, 2011). The development of the Belgian ignition interlock device demands for further research (Policy Research Centre for Traffic Safety, 2008).

Public support

For the installation of alcohol ignition interlocks in all vehicles no large public support will be found. Drivers are asked to indicate at irregular intervals that they are not driving under influence of alcohol. This affects the driving comfort negatively, which will not be accepted by the majority of the drivers (Verlaak, 2004). From an American research concerning alcohol ignition interlock devices appears that if offenders have the choice between an AIID or a revocation of the drivers license, most offenders choose for the second option. This is a strange decision because a revocation of the driver's license is seen as a heavier punishment than the installation of an AIID. With the presence of an AIID the vehicle still can be used by the offender, while at a revocation of the driver's license the vehicle is no longer available for the offender (Van Vlierden, 2005). These studies are giving the public support for people who are obligated to use the alcohol ignition interlock device. There was not found a study which takes into account the public support of the general population.

Effectiveness

- Effectiveness in terms of reduction in driving under influence?

American research approves that alcohol ignition interlocks are very effective in the prevention of driving under influence. The AIID could reduce recidivism with 50 to 90%. Once the system is removed, the chance on recidivism turns back on the same level as offenders who never had used an AIID (Van Vlierden, 2005).

- Effectiveness in terms of accident reduction?

The effectiveness of the alcohol ignition interlock device on the reduction of traffic victims is still unknown in Europe; this is because the system is relatively new here. In the United States, Canada and Australia the AIID is already in use for a longer period (Verlaak, 2004). Lahausse and Fildes (2009) conducted a cost-benefit analysis of an alcohol ignition interlock device in preventing alcohol-related fatalities and serious injuries when installed in all newly registered vehicles in Australia. Out of this study was concluded that there could be a reduction of 24% of all fatal accidents and a reduction of 11% of the seriously injured victims due to the ignition interlock device.

Costs

The study of Verlaak (2004) showed that the installation of an AIID in the United States costs about $100 to $150 per month. In addition to the installation costs, also a monthly rent cost of $65 has to be paid. The total price for a year would be about $2400 or €1800. In Flanders the total number of motorized vehicles was equal to 3,7 million

(Vlaamse Stichting Verkeerskunde, 2010b). If all these vehicles would receive such system, this would cost about €6660 million per year. The law provides that the driver pays both installation costs and the using costs of the alcohol ignition interlock device. Given the high costs, the legislature has provided a mechanism where the fine due to driving under influence can be decreased with the full or partly costs of the installation and the use of the alcohol ignition interlock device.

Conclusions for the environment measures

One environmental measure to counteract drunk driving is the alcohol ignition interlock device. In the literature it was hard to find a number for the public support of the system. But some statements gave a very clear indication about the feelings of the public towards the system. An American research showed that the majority of the offenders, who had the choice between an AIID and a revocation of the driver's license, choose the second option. Also a study from Verlaak (2004) showed that there is no large public support for the system, because it affects the driving comfort negatively. Out of an Australian study appeared that there could be a reduction in fatal accidents of 24% due to the system and that there could be a reduction of 11% of the seriously injured victims. The costs of the installation of an alcohol ignition interlock device would be around €1800 a year and about €6600 million if each Flemish car would have this system.

2.2.3 Enforcement

An important traffic safety measure to restrict drunk driving, are the alcohol controls. Drinking and driving occurs to be a larger problem during weekend nights compared to other moments (Vanlaar, 2005). Therefore it is important to execute a sufficiently high percentage of alcohol controls during these nights.

A) Alcohol control

There are different methods in order to verify if a driver has used alcohol. This can be verified through a blood test and/or a breath test. Following the Belgian law the police may conduct a breath test at the suspect causer of an accident, at any other driver who may had caused an accident, at any driver on the public road and at any driver who has the intention to drive a vehicle or an animal on a public place (Van Vlierden et al., 2004).

Public support

The 'Openbaar Ministerie' (2009) performed in 2008 in the Netherlands a study to investigate the public support for traffic safety measures. Out of this study appeared that alcohol controls can count on a lot of public support, namely 99% of the respondents (of

6000 persons) find alcohol controls very useful. Also 95% of the respondents are satisfied with the BAC limit for alcohol. This same group of respondents has also a preference for stricter regulations.

Effectiveness

- Effectiveness in terms of reduction in driving under influence?

Out of the study of Wesemann (2003) appeared that police controls are an effective measure to reduce the number of drunk drivers. Thereby it is important that these controls are executed appropriately. This means that control teams should be clearly visible and should regularly change of location. They need to stop every passing driver and take of a breath test. Also the public campaigns around alcohol controls are very important.

- Effectiveness in terms of accident reduction?

Elvik (2001) carried out a meta-analysis on a total of 39 studies for the enforcement of drinking and driving. Twenty-six of these studies have evaluated drinking and driving alone or in combination with another measure, in most cases in combination with campaigns. This analysis found a reduction of 9% in fatal accidents and a reduction of 7% of accidents with injuries.

Costs

From own survey (personal communication, Flamez et al.) by 10 of the 117 police zones in Flanders could the total cost for all breathalyzers in Flanders be found. The costs which will be taken into account to determine this total cost are the purchase costs of all the breathalyzers and breathalyzers with suitcase available at the police zones in Flanders, the annual costs to calibrate the breathalyzers and the costs of the mouth pieces based on the number of controls which occur each year in Flanders. There was chosen to examine large and small police zones and extrapolate the number a breathalyzers. This can give a proxy for all the devices in Flanders.

Number of police zones (A)	117
Average available breathalyzer / police zone (B)	12,6
Average cost / Breathalyzer (C)	€ 1.500
Average available breathalyzer suitcase / police zone (D)	2,3
Average cost breathalyzer suitcase (E)	€ 4.300
Annual calibration cost / breathalyzer (F)	€ 193
Annual number of controls in Flanders (G)	200.000
Cost / mouth piece (H)	€ 0,95

Total cost breathalyzers:	A * B * C	€ 2.211.300
Total cost breathalyzer suitcases:	A * D * E	€ 1.157.130
Total calibration costs:	A * B * F	€ 284.521
Total cost mouth pieces:	G * H	€ 190.000
Total cost		**€ 3.842.951**

Table 40 Calculation for the total cost of all breathalyzers in Flanders

The personnel costs per year are assumed around €50.000 for direct personnel (Wesemann, 2003; Wijnen et al., 2010). The best estimation of the processing costs of the police reports were found in a study about fixed cameras executed by De Brabander (2007), namely a cost of €1651 per year.

Conclusions enforcement measures

For the problem driving under influence of alcohol, one enforcement measure was discussed. The best known enforcement measure in Belgium for alcohol is alcohol controls. For the public support of alcohol controls two studies were found. The results of the Openbaar Ministerie (2009) seemed to be the most relevant value for the overall analysis, which showed a public support of 99% for alcohol controls. For the determination of the effectiveness in terms of accident reductions, a good meta-analysis of Elvik (2001) was found. Out of this study appeared that alcohol controls could reduce the number of fatal accidents with 9% and the number of accidents with injuries with 7%. The implementation cost for all breathalyzer(suitcase)s and their extra annual costs (calibration costs + mouth pieces) in Flanders are estimated at €3.842.951. The personnel costs are estimated at €50.000 for direct personnel and €1651 for processing the police reports.

2.2.4 Conclusions for the safety measures driving under influence of alcohol

In examining the traffic safety problem drinking and driving, three different measures were examined. These different measures are public campaigns, alcohol ignition interlock device and alcohol controls. This is only a selection of the possible measures which could be taken in order to resolve or reduce drunk driving behavior, and are the measures that are used the most in Flanders. For every domain of the three E's (education, environment, and enforcement) was tried to select at least one measure. The results are summarized in the table below.

For comparing the costs for the measures will a distinction will be made between implementation costs per maintained kilometer regional road on the one hand and operational and personnel costs per year on the other hand.

Implementation costs (per maintained kilometer regional road):

- Public campaigns = €325.000/6055 = €54
- Alcohol Ignition Interlock Device = €6.600.000.000/6055 = €1.090.008
- Alcohol control = €3.842.951/6055 = €635

Operational + personnel costs (per year)

- Public campaigns = €0 (the operational and personnel costs are already included in the implementation costs)
- Alcohol Ignition Interlock Device = €0 (no costs)
- Alcohol control = €50.000 + €1651 = €51.651

	Public campaigns	AIID	Alcohol controls
Public support	61%	Low	68,30%
Effectiveness	13%	11%	7%
Implementation costs	€ 54	€ 1.090.008	€ 635
Operational + personnel costs	€ 0	€ 0	€ 51.651

Table 41 Summary table traffic safety measures for driving under influence of alcohol

2.3 Multicriteria analysis driving under influence of alcohol

The weighing method described in chapter 5 of the theoretical introduction of this thesis, will also be applied for the safety problem driving under influence of alcohol, on the same way as for the safety problem speeding.

2.3.1 Traffic safety problem

Figure 13 shows the relationship between the population attributable risk for fatalities and the public support for stronger policy interventions. For the PAR for fatalities two different percentages were calculated for the population attributable risk: One for a BAC limit of 0,5g/l and one for a BAC of 0,8g/l. If all the drivers who had a BAC of 0,5g/l would be reduced to zero, the number fatal accidents could be reduced with 5%. If all the drivers who had a BAC of at least 0,8g/l would be reduced to zero, the number of fatal accidents could reduce with 25%. Because it would be interesting to have one value for the attributable risk, the average of the two values (5% and 25%) will be taken, so that at the end of this Master thesis all three problems (speeding, drunk driving and seat belt use) can be compared with each other. The average of these two values is equal to 15% or 0,15. For the percentage of public support was found that 59% supports the enforcement of traffic rules for driving under influence of alcohol.

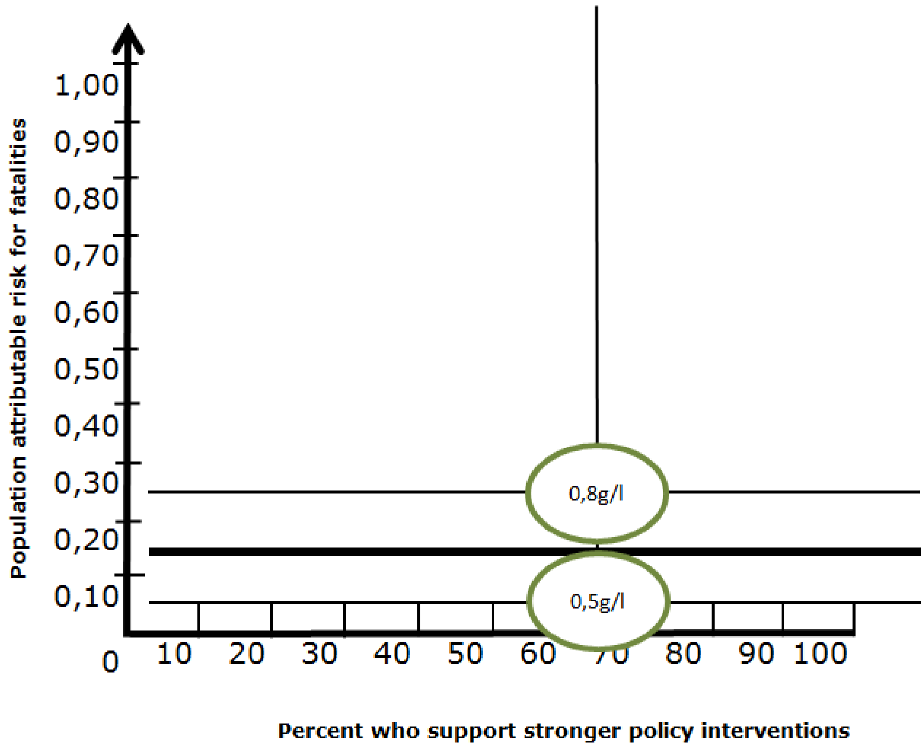


Figure 13 Relationship between support for stronger policy interventions and attributable to the traffic safety problem driving under influence of alcohol

2.3.2 Traffic safety measures

Here the same method will be applied as described in chapter 5.2 of the theoretical introduction. The calculations will be analogue with the calculations which were done for the safety measures for speeding and can be found in attachment 3.

In order to execute this analysis the values for public support, effectiveness and costs for the different measures are required. In the analysis of driving under influence of alcohol three different measures were discussed. These measures are public campaigns, AIID and alcohol controls. The most important results which will be used for this analysis are presented in table 42. The explanation of these results can be found in the conclusions per type (2.2.1 to 2.2.3) of traffic safety measures for driving under influence of alcohol.

	Public campaigns	AIID	Alcohol controls
Public support	61%	Low	68,30%
Effectiveness	13%	11%	7%
Implementation costs	€ 54	€ 1.090.008	€ 635
Operational + personnel costs	€ 0	€ 0	€ 51.651

Table 42 Summary table traffic safety measures for driving under influence of alcohol

Public support

The public support and the ranking scores for the drunk driving measures are presented in table 43. As can be seen there is the highest public support for alcohol controls. The measure with the lowest public support is the AIID.

	Public support	Score
Public campaigns	61%	2
AIID	Low public support	1
Alcohol controls	68,30%	3

Table 43 Allocation of ranking scores for the public support of traffic safety measures for driving under influence of alcohol

The measures could therefore be ranked as follows: Alcohol controls (3) > Public campaigns (2) > AIID (1)

Now that the scores for public support are known for the different measures for driving under influence, some calculations need to be done. The goal is to find the eigenvector as explained in chapter 5 of the theoretical introduction, in order that this eigenvector can contribute in the overall weighting process of determining the best measure for the traffic safety problem driving under influence of alcohol. In table 44 the results can be found of the calculation. After two iterations, the eigenvector was already the same as the first one at four decimal places.

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	54,0000	18,0000	99,0000	0,3333
AIID	13,5000	27,0000	9,0000	49,5000	0,1667
Alcohol controls	40,5000	81,0000	27,0000	148,5000	0,5000
				297,0000	1
					Eigenvector (2)

Table 44 Calculating eigenvector for the public support of different measures for driving under influence of alcohol

Effectiveness

The effectiveness and the ranking scores for the drunk driving measures are presented in table 45. As can be seen there is found the highest effectiveness for pubic campaigns.

The measure with the lowest found effectiveness is alcohol controls. This measure will receive score 1.

	Effectiveness	Score
Public campaigns	13%	3
AIID	11%	2
Alcohol controls	7%	1

Table 45 Allocation of ranking scores for the effectiveness of traffic safety measures for driving under influence of alcohol

The measures could therefore be ranked as follows: Public campaigns (3) > AIID (2) > Alcohol controls (1)

Also here the eigenvector need to be calculated. As one can see in table 46, the eigenvector was already found after two iterations.

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	40,5000	81,0000	148,5000	0,5000
AIID	18,0000	27,0000	54,0000	99,0000	0,3333
Alcohol controls	9,0000	13,5000	27,0000	49,5000	0,1667
				297,0000	1
					Eigenvector (2)

Table 46 Calculating eigenvector for the effectiveness of different measures for driving under influence of alcohol

Costs

The costs are divided into implementation costs and maintenance + personnel costs. The same procedure will be applied here as done for the problem speeding. All the calculations can be found in attachment 3. The result is given in table 49.

	Costs 1	Score
Public campaigns	€ 54	3
AIID	€ 1.090.008	1
Alcohol controls	€ 635	2

Table 47 Allocation of ranking scores for the implementation costs of traffic safety measures for driving under influence of alcohol

	Costs 2	Score
Public campaigns	€ 0	2,5
AIID	€ 0	2,5
Alcohol controls	€ 51.651	1

Table 48 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for driving under influence of alcohol

Total costs	Public campaigns	AIID	Alcohol controls		
Public campaigns	3,0000	4,6000	4,5000	12,1000	0,3735
AIID	3,0000	1,5333	3,8333	8,3667	0,2582
Alcohol controls	1,2000	3,0667	7,6667	11,9333	0,3683
				32,4000	1

Table 49 Calculation of the eigenvector for the two cost factors for driving under influence of alcohol

The measures for drunk driving can be ranked as follows: Public campaigns (3) > Alcohol controls (2) > AIID (1)

Now that the new ranking for the total costs is known, the eigenvector can be calculated.

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	81,0000	40,5000	148,5000	0,5000
AIID	9,0000	27,0000	13,5000	49,5000	0,1667
Alcohol controls	18,0000	54,0000	27,0000	99,0000	0,3333
				297,0000	1
					Eigenvector (2)

Table 50 Calculating eigenvector for the costs of different measures for driving under influence of alcohol

Table 51 gives all the eigenvectors which were calculated for the three discussed traffic safety measures.

	Public support	Effectiveness	Costs
Public campaigns	0,3333	0,5000	0,5000
AIID	0,1667	0,3333	0,1667
Alcohol controls	0,5000	0,1667	0,3333

Table 51 The eigenvectors for the public support, effectiveness and costs for the different measures for driving under influence of alcohol

The results of part B (see table 51) need to be multiplied with each scenario of part A. These calculations can be found in table 52 and the results of these calculations can be found in table 53.

	Public support	Effectiveness	Costs
Public campaigns	0,3333	0,5000	0,5000
AIID	0,1667	0,3333	0,1667
Alcohol controls	0,5000	0,1667	0,3333

X

	Weighting Scenario 1
Public support	0,3333
Effectiveness	0,3333
Costs	0,3333

	Public support	Effectiveness	Costs
Public campaigns	0,3333	0,5000	0,5000
AIID	0,1667	0,3333	0,1667
Alcohol controls	0,5000	0,1667	0,3333

X

	Weighting Scenario 2
Public support	0,5000
Effectiveness	0,2500
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,3333	0,5000	0,5000
AIID	0,1667	0,3333	0,1667
Alcohol controls	0,5000	0,1667	0,3333

X

	Weighting Scenario 3
Public support	0,2500
Effectiveness	0,5000
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,3333	0,5000	0,5000
AIID	0,1667	0,3333	0,1667
Alcohol controls	0,5000	0,1667	0,3333

X

	Weighting Scenario 4
Public support	0,2500
Effectiveness	0,2500
Costs	0,5000

Table 52 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios

Scenario 1	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,1111	0,1667	0,1667	0,1481
AIID	0,0556	0,1111	0,0556	0,0741
Alcohol controls	0,1667	0,0556	0,1111	0,1111

Scenario 2	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,1667	0,1250	0,1250	0,1389
AIID	0,0833	0,0833	0,0417	0,0694
Alcohol controls	0,2500	0,0417	0,0833	0,1250

Scenario 3	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0833	0,2500	0,1250	0,1528
AIID	0,0417	0,1667	0,0417	0,0833
Alcohol controls	0,1250	0,0833	0,0833	0,0972

Scenario 4	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0833	0,1250	0,2500	0,1528
AIID	0,0417	0,0833	0,0833	0,0694
Alcohol controls	0,1250	0,0417	0,1667	0,1111

Table 53 Final results of the weighting process for driving under influence of alcohol

From this analysis appears that in each scenario public campaigns came out as the best measure to solve the drunk driving problem. It also appeared that in each scenario the alcohol controls came out as second best measure and alcohol ignition interlock devices as least desirable. The reason why public campaigns came out as the best measure is mainly due to the slightly higher effectiveness compared to the two other measures and the lowest costs. The AIID system scores in each scenario low. This is mainly due to the low public support for the measure and extremely higher costs in comparison with the other to measures. Only in the third scenario where effectiveness plays the most important role, the results for AIID and alcohol controls are very similar. In scenario 1 and 4 the results for the different measures are clearly distinguished. Here is sufficiently clear which measure scores the best and the lowest. In scenario 2 where the public support plays an important role, the measures public campaigns and alcohol controls are lying very close to each other. The visualization of the different scenarios can be found in the four graphs below.

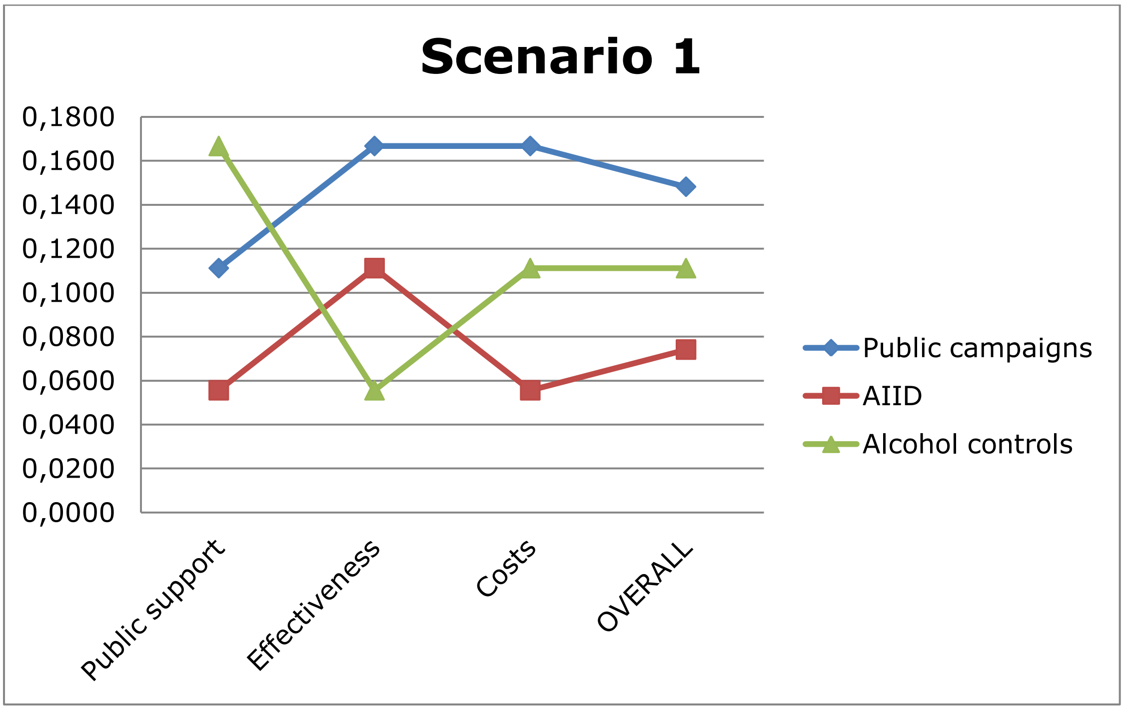


Figure 14 Results scenario 1

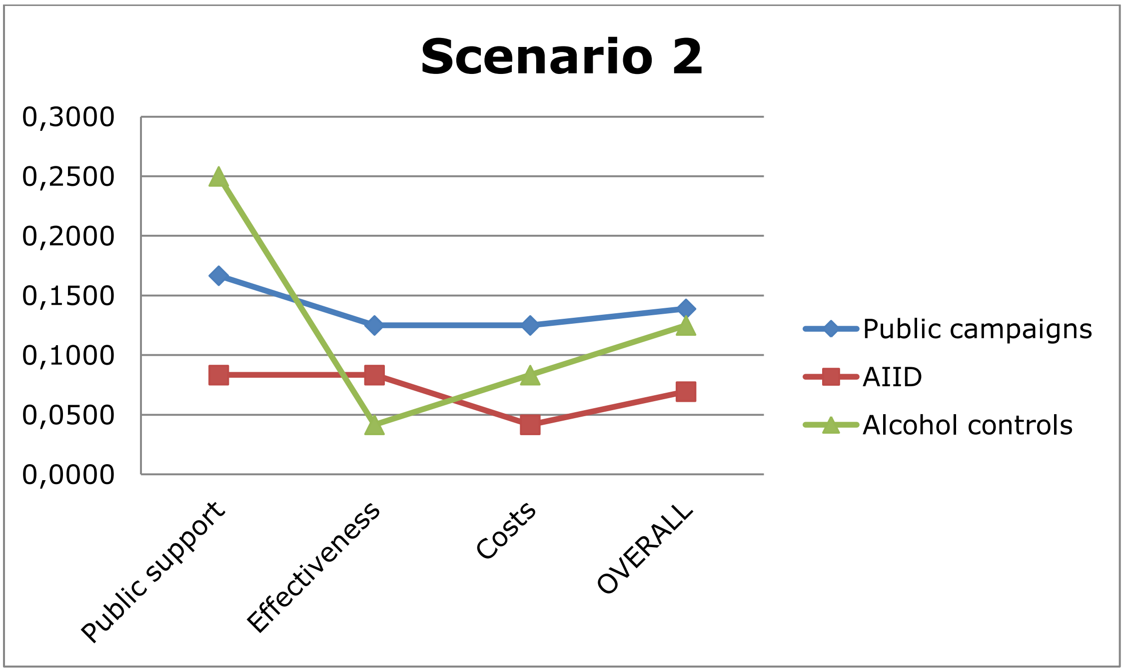


Figure 15 Results scenario 2

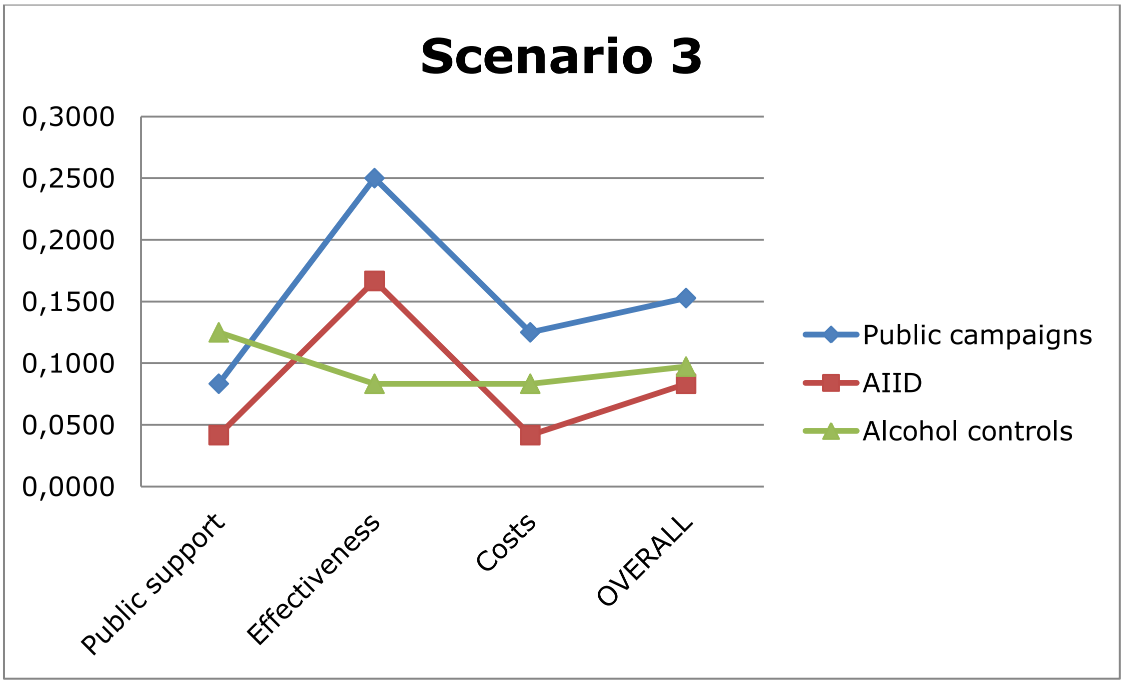


Figure 16 Results scenario 3

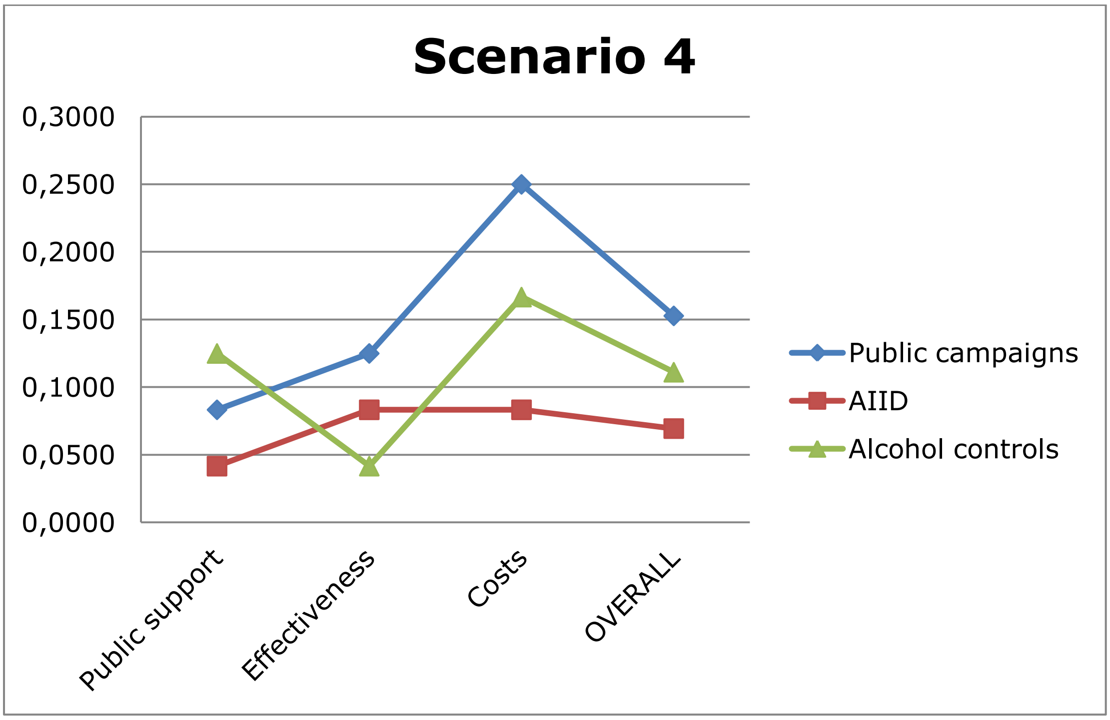


Figure 17 Results scenario 4

3. Seat belt use

3.1 Safety problem

3.1.1 Magnitude

Wearing a seat belt in a moving car is obligated in Belgium since 1975 for the driver and the front passenger. Since 1991 the seat belt use in the back of the car is also mandatory. Since April 2003 all new registered auto cars must be equipped with safety belts and must be worn by every passenger (Policy Research Centre for Traffic Safety, 2008). Nevertheless, Belgium is still behind in comparison with other countries regarding the use of the seat belt (BRSI, 2011c; Daniels, Deben, De Brabander, Verlaak, & Vesentini, 2004; Policy Research Centre for Traffic Safety, 2008). The latest figures show that meanly 80% of the Belgium population always wears their seat belt when sitting in the front of the car (BRSI, 2009). Our neighboring countries do better with 90% seat belt use in the front of the car (BRSI, 2011c). Wearing a seat belt is a simple, inexpensive and effective measure. The risk of being killed in a car crash can decrease with about 40% by wearing a seat belt and can reduce the risk of death injuries with 50% (BRSI, 2011c; Daniels et al., 2004; Policy Research Centre for Traffic Safety, 2008).

In a report of Daniels et al. (2004) is indicated that there are three possible ways to give an indication about the seat belt use in Belgium. First of all, the accident registration form whereby the police can fill in if the seat belt was worn when the accident occurred. The results of the accident registration forms are saved by the National Institute of Statistics. A second possible source for having an idea about the seat belt use in Belgium can be obtained by measurements of the BRSI. A last way to have an indication of the seat belt use can be received by attitude measurement of the European SARTRE research.

The most recent European SARTRE research was executed in 2002. In different European countries the attitudes towards a range of traffic safety measures were measured. Out of this attitude measurement appeared that the 73% of the Belgian respondents indicated that they always wear their seat belt when driving on motorways (Daniels et al., 2004).

According to a seat belt use measurement of the BRSI in 2006, there was registered a seat belt use of 76,9% for the drivers and a 72,5% seat belt use for the passengers in the front of the car (BRSI, 2006). More people seem to buckle up in proportion with the increase of the speed limits. Although, the seat belt gives a better protection at lower and average speeds. Various studies have shown that drivers who don't wear a seat belt are more involved in road accidents than others (Policy Research Centre for Traffic Safety, 2008; Vesentini & Cuyvers, 2003).

BRSI (2009) asked her respondents in an attitude measurement how often they wear their seat belt. When regarding the results over the three measurement years (2003, 2006 and 2009) in table 54, a certain evolution can be noticed. Certainly the seat belt use in the back of the car has slightly increased over the last 6 years. In the study of 2009, one out of two passengers said to wear always their seat belt in the back of the car. The self reported seat belt use in the front of the car did not really increase. Eighty percent of the Belgian drivers always wear their seat belt and 81% of the front passengers always wear a seat belt (BRSI, 2009).

How often do you wear your seat belt?			
Driver	2003	2006	2009
Never	5,50%	4,10%	3,07%
Rarely	8,00%	4,35%	3,91%
Often	23,90%	12,13%	13,38%
Always	62,70%	79,42%	79,65%
Passenger (front)			
Never	5,50%	4,71%	2,99%
Rarely	6,60%	3,90%	3,75%
Often	20,10%	12,06%	12,35%
Always	67,80%	79,34%	80,91%
Passenger (back)			
Never	26,30%	18,50%	14,65%
Rarely	16,20%	19,07%	12,40%
Often	16,70%	16,05%	23,21%
Always	40,90%	46,38%	49,73%

Table 54 Self reported behavior seat belt use (BRSI, 2009)

Evans (2004) indicates that using a seat belt gives an effectiveness of 42%, this means that for 100 fatalities, 42 persons could be saved if they wore a seat belt. From the attitude measurement of the BRSI (2009) it is known that there is a seat belt use of 80% in front of the car. By means of the formula of Elvik (2008) the population attributable risk for seat belt use can be determined. So if one had a population of identical drivers experiencing random crashes, with 80% seat belt use, and a 42% decrease of fatalities when wearing a seat belt, this would imply that wearing a seat belt reduced fatality risk by:

$$\frac{PE\,(RR - 1)}{(PE\,(RR - 1\,)) + 1}$$

With PE = 1 – the percentage that wears a seat belt = 1 – 0.80 = 0,20

With RR = 1 / (1 – the effectiveness of wearing a seat belt) = 1 / 0,58 = 1,72

$$\frac{0,20 * (1,72 - 1)}{(0,20 * (1,72 - 1)) + 1}$$

= 0,13 or 13%

According to Evans (2004) this is not even an approximate estimate of seat-belt effectiveness, but rather a value that is substantially higher than the true value, because two effects bias the estimate upwards. Drivers who wear seat belts have lower crash rates than no-wearers, some of the reduction in death attributed to the belt's effectiveness is due instead to the avoidance of crashes. Secondly when seat belt users do crash, they have lower severity crashed than non-wearers. Though this calculation of the reduced fatality risk for seat belt use can be a good approximation to measure the population attributable risk for seat belt use.

Recent research suggests that the risk of dying in a crash could be reduced by about 60% when using a seat belt (Janitzek & Achterberg, 2006). This is much higher than the 40% reduction by Evans (2004). When refilling the formula of Elvik (2008) with a 60 reduction and the same current seat belt use of 80%, this will give a higher percentage in reduction of accident fatalities.

With RR = 1 / (1 – the effectiveness of wearing a seat belt) = 1 / 0,40 = 2,5

$$\frac{0,20 * (2,5 - 1)}{(0,20 * (2,5 - 1)) + 1}$$

= 0,23 or 23%

3.1.2 Public support

Not wearing a seat belt is seen as a serious offense in the Belgian traffic law. Research shows that heavier fines and more checks are motives for many drivers to wear a seat belt (Daniels et al., 2004). This shows that a higher level of enforcement would increase the seat belt use. If enforcement is for some road users an important motive to wear a seat belt and this road users feel that there is a low probability of being detected, this may possible lead to a reduction in seat belt use. This leads to a decrease in road safety (Daniels et al., 2004).

The BRSI conducted a survey on the attitude towards the most common traffic safety problems in Belgium in the year 2003, 2006 and 2009 (BRSI, 2009). At this survey, about 1500 respondents had to indicate whether they agreed with some traffic related statements. In table 55 the results for some statements for the public support of the most common traffic safety problems are presented. More than 40% of the respondents are saying that the rules for wearing a seat belt should be stronger. In 2006 the seat belt use in Belgium was 75% and there was a 32,26% support for stronger rules (BRSI, 2006). In 2009 the seat belt use was 82% (BRSI, 2009) and there was a public support of 42% for stronger rules. So the higher the seat belt use in the population, the stricter the rules for not wearing a seat belt may be. Eleven percent of the respondents have difficulties with respecting the rules for seat belt use. Only 14% is saying that the rules concerning seat belt use are not clear. It is not a surprise that the regulations concerning seat belt use are experienced as most clear. The rules for seat belt use are very simple. The haziness could be related with the rules concerning the seat belt use in the back of the car (obligated or not). Remarkable is that the public support for the enforcement of seat belt use is the lowest for the three given traffic safety problems, but still is 44%. Various studies have shown that drivers who do not wear a seat belt are more involved in road accidents than others (Vesentini & Cuyvers, 2003). Thirty percent is saying that there is too strong punishment for not wearing a seat belt.

	Seat belt use	Speeding	Alcohol
The rules should be stronger	42%	35%	63%
It is difficult to respect the rules	11%	33%	12%
The rules are unclear	14%	30%	18%
The public support for the enforcement of traffic rules	44%	56%	59%
Too heavy punishment	30%	35%	11%

Table 55 Attitude measurement for the public support of policy interventions of various traffic safety problems (BRSI, 2009)

Next to the attitude measurement of the BRSI (2009), AXA (2009) also performed an attitude measurement concerning traffic safety problems with 802 Belgium respondents. There were two questions concerning seat belt use:

Which forms of driving behavior you think are dangerous?

- Driving without safety belt (84%)

Are you doing the following things very often/often/sometimes or never?

- Driving without safety belt (24%)

In the attitude measurement of AXA this was the only question about seat belt use. Eighty-four percent said that driving without a seat belt is dangerous and 24% said that they (very) often to sometimes drive without wearing a seat belt. From the BRSI (2011c) is know that 80% of the front passengers is always wearing their seat belt. The population who wears the seat belt is almost the same as the population who is saying that not wearing a seat belt is dangerous, when the two measurements are compared.

A report from The Netherlands indicated that the expected safety effect can be influenced by a number of factors. Selective recruitment is an example of a factor. People who have relatively many crashes are less likely to wear a seat belt. Another example is negative interaction: the quality of cars increases considerably (crumple zones, airbags) and also the quality of the roads improves. This creates a more pleasant feeling of driving, and could lead to a decrease in the use of seat belts (Vesentini & Cuyvers, 2003).

3.1.3 Conclusions for the safety problem seat belt use

The magnitude for the problem seat belt use could be determined by a formula presented by Elvik (2008). The BRSI found in 2011 a seat belt use of 80% in front of the car. The effectiveness of a seat belt should be following Evans (2004) be equal to 42%. Out of a more recent study of Janitzek & Achterberg (2006) appears that the effectiveness of the seat belt is 60%. When calculating the population attributable risk as well for the effectiveness of 42% and 60% in terms of reduction of accident fatalities, the outcomes are respectively 13% and 23%. For determining the public support for the safety problem seat belt use are the results from the attitude measurement of the BRSI (2009) taken. There out appears that only 44% supports the enforcement of the traffic rules for seat belt use.

3.2 Safety measures

For the safety problem 'seat belt use' was also tried to find for each of the three E's at least one measure. During the most recent assembly of the Federal States General of Road Safety in 2007 was recommended to strive for a 95% seat belt use for the drivers and passengers in front of the car and 80% seat belt use by passengers in the back of the car by 2010. To achieve this goal it seems therefore important that good measures will be taken.

3.2.1 Education

One way to teach people why they should wear their seat belt can be done by traffic education. To learn the road user that wearing a seat belt is useful seems to have a more sustainable effect then the insurance of an attitude change due to the higher controls and fines without a public support by the population. Examples of measures which lead to internalized behavior changes are education in schools or in driving lessons, or public campaigns through media (Daniels et al., 2004). For the education measures for seat belt use is chosen to discuss only the measure public campaigns.

A) Public campaigns

Sensitization is a way of education for learning car occupants why they should wear their seat belt. Sensitization can for example be applied by means of campaigns, traffic education or attitude change. For seat belt use in Belgium it is recommended that sensitization is focused in the first place to young people and men, because the belt is worn the least at those groups (Vesentini & Cuyvers, 2003). As already mentioned by the education measures for speeding and driving under influence of alcohol, the BRSI executes each year different national campaigns concerning the most actual traffic safety themes. One of those themes is seat belt use. Because no results for public support, effectiveness and costs were found related to seat belt campaigns, more general results will be used.

Public support

Sixty-one percent of the respondents in the attitude measurement of the BRSI in 2009 indicated that sensitization campaigns would help them to drive safer (BRSI, 2009).

Effectiveness

In the chapter of the speeding measures was the general effectiveness of public campaigns in detail discussed. Out these results can be found that road safety campaigns could have an effectiveness of a 9% accident reduction (Phillips et al., 2011).

Costs

Following the BRSI (2008) the price of a public campaign depends on the theme, the period and on the chosen media. The cost of an average campaign is estimated at €150.000 to €500.000 euro. These campaigns are partly financed by the BRSI and are partly sponsored by externals.

Conclusions education measures

For the public support for public campaigns was found a study of the BRSI (2009) where the respondents were asked which measures would help them to drive safer. Sixty-one percent of the respondents indicated that sensitization campaigns would them to drive safer. Due to the lack of other information about the public support for public campaigns of seat belt use, this seems to be a good indication. For determining the effectiveness of public campaigns different studies have been examined. The study of Phillips et al. (2011) seemed the most extended study. The study took into account 119 individual road safety campaigns. The results of this study suggested that road safety campaigns have an overall significant accident-reducing effect of 9%. The BRSI (2008) indicates that an average campaign costs about €150.000 to €500.000. Because one value is needed for the analysis, the average of these two prices will be taken, that is €325.000.

3.2.2 Environment

A) Seat belt reminder

Seat belt reminders warn car drivers and passengers if the seat belt is not fastened. This can be done by a visual signal or an acoustic signal or by the combination of the two. The EU is expected to decide to make seat belt reminders compulsory for passenger cars, and, in the somewhat longer term, also for other vehicle categories (SWOV, 2010b).

Public support

Results from an Australian study generally showed positive reactions to the prospect of the introduction of the seat belt reminder system. In a telephone survey, part-time users (buckle up less than all the time), agreed that a seat belt reminder system would help vehicle occupants to develop better seat belt wearing habits. But the participants in this survey were concerned that seat belt reminders should be introduced to all passenger seats in new vehicles in Europe (Janitzek & Achterberg, 2006). Following a study of Harrison (2001) non seat belt users have a positive feeling towards seat belt reminders. This indicates that there certainly can be found a public support for seat belt reminders (Verlaak, 2003). A study of Ferguson et al. (2007) investigated the effectiveness and driver acceptance of the Honda seat belt reminder system. Ninety percent of the participants said they wanted a seat belt reminder in their car. Also found in the study was that the reminder was perceived to be most effective by part-time users, namely 81% of part-time users said that would now use their seat belt more often. This is a good sign, because the goal of seat belt reminders is to motivate the non-users and the part-time users to wear their seat belt.

Effectiveness

- Effectiveness in terms of an increasing seat belt use?

A recent study carried out for Belgium by the Belgian Policy Research Centre for Traffic Safety found that a seat belt reminder system would be beneficial to the society if 5 to 15% of the current non-users would fasten up for over a period of ten years. Therefore three different types of seat belt reminders were taken into account. Each of these three types had a different level of intrusiveness and implementation costs (€63, €127 and €150). It was assumed that all new vehicles would be equipped with seat belt reminders in Belgium within 10 years. The costs and benefits for different levels of effectiveness were calculated. The findings were that with the least expensive system (€63), the introduction would already be beneficial when 5% of the non users would use their seat belt due to the seat belt reminder. The introduction of the second cheapest system (€127) would give an effectiveness in 10% more seat belt use. The most expensive system (€150) would reach an effectiveness of 10 to 15% (De Brabander & Vereeck, 2003).

An American observation study among Ford drivers (Williams e.a., 2002) showed that significantly more seat belts were used in Fords with a seat belt reminder then Fords without one; 76% and 71% respectively. A similar study among Honda drivers several years later (Ferguson e.a., 2007) confirmed this situation: the observed use in Hondas with a seat belt reminder was larger than in those without one; 90% and 84% respectively (SWOV, 2010b). Following Harrison et al. (2000) seat belt reminders can achieve a seat belt use up to 99%. Moreover, people are likely to recognize the usefulness of the reminder and the user acceptance will increase with the experience.

- Effectiveness in terms of accident reduction?

Following the study of Turbell et al. (1996) who examined the effectiveness of a seat belt reminder system, the seat belt reminder could reduce the number of fatalities in road accidents by 16,1 % in Europe if seat belts are worn by 100 % of car occupants.

Costs

Seat belt reminders could be very effective in increasing seat belt use with the result that car occupants could eventually be prevented from physical injuries. Seat belt reminders require a relatively small investment and have a high potential to reduce injuries and the associated social costs. The price of the seat belt reminder depends on the type. Different studies showed varying prices for seat belt reminders. Verlaak (2003) said that the costs of a seat belt reminder could range from €75 to €155 in the store and that the installation in the factory before buying a car is even less expensive. De Brabander & Vereeck (2003) discussed three types of seat belt reminders in their study, one of €63, one of €127 and one of €150. An Australian study (Flides e.a., 2002) estimated the costs to be less than €50 for a simple seat belt reminder which is just for the driver and to about €100 for an intelligent seat belt reminder for all seats in the car.

Conclusions environment measures

In a study of Ferguson et al. (2007) was found that 90% wanted to have a seat belt reminder in their car. This gives a good indication of the public support for the system. For giving a good indication of the effectiveness of seat belt reminders in terms of accident reduction were not found many studies. The best estimation was a reduction of 16,1% in road fatalities. For the costs of the system different amounts were found in a range of €50 to €155 euro. An average system would cost about €100. If all 3.700.000 Flemish cars would install a seat belt reminder, this would give a total cost of €370 million.

3.2.3 Enforcement

A) Seat belt controls

An action around seat belt use has the greatest chance on positive results if there are next to sensitization also controls. Control actions by the police are during a seat belt campaign very desirable. The way that these actions are done, is determined by the local police zones. The Flemish government recommends however that the timing of the controls is closely connected to the sensitization campaigns (Flemish Government, 2006).

Public support

There is a high fear of controls by drivers and passengers. Executing police controls are therefore very important and the probability of detection of violations needs to be therefore sufficiently high (Daniels et al., 2004). It is necessary to examine which support there is among the population for interventions. For example, not wearing a seat belt is often considered as a minor violation compared to speeding or driving under influence. Enforcement can lead to resistance among the population, because the enforcement may be seen as unfair (Vesentini & Cuyvers, 2003). According to the research of the Openbaar Ministerie (2009) police controls can count on a lot of public support, namely 83% thinks that controls for seat belt use are important.

Effectiveness

- Effectiveness in terms of an increasing seat belt use?

Shults et al. (2004) and Dinh-Zarr et al. (2001) indicate that when enforcement is used, namely an increase of controls and/or fines, this would result in a higher seat belt use. They also concluded that enforcement can have an effect on different target groups and that the group who uses the seat belt the least will be more influenced then the group which used the seat belt the most. Enforcement seems to be an effective measure to increase the seat belt use. Behavior scientists are of judgment that reward programs in combination with enforcement are leading to even better results. Mathijssen & de Craen (2004) have estimated what the effect of intensive police control is on seat belt use on certain locations in the Netherlands. In the period of 1995-2002 the intensive controls on seat belt use would have lead to a 23% higher seat belt use of the drivers and their passengers.

- Effectiveness in terms of accident reduction?

As a result of this higher seat belt use in the study of Mathijssen & de Craen (2004), the number of deaths reduced with 4 to 5% (= about 30 traffic deaths). For the whole Netherlands the increased seat belt use has caused a decrease in traffic deaths with 3%. Elvik (2001) evaluated fourteen studies which investigated the effect of seat belt use enforcement. Most of these studies have evaluated the effect on the wearing rates for seat belts. Two studies considered in addition the effects of wearing a seat belt on accident occurrence. The study of Elvik confirms that increased seat belt use reduces the number of fatalities and accidents with injuries. The best estimate was a reduction in the number of fatal accidents with 6% and a reduction in the number of accidents with injuries with 8%. Unfortunately these values were statistically not significant, but give an approximation of the effect of seat belt use in terms of accident reduction.

Costs

For seat belt controls there are no installation costs needed, but there are only personnel costs. The costs per year are assumed around €50.000 for direct personnel and €50.000 for indirect costs (such as housing, vehicles and managerial support) (Wijnen et al., 2010).

Conclusions enforcement measures

The best reference value for the public support of seat belt controls was found in a research of the Openbaar Ministerie (2009). Here was found that police controls can count on a lot of public support, namely 83% thinks that controls for seat belt use are important. Despite the fact that the results of the study of Elvik (2001) are not significant, they are giving a good indication for the effectiveness of seat belt controls, namely an effectiveness of 8%. For seat belt controls no implementation costs are needed, but only personnel is required for executing the controls. These personnel costs are estimated at €50.000 per year.

3.2.4 Conclusions for the safety measures of seat belt use

For each of the three E's (education, environment and enforcement) was tried to select at least one measure. The results are summarized in table 56. In total three different measures were discussed, which could motivate car passengers to wear their seat belt. These different measures are public campaigns, seat belt reminder and seat belt controls. Also here a distinction is made between implementation costs and operational + personnel costs.

Implementation costs (per maintained kilometer regional road):

- Public campaigns = €325.000/6.055 = €54
- Seat belt reminder = €370.000.000/6.055 = €61.107
- Seat belt controls = €0

Operational costs + personnel costs (per year):

- Public campaigns = €0 (the personnel and operational costs are already included in the implementation costs)
- Seat belt reminder = €0 (no costs)
- Seat belt controls = €50.000 + €1.651 = €51.651

	Public campaigns	Seat belt reminder	Seat belt controls
Public support	61%	90%	83%
Effectiveness	9%	16,1%	8%
Implementation costs	€ 54	€ 61.107	€ 0
Operational + personnel costs	€ 0	€ 0	€ 51.651

Table 56 Summary table traffic safety measures for seat belt use

3.3 Multicriteria analysis seat belt use

3.3.1 Traffic safety problem

The magnitude was calculated by means of the formula presented by Elvik (2008). In first instance the PAR was determined for a seat belt use effectiveness of 42%, in second instance with a seat belt use effectiveness of 60%. There out appeared that the PAR respectively equals to 0,13 and 0,23. These values are presented on the y-axis as can be seen on figure 18. Because it would be interesting to have one value for the attributable risk, the average of the two values will be taken as the overall PAR, that is 0,18. For determining the public support for the safety problem seat belt use, the results from the attitude measurement of the BRSI (2009) are taken. There out appears that 44% supports the enforcement of the traffic rules for seat belt use.

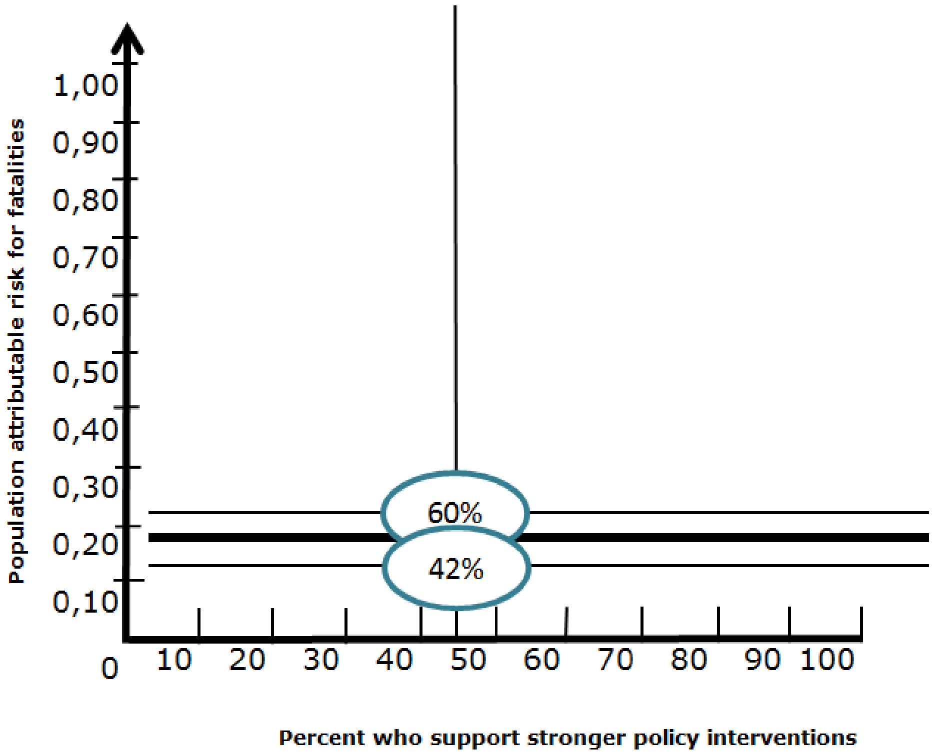


Figure 18 Relationship between support for stronger policy interventions and risk for different effectiveness's of seat belt use attributable to the traffic safety problem seat belt use

3.3.2 Traffic safety measures

Also here the same method will be discussed as described in chapter 5.2 of the theoretical introduction. The calculations will be analogue with the calculations which were done for the safety measures for speeding and for driving under influence of alcohol.

For this analysis the values for public support, effectiveness and costs for the different discussed measures are required. These different measures are public campaigns, the seat belt reminder and seat belt controls. The obtained values are given in table 57.

	Public campaigns	Seat belt reminder	Seat belt controls
Public support	61%	90%	83%
Effectiveness	9%	16,1%	8%
Implementation costs	€ 54	€ 61.107	€ 0
Operational + personnel costs	€ 0	€ 0	€ 51.651

Table 57 Summary table traffic safety measures for seat belt use

Public support

The public support and the ranking scores for the seat belt use measures are presented in table 58. The measures could therefore be ranked as follows: Seat belt reminder (3) > Seat belt controls (2) > Public campaigns (1)

	Public support	Score
Public campaigns	61%	1
Seat belt reminder	90%	3
Seat belt controls	83%	2

Table 58 Allocation of ranking scores for the public support of traffic safety measures for seat belt use

The eigenvectors for the public support of the measures were already found after two iterations. The results of this calculation can be found in table 59.

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	9,0000	13,5000	49,5000	0,1667
Seat belt reminder	81,0000	27,0000	40,5000	148,5000	0,5000
Seat belt controls	54,0000	18,0000	27,0000	99,0000	0,3333
				297,0000	1
					Eigenvector (2)

Table 59 Calculating eigenvector for the public support of different measures for seat belt use

Effectiveness

The effectiveness and the ranking scores for the seat belt use measures are presented in table 60. The measures could therefore be ranked as follows: Seat belt reminder (3) > Public campaigns (2) > Seat belt controls (1)

	Effectiveness	Score
Public campaigns	9%	2
Seat belt reminder	16,1%	3
Seat belt controls	8%	1

Table 60 Allocation of ranking scores for the effectiveness of traffic safety measures for seat belt use

Also here need the table need to be squared. As one can see in table 61, the eigenvector was already found after two iterations.

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	18,0000	54,0000	99,0000	0,3333
Seat belt reminder	40,5000	27,0000	81,0000	148,5000	0,5000
Seat belt controls	13,5000	9,0000	27,0000	49,5000	0,1667
				297,0000	1
					Eigenvector (2)

Table 61 Calculating eigenvector for the effectiveness of different measures for seat belt use

Costs

The costs are divided into implementation costs and maintenance + personnel costs. The same procedure will be followed as for the speeding and drunk driving problem. The detailed calculation can be found in attachment 4. The result of the new ranking of the costs for the measures of seat belt use can be found in table 64.

	Costs 1	Score
Public campaigns	€ 54	2
Seat belt reminder	€ 61.107	1
Seat belt controls	€ 0	3

Table 62 Allocation of ranking scores for the implementation costs of traffic safety measures for seat belt use

	Costs 2	Score
Public campaigns	€ 0	2,5
Seat belt reminder	€ 0	2,5
Seat belt controls	€ 51.651	1

Table 63 Allocation of ranking scores for the maintenance and personnel costs of traffic safety measures for seat belt use

Total costs	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	5,2500	3,2667	3,5000	12,0167	0,2845
Seat belt reminder	5,2500	1,6333	4,0833	10,9667	0,2597
Seat belt controls	2,1000	4,9000	12,2500	19,2500	0,4558
				42,2333	1

Table 64 Calculation of the eigenvector for the two costs factors for seat belt use

The measures could therefore be ranked as follows: Seat belt controls (3) > Public campaigns (2) > Seat belt reminder (1)

Also here the table needs to be squared. The eigenvector was already found after two iterations.

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	54,0000	18,0000	99,0000	0,3333
Seat belt reminder	13,5000	27,0000	9,0000	49,5000	0,1667
Seat belt controls	40,5000	81,0000	27,0000	148,5000	0,5000
				297,0000	1
					Eigenvector (2)

Table 65 Calculating eigenvector for the costs of different measures for seat belt use

Table 66 gives all the eigenvectors which were calculated for the three discussed traffic safety measures.

	Public support	Effectiveness	Costs
Public campaigns	0,1667	0,3333	0,3333
Seat belt reminder	0,5000	0,5000	0,1667
Seat belt controls	0,3333	0,1667	0,5000

Table 66 The eigenvectors for the public support, effectiveness and costs for the different measures for seat belt use

Now the eigenvectors need to be combined with the values for the four different scenarios. The calculations and outcomes are given in table 67 and 68.

	Public support	Effectiveness	Costs
Public campaigns	0,1667	0,3333	0,3333
Seat belt reminder	0,5000	0,5000	0,1667
Seat belt controls	0,3333	0,1667	0,5000

X

	Weighting Scenario 1
Public support	0,3333
Effectiveness	0,3333
Costs	0,3333

	Public support	Effectiveness	Costs
Public campaigns	0,1667	0,3333	0,3333
Seat belt reminder	0,5000	0,5000	0,1667
Seat belt controls	0,3333	0,1667	0,5000

X

	Weighting Scenario 2
Public support	0,5000
Effectiveness	0,2500
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,1667	0,3333	0,3333
Seat belt reminder	0,5000	0,5000	0,1667
Seat belt controls	0,3333	0,1667	0,5000

X

	Weighting Scenario 3
Public support	0,2500
Effectiveness	0,5000
Costs	0,2500

	Public support	Effectiveness	Costs
Public campaigns	0,1667	0,3333	0,3333
Seat belt reminder	0,5000	0,5000	0,1667
Seat belt controls	0,3333	0,1667	0,5000

X

	Weighting Scenario 4
Public support	0,2500
Effectiveness	0,2500
Costs	0,5000

Table 67 Multiplying the results of the eigenvectors for the measures with the eigenvectors of the scenarios

Scenario 1	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0556	0,1111	0,1111	0,0926
Seat belt reminder	0,1667	0,1667	0,0556	0,1296
Seat belt controls	0,1111	0,0556	0,1667	0,1111

Scenario 2	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0833	0,0833	0,0833	0,0833
Seat belt reminder	0,2500	0,1250	0,0417	0,1389
Seat belt controls	0,1667	0,0417	0,1250	0,1111

Scenario 3	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0417	0,1667	0,0833	0,0972
Seat belt reminder	0,1250	0,2500	0,0417	0,1389
Seat belt controls	0,0833	0,0833	0,1250	0,0972

Scenario 4	Public support	Effectiveness	Costs	OVERALL
Public campaigns	0,0417	0,0833	0,1667	0,0972
Seat belt reminder	0,1250	0,1250	0,0833	0,1111
Seat belt controls	0,0833	0,0417	0,2500	0,1250

Table 68 Final results of the weighting process for seat belt use

The first overall impression of the results is that the seat belt reminder scores three times the best. This is due to the fact that there was found the highest public support for this measure and also the highest effectiveness. Nevertheless this measure received the lowest score for costs. The measure public campaigns scored in each scenario the lowest. This is mainly due to the low public support and the fact that public campaigns did not received the best score on one of the three criteria. Seat belt controls score in general also well. In the fourth scenario the overall score is slightly higher for seat belt controls then for the seat belt reminder. This is because the costs for seat belt controls received a better score than the other two measures. For the other criteria scored the seat belt controls a second (public support) or third place (effectiveness). Out of these results can be concluded that there should be invested in the measure seat belt reminder.

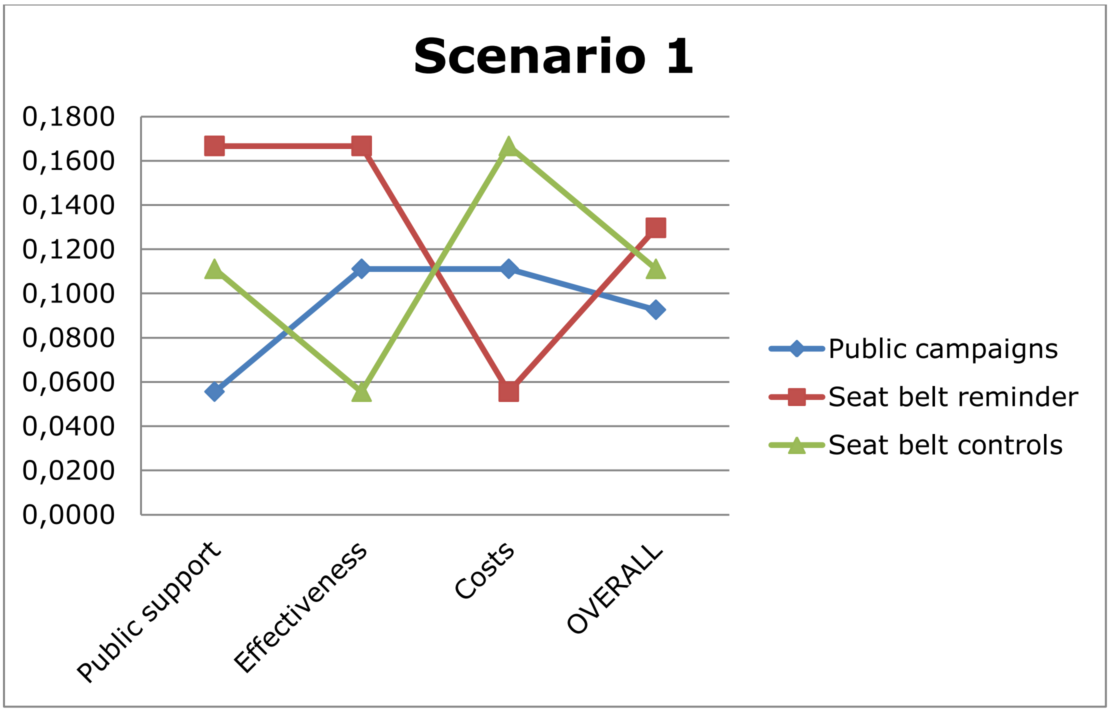


Figure 19 Results scenario 1

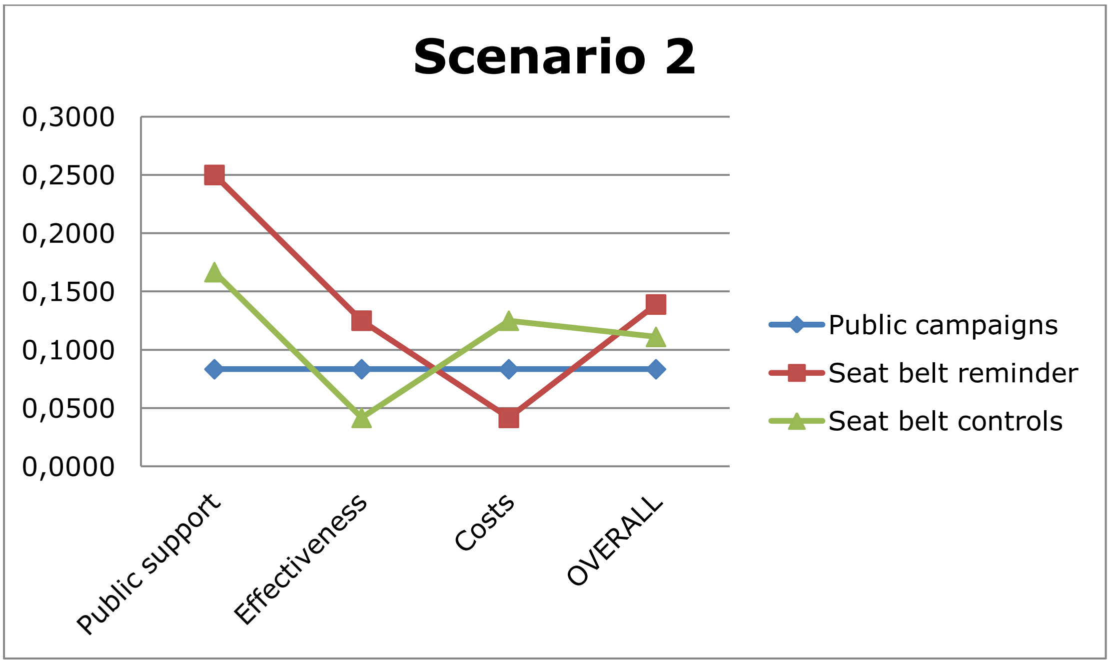


Figure 20 Results scenario 2

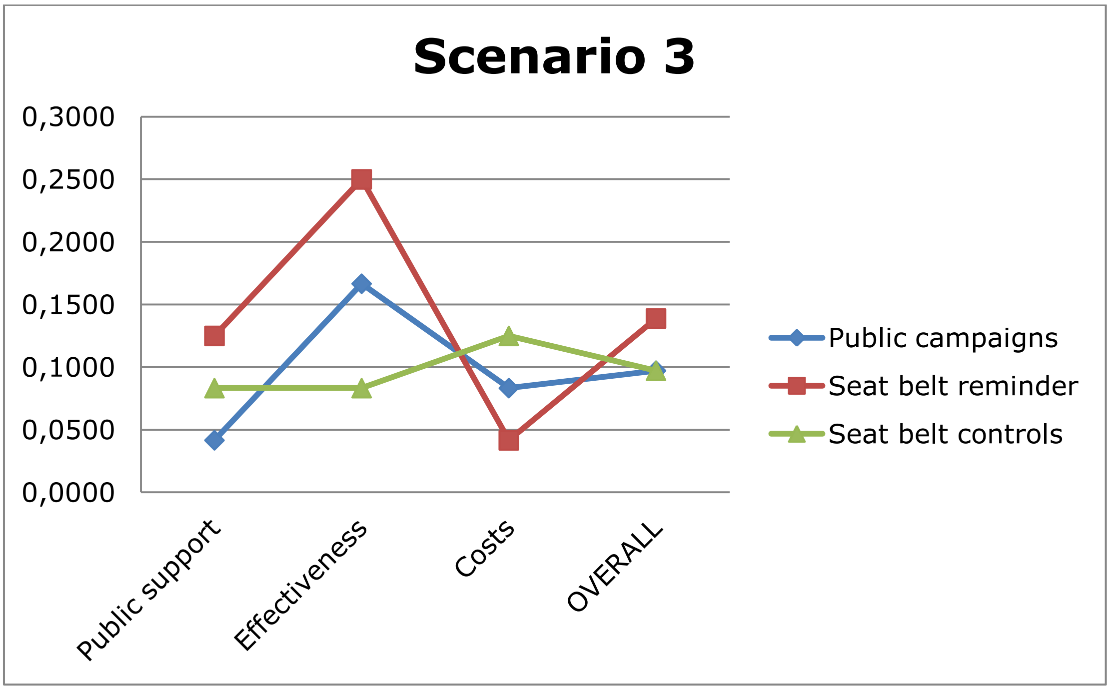


Figure 21 Results scenario 3

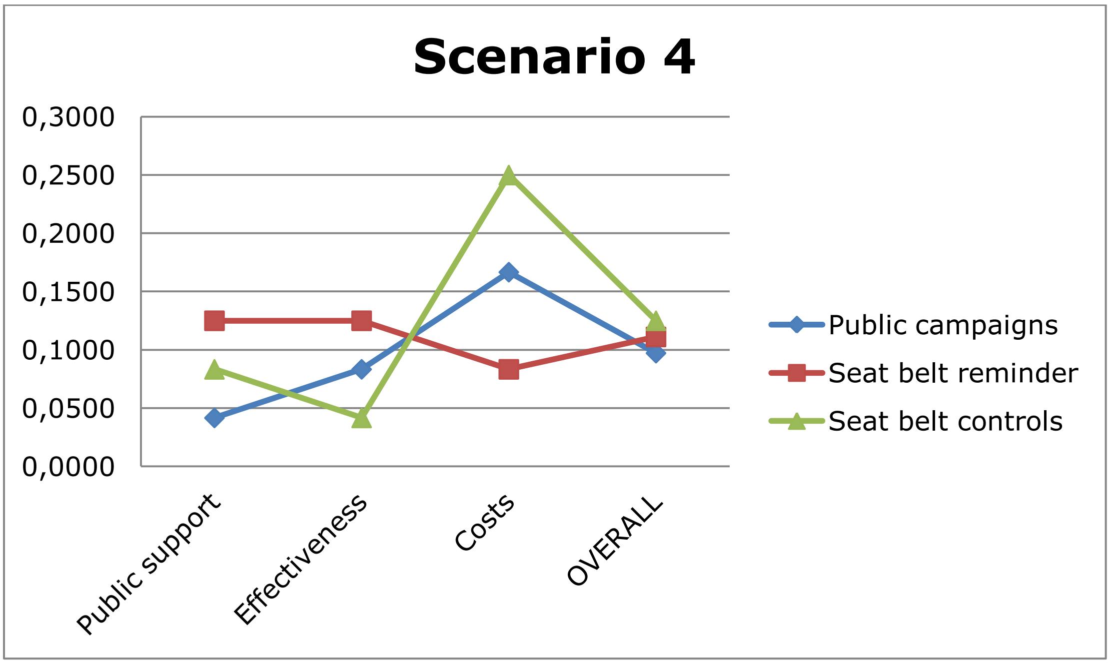


Figure 22 Results scenario 4

PART 3: DISCUSSION

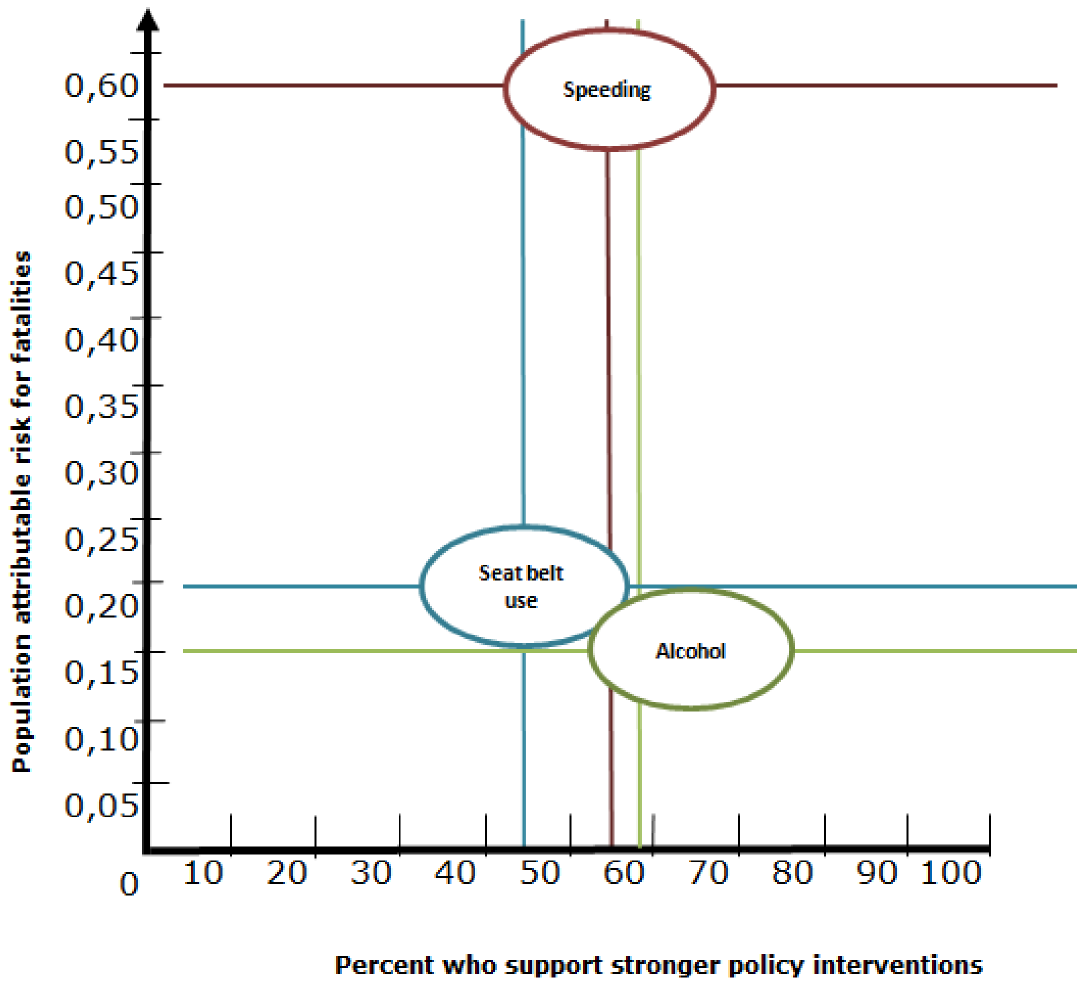
1. Summary results

The purpose of this Master thesis was to examine the amenability to treatment for traffic safety problems. Two main purposes could be distinguished, that is first an examination of the method to study the amenability to treatment and secondly the application of this method on several traffic safety measures in Belgium. Three important traffic safety problems are discussed, that is speeding, driving under influence of alcohol and seat belt use. Next to an examination of the three problems, measures to reduce the problem were extensively examined.

1.1 Traffic safety problems

These problems, namely speeding, driving under influence of alcohol and seat belt use, were chosen because these are the most occurring problems in our country Belgium. Both the magnitude of the problem, measured through the population attributable risk, and the public support to tackle this problem were studied.

First of all was given a regard to the magnitude of the problem. This is the size of contribution a problem makes to the total number of accidents or injured road users and can be measured by calculating the population attributable risk. This population attributable risk is the fraction of accidents or injuries that is attributable to a certain risk factor, or stated differently, the size of the reduction in the number of accidents or injuries that could be achieved by removing the risk factor. Secondly the public support for each traffic safety problem was measured. This public support is mainly measured through attitude measurements. Frequent attitude measurements that were used in this thesis were the attitude measurement of the BRSI and the measurement of AXA. For all the discussed problems the same source (BRSI, 2009) and indication of public support was used, that is the percentage of respondents that supports the enforcement of traffic rules. From this appeared that each of the three discussed traffic safety problems could count on a public support of more than 44% each. Both the magnitude and the public support for each of the three problems could be located at a graph, in order to make a clear comparison possible. In the table below the magnitude and the public support for each of the three problems are displayed. For the population attributable risk (PAR) for fatalities for speeding was found a percentage of 56%. This means that 56% of the accidents with fatalities for speeding could be reduced if the risk factor, namely speeding, was eliminated. The PAR for driving under influence of alcohol and seat belt were much lower, respectively 15% and 18%. In contrast to these very different values for the PAR, the values for the public support for stronger policy interventions are lying closer to each other. There was found a public support of 56% for the enforcement of the traffic rules for speeding, a support of 59% for drunk driving and a support of 44% for seat belt use.



1.2 Traffic safety measures

Secondly was examined which measures could contribute to resolve or reduce the different discussed traffic safety problems. For each of the traffic safety problems was tried to discuss at least one measure for each of the three E's (education, environment and enforcement). Through a literature study, per measure different results were found for public support, effectiveness and costs. Depending on the extensiveness of the study and the reliability of the source, one number for each of the three criteria per safety measure was chosen. Through the analytic hierarchy process, those different results were weighted against each other, and the measure with the highest amenability to treatment could be selected. Therefore, per criteria (public support, effectiveness, costs) the different selected measures for a certain traffic safety problem were ranked, based on the selected results from the literature study. A measure which scored better than

another measure received a higher score. Furthermore four different scenarios were handled, in which the three criteria got a different weight one scenario where all criteria received equal weights, and three scenarios in which each of the criteria received a two times higher value than the other criteria. Thereby could be verified if there were measures which score always good or score good in a particular scenario. The scenarios were applied on all the measures per traffic safety problem. Consequently the following conclusions could be made.
For the problem speeding five measures were discussed, that are public campaigns, intelligent speed adaptation (ISA), fixed cameras, section control and mobile speed cameras. At first sight, ISA scored in each scenario very high, wherefrom three times the highest. A closer look to the more detailed results moreover shows that fixed cameras and section control also score very well over the four scenarios. Public campaigns scored somewhat lower and mobile speed cameras scored very badly in each scenario. When comparing ISA and fixed cameras to each other, there can be seen that ISA scores better on public support and effectiveness, however fixed cameras are less expensive.
For the problem drunk driving three measures were selected, that are public campaigns, alcohol ignition interlock device (AIID) and alcohol controls. In each scenario the measure public campaigns appeared to be the best measure. This is because there are very high costs for the AIID and there is a very low public support for this system. Alcohol controls can count on the highest public support of the three measures, but scores low on effectiveness.
For the problem seat belt use also three measures were discussed, that is public campaigns, seat belt reminder and seat belt controls. In general the scores are lying very close together, nevertheless the seat belt reminder scores three times the highest. Only in the fourth scenario, in which the costs receive a two times as higher weight compared to the other criteria, the seat belt controls get the highest score. This is because the costs for seat belt controls are very low compared to the two other measures. The public campaigns scored the lowest in each scenario, but still achieved a reasonable overall score.

Analyzing the most favorite measures for the different traffic safety problems, there can be concluded that there is not one specific category of the three E's which is preferred most. For the speeding problem environment and enforcement measures scored the best, for drunk driving the education measure and for seat belt use also an environment measure. In some cases the three E's cannot be regarded separately. For example the combination of public campaigns and enforcement is a common phenomenon in Belgium.

2. Limitations

With the aim to support the traffic safety policy, this thesis tried to find out which are the best measures to address specific traffic safety problems. Thereby was attempted to determine the magnitude and the public support of the problem as objective as possible. There was also tried to give an as much as possible representative image of the public support, effectiveness and costs of the different traffic safety measures. Nevertheless there can be addressed a few weaknesses/limitations in this thesis.

At first a few weaknesses can be formulated that arise from the sources of information to data on public support, effectiveness and costs, which were found in national and international literature. First of all it may be difficult for some international results to extrapolate them to Belgium. Here it could be interesting to execute a (more extensive) Belgian or Flemish research. When literature of international studies was used in this thesis, there was ensured that this data could be applicable for the Belgium population. Mostly there were used results from the Netherlands (e.g. Openbaar Ministerie (2009)).
Secondly, selecting one single result to make a balance between different measures is difficult. In this thesis was tried to base results on the most extensive studies, but this could sometimes give an arbitrary outcome. This is an important weakness, because there is need for solutions which can be taken by the Flemish government. Though there was sought for the most representative results as possible.
More specific for the results of public support it might be a weakness that respondents gave socially desirable answers. This should always be kept in mind.
A third important weakness related to data and sources is that there is sometimes data compared to other data which is based on a different population. For example for the public support for fixed cameras was used data from the Netherlands, while for ISA was used data based on the Belgian population. Another example is that the effectiveness of the measures not always was expressed in the same terms. There was tried to find for each measure the reduction in the number of accidents. For the effectiveness of the seat belt reminder was only found the reduction in terms of accident fatalities. This was due to the fact that there was no other value found in the literature. In this thesis was tried as much as possible to avoid the use of incomparable values.

Secondly, there were found some weaknesses by weighing the different measures. Here as well for the weights that were addressed to the three criteria, as for the weights that were addressed to the different measures limitations can be formulated.
The weights of the different scenarios were based on very simple principles, namely all weights equal or one of the three criteria that received a weight twice as high as the

other criteria. In practice a group of experts can allocate the weights to the different criteria, depending on the importance of their goals.
Small differences in the percentages for the values of public support, effectiveness and costs, which were found in the literature studies, can lead to large differences in the overall outcome of the analysis. By only 1% more or less, a measure can score in the overall score more or less better than the other measure. This can lead to a distorted impression of the overall score of each measure.

Another weakness in the weighing process of the different measures is the calculation of the costs for the different measures. Here was chosen to calculate the implementation costs in function of one kilometer regional road. This might not be the most correct solution. There can be expected that fixed cameras, mobile speed cameras and section controls especially will occur on these roads. This is not entirely the case for public campaigns and ISA. These last two will also have their effect on accidents on local roads. However, in order to make a comparison possible, this seemed to be a good solution. It is very difficult to weigh the different costs on a simple way. The maintenance and operational costs were expressed in costs per year. Comparing the implementation costs which are expressed in function of one kilometer road to the maintenance and personnel cost which are expressed in costs per year can be defined as another weakness. Therefore it is necessary in future research to find a good solution to weigh the costs on a more objective and correct way to each other.

3. Recommendations

The research as applied here can be an example for future research. In a good road safety policy, measures should be carefully selected. An evaluation of the different elements that play a role is important. It is important that the measures are effective and may exert a positive effect on the number of road accidents. However this is not sufficient, and often it is also important that these measures are supported by the population (Goldenbeld, 2002). In addition, the execution of a measure needs to be done within the limits of a particular budget. Also this element needs to be taken into account.

A first step is to perform a carefully examination of each of those three elements. Public support can be investigated by means of an attitude measurement which can consist out of open ended questions or closed ended questions with a number of respond options from which the respondent can choose. Next to this, there are also many existing sources which can be used here, such as the measurement of the BRSI (2003, 2006 and 2009), Scheers (2006), Openbaar Ministerie (2009), … . The examination of the effectiveness can be based on existing Flemish research, e.g. research executed by the Policy Research Centre for Traffic Safety (e.g. Nuyts (2004), effectiveness of unmanned cameras), or new studies could be executed. This can also be supplemented with information from well-conducted international studies. This is especially interesting when this goes about new measures which are not yet applied in Flanders. Thirdly, the costs should be properly viewed. A full calculation of all the costs is important here.

When a good view is formed on each of these three elements, they must be weighed. The method used in this thesis forms an example. The different elements have been weighed by means of the analytical hierarchy process. The analytical hierarchy process translates a complex problem into a hierarchy consisting of an overall goal. There can be several criteria contributing to this goal and a number of alternatives of which the best has to be selected. In this case the criteria are public support, effectiveness and costs. They will receive a weight, which determines their importance. Subsequently all possible alternatives, which are the different safety measures per problem, are compared to each other on the basis of the different criteria. All these calculations will be combined in one overall score. Next to this method, also other methods can be used, e.g. 'Equal weighting' (Hermans et al., 2008) where the same weight is assigned to each indicator.
The method which is used in this thesis can be applied to various road safety problems, both for new and existing measures. This thesis investigated for example the measure section control, a new measure, which could be investigated more profoundly in the future.

Bibliography

AXA. (2009). *Press conference AXA rijgedrag*. Brussels. Retrieved from https://web.wcc.axa.be/wcc/SiteCollectionDocuments/rijgedragbarometer_2009_nl.pdf

Belgian Federal Government. (2010). Traffic accidents with fatalities and injuries. Retrieved March 7, 2012, from http://statbel.fgov.be/nl/statistieken/webinterface/?loadDefaultId=93&IDBr=tcm:325-30493-4

Belgian Federal Government. (2011). Go for Zero: elke verkeersdode is er één te veel! Retrieved January 21, 2012, from http://www.belgium.be/nl/nieuws/2011/news_bivv-go-for-zero.jsp

Bernhoft, M. (2011). *Results from epidemiological research - prevalence, risk and characteristics of impaired drivers*. Denmark: Technical University of Denmark.

BRSI. (2006). *Attitudemeting verkeersveiligheid 2006 - Deel 1: Attitudes van de total populatie*. Brussels: BRSI. Retrieved from http://bivvweb.ipower.be/Observ/NL/Attitudemeting%20verkeersveiligheid%202006%20def.pdf

BRSI. (2008). Schriftelijke vraag nr. 4-1878. Retrieved from http://www.senate.be/www/?MIval=/Vragen/SchriftelijkeVraag&LEG=4&NR=1878&LANG=nl

BRSI. (2009). *Attitudemeting verkeersveiligheid 2009. Evoluties sinds 2003 en 2006*. BRSI. Retrieved from http://bivvweb.ipower.be/Observ/NL/Attitudemeting%20verkeersveiligheid%202009.pdf

BRSI. (2010). *Verlaagde alcohollimiet voor onervaren bestuurders en voor bestuurders van grote voertuigen: 0,2%*. Brussels: BRSI.

BRSI. (2011a). Te snel rijden. Retrieved December 3, 2011, from http://www.goforzero.be/nl/veilig-verkeer/te-snel-rijden

BRSI. (2011b). Alcohol & drugs. Retrieved December 3, 2011, from http://www.goforzero.be/nl/veilig-verkeer/alcohol-and-drugs

BRSI. (2011c). Autogordel. Retrieved December 3, 2011, from http://www.goforzero.be/nl/veilig-verkeer/autogordel

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

Daniels, S., Deben, L., De Brabander, B., Verlaak, J., & Vesentini, L. (2004). *De veiligheidsgordel: een eenvoudig, goedkoop en doeltreffend middel voor méér verkeersveiligheid*. Diepenbeek: Policy Research Centre for Traffic Safety.

De Brabander. (2007). *De maatschappelijke efficiëntie van onbemande camera's* (No. RA-2007-112). Diepenbeek: Policy Research Centre for Traffic Safety.

De Brabander, B., & Vereeck, L. (2003). *Cost-Benefit Analysis for Road Safety Investments in Belgium, Case study for a Seat Belt Reminder system* (No. RA-2003-16). Diepenbeek.

De Brabander, B., & Vereeck, L. (2005). Verkeersongevallen in België kosten jaarlijks 12,5 miljard. *Verkeersspecialist*, *122*, 23–26.

Delaney, A., Ward, H., & Cameron, M. (2005). *The history and development of speed camera use* (No. 242). Australia: Monash University Accident Research Centre.

Eksler, V. (2007). *The role of structural factors in road safety*. Czech Republic/France.

Elder, R. W., Shults, R. A., Sleet, D. A., Nichols, J. L., Thompson, R. S., & Rajab, W. (2004). Effectiveness of mass media Campaigns for reducing drinking and driving and alcohol-involved crashes. *American Journal of Preventive Medicine*, *27*(1), 57–65.

Elvik, R. (2001). *Cost-Benefit Analysis of Police enforcement* (No. RO-98-RS.3047).

Elvik, R. (2008). Dimensions of road safety problems and their measurement. *Accident Analysis and Prevention*, *40*(3), 1200–1210.

Elvik, R. (2010). Why some road safety problems are more difficult to solve than others. *Accident Analysis and Prevention*, *42*(4), 1089–1096.

Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). *The handbook of road safety measures* (Second ed.). United Kingdom: Emerlad.

Elvik, R., & Vaa, T. (2004). *The handbook of road safety measures*. Oxford: Elsevier.

Evans, L. (2004). *Traffic safety*. USA: Bloomfield.

Ferguson, S., Wells, J., & Kirley, B. (2007). Effectiveness and driver acceptance of the Honda belt reminder system. *Traffic Injury Prevention*, *8*(2), 123–9.

Flemish Government. (2006). *Sensibilisatiecampagne voor het dragen van de gordel: Gebruiksaanwijzing voor gemeenten, provincies en politiezones*. Brussels: Mobiliteit en Openbare Werken.

Goldenbeld, D. C. (2002). *Publiek draagvlak voor verkeersveiligheid en veiligheidsmaatregelen* (No. D-2002-2). Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Goldenbeld, D. C. (2004). *Politiek draagvlak voor intelligente snelheidsaanpassing - ISA* (No. R-2004-5). Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Ha, Kang, & Park. (2003). The effects of Automated Speed Enforcement Systems on Traffic-Flow Charachteristics and Accidents in Korea. *ITE-journal*, *73*(2), 28–31.

Haas, R., & Meixner, O. (2006). *An illustrated guide to the analytic hierarchy process*. Presentation Institute of Marketing and Innovation, Vienna.

Harrison, W. A. (2001). Seat belt use and reminder systems: assessing the acceptability of intelligent seat belt reminder systems. *Transportation Research Board*, 551–556.

Harrison, W. A., Senserrick, T., & Tingvall, C. (2000). *Development and trial of a method to investigated the acceptability of seat belt reminder systems* (No. 170). Monash University Accident Research Centre.

Hermans, E., Van den Bossche, F., & Wets, G. (2008). Combining road safety information in a performance index. *Accident Analysis and Prevention*, *40*, 1337–1344.

ICBC. (2004). *Intersection Safety Camera Program - Submission to Measurement & Monotoring Committee*. Insurance Corporation of British Columbia.

Janitzek, T., & Achterberg, F. (2006). *Seat Belt Reminders - Implementing advanced safety technology in Europe's cars*. Brussels: European Transport Safety Council.

Kabinet van H. Crevits. (2011). Grote respons op de publieke consultatie rond het Mobiliteitsplan Vlaanderen - Vlamingen plaatsen verkeersveiligheid voorop. Retrieved November 19, 2011, from http://mobielvlaanderen.be/persberichten/artikel.php?a=1&id=436

Kallberg, V., Ziadel, D., Vaa, T., Malenstein, J., Siren, A., & Gaitanidou, E. (2008). *Sixth framework programme. Priority 1.6 sustainable development, global change and ecosystem* (p. 14). Police Enforcement Policy and Programmes on European Roads.

Keenan, D. (2004). Speed Cameras - how do drivers respond? *Traffic Engineering and Control*, *43*(4), 104–111.

Kennis platvorm verkeer en vervoer. (2007). *Beste werkwijzen op het gebied van verkeersveiligheid. Handboek op nationaal niveau* (p. 52). Utrecht.

Lahausse, J., & Fildes, B. (2009). Cost-benefit analysis of an alcohol ignition interlock for installation in all newly registered vehicles. *Traffic Injury Prevention*, (10), 528–537.

Mathijssen, M. P. M., & de Craen, S. (2004). *Evaluatie van de regionale verkeershandhavingsplannen* (R-2004-4). Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Moons, E. (2009). *Evaluatie van het programma "gevaarlijke punten"* (No. RA-MOW-2009-012). Diepenbeek: Policy Research Centre for Traffic Safety.

Nilsson, G. (2004). *Traffic safety dimensions and the power model to describe the effect of speed on safety*. Lund: Lund Institue of Technology.

Nuyts, E. (2006). *Effectiviteit van onbemande camera's* (No. RA-2006-90). Diepenbeek: Policy Research Centre for Traffic Safety.

Openbaar Ministerie. (2008). Section control. Retrieved January 13, 2012, from http://www.om.nl/onderwerpen/verkeer/english/section_control/

Openbaar Ministerie. (2009). Draagvlak voor verkeersregels en -controles in 2008 toegenomen. Retrieved November 16, 2011, from http://www.om.nl/onderwerpen/@150202/draagvlak_voor/

Paris, H. (2007). *Onderzoek naar de psychologische determinanten van snelheidsgedrag bij een representatieve steekproef van Vlaamse automobilisten*. Leuven: Katholieke Universiteit Leuven.

Persaud, B., & Lyon, C. (2006). Empirical Bayes before-after safety studies: Lessons learned from two decades of experience and future directions. *Elsevier*, *Accident Analysis & Prevention*, 546–555.

Phillips, R. O., Ulleberg, P., & Vaa, T. (2011). Meta-analysis of the effect of road safety campaigns on accidents. *Elsevier*, *43*(3), 1204–1218.

Policy Research Centre for Traffic Safety. (2008). *Verkeersveiligheidsplan Vlaanderen*. Brussels.

Rienstra, S. A., Rietveld, P., & Verhoef, (Erik T. . (1999). The social suport for policy measures in passenger transport. A statistical analysis for the Netherlands. *Transportation Research part D: Transport and Environment*, *4*(3), 181–200.

Rutten, M. C., & Van den Bulck, P. D. J. (2007). *Mobiliteitscommunicatie in Vlaanderen: Sensibilisatie en gedragsbeïnvloeding door mobiliteitscampagnes of andere communicatietechnieken*. Leuven: Katholieke Universiteit Leuven.

Scheers, M. (2006). *Veilig door Tienen*. Brussels.

SGVV. (2002). *Dosier 1 - Onaangepaste en overdreven snelheid*. Retrieved from http://www.fcvv.be/Docs/2002/Dossier%201%20Snelheid.pdf

Silverans, P., Drevet, M., & Vanlaar, W. (2005). *Attitudemeting verkeersveiligheid 2003-2004*. Brussels: BRSI.

Stefan, C. (2006). *Section Control - Automated speed enforcement in the Kasiermühlen tunnel*. Austian Road Safety Board.

SWOV. (2010a). *Intelligent Speed Assistance*. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

SWOV. (2010b). *Seat belt reminders*. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

SWOV. (2011). *Speed camera's: how they work and what effect they have*. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

SWOV. (2012). *Waardering van immateriële kosten van verkeersdoden*. Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Turbell, T., Andersson, T., Kullgren, A., Larsson, P., Lundell, B., Loesvund, P., Nilsson, C., et al. (1996). *Optimizing seat belt usage by interlock systems. Fifteenth international technical conference on the enhanced safety of vehicles*. Melbourne.

Van Geirt, F. (2004). *Risico-analyse op gewestwegen buiten de bebouwde kom* (No. RA-2004-31) (p. 13). Diepenbeek: Policy Research Centre for Traffic Safety.

Van Malderen, F., & Macharis, C. (2009). *Handleiding voor het evalueren van verkeersveiligheidsmaatregelen* (No. RA-MOW-2009-003). Diepenbeek: Policy Research Centre for Traffic Safety.

Van Moerkerke, B. (2011a). Andere landen boeken resultaat met trajectcontrole, binnenkort ook België? *Kluwer*, *178*, 4–6.

Van Moerkerke, B. (2011b). Systeem voor trajectcontrole op viaduct Gentbrugge werkt. *Kluwer*, *178*, 7–9.

Van Vlierden, K. (2005). *Jongeren en alcohol in het verkeer* (No. RA-2005-57). Diepenbeek: Policy Research Centre for Traffic Safety.

Van Vlierden, K., Vesentini, L., & Cuyvers, R. (2004). *Vooronderzoek naar alcoholgebruik in relatie tot verkeersveiligheid* (RA-2004-32). Diepenbeek: Policy Research Centre for Traffic Safety.

Vanlaar, W. (2005). Drink driving in Belgium: results from the third and improved roadside survey. *Accident Analysis and Prevention*, *37*(3), 391–397.

Verlaak, J. (2003). *De veiligheidsgordel: Technische aspecten en effectiviteit* (No. RA-2003-14). Diepenbeek: Policy Research Centre for Traffic Safety.

Verlaak, J. (2004). *Bestuurderscontrolesystemen voor vermoeidheid en rijden onder invloed* (No. R-2004-45). Diepenbeek: Policy Research Centre for Traffic Safety.

Vermote, L., Van Malderen, F., & Macharis, C. (2012). *Multicriteria analyse van snelheidsreducerende handhavingsmaatregelen op snelwegen*. Diepenbeek: Policy Research Centre for Traffic Safety.

Vesentini, L., & Cuyvers, R. (2003). *Gordeldracht. Literatuurstudie over de determinanten van het gordelgebruik en mogelijke interventies* (No. RA-2003-12). Diepenbeek: Policy Research Centre for Traffic Safety.

Vlaamse Stichting Verkeerskunde. (2010a). *Snelheidsmanagement: Waarom snelheid in het verkeer een probleem is en wat u eraan kunt doen*.

Vlaamse Stichting Verkeerskunde. (2010b). Het woon-werkverkeer in cijfers. Retrieved May 25, 2012, from http://www.mobiliteitsmanagement.be/ndl/woonwerkverkeer/

Vlassenroot, S., Broekx, S., De Mol, J., Int Panis, L., Brijs, T., & Wets, G. (2006). Driving with intelligentspeed adaptation: Final results of the Belgian ISA-trial. *Transportation Research Part A: Policy and Practice*, *41*, 267–279.

Vlassenroot, S., & De Mol, J. (2005). *The Acceptance of Intelligent Speed Adaptation (ISA) and the Use of Role-models*. Belgium: Ghent University.

Vlassenroot, S., & De Mol, J. (2011). Veel bestuurders gewonnen voor ISA in hun auto. *Kluwer*, *178*, 27–31.

Wegcode vzw. (2011). Waarom is de praktische toepassing van het alcoholslot zo moeilijk? *Kluwer*, *December 2011*(182), 12–13.

Wesemann, P. (2003). *Kosten en baten van alcoholcontroles in het verkeer*. Den Haag: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Wijnen, D. W., Mesken, dr. J., & Vis, (dr. ir. M. A. . (2010). *Effectiviteit en kosten van verkeersveiligheidsmaatregelen* (No. R-2010-9). Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid.

Wilmots, B., Van Hout, K., Daniels, S., Brijs, T., Hermans, E., & Nambuusi, B. B. (2009). *Verkeersonveiligheid in Vlaanderen. Probleemanalyse tot en met 2007* (No. RA-MOW-2009-013) (p. 44). Diepenbeek: Policy Research Centre for Traffic Safety.

Ysebaert, T. (2009). Trajectcontrole maakt remmen voor flitspalen nutteloos. Retrieved February 4, 2012, from http://www.nieuwsblad.be/article/detail.aspx?articleid=GCT2E4I2K

Attachments

Attachment 1: Calculations of the four weighting scenarios 112

Attachment 2 The weighting for different elements for speeding 115

Attachment 3 The weighting for different elements for driving under influence of alcohol 118

Attachment 4 The weighting for different elements for seat belt use 122

Attachment 1: Calculations of the four weighting scenarios

A) Equal weights

	Public support	Effectiveness	Costs
Public support	1/1	1/1	1/1
Effectiveness	1/1	1/1	1/1
Costs	1/1	1/1	1/1

Equal weights

	Public support	Effectiveness	Costs
Public support	1,0000	1,0000	1,0000
Effectiveness	1,0000	1,0000	1,0000
Costs	1,0000	1,0000	1,0000

Equal weights converted into decimals

	Public support	Effectiveness	Costs		
Public support	3,0000	3,0000	3,0000	9,0000	0,3333
Effectiveness	3,0000	3,0000	3,0000	9,0000	0,3333
Costs	3,0000	3,0000	3,0000	9,0000	0,3333
				27,0000	1
					Eigenvector (1)

Calculation of the eigenvector

B) Public support as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1/1	2/1	2/1
Effectiveness	1/2	1/1	1/1
Costs	1/2	1/1	1/1

Public support as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1,0000	2,0000	2,0000
Effectiveness	0,5000	1,0000	1,0000
Costs	0,5000	1,0000	1,0000

Public support as two times important as the other criteria converted into decimals

	Public support	Effectiveness	Costs		
Public support	3,0000	6,0000	6,0000	15,0000	0,5000
Effectiveness	1,5000	3,0000	3,0000	7,5000	0,2500
Costs	1,5000	3,0000	3,0000	7,5000	0,2500
				30,0000	1
					Eigenvector (1)

Calculation of the eigenvector

C) Effectiveness as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1/1	1/2	1/1
Effectiveness	2/1	1/1	2/1
Costs	1/1	1/2	1/1

Effectiveness as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1,0000	0,5000	1,0000
Effectiveness	2,0000	1,0000	2,0000
Costs	1,0000	0,5000	1,0000

Effectiveness as two times important as the other criteria converted into decimals

	Public support	Effectiveness	Costs		
Public support	3,0000	1,5000	3,0000	7,5000	0,2500
Effectiveness	6,0000	3,0000	6,0000	15,0000	0,5000
Costs	3,0000	1,5000	3,0000	7,5000	0,2500
				30,0000	1
					Eigenvector (1)

Calculation of the eigenvector

D) Costs as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1/1	1/1	1/2
Effectiveness	1/1	1/1	1/2
Costs	2/1	2/1	1/1

Costs as two times important as the other criteria

	Public support	Effectiveness	Costs
Public support	1,0000	1,0000	0,5000
Effectiveness	1,0000	1,0000	0,5000
Costs	2,0000	2,0000	1,0000

Costs as two times important as the other criteria converted into decimals

	Public support	Effectiveness	Costs		
Public support	3,0000	3,0000	1,5000	7,5000	0,2500
Effectiveness	3,0000	3,0000	1,5000	7,5000	0,2500
Costs	6,0000	6,0000	3,0000	15,0000	0,5000
				30,0000	1
					Eigenvector (1)

Calculation of the eigenvector

Attachment 2 The weighting for different elements for speeding

Public support:

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	2/2	2/3	2/5	2/4	2/1
ISA	3/2	3/3	3/5	3/4	3/1
Fixed cameras	5/2	5/3	5/5	5/4	5/1
Section control	4/2	4/3	4/5	4/4	4/1
Mobile speed cameras	1/2	1/3	1/5	1/4	1/1

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	0,6667	0,4000	0,5000	2,0000
ISA	1,5000	1,0000	0,6000	0,7500	3,0000
Fixed cameras	2,5000	1,6667	1,0000	1,2500	5,0000
Section control	2,0000	1,3333	0,8000	1,0000	4,0000
Mobile speed cameras	0,5000	0,3333	0,2000	0,2500	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	0,6667	0,4000	0,5000	2,0000
ISA	1,5000	1,0000	0,6000	0,7500	3,0000
Fixed cameras	2,5000	1,6667	1,0000	1,2500	5,0000
Section control	2,0000	1,3333	0,8000	1,0000	4,0000
Mobile speed cameras	0,5000	0,3333	0,2000	0,2500	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	5,0000	3,3333	2,0000	2,5000	10,0000	22,8333	0,1333
ISA	7,5000	5,0000	3,0000	3,7500	15,0000	34,2500	0,2000
Fixed cameras	12,5000	8,3333	5,0000	6,2500	25,0000	57,0833	0,3333
Section control	10,0000	6,6667	4,0000	5,0000	20,0000	45,6667	0,2667
Mobile speed cameras	2,5000	1,6667	1,0000	1,2500	5,0000	11,4167	0,0667
						171,25	1
							Eigenvector (1)

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	3,3333	2,0000	2,5000	10,0000
ISA	7,5000	5,0000	3,0000	3,7500	15,0000
Fixed cameras	12,5000	8,3333	5,0000	6,2500	25,0000
Section control	10,0000	6,6667	4,0000	5,0000	20,0000
Mobile speed cameras	2,5000	1,6667	1,0000	1,2500	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	3,3333	2,0000	2,5000	10,0000
ISA	7,5000	5,0000	3,0000	3,7500	15,0000
Fixed cameras	12,5000	8,3333	5,0000	6,2500	25,0000
Section control	10,0000	6,6667	4,0000	5,0000	20,0000
Mobile speed cameras	2,5000	1,6667	1,0000	1,2500	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	83,3333	50,0000	62,5000	250,0000	570,8333	0,1333
ISA	187,5000	125,0000	75,0000	93,7500	375,0000	856,2500	0,2000
Fixed cameras	312,5000	208,3333	125,0000	156,2500	625,0000	1427,0833	0,3333
Section control	250,0000	166,6667	100,0000	125,0000	500,0000	1141,6667	0,2667
Mobile speed cameras	62,5000	41,6667	25,0000	31,2500	125,0000	285,4167	0,0667
						4281,2500	1
							Eigenvector (2)

Effectiveness:

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	2/2	2/4	2/3	2/5	2/1
ISA	4/2	4/4	4/3	4/5	4/1
Fixed cameras	3/2	3/4	3/3	3/5	3/1
Section control	5/2	5/4	5/3	5/5	5/1
Mobile speed cameras	1/2	1/4	1/3	1/5	1/1

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	0,5000	0,6667	0,4000	2,0000
ISA	2,0000	1,0000	1,3333	0,8000	4,0000
Fixed cameras	1,5000	0,7500	1,0000	0,6000	3,0000
Section control	2,5000	1,2500	1,6667	1,0000	5,0000
Mobile speed cameras	0,5000	0,2500	0,3333	0,2000	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	0,5000	0,6667	0,4000	2,0000
ISA	2,0000	1,0000	1,3333	0,8000	4,0000
Fixed cameras	1,5000	0,7500	1,0000	0,6000	3,0000
Section control	2,5000	1,2500	1,6667	1,0000	5,0000
Mobile speed cameras	0,5000	0,2500	0,3333	0,2000	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	5,0000	2,5000	3,3333	2,0000	10,0000	22,8333	0,1333
ISA	10,0000	5,0000	6,6667	4,0000	20,0000	45,6667	0,2667
Fixed cameras	7,5000	3,7500	5,0000	3,0000	15,0000	34,2500	0,2000
Section control	12,5000	6,2500	8,3333	5,0000	25,0000	57,0833	0,3333
Mobile speed cameras	2,5000	1,2500	1,6667	1,0000	5,0000	11,4167	0,0667
						171,25	1
							Eigenvector (1)

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	2,5000	3,3333	2,0000	10,0000
ISA	10,0000	5,0000	6,6667	4,0000	20,0000
Fixed cameras	7,5000	3,7500	5,0000	3,0000	15,0000
Section control	12,5000	6,2500	8,3333	5,0000	25,0000
Mobile speed cameras	2,5000	1,2500	1,6667	1,0000	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	2,5000	3,3333	2,0000	10,0000
ISA	10,0000	5,0000	6,6667	4,0000	20,0000
Fixed cameras	7,5000	3,7500	5,0000	3,0000	15,0000
Section control	12,5000	6,2500	8,3333	5,0000	25,0000
Mobile speed cameras	2,5000	1,2500	1,6667	1,0000	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	62,5000	83,3333	50,0000	250,0000	570,8333	0,1333
ISA	250,0000	125,0000	166,6667	100,0000	500,0000	1141,6667	0,2667
Fixed cameras	187,5000	93,7500	125,0000	75,0000	375,0000	856,2500	0,2000
Section control	312,5000	156,2500	208,3333	125,0000	625,0000	1427,0833	0,3333
Mobile speed cameras	62,5000	31,2500	41,6667	25,0000	125,0000	285,4167	0,0667
						4281,2500	1
							Eigenvector (2)

Costs:

Costs 1	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5/5	5/1	5/2	5/3	5/4
ISA	1/5	1/1	1/2	1/3	1/4
Fixed cameras	2/5	2/1	2/2	2/3	2/4
Section control	3/5	3/1	3/2	3/3	3/4
Mobile speed cameras	4/5	4/1	4/2	4/3	4/4

Costs 2	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5/5	5/4	5/3	5/1	5/2
ISA	4/5	4/4	4/3	4/1	4/2
Fixed cameras	3/5	3/4	3/3	3/1	3/2
Section control	1/5	1/4	1/3	1/1	1/2
Mobile speed cameras	2/5	2/4	2/3	2/1	2/2

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	5,0000	2,5000	1,6667	1,2500
ISA	0,2000	1,0000	0,5000	0,3333	0,2500
Fixed cameras	0,4000	2,0000	1,0000	0,6667	0,5000
Section control	0,6000	3,0000	1,5000	1,0000	0,7500
Mobile speed cameras	0,8000	4,0000	2,0000	1,3333	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	1,2500	1,6667	5,0000	2,5000
ISA	0,8000	1,0000	1,3333	4,0000	2,0000
Fixed cameras	0,6000	0,7500	1,0000	3,0000	1,5000
Section control	0,2000	0,2500	0,3333	1,0000	0,5000
Mobile speed cameras	0,4000	0,5000	0,6667	2,0000	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	6,9167	34,5833	17,2917	11,5278	8,6458	78,9653	0,3343
ISA	5,5333	27,6667	13,8333	9,2222	6,9167	63,1722	0,2674
Fixed cameras	4,1500	20,7500	10,3750	6,9167	5,1875	47,3792	0,2006
Section control	0,7300	6,9167	3,4583	2,3056	1,7292	15,1397	0,0641
Mobile speed cameras	2,7667	13,8333	6,9167	4,6111	3,4583	31,5861	0,1337
						236,2425	

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5/5	5/4	5/3	5/1	5/2
ISA	4/5	4/4	4/3	4/1	4/2
Fixed cameras	3/5	3/4	3/3	3/1	3/2
Section control	1/5	1/4	1/3	1/1	1/2
Mobile speed cameras	2/5	2/4	2/3	2/1	2/2

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	1,2500	1,6667	5,0000	2,5000
ISA	0,8000	1,0000	1,3333	4,0000	2,0000
Fixed cameras	0,6000	0,7500	1,0000	3,0000	1,5000
Section control	0,2000	0,2500	0,3333	1,0000	0,5000
Mobile speed cameras	0,4000	0,5000	0,6667	2,0000	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	1,0000	1,2500	1,6667	5,0000	2,5000
ISA	0,8000	1,0000	1,3333	4,0000	2,0000
Fixed cameras	0,6000	0,7500	1,0000	3,0000	1,5000
Section control	0,2000	0,2500	0,3333	1,0000	0,5000
Mobile speed cameras	0,4000	0,5000	0,6667	2,0000	1,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	5,0000	6,2500	8,3333	25,0000	12,5000	57,0833	0,3333
ISA	4,0000	5,0000	6,6667	20,0000	10,0000	45,6667	0,2667
Fixed cameras	3,0000	3,7500	5,0000	15,0000	7,5000	34,2500	0,2000
Section control	1,0000	1,2500	1,6667	5,0000	2,5000	11,4167	0,0667
Mobile speed cameras	2,0000	2,5000	3,3333	10,0000	5,0000	22,8333	0,1333
						171,25	1
							Eigenvector (1)

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	6,2500	8,3333	25,0000	12,5000
ISA	4,0000	5,0000	6,6667	20,0000	10,0000
Fixed cameras	3,0000	3,7500	5,0000	15,0000	7,5000
Section control	1,0000	1,2500	1,6667	5,0000	2,5000
Mobile speed cameras	2,0000	2,5000	3,3333	10,0000	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras
Public campaigns	5,0000	6,2500	8,3333	25,0000	12,5000
ISA	4,0000	5,0000	6,6667	20,0000	10,0000
Fixed cameras	3,0000	3,7500	5,0000	15,0000	7,5000
Section control	1,0000	1,2500	1,6667	5,0000	2,5000
Mobile speed cameras	2,0000	2,5000	3,3333	10,0000	5,0000

	Public campaigns	ISA	Fixed cameras	Section control	Mobile speed cameras		
Public campaigns	125,0000	156,2500	208,3333	625,0000	312,5000	1427,0833	0,3333
ISA	100,0000	125,0000	166,6667	500,0000	250,0000	1141,6667	0,2667
Fixed cameras	75,0000	93,7500	125,0000	375,0000	187,5000	856,2500	0,2000
Section control	25,0000	31,2500	41,6667	125,0000	62,5000	285,4167	0,0667
Mobile speed cameras	50,0000	62,5000	83,3333	250,0000	125,0000	570,8333	0,1333
						4281,2500	1
							Eigenvector (2)

Attachment 3 The weighting for different elements for driving under influence of alcohol

Public support:

	Public campaigns	AIID	Alcohol controls
Public campaigns	2/2	2/1	2/3
AIID	1/2	1/1	1/3
Alcohol controls	3/2	3/1	3/3

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	2,0000	0,6667
AIID	0,5000	1,0000	0,3333
Alcohol controls	1,5000	3,0000	1,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	2,0000	0,6667
AIID	0,5000	1,0000	0,3333
Alcohol controls	1,5000	3,0000	1,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	3,0000	6,0000	2,0000	11,0000	0,3333
AIID	1,5000	3,0000	1,0000	5,5000	0,1667
Alcohol controls	4,5000	9,0000	3,0000	16,5000	0,5000
				33,0000	1
					Eigenvector (1)

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	6,0000	2,0000
AIID	1,5000	3,0000	1,0000
Alcohol controls	4,5000	9,0000	3,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	6,0000	2,0000
AIID	1,5000	3,0000	1,0000
Alcohol controls	4,5000	9,0000	3,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	54,0000	18,0000	99,0000	0,3333
AIID	13,5000	27,0000	9,0000	49,5000	0,1667
Alcohol controls	40,5000	81,0000	27,0000	148,5000	0,5000
				297,0000	1
					Eigenvector (2)

Effectiveness:

	Public campaigns	AIID	Alcohol controls
Public campaigns	3/3	3/2	3/1
AIID	2/3	2/2	2/1
Alcohol controls	1/3	1/2	1/1

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	1,5000	3,0000
AIID	0,6667	1,0000	2,0000
Alcohol controls	0,3333	0,5000	1,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	1,5000	3,0000
AIID	0,6667	1,0000	2,0000
Alcohol controls	0,3333	0,5000	1,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	3,0000	4,5000	9,0000	16,5000	0,5000
AIID	2,0000	3,0000	6,0000	11,0000	0,3333
Alcohol controls	1,0000	1,5000	3,0000	5,5000	0,1667
				33,0000	1
					Eigenvector (1)

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	4,5000	9,0000
AIID	2,0000	3,0000	6,0000
Alcohol controls	1,0000	1,5000	3,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	4,5000	9,0000
AIID	2,0000	3,0000	6,0000
Alcohol controls	1,0000	1,5000	3,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	40,5000	81,0000	148,5000	0,5000
AIID	18,0000	27,0000	54,0000	99,0000	0,3333
Alcohol controls	9,0000	13,5000	27,0000	49,5000	0,1667
				297,0000	1
					Eigenvector (2)

Costs:

Costs 1	Public campaigns	AIID	Alcohol controls
Public campaigns	3/3	3/1	3/2
AIID	1/3	1/1	1/2
Alcohol controls	2/3	2/1	2/2

Costs 2	Public campaigns	AIID	Alcohol controls
Public campaigns	2,5/2,5	2,5/2,5	2,5/1
AIID	2,5/2,5	2,5/2,5	2,5/1
Alcohol controls	1/2,5	1/2,5	1/1

Costs 1	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	3,0000	1,5000
AIID	0,3333	1,0000	0,5000
Alcohol controls	0,6667	2,0000	1,0000

Costs 2	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	1,0000	2,5000
AIID	1,0000	1,0000	2,5000
Alcohol controls	0,4000	0,4000	1,0000

Total costs	Public campaigns	AIID	Alcohol controls		
Public campaigns	3,0000	4,6000	4,5000	12,1000	0,3735
AIID	3,0000	1,5333	3,8333	8,3667	0,2582
Alcohol controls	1,2000	3,0667	7,6667	11,9333	0,3683
				32,4000	1

	Public campaigns	AIID	Alcohol controls
Public campaigns	3/3	3/1	3/2
AIID	1/3	1/1	1/2
Alcohol controls	2/3	2/1	2/2

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	3,0000	1,5000
AIID	0,3333	1,0000	0,5000
Alcohol controls	0,6667	2,0000	1,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	1,0000	3,0000	1,5000
AIID	0,3333	1,0000	0,5000
Alcohol controls	0,6667	2,0000	1,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	3,0000	9,0000	4,5000	16,5000	0,5000
AIID	1,0000	3,0000	1,5000	5,5000	0,1667
Alcohol controls	2,0000	6,0000	3,0000	11,0000	0,3333
				33,0000	1
					Eigenvector (1)

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	9,0000	4,5000
AIID	1,0000	3,0000	1,5000
Alcohol controls	2,0000	6,0000	3,0000

	Public campaigns	AIID	Alcohol controls
Public campaigns	3,0000	9,0000	4,5000
AIID	1,0000	3,0000	1,5000
Alcohol controls	2,0000	6,0000	3,0000

	Public campaigns	AIID	Alcohol controls		
Public campaigns	27,0000	81,0000	40,5000	148,5000	0,5000
AIID	9,0000	27,0000	13,5000	49,5000	0,1667
Alcohol controls	18,0000	54,0000	27,0000	99,0000	0,3333
				297,0000	1
					Eigenvector (2)

Attachment 4 The weighting for different elements for seat belt use

Public support:

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1/1	1/3	1/2
Seat belt reminder	3/1	3/3	3/2
Seat belt controls	2/1	2/3	2/2

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	0,3333	0,5000
Seat belt reminder	3,0000	1,0000	1,5000
Seat belt controls	2,0000	0,6667	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	0,3333	0,5000
Seat belt reminder	3,0000	1,0000	1,5000
Seat belt controls	2,0000	0,6667	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	3,0000	1,0000	1,5000	5,5000	0,1667
Seat belt reminder	9,0000	3,0000	4,5000	16,5000	0,5000
Seat belt controls	6,0000	2,0000	3,0000	11,0000	0,3333
				33,0000	1
					Eigenvector (1)

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	1,0000	1,5000
Seat belt reminder	9,0000	3,0000	4,5000
Seat belt controls	6,0000	2,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	1,0000	1,5000
Seat belt reminder	9,0000	3,0000	4,5000
Seat belt controls	6,0000	2,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	9,0000	13,5000	49,5000	0,1667
Seat belt reminder	81,0000	27,0000	40,5000	148,5000	0,5000
Seat belt controls	54,0000	18,0000	27,0000	99,0000	0,3333
				297,0000	1
					Eigenvector (2)

Effectiveness:

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	2/2	2/3	2/1
Seat belt reminder	3/2	3/3	3/1
Seat belt controls	1/2	1/3	1/1

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	0,6667	2,0000
Seat belt reminder	1,5000	1,0000	3,0000
Seat belt controls	0,5000	0,3333	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	0,6667	2,0000
Seat belt reminder	1,5000	1,0000	3,0000
Seat belt controls	0,5000	0,3333	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	3,0000	2,0000	6,0000	11,0000	0,3333
Seat belt reminder	4,5000	3,0000	9,0000	16,5000	0,5000
Seat belt controls	1,5000	1,0000	3,0000	5,5000	0,1667
				33,0000	1
					Eigenvector (1)

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	2,0000	6,0000
Seat belt reminder	4,5000	3,0000	9,0000
Seat belt controls	1,5000	1,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	2,0000	6,0000
Seat belt reminder	4,5000	3,0000	9,0000
Seat belt controls	1,5000	1,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	18,0000	54,0000	99,0000	0,3333
Seat belt reminder	40,5000	27,0000	81,0000	148,5000	0,5000
Seat belt controls	13,5000	9,0000	27,0000	49,5000	0,1667
				297,0000	1
					Eigenvector (2)

Costs:

Costs 1	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	2/2	2/1	2/3
Seat belt reminder	1/2	1/1	1/3
Seat belt controls	3/2	3/1	3/3

Costs 2	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	2,5/2,5	2,5/2,5	2,5/1
Seat belt reminder	2,5/2,5	2,5/2,5	2,5/1
Seat belt controls	1/2,5	1/2,5	1/1

Costs 1	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	2,0000	0,6667
Seat belt reminder	0,5000	1,0000	0,3333
Seat belt controls	1,5000	3,0000	1,0000

Costs 2	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	1,0000	2,5000
Seat belt reminder	1,0000	1,0000	2,5000
Seat belt controls	0,4000	0,4000	1,0000

Total costs	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	5,2500	3,2667	3,5000	12,0167	0,2845
Seat belt reminder	5,2500	1,6333	4,0833	10,9667	0,2597
Seat belt controls	2,1000	4,9000	12,2500	19,2500	0,4558
				42,2333	1

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	2/2	2/1	2/3
Seat belt reminder	1/2	1/1	1/3
Seat belt controls	3/2	3/1	3/3

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	2,0000	0,6667
Seat belt reminder	0,5000	1,0000	0,3333
Seat belt controls	1,5000	3,0000	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	1,0000	2,0000	0,6667
Seat belt reminder	0,5000	1,0000	0,3333
Seat belt controls	1,5000	3,0000	1,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	3,0000	6,0000	2,0000	11,0000	0,3333
Seat belt reminder	1,5000	3,0000	1,0000	5,5000	0,1667
Seat belt controls	4,5000	9,0000	3,0000	16,5000	0,5000
				33,0000	1
					Eigenvector (1)

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	6,0000	2,0000
Seat belt reminder	1,5000	3,0000	1,0000
Seat belt controls	4,5000	9,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls
Public campaigns	3,0000	6,0000	2,0000
Seat belt reminder	1,5000	3,0000	1,0000
Seat belt controls	4,5000	9,0000	3,0000

	Public campaigns	Seat belt reminder	Seat belt controls		
Public campaigns	27,0000	54,0000	18,0000	99,0000	0,3333
Seat belt reminder	13,5000	27,0000	9,0000	49,5000	0,1667
Seat belt controls	40,5000	81,0000	27,0000	148,5000	0,5000
				297,0000	1
					Eigenvector (2)

Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
Amenability to treatment for various traffic safety problems

Richting: **master in de verkeerskunde-verkeersveiligheid**
Jaar: **2012**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

Kopmanis, Caroline

Datum: **24/08/2012**