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Europe (EU28) vs. Norway - Assessment of Socio-economic Impact of In-vehicle Emergency Call (eCall)

Ann-Helen Brembo

Master of Science in Communication Technology
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Supervisor: Kjersti Moldeklev, ITEM

Norwegian University of Science and Technology
Department of Telematics

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Student: Ann-Helen Brembo

Problem description:

The European Union (EU) passed in 2014 a regulation to implement eCall, a pan-European emergency system, which automatically reports an accident from the vehicle to an emergency centre, based on the existing E112 system. A device and sensors are installed in vehicles, and in the event of an accident, detected by the sensors, the in-vehicle device calls the emergency centre automatically. The call includes a minimum set of data, e.g. the exact location of the crash site. In 2015, Norway incorporated the eCall initiative into their EEA agreement, after being involved in the effort since 2005.

The EU based their decision on an impact assessment done in 2011 which states that the mandatory introduction of eCall will be socio-economically beneficial. According to the study's calculations, the reduction in deaths will be between 1% and 10%, and for severe injuries a 2% to 15% reduction for the initiative as a whole. To ensure the provision of accurate and reliable positioning information for the eCall in-vehicle system, the EU has required compatibility with the services provided by the Galileo and European Geostationary Navigation Overlay Service (EGNOS) programmes.

This thesis will consist of three parts. First, a high-level review of European eCall impact assessments. Then, a more detailed review of the eCall impact assessment from 2011, also from a more technical standpoint. The thesis will evaluate the parameters and values for the calculation of socio-economical benefit, analyse the accuracy and reliability demands for the positioning information, and review the benefits appropriated to the positioning information.

In the second part, the thesis will apply the impact assessment of eCall to Norwegian conditions, evaluate the validity of the impact assessment's parameters and values for these conditions, and suggest potential changes.

Finally, the thesis will assess the suitability of using The Norwegian Public Roads Administration's evaluation tool for ITS measures, "Verktøy for beregning av ITS-tiltak," in the case of eCall.

Responsible professor/Supervisor: Kjersti Moldeklev, ITEM

Abstract

In 2018, the emergency service eCall, based on the E112 initiative, will be implemented throughout the European Union (EU) and the European Economic Area (EEA). In the event of a traffic accident, the in-vehicle system will automatically create a communication channel with the nearest emergency response centre. The system will also send a minimum set of data which includes the vehicle's location, what sensor in the vehicle that was activated, and more. The purpose of the emergency service is to reduce the consequences of traffic accidents by improving the response time of emergency services.

Since, the introduction of the eCall project, the EU and several member states have conducted studies to determine the socio-economic impact of the service for society. Through literature studies, this thesis has reviewed a selection of these studies and compared them in term of results, methods, and models. Most of the studies results are not that accurate since the framework of the eCall system was completed after their publication.

In 2011, the European Commission (EC) created their own impact assessment of eCall. This study was the basis for the decision to make the introduction of eCall mandatory in the EU and EEA. A thorough evaluation of the EC's impact assessment has been conducted in this thesis. The model used for the benefit-cost analysis was reviewed together with the main benefit and cost parameters. The thesis also looked at the technical aspects included and excluded from the study. Even tough the study is more pessimistic than earlier reports some parameters are still too optimistic. As for the technical part, very few aspects are included in the assessment. The system is just assumed to be fully operational.

As part of the EEA, Norway is obligated to implement the eCall service. However, very few analyses have included this country. This thesis has therefore conducted a benefit-cost analysis utilising the model of the EC's impact assessment with modifications to fit it to Norwegian conditions. In an overall perspective, eCall might be beneficial for Norway. However, a sensitivity analysis showed that small changes to the estimated reductions can render eCall unbeneficial for Norway.

The Norwegian Public Roads Administration have their own evaluation tool for ITS measures. This thesis assessed the tool's suitability for the eCall service in its current version and suggested potential changes.

Sammendrag

I 2018 vil den nye nødtjenesten eCall, basert på E112-initiativet, bli implementert i hele den Europeiske Union og det Europeiske Økonomiske Samarbeidsområde. Ved en trafikkulykke vil systemet i kjøretøyet opprette en kommunikasjonskanal med den nærmeste alarmsentralen. Systemet vil også sende et minimumsdatasett som inkluderer kjøretøyets posisjon, hvilken sensor i kjøretøyet som ble utløst og lignende. Målet med nødtjenesten er å redusere konsekvensene av trafikkulykker ved å forbedre responstiden til nødetatene.

Siden introduksjonen av eCall-prosjektet har EU og flere medlemsland gjennomført studier for å bestemme den sosioøkonomiske innvirkningen av tjenesten på samfunnet. Gjennom litteraturstudier har denne oppgaven vurdert et utvalg av disse studiene og sammenlignet dem i forhold til resultater, metoder og modeller. De fleste av studienes resultater er ikke så nøyaktige da rammeverket til eCall-systemet ble fullført etter deres publikasjon.

I 2011 utførte den Europeiske Kommisjon sin egen konsekvensutredning av eCall. Denne studien var grunnlaget for avgjørelsen om å gjøre introduksjonen av eCall obligatorisk for EU og EØS. En grundig evaluering av Kommisjonens konsekvensutredning har blitt gjennomført i denne oppgaven. Modellen brukt i nytte-kost-analysen ble vurdert sammen med hovedparameterne av nytte og kost. Oppgaven har også sett på det tekniske aspektet inkludert og ekskludert fra studien. Selv om studien er mer pessimistisk enn tidligere rapporter er det noen parametere som fortsatt er for optimistiske. Når det gjelder den tekniske delen har veldig få aspekter blitt inkludert i vurderingen. Det antas bare at systemet er fullt operativt.

Som en del av EØS er Norge forpliktet til å implementere eCall-tjenesten. Men veldig få analyser omfatter dette landet. I oppgaven har det derfor blitt gjennomført en nytte-kost-analyse ved å bruke modellen fra Kommisjonens konsekvensanalyse med endringer for å tilpasse den til norske forhold. I et overordnet perspektiv kan eCall være nyttig for Norge, men en sensitivitetsanalyse viste at små endringer i reduksjonsestimatene kan gjøre eCall ugunstig for Norge.

Statens Vegvesen har deres eget vurderingsverktøy for ITS-tiltak. Oppgaven vurderte verktøyets egnethet for eCall-tjenesten i den nåværende versjon, og foreslo mulige endringer.

Preface

This masters' thesis is the final work of my Master of Science in Communication Technology at the Norwegian University of Science and Technology (NTNU). My specialisation has been in the field of ICT economics at the Department of Telematics (ITEM).

First, I would like to thank my supervisor and responsible professor Kjersti Moldeklev for her guidance and invaluable input throughout this thesis.

I would also like to thank the fabulous women at Casa Rosa for their good humour and support through the last year. It would not have been the same without you. And, a final thanks to Torres for inspiration when words were hard to find.

"Think, think, think."

by A.A. Milne, Winnie-the-Pooh

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List of Acronyms

AINO AINO study on Impacts of an automatic emergency call system on accident consequences.

BCR Benefit-Cost Ratio.

EC European Commission.

EC IA European Commission's Impact Assessment on eCall.

EEA European Economic Area.

EGNOS European Geostationary Navigation Overlay Service.

eIMPACT Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems in Europe – Deliverable D6.

E-MERGE Pan-European Harmonisation of Vehicle Emergency Call Service Chain.

EU European Union.

Euro NCAP The European New Car Assessment Programme.

GNSS Global Navigation Satellite System.

ITS Intelligent Transportation Systems.

IVS In-Vehicle System.

IVSS Intelligent Vehicle Safety Systems.

MNO Mobile Network Operator.

MoU Memorandum of Understanding.

MSD Minimum Set of Data.

PSAP Public Safety Answering Point.

SEiSS Socio-Economic impact of intelligent Safety Systems.

SMART Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/legal issues.

STORM Stuttgart Transport Operation by Regional Management project.

Swedish Ekonomisk värdering av eCall i Sverige.

TØI Institute of Transport Economics Norwegian Centre for Transport Research.

UK report eCall UK 2013 Review and Appraisal.

Chapter 1
Introduction

1.1 Motivation

During the last decade, there has been a significant evolution in road safety. New Intelligent Transportation Systems (ITS) are continuously developed, and the knowledge among people of the risks and consequences when it comes to road transport has increased. However, there are still accidents and casualties.

Traffic safety work in Norway is based on a zero-vision. No accidents with any fatalities or severe injuries should occur in road traffic. In 2014, a national transport plan was presented with the goal that there should be maximum 500 fatalities and severe injuries in the road traffic of Norway in 2024 [6].

There are similar visions and targets in Europe. The European Union (EU) established the eSafety Initiative to work on and review different ITS measures to improve road safety. One of these measures was the Pan-European eCall system, which is thought to decrease response time for emergency services in the case of an accident, and with this reduce the number of fatalities and the severity of injuries. In 2014, the EC decided to make the introduction of the eCall system mandatory for all member states after several reports evaluated the system to be beneficial for society. Norway followed in 2015 and incorporated eCall in the EEA agreement [7].

All the reports and projects evaluating the eCall system have been conducted on various basis' and at different times. For Norway, no review on a national level has been done since 2006. The Institute of Transport Economics Norwegian Centre for Transport Research (TØI) has developed a tool to review different ITS measures and their benefit for Norwegian roads based on the ITS Handbook for Norway from 2011 [8]. However, eCall arrived at the scene after this was published.

Are the evaluations done of the eCall system in 2011 still applicable? Moreover, is the system suitable for Norwegian conditions?

1.2 Objective and Scope

There are three primary objectives for this thesis, all presented in the project description:

- To review and evaluate reports on eCall, with the main focus on the impact assessment from 2011.
- To apply the 2011 impact assessment to Norwegian conditions.
- To assess the suitability of the evaluation tool of ITS measures, made by TØI, for the eCall system.

When the European Commission's Impact Assessment on eCall (EC IA) was applied to Norwegian conditions, the data available for the EU and Norway differed. Assumptions for Norway were made based on data from the EU as national data was not available.

1.3 Methodology

For this thesis the methodologies used can be divided into two parts: literature study and socio-economic calculations. In this section, these two are explained below.

1.3.1 Literature study

To investigate the topics presented in the project description a literature study was conducted. The main part of the literature study was connected to the first part of the thesis. When reviewing the impact assessments conducted on eCall a literature study was used to identify the assessments that had been completed, and then the most relevant ones were chosen for the review. The main source of information has been written reports and articles, but essential information has also been collected through personal correspondence with the Norwegian Public Roads Administration [9, 10].

1.3.2 Socio-economic calculations

For the second part of the thesis several socio-economic calculations were conducted. The main method was a benefit-cost analysis which was completed with different parameters to estimate the Benefit-Cost Ratio (BCR) for eCall in Norwegian conditions. A sensitivity analysis was done on the result from the benefit-cost analysis as well as a break-even analysis.

This thesis will utilise the term benefit-cost analysis instead of cost-benefit analysis because the focus of the work is primarily on the benefits, not the costs.

1.4 Contribution

The main contribution of this thesis is the socio-economic analysis of eCall for Norwegian conditions. Hopefully, this will give a clearer picture of the possible benefits and costs of eCall for the Norwegian implementation.

1.5 Outline

This thesis is structured into seven chapters, and the outline is as follows:

- Chapter 1 - Introduction: presents the motivation and objective for the thesis. In addition, the chapter includes scope, methodology, and contribution.
- Chapter 2 - Background: explains the eCall system and EU's intention with this system. A timeline is also presented describing the evolution of the eCall system and the related work of this thesis.
- Chapter 3 - Summary and High-level Review of Impact Assessments: evaluates different impact assessments of eCall, through analysis and review according to specific parameters. Their accuracy is also evaluated.
- Chapter 4 - Review of the European Commission's Impact Assessment on eCall (EC IA): investigates the EC IA in detail. Two aspects are considered: the benefit-cost analysis and the technical side. For the benefit-cost analysis, all the parameters are reviewed as well as the model used for the analysis. The technical assessment evaluates estimates and assumptions made in the assessment.
- Chapter 5 - Benefit-Cost Analysis for Norwegian Conditions: takes the model from the EC IA and applies it to Norwegian conditions, statistics, and estimates. Different parameters are evaluated to find the most realistic estimate for Norway regarding eCall. The chapter also includes a sensitivity analysis and a break-even analysis.
- Chapter 6 - Evaluation of the ITS tool, "Verktøy for virkningsberegninger av ITS-tiltak", developed by TØI: investigates the possibility to apply the ITS tool to eCall and suggest potential changes.
- Chapter 7 - Concluding Remarks and Further Work: summarises and concludes the thesis as well as suggests further work.

Chapter 2

Background

2.1 What is eCall?

In the European Union (EU), the existing emergency initiative is the E112. The point of this initiative is to have the same emergency number throughout the EU. Today all 28 member states have 112 as their emergency number, as well as other countries in Europe and elsewhere [11].

eCall is an emergency system for vehicles based on the E112 system [1]. Vehicles equipped with eCall will have an In-Vehicle System (IVS) installed. The IVS consists of a communication platform and sensors. In the case of an accident registered by the sensors, the eCall system will be activated and automatically call the nearest emergency centre or Public Safety Answering Point (PSAP). With the establishment of the E112 eCall a Minimum Set of Data (MSD) is also sent to the PSAP, including the vehicle's location, travel direction and some information about the vehicle itself. The eCall system can also be activated manually.

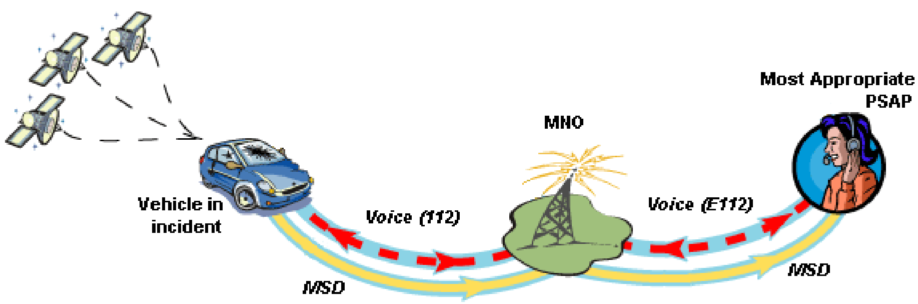

Figure 2.1: Illustration of the eCall process. Source [1]

2.2 EU's intention

One of EU's priorities for over 10 years has been road safety. In 2002, the eSafety Initiative was launched by the European Commission (EC). The idea for the initiative was to accelerate the deployment of different information and communication technology safety systems [12]. In 2009, the cost to society for the about 1.15 million traffic accidents on roads in the EU was approximately 160 billion EUR. More than 1.5 million people were injured and around 35 000 were killed [2].

eCall is one of the services that the eSafety initiative introduced to reduce the number of deaths and injuries on European roads [12]. Other services were introduced to reduce the number of accidents, while the purpose of eCall is to reduce the consequences and outcomes of accidents.

2.3 Timeline and related work

Since the presentation of a European eCall project in 2001 [13], there has been numerous projects, studies, and reports on the impact the system could have on society. Several of the projects were on call from the European Commission (EC) and the eSafety Initiative, while others were projects at national levels. All of them leading to the decision made in 2014 on the mandatory introduction of eCall in the European Union [14].

A compiled timeline from the beginning of eCall to the point when the system should be fully operational is presented in Figure 2.2. It includes a selection of the studies that have been conducted throughout the years. Most of them will be reviewed in Chapter 3.

After the introduction of eCall, the eCall Driving Group was established in 2002 to work on the specifications of the system. Parallel projects, like E-MERGE, looked more at the socio-economic aspects of the system. When the work of the Driving Group was finished in 2006, the European Commission asked the Member States to sign a Memorandum of Understanding (MoU) to state their intention to implement eCall in their country. Norway signed the MoU together with eight other European countries [15].

Unfortunately, the implementation went too slow. All the stakeholders waited on each other to make the necessary investments. So, the system was subject to market failure, which means that the resources in the free market were allocated inefficiently [16]. According to the EC IA the market failures in the case of eCall were: market prices that did not reflect the real costs and benefits to society, the public emergency response infrastructure was insufficiently upgraded, and markets were missing (service offered only in member states with clear business cases) [2].

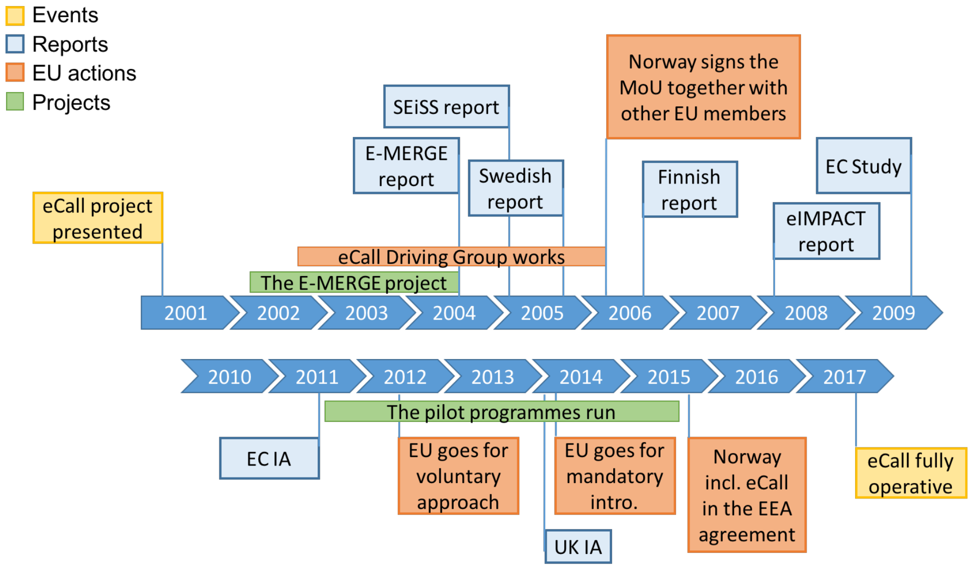

Figure 2.2: Timeline presenting eCall projects conducted from the EC's introduction of eCall until deployment

The market failure and slow market penetration were the reasons why the EC, in the end, went for the mandatory introduction of eCall. This decision was based on the Impact Assessment done in 2011 which will be evaluated in Chapter 4.

Chapter 3

Summary and High-level Review of eCall Assessments

This chapter will give a high-level review of different impact assessments done of eCall and conclude with a comparison of the evaluated reports. The focus will be on the information foundation, assumptions, parameters, and the calculation of the Benefit-Cost Ratio (BCR). More detailed summaries of the reports can be found in Appendix A. These studies were chosen because the European Commission's Impact Assessment of 2011 is based on them, and use their results in its calculations.

The studies to be reviewed are:

- Pan-European Harmonisation of Vehicle Emergency Call Service Chain (E-MERGE) by ERTICO – ITS Europe, 2004
- Socio-Economic impact of intelligent Safety Systems (SEiSS) by VDI/VDE Innovation + Technik GmbH and Institue for Transport Economics at the University of Cologne, 2005
- Ekonomisk värdering av eCall i Sverige (Swedish) by the Swedish Road Administration, 2006
- AINO study on Impacts of an automatic emergency call system on accident consequences (AINO) by the VTT Technical Research Centre of Finland, 2006
- Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems in Europe – Deliverable D6 (eIMPACT) by the eIMPACT Consortium, 2008
- Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/legal issues (SMART) by TRL (UK), Inter-utXXI (Hungary), TNO (Netherlands), VTT (Finland), ERITCO (Belgium), eSafetyAware (Belgium), Vrije University (Netherlands), 2009

Most of the studies conduct a benefit-cost analysis to evaluate whether the eCall system is beneficial. By dividing the benefits over the costs, the ratio will indicate whether or not eCall is worth to implement. If the ratio is one or more, then eCall is beneficial. In these studies, the main benefit parameters are:

- Reduction in fatalities - number of lives saved by eCall
- Reduction in the severity of injuries - number of mitigated severe injuries
- Reduction in accident related congestion - a result of roads being cleared more quickly due to eCall

versus the cost of In-Vehicle System (IVS) and Public Safety Answering Point (PSAP), with some variations which will be discussed in the following sections.

A particular feature with several of the reports on eCall is that they often utilise each other's information. Figure 3.1 shows the relationship between them. One significant thing to notice is that the Stuttgart Transport Operation by Regional Management project (STORM) is the basis of almost all the reports. STORM was a project in the early 1990s testing new traffic information technologies, one of them being an emergency call system [17]. The results of the project were that an automatic emergency call could potentially reduce rescue time from 13 to 8 minutes in urban areas, and from 21.2 to 11.7 minutes in rural areas [18], as shown in Figure 3.2. That is about 40%. Of the five different time periods considered, eCall is likely to have the largest effect on the detection and communication times according to the STORM project.

Many of the reports are also based on the Golden Hour principle. This principle is the following: "In emergency medicine, the golden hour refers to a time period lasting from a few minutes to several hours following traumatic injury being sustained by a casualty, during which there is the highest likelihood that prompt medical treatment will prevent death" [19]. Studies have shown that approximately 50% of fatalities occur within minutes, 30% within a couple of hours, and 20% during the following days and weeks [2].

Another thing worth noticing about these reports is that they are written at different points in time, as presented in the timeline in Figure 2.2. This means that different information about the specifications of eCall, statistical data, and information about the plans of the European Commission (EC) was available. Also, the EU went from being 15 countries to 25 countries during the time period of the reports publications. This point needs to be considered when they are compared later. To emphasise this some of the reviews specifies, for example, EU15 when they mean the 15 member states as of 2003, and EU25, meaning the member states as of 2006.

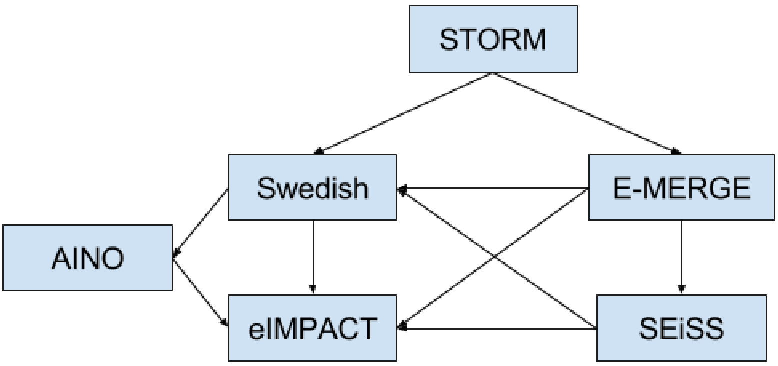

Figure 3.1: Illustration of information flow between the reviewed reports.

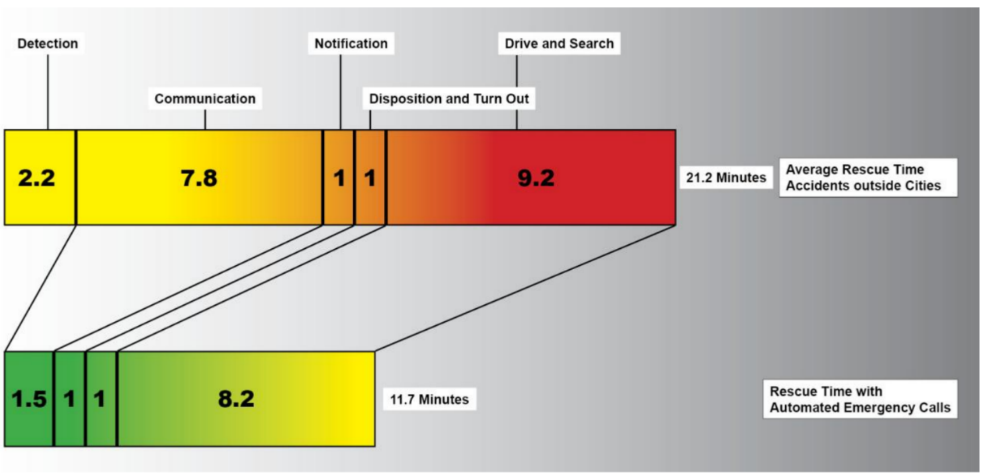

Figure 3.2: Average rescue time (minutes) outside urban areas with and without eCall. Source [2].

3.1 E-MERGE - harmonisation of the eCall service chain

One of the first major projects on eCall was the Pan-European Harmonisation of Vehicle Emergency Call Service Chain (E-MERGE) [20]. The project started in 2002 to develop, test, and validate common specifications for the eCall system. It also looked at what was needed for a European-wide take-up of the solution regarding necessary technical, organisational, and business structures. The specified requirements were user-friendliness, creating added value, and ensuring that the system worked throughout Europe. The project conducted several tests, including testing real-life conditions, in six EU countries. In all the tests experts from different PSAPs were participating by responded to a survey. It was these answers the project used as information foundation for the calculations of savings, together with the results from the STORM project.

In the report from 2004, the E-MERGE project presented the business cases for the different stakeholders, including their costs and benefits. However, no benefit-cost ratio was calculated. Instead, the project concluded that the introduction of eCall potentially could cut fatalities in road accidents with 5%, and reduce the number of severe injuries with 10% for EU15. No positive effect was foreseen for light injuries. If the Minimum Set of Data (MSD) information is available at the PSAP immediately after the crash the PSAP experts expected a 5-10% improvement in the response time of the emergency services.

The project identified three potential paths of deployment for the eCall solution; a volunteer approach, EC creates a directive on eCall or adding an extra star in the Euro NCAP. The European New Car Assessment Programme (Euro NCAP) is a voluntary programme that rates cars based on their safety by giving them stars [21].

The main impression of the report is that the project's focus was more on the technical side. The conclusions made with regards to reduction of casualties, fatalities and severe injuries, were mostly based on the experts' personal opinions rather than statistics.

3.2 SEiSS - socio-economic impact of intelligent safety systems

In 2005, the report from the Socio-Economic impact of intelligent Safety Systems (SEiSS) project was presented [22]. The European Commission (EC) initiated it with the goal to provide a survey of current approaches to assess the impact of new Intelligent Vehicle Safety Systems (IVSS), and develop a methodology to evaluate the potential impact of IVSS in Europe. The project would provide factors to estimate the socio-economical benefits of the IVSS, identify the major indicators influencing market deployment, and develop deployment scenarios for selected technologies or regions. One of the case studies was on eCall, and the objective of it was to work out the benefits and costs of an implementation at a European level.

A mix of methodologies was used in the project, consisting of desk research and expert opinion, and quantitative and qualitative data was applied: a bibliographic analysis, scanning existing literature, a series of expert interviews and workshops with representatives. The basis for the calculations made was the Golden Hour Principle of accident medicine, together with the results of the E-MERGE project and estimations made by the eSafety Driving Group. This led to the assumptions of 5-15% reduction of road fatalities to severe injuries and 10-15% of severe injuries to slight injuries. Additional assumptions were 100% penetration of eCall in passenger cars, an annual discount rate of 3%, and a reduction in congestion time of 20% in the high-impact case and 10% reduction in the low-impact case. The benefits in the analysis were all calculated for the same base year, while the costs were divided over two different analysis periods. For the In-Vehicle System (IVS), a depreciation period of 8 years was considered, whereas for the PSAP a period of 20 years was. This together with the discount rate gave the annual costs.

Table 3.1: BCR calculation of the SEiSS project.

Annual Benefits (Million €)	**Pessimistic scenario**	**Optimistic scenario**
Accident Cost Savings	5 700	21 900
Congestion Cost Savings	170	4 000
Total Benefits	5 870	25 900
Annual Cost (Million €)		
System Costs	4 500	3 000
PSAP Equipment Costs	5	3
Training Costs	45	27
Total Costs	4 550	3 030
Benefit-Cost Ratio	**1.3**	**8.5**

For the benefit-cost analysis, the SEiSS project considered two scenarios; the pessimistic view and the optimistic view. For the pessimistic view, the benefits for the low-impact case of eCall was compared with the maximum value of the costs and for the optimistic view vice versa. The Benefit-Cost Ratio (BCR) calculation of the SEiSS project can be seen in Table 3.1, and include not only accident savings, but also accident related congestion savings.

In this report, the IVS costs are called system costs and are 90-100 times bigger than the other costs. Of the benefits, the accident cost savings is the absolute biggest.

The conclusion of the project was a BCR between 1.3 and 8.5, and that even under pessimistic assumptions and hypotheses, eCall would contribute to the welfare of EU member states.

When reviewing the assumptions and parameters used for the BCR calculation in the SEiSS project, the assumption of 100% penetration, used in calculating the congestion cost savings and system costs, are not very realistic. The reason for this is that the report assumes that all vehicles will be equipped in the base year, but in reality this will take several years. Another uncertainty is the difference between the high-impact and the low-impact case. When calculating the accident cost savings, both international and European cost unit rates are used, and the difference between the two rates for avoided severe injury is 240.5%. This difference indicates that neither of the values are very good estimates, and maybe the use of an average would give a more realistic picture.

3.3 Swedish national study of eCall

Sweden made a national economic evaluation of eCall [23] using the results of the international studies E-MERGE, eSafety Driving Group and SEiSS, in combination with Swedish statistics and assessments. For the calculations, a 100% penetration rate of the vehicle fleet was assumed. This includes passenger cars, motorcycles, buses, and trucks, together with an annual discount rate of 3%, and a depreciation period of 8 years for the IVS.

The results from the international studies were 5-15% of road fatalities reduced to severe injuries, and 10-15% of severe injuries reduced to slight injuries. The Swedish assessment of the number of people saved with eCall was eight people per year. With these parameters, the study concluded that the implementation of eCall could reduce road fatalities by 2-4%, and reduce severe injuries with 3-4%. For the benefit-cost analysis, the congestion cost savings and the infrastructure costs were not included as they were considered marginal. The parameters used were the road casualty cost savings and the implementation costs of the IVS in the vehicle fleet. Casualties include both fatalities and injuries. These were the most important benefit and cost components. The BCR was then concluded to be between 1.1 and 4.2.

When analysing the study, the assumption of 100% penetration rate in the vehicle fleet can be said to be unrealistic, especially when including motorcycles since there today is no eCall system compatible with two wheel vehicles. Also, the weighting of the results from the international studies versus the Swedish evaluations when calculating the benefits is unclear.

3.4 AINO - a Finnish national study on eCall

On the request of the Ministry of Transport and Communications Finland, the organisation AINO conducted a case study in 2006 with the goal to estimate the impacts of eCall on accident consequences in Finland [24]. The data utilised were case reports from the Road Accident Investigation Teams in the period 2001-2003. The reason for the limitation in time was the level of cellular phone density, which from 2001 was considered practically maximum. Only accidents leading to fatalities were investigated in detail in Finland, so the study was limited to only traffic accident fatalities to secure 100% statistical coverage. For the reduction of injuries, the Swedish statistics from the report reviewed above were used in the calculations.

The most significant assumption made by this study was the 100% penetration of the vehicle fleet, including snowmobiles. This assumption was made because they expect the eCall system to develop so that two wheel vehicles and snowmobiles can be equipped in the future. Since this case study only includes fatalities a reduction in severe injuries of 3-4% was assumed based on Swedish estimates. An annual discount rate of 3% was also assumed.

Based on the case study it was estimated that eCall could be able to reduce 4-8% of all road fatalities. The benefit parameters include fatalities converted into injuries, milder injuries, and congestion savings. For the cost parameters, two scenarios were considered. One where it was assumed that the eCall terminal would be retrofitted in all vehicles, and another where the eCall terminal was assumed to be standard equipment for the vehicles. The main benefit components were the avoided fatalities and reduction of severity in injuries, and for the cost, the main component was the equipping of vehicles. Based on the elements mentioned above the resulting BCR for this study was 0.5-2.3.

Reviewing the assumptions and parameters what stands out is, again, the assumption of 100% penetration. However, in this study, it is taken one step further to include the whole vehicle fleet with two wheel vehicles and snowmobiles as well. Two other points which separate this report from the others are firstly the Swedish estimates used and their suitability for Finnish conditions. Secondly, in Finland and this report, the monetary values of accident costs are based on the populations willingness to pay to avoid an accident not only the cost of an accident.

3.5 eIMPACT - socio-economic impact assessment of intelligent vehicle safety systems in Europe

The Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems in Europe – Deliverable D6 (eIMPACT) started in 2006 with the objective of evaluating different Intelligent Vehicle Safety Systems (IVSS) for Europe [25]. For this analysis and review the relevant deliverable from this project is the D6; Cost-Benefit Analyses for stand-alone and co-operative Intelligent Vehicle Safety Systems, which has the objective to present the economic assessment of the IVSS on the societal level. The basis of this report is the results of previous deliverables, as well as European Transport Report 2007/2008, AINO, E-MERGE and the eCall Driving Group.

For the vehicle fleet, the eIMPACT project includes passenger cars, goods vehicles, and buses. The fleet's penetration rate is taken from the results of deliverable D4; Impact assessment of Intelligent Vehicle Safety Systems [26] and is set to be 0.1-0.3% in 2010 and 35.6-49.8% in 2020. A discount rate of 3% is also assumed, together with an inflation rate of 2% to express all the values in the report in the year 2008 prices. In the benefit-cost analysis, the parameter of the infrastructure cost was the mean of the values from the AINO and SEiSS studies and the analysis also included congestion cost savings.

For 2010, no BCR was initially calculated, because of the low penetration rate assumed. For 2020, the penetration rates were estimated above 30%. Thus, the BCR was calculated to be between 2.4, for low benefits and low costs, and 2.3, for high benefits and high costs. However, the study states that since eCall has infrastructure costs related to the establishment or adaption of PSAPs, the only relevant issue is the potential case where a 100% penetration rate is considered. In that case the BCR for 2010 is 1.5-3.6 and 1.1-2.5 in 2020. These results differentiate themselves from the results of the other reports with the fact that the BCR decrease over the years. The reason for this is that it is expected to be fewer accidents, in the years to come, and therefore fewer casualties leading to less benefit of the eCall system. While the costs still will remain.

In this study, the project stated that there is a need for further safety analysis since changes in the safety parameters; fatality and severe injury reductions leads to a significant change of the BCR. It should also be noted that the study calculated the BCRs in a variety of ways. First with the high (high benefits and high costs) and low case (low benefits and low costs), then with an optimistic (high benefits and low costs) and pessimistic (low benefits and high costs) view. Another consideration is the validity of the assumption that the potential case is the only relevant one.

3.6 SMART - impact assessment on the introduction of eCall

On behalf of the European Commission, the Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/legal issues (SMART) was conducted in 2009 [18]. The objective of the study was to assess all impacts and benefits of eCall, including the indirect benefits. It also assessed all costs and other key deployment issues related to eCall and compared the three scenarios, 'do nothing', voluntary agreement, and mandatory instalment, concerning their socio-economic profitability. Data collected from all 27 member states and some non-member states together with the results of several international and national studies, including four in-depth studies, were used as the information foundation.

Fleet penetration rate was assumed to be 6% in the 'do nothing' scenario, 23% in the voluntary approach, and 42% in the mandatory introduction scenario in 2020. Here the vehicle fleet includes passenger cars, trucks, and buses. To arrive at the parameters for the benefit-cost analysis the study developed an extensive list of 'indicators'. Both qualitative and quantitative indicators were utilised and addressed both by in-depth national studies and at a European level. Six clusters of countries were created to simplify the analysis. The study assumed that the countries within one cluster would have a similar enough environment for eCall to consider them as equal.

Initially, the idea was to create the clusters based on several parameters regarding the road network in the different countries, as well as the level of urbanisation, fatality statistics, and rescue service level. However, the problem was a lack of information for several countries. Several trials were conducted, but it proved difficult to create clear and logical clusters. In the end, the clusters were created based only on population density and fatalities per million passenger-kilometres.

The difference between this study and the others is that here an alternative approach towards the benefit-cost calculation was taken. Instead of using the discounting approach a 'snapshot' of the years 2020 and 2030 was used. This method produced a higher BCR since the infrastructure and IVS investments in previous years are considered as sunk costs, while still benefitting from that investment. It also included indirect benefits, which no other report does. On a European level, this method gives the BCRs in Table 3.2.

Table 3.2: BCR results of the SMART Study for the three scenarios.

Scenario/Year	**2020**	**2030**
Do nothing scenario	0.06	0.08
Voluntary approach	0.15	0.15
Mandatory introduction	0.53	1.31

These results are significantly lower than several of the earlier results, and there are several reasons for this. Firstly, the estimated casualty reductions are much lower than the ones of previous studies. Secondly, the penetration rates utilised in this study are more realistic by not being 100%. Another difference with these results is the main benefit components. In all the previous studies the casualty reduction has been the most important element. However, in this study, the estimates for congestion reduction are higher. So, for almost all the clusters, it is the congestion reduction which is the main benefit component, while the IVS remains the main element for the costs.

This study stated that the socio-economic profitability of eCall is quite sensitive to the unit cost of the IVS and the magnitude of its safety effects because of the large number of vehicles to be equipped. When reviewing the other assumptions, a considerable uncertainty is the hypothesis of the country clusters. The biggest cluster includes 12 countries while the smallest includes only one. Another uncertainty is the weighting of the results from the different studies used in the calculations. Moreover, is the “snapshot” approach better than the discounting approach?

3.7 Comparison and summary

As several of the studies themselves have pointed out, one should be careful in the comparison of the studies since they all are based on different values and variations of the same assumptions. Table 3.3 gives an overview of the reviewed studies and their components. Some important notes are that nearly all the studies refer and build on each other, and this increases the uncertainties of the later studies. When the later studies just assume that the results of the previous studies are right, they ignore the uncertainties that could have been revised in subsequent years due to new information about statistics or the eCall system.

As the table also shows, what is included in the vehicle fleet varies. So even though the penetration rate of 100% looks the same for almost all the studies it’s not. The 100% penetration rate in itself is also not realistic since it will take several years to equip all vehicles but of course, it makes the calculations easier. The same goes for the benefits and costs; some variables are considered marginal in some studies but not in others. The SEiSS study makes a crucial point in the statement that political decision makers, which orientate themselves at benefit-cost results, should be explicitly informed about existing risks and restrictions. Several aspects of the eCall system are not included in the presented calculations because they are not considered as essential or not possible to calculate, e.g. the cost for the Mobile Network Operators (MNOs) and added value resulting from the IVS, like potential new services utilising the GNSS. That goes for both positive and negative aspects.

In this chapter, a high-level review of some impact assessment studies of eCall was presented, and the uncertainties of the different studies were highlighted.

Table 3.3: Summary of interesting values from the reviewed studies.

Category/ Study	**E-MERGE**	**SEiSS**	**Swedish**	**AINO**	**eIMPACT**	**SMART**
Year	2004	2005	2005	2006	2008	2009
Based on other studies	STORM	E-MERGE, eSafety	STORM, E-MERGE, SEiSS	Swedish	E-MERGE, SEiSS, AINO	E-MERGE, SEiSS, Swedish, AINO, eIMPACT, etc.
BCR	-	1.3 - 8.5	1.1 - 4.2	0.5 - 2.3	2010: 2.7, 2020: 1.9	2020: 0.06, 0.15, 0.53, 2030: 0.08, 0.15, 1.31
Penetration rate	-	100%	100%	100%	100%	6% for 'do nothing', 23% for voluntary, 42% for mandatory
Included in vehicle fleet	-	passenger cars	passenger cars, motorcycles, buses and trucks	entire fleet, including two wheel vehicles and snowmobiles	passenger cars, good vehicles and buses	passenger cars, trucks, and buses
Benefit parameters	Casualty savings	Casualty savings, congestion savings	Casualty savings	Casualty savings, congestion savings	Casualty savings, congestion savings	Casualty savings, congestion savings, emission savings

Reductions of fatalities	5%	5-15%	2-4%	4-8%	3.6-7.3%	1-6% (estimated per cluster)
Reduction of severe injuries	10%	10-15%	3-4%	3-4%	-	0.5-2% (estimated per cluster)
Reduction of congestion	-	10-20%	-	-	-	3-17% (estimated per cluster)
Unit cost rate per fatality per accident	-	Fatalities: 977 000-1 million €	Fatalities: 14.4MSEK	Fatalities: 1 934 161 €	Fatalities: 2010: 1.28M €, 2020: 1.63M €	Fatalities: 2020: 1.6M €, 2030: 2.56M €
Monetary benefits [M€]	4000 each year	5870 - 25900	550 - 830 MSEK	54.29 - 87.31	2010: 4558, 2020: 3542	2020: 278 - 1903.8, 2030: 783 - 3559
Cost parameters	IVS, PSAP	System, PSAP, training	IVS	System, PSAP	IVS, Infrastructure	IVS, PSAP
Monetary costs [M€]	-	3030 - 4550	350 - 500 MSEK	37.58 - 99.59	2010: 1710, 2020: 1878	2020: 3569 - 4309.6, 2030: 2712 - 10273.6
Scenarios	-	Optimistic, pessimistic	Optimistic, pessimistic	Optimistic, pessimistic	Potential case	‘Do nothing’, voluntary, mandatory
Discount rate	-	3%	3%	3%	3%	-
Lifetime	-	8 years	8 years	8 years	12 years	-

Chapter 4

Review of the European Commission's Impact Assessment

In this chapter, the focus will be on the European Commission's Impact Assessment on eCall (EC IA) from 2011, SEC(2011) 1020 [2]. This report was the basis for EU's decision to implement eCall. The first part will discuss and evaluate the basis of the Impact Assessment's socio-economic calculations, concentrating on the parameters and values used. Afterwards, the focus in the second part will be on the technical side of the eCall emergency system, and in particular on the positioning information requirements that EU have decided.

In the previous chapter, several reports on eCall were presented, all of them forming part of the basis for the EC IA. Many of them made for the European Commission (EC) with more or less the same goal; to find the best policy for the eCall system based on the socio-economic impact. As stated earlier, the final decision of the EC was made in 2014 based on the last impact assessment from 2011. The aim of the EC IA was to find the most appropriate solutions to the implementation of eCall from the three policy options; 'No EU action,' 'Voluntary approach', and 'Regulatory measures'. Effectiveness and efficiency were the main points in the analysis together with a comparison of the three policies. Including their assessment of stakeholders and their economic, social, and environmental impacts.

Several other reports have also come later. One of these came in 2013 after the EU decided to go for Option 2 in 2012, and before they changed their decision in 2014 to go for Option 3. The Department for Transport in the UK ordered eCall UK 2013 Review and Appraisal (UK report) on a national level [27]. In this report, the EC IA was also discussed with a focus on the benefit-cost calculations. Some of the UK report's most interesting findings are included in the discussions below.

4.1 The benefit-cost analysis

The benefit-cost analysis in the EC IA was done for three different policy options, which are presented below. Not all parameters are included in this review of the analysis, the ones considered to have a minor impact on the results have been left out. One interesting aspect of the EC IA report is the fact that all actual calculations are excluded from the report itself and are located in the appendices.

Later in this section, a closer look at the baseline parameters, in-vehicles system costs, the clustering methodology, congestion and casualty cost savings, and other aspects is taken.

4.1.1 The three policy options

For the '**No EU action**' option the implementation of eCall will be left up to the market. In 2011, the 'Private eCall' services have a penetration rate below 0.4% of the vehicle fleet, even though it was introduced more than 12 years earlier. In the EC IA this was considered as the baseline scenario. The second option, '**Voluntary approach**', rely on the eCall Memorandum of Understanding (MoU) from 2004. Here the EU would create standards and encourage Member States and relevant Stakeholders to implement eCall on their own initiative. In 2012, this was decided the preferred option, as illustrated in Figure 2.2, but the progress was limited. In 2014, the decision was again changed to the '**Regulatory measures**' option. For this option, the eCall IVS will be a standard factory equipment installed in all vehicles in Europe and the framework for the handling of eCall in the telecommunication networks and PSAPs will be set up. This option would ensure eCall as a EU-wide service.

4.1.2 Baseline parameters

2008 has been used as the baseline year for the benefit-cost analysis, and a discount rate of 4% was used as recommended by the Impact Assessment Guidelines. While all the reports that the EC IA is based on used a 3% discount rate. The EC IA have also used two periods in the calculations. The initial period is six years until the system matures and prices likely decrease. The second period is then from year seven and onwards. The total analysis period is set from 2008 to 2033, which is the year Option 3, Regulatory measures, is estimated to reach 100% penetration.

The penetration rates of the different policies vary, as Figure 4.1 shows. Due to lack of information predicting these kinds of rates are difficult. For Options 1 and 2 these estimations were based on different literature. While for Option 3, the penetration rate was based on figures provided by the European Automobile Manufacturers Association.

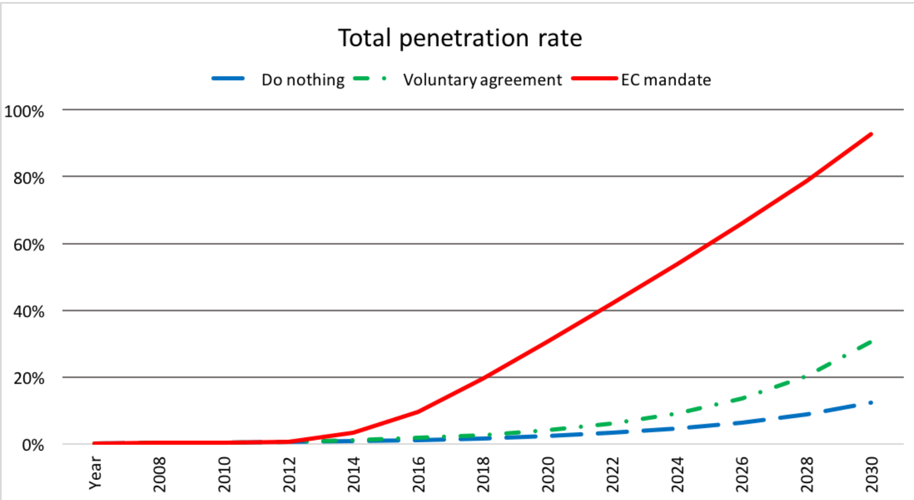

Figure 4.1: Estimated penetration rate of eCall in the EC IA.

How the EC IA derived the rates for Option 1 and 2 is unclear, as no precise information is provided. Most of the reports reviewed in the previous chapter assumed a penetration rate of 100%, for various parts of the vehicle fleet, to simplify the BCR calculations. Even though the penetration rate for these reports might look similar at first glance, the actual variations are huge in terms of what is included in the vehicle fleet. For the EC IA the vehicle fleet includes passenger cars and light duty vehicles.

4.1.3 In-vehicle system costs

In the EC IA, the IVS costs for the whole of Europe has been set to the prices presented in Table 4.1. For Option 1 the prices are based on an assessment of the price of different private eCall systems, while for Option 2 they are based on different studies and for Option 3 the EC IA made own estimates.

Table 4.1: IVS costs per vehicle for the different policy options in the EC IA.

	No EU action	Voluntary	Regulatory
Initial cost	800 €	450 €	180 €
Cost after 6 years	600 €	350 €	125 €

The UK report concluded, after discussions with different stakeholders, that the assumed costs for the IVS in Option 1 in the EC IA were too high. They were the consumer prices while for an economic appraisal the manufacturers' net costs should be the values used. However, the cost for Option 3 seemed realistic according to manufacturers.

4.1.4 The clustering methodology

One other aspect that is interesting in the EC IA study, is the clustering methodology. Both the SMART and the EC IA used this method to allocate values to countries where they lacked information and to simplify the calculations [18]. However, the two reports used quite different clusters as can be seen in Table 4.2.

Table 4.2: Comparison of the SMART study and the EC IA.

Cluster	SMART (2009)	EC IA (2011)
1	***Malta.*** Very small country with very few fatalities and severe injuries; eCall implementation will not change current safety situation dramatically; outlier in country data	***Malta.*** Specific country, very small, high density of population. No-cross border, but tourist destination.
2	***Netherlands, Belgium, Italy, Germany.*** Countries with relatively small geographical area and developed rescue systems; low estimates of impact on reduction in fatalities and severe injuries. Italy and Germany are treated in the CBA in this group due to accident characteristics.	***Netherlands, UK.*** Countries with high density of population, developed and with centralised emergency call response systems and developed incident management
3	***UK, Luxembourg, Switzerland.*** Countries where estimated impact of eCall on accidents is small; in most cases explained by short distances between accidents and rescue service points; also by level of emergency services.	***Finland, Sweden, Spain.*** Wide countries with extensive areas with very low density of population. Advanced integrated emergency call response systems centralised. Spain is an important tourist destination.
4	***Finland, Austria, Denmark, Sweden, Norway, Iceland, Ireland, France, Portugal, Spain, Slovenia, Czech Republic.*** Most countries already have low severe injury and fatality numbers.	***France, Germany, Italy.*** Big countries with medium high-density and some areas with lower density. Emergency call response systems distributed with numerous PSAPs and different level of equipment. High number of foreign people crossing the country.

5	***Hungary, Cyprus, Greece, Estonia, Latvia, Lithuania, Poland, Slovakia, Romania, Bulgaria.*** Accident levels tend to remain above EU average; eCall will produce rapid improvements in safety situation due to savings in accident costs.	***Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Ireland, Luxembourg, Portugal, Slovak Republic.*** Countries of generally mid size, with average density of population, fatality levels close to the average, and good emergency response service infrastructures.
6	***Croatia, Macedonia, Turkey.*** Non-EU countries, where accident levels are above EU average.	***Bulgaria, Hungary, Latvia, Lithuania, Poland, Romania.*** Countries of medium size with fatalities and severity of injuries level above the average. eCall could provide good improvements on road safety.

The EC IA's clustering methodology was based on the method of the SMART study and another report, CODIA [2]. SMART and EC IA used similar parameters, population density and safety level, so it is interesting that the results vary so much. In the SMART study, the evaluations made to reach the given clusters are presented, but in the EC IA, again, the details are excluded. In the analyses, the clusters are used to determine the reduction in fatalities, reduction in severe injuries, and congestion cost savings. The SMART study included non-EU countries as well, but they were excluded in the final calculation of the BCR of the EU. Two EU member states, Italy and Germany, are included in Cluster 2 but in the calculations, they are moved to Cluster 3 because of what the SMART calls accident statistics characteristics.

4.1.5 Congestion cost savings seems too optimistic

Congestion saving is the reduced congestion time, which the EC IA stated as a result of roads being cleared more quickly due to eCall, and faster traffic management. In the BCR calculation, the EC IA included a reduction of congestion cost savings of 3-17% per year depending on the cluster. The monetary values for congestion cost savings presented in the EC IA report for the European level are based on the average of two different reports. This average is shown in Table 4.3.

Table 4.3: Congestion costs per accident presented in the EC IA

Congestion costs - fatalities	37 500 €
Congestion costs - serious injury	10 250 €

However, in the actual calculations of congestion savings the EC IA study utilises the cluster methodology. This means that the values in Table 4.3 were not actually the ones used, rather country or cluster specific values.

The majority of the reports reviewed in the previous chapter included congestion cost savings, while some stated that this benefit was marginal. This uncertainty of the possible benefit can easily be seen in the different estimates presented. One example is the UK estimates in the SMART study versus the EC IA, where the first report's estimate is one-tenth of the estimate of the second. One reason why congestion saving might be seen as marginal is that eCall reduces response time, but the amount of time saved is relatively small compared to the time it takes to clear an accident site, so in total the reduction might be small or marginal.

This point is also highlighted in the UK report. In the EC IA a 3% reduction of all UK congestion was assumed, but as the UK report states, it is only the incident-related congestion that should be considered. Moreover, when there is enough traffic to cause congestion, the study states that the incident is likely to be reported very quickly without eCall. So, eCall is likely not to provide any congestion savings.

4.1.6 Casualty cost savings too comprehensive

For the benefit-cost analysis value added services and reduction of slight injuries were not included because of the lack of information and statistics. However, for the different clusters, a reduction of fatalities of 2-6% to the total figure of all accidents was used together with a 1-7.5% reduction of severe injuries. The monetary values used for accident cost savings on the European level are shown in Table 4.4, and are based on recommendations given by the European Road Safety Observatory. However, again because of the cluster methodology these are not the values used in the actual benefit-cost calculation.

Table 4.4: Casualty cost presented in the EC IA

Fatality	1 361 262 €
Severe injury	214 074 €

Since the effect of eCall is difficult to estimate the reduction estimates for casualties in the reviewed reports vary. However, it is clear that older reports were more optimistic than the newer ones. Looking at Europe as a whole makes the assumptions less certain. Whereas using a clustering methodology like in the SMART and the EC IA opens up the possibility to be more precise. Comparing these two on a general level the EC IA is more optimistic. However, are they too optimistic? The UK report looked at their case in the EC IA. They concluded that the estimates made in the report were too optimistic based on the reviewed information, especially considering that the reduction applies to all casualties including motorcycles, cyclists and pedestrians. The UK report states that including all casualties is not an appropriate analysis method when the only vehicles being equipped are cars and vans.

Another uncertainty is the severity estimate done in different countries as well as in the EC IA report. First of all, the grading of injury severity varies vastly from country to country. Secondly, the EC IA does not specify the estimated reduction in severity of an avoided fatality or mitigated injury. Based on the calculations it seems the EC IA assumes that all avoided fatalities will be reduced to severe injuries, and all mitigated severe injuries will be reduced to serious injuries.

4.1.7 Other aspects

In the EC IA analysis, some aspects were only mentioned as benefits but excluded from the calculations because it was difficult to set a monetary value on them. One such aspect is the estimated 99% GSM coverage in Europe. The UK report highlights this point and the difference between the EC IA estimate and the actual GSM coverage in the UK. Another important point is the emergency response time. In the EC IA, the estimates are based on the STORM study and consultation with the PSAP Expert Group within the eCall Driving Group. However, UK stakeholders say that the net gain time of 10 minutes is over-optimistic and that the Ambulance Service would not respond to a silent eCall as they require confirmation of an injury.

4.1.8 Discussion

The conclusion of the benefit-cost analysis for the three options can be seen in Table 4.5. Only Option 3, Regulatory measure, comes above the Benefit-Cost Ratio limit of 1, with a ratio of 1.74. For this option, the main benefit and cost components are the same as most of the previous studies, casualty cost savings and IVS costs.

Table 4.5: Benefit-Cost Ratio result from the EC IA

	Policy 1	Policy 2	Policy 3
BCR	0.29	0.68	1.74

When reviewing this impact assessment and the benefit-cost analysis the first striking thing, which was presented at the beginning of this section, is that in the EC IA report itself the calculations have not been included. Some values are presented, but for the rest, the report refers to the appendices. This is, of course, fine but what can be confusing is that of all the values presented in the report only one is actually used in the calculations, the cost of the IVS. All the values in the report are stated for the European level. However, when reviewing the methodology for the calculations, it becomes clear that the clustering method has been used. This means that in the calculations either country or cluster specific values are used. However, these values are not given in the report or its appendices, just the results of the calculations are included. Additionally, parameters and values from different sources are used, not all stated clearly from where. The biggest concern is that the first impression of the whole report is just confusing.

For decision makers who want the results given clearly with a precise direction of which policy option they should choose the report is clear, but how they reached that result is not. One detail regarding this is the EC IA's use of other reports. It states that the basis for the calculations are other reports, as mentioned earlier, but the problem is that when using values and parameters from these other reports it is usually not clear which reports the values are from, and if several reports are used how the different values are weighted. The EC IA says that different values are weighted differently, but the details of it are not presented, as also was the case for the penetration rate.

4.2 The technical aspects

In this section the more technical parts of the EC IA is reviewed, with a focus on the requirements for position information. Especially with regards to the accuracy and reliability demands and the benefits appropriated to the position information. However, the EC IA does not have a very detailed evaluation of the technical aspects of eCall. Two aspects that the report mentions are the positioning information and the GSM coverage, which both will be discussed next.

4.2.1 Position information

Directive 2010/40/EU on the deployment of ITS applications and services identify some principles that need to be followed. One of these principles is to deliver a quality of timing and positioning [28]. This is the only thing mentioned in the EC IA with regards to the accuracy and reliability demands for the positioning information. These parameters were not included in the economic analysis either. Most of the reports that have been reviewed take it for granted that the location of the vehicle will be based on Global Navigation Satellite System (GNSS) and that this is entirely reliable. The SMART study is the only one that mentions that their literature review provided no answer to the question of how reliable the future eCall service will be, but in the economic analysis, this part is again not considered.

At the time of most of the studies, neither a standard for the Minimum Set of Data (MSD) had been released, nor any assumptions were made on the data. In 2011 the MSD standard was ready. It was decided that the MSD at most should be 140 bytes, sent through an in-band solution, and be available to the Public Safety Answering Point (PSAP) within 4 seconds. For the location in the MSD, it should be determined by the in-vehicle system at the time of message generating based on latitude and longitude of the last known vehicle position. A separate bit indicates the confidence in the position. If the position is not within the limits of +/-150m with 95% confidence, the 'Low confidence in position' bit is set. The network operators should provide the vehicle position with triangulation as for E112 calls if the MSD, with the GNSS coordinates, does not reach the PSAP [29].

In the EC IA none of the technical aspects above are included, the focus was on the benefits appropriated to the position information. The main point which several benefits are hinged on is the exact position of the accident. This information makes it possible for the emergency services to provide assistance within the 'golden hour' principle, presented earlier. With the exact location and based on the principle, the risk of deaths and severity of the injuries can be reduced.

The EC IA also states that the exact location makes it possible for the emergency services to be dispatched and reach the location earlier. A study referenced in the EC IA says that in 53% of the cases assessed, the caller to an emergency service cannot locate the accident site sufficiently. With the GNSS coordinates the PSAPs no longer have to rely on the caller, this will be especially beneficial for citizens travelling abroad. Moreover, according to the EC IA it may also be beneficial for vulnerable road users (e.g.: bicycles, pedestrians) from the manual triggering of eCall by the involved vehicle.

However, according to the UK report, as mentioned in the previous section, the benefits associated with the increased effectiveness of the emergency services are too optimistic. At least in the UK, the ambulance services are dispatched almost right away even though the location is not exact and then updates are sent as they are on their way. However, the processes of the emergency services are different between the member states, so this evaluation cannot be extended to the whole of the EU without further inquiry.

Additionally, the exact location that the EC IA presents is not defined as to how accurate it needs to be to achieve the stated benefits. In the eCall standards, +/-150m of the actual position of an accident is accepted, but is this accurate enough? In Regulation (EU) 2015/758 [30] the European Parliament states that "accurate and reliable position information is an essential element of the effective operation of the 112-based eCall in-vehicle system." The system is therefore required to be compatible with the services provided by the Galileo and European Geostationary Navigation Overlay Service (EGNOS) programmes. However, the more widely used GPS system has an accuracy of 9m [31], which is more than enough to cover the set standard. Why require compatibility with Galileo and EGNOS as well? Of course, EGNOS have an accuracy of 3m [32], that is better than GPS, but again the eCall standards do not call for that kind of accuracy. The reasons for the compatibility requirement of Galileo and EGNOS are most likely political [33]. The EU has put a lot of money into the two programmes. Still, one question remains; why set the standard at +/-150m, why not demand better accuracy when GNSS systems can provide it?

4.2.2 Communication infrastructure

Another technical aspect presented in the EC IA, and some other reports, is the GSM coverage of the EU. For the eCall system to work the In-Vehicle System (IVS) depends on having GSM coverage to be able to communicate with the Public Safety Answering Point (PSAP). For the EC IA, the GSM Association Europe declared a GSM geographical coverage of 99% of the EU territory, with at least one operator. It has been stated that it is in the more remote rural areas that the benefit of eCall will be the largest, but these areas are likely to be the ones not to have GSM coverage as well. In Scotland, 8% of A and B roads have no GSM coverage according to the UK report. This aspect could impact the performance of eCall and the estimated benefits.

Other communication channels/infrastructures were not considered in the EC IA since the standards for eCall were already in progress. However, it was mentioned in Option 1, 'no EU action,' that using SMS might imply limited coverage, especially considering roaming agreements. Some earlier reports also evaluated SMS, when the E-MERGE project came up with the current solution, they first considered it. However, during gamma tests, it became apparent that transfer time of data was not acceptable since it differed from 2 to 260 seconds, even though this solution is used by most private eCall systems.

For ships and aeroplanes, an emergency position-indicating radio beacon station is often used. This solution has not been considered by any of the reviewed reports, possibly because of challenges with scaling. All the reviewed reports have also used the existing private eCall systems as a basis, which uses the GSM network and SMS.

Chapter 5
Benefit-Cost Analysis for Norwegian Conditions

In this chapter, the focus is switched from the European Union to Norway. The road conditions in Norway differ from the rest of Europe in several ways. Even though the road quality in Norway is one of the worst in Europe [34], the country is also the safest for motorists [35]. The government has a goal, similar to the EU to reduce traffic casualties, called the zero-vision, to achieve a society with zero casualties in traffic accidents [36].

As presented in this thesis, a lot of research has been done on the eCall system. However, since Norway is not a part of the EU, there has not been done much research on eCall with respects to Norwegian conditions, even though Norway has had representatives in the eCall Driving Group and signed the Memorandum of Understanding (MoU) in 2006 [15]. Of the research reviewed the only one which partly included Norway is the SMART study from 2009 [18]. The Institute of Transport Economics Norwegian Centre for Transport Research (TØI) did their own analysis of eCall in 2006 with the information available at that time. The resulting Benefit-Cost Ratio (BCR) varied from 0.25 to 5.42, which shows the uncertainty of the analysis.

When the European Commission (EC) decided to make the introduction of eCall mandatory, they also stated it to be European Economic Area (EEA) relevant. This meant that Norway, as part of the EEA, also would be obligated to implement the system. As noted before, the EC made this decision based on the 2011 Impact Assessment, which does not include Norway. Thus, in the following this thesis evaluates the suitability of the EC IA calculations and results to Norwegian conditions. National statistics are incorporated, and potential changes are suggested to make the estimates as reliable as possible for Norway.

Firstly, the current situation in Norway concerning the emergency system is presented. Followed by the evaluation of the EC IA with respect to Norwegian conditions, potential changes to the model, and the resulting estimations for Norway.

Finally, some non-quantifiable aspects that might affect the benefits and costs of the eCall system are presented.

5.1 The current emergency system in Norway

Today there are three emergency numbers in Norway. 112 is the same emergency number as the one in both the EU and EEA, and will connect you to the police. The two others are 110 for the fire department, and 113 for ambulance/medical emergencies. However, looked at from a technical standpoint 112 is the only real emergency number in Norway. The reason for this is that mobile phones have a software called "Emergency Call Setup" which only recognises the 112 number [37]. Moreover, it allows you to call 112 even if you only have coverage from a different network operator, don't have an SIM card or no money on your subscription. There have been discussions about changing from three emergency numbers to one, but the government has not managed to come to an agreement [38].

When it comes to the implementation plan for the eCall system, all the regulations have been incorporated into the EEA Agreement, and changes needed in Norwegian legislation are in progress. However, the one thing that is yet to be decided is which entity should act as Public Safety Answering Point (PSAP). This discussion has now reached the government at the highest level. The emergency centres (AMK-sentralene) are sceptical about the costs, and are afraid of the number of false calls when some of the centres already have limited resources [39, 40]. Another entity considered for the PSAP position is the Norwegian Public Roads Administration's traffic centres. They are willing to receive the eCalls, but there has been raised concern about the flow of sensitive information as well as the potential cost of routeing the eCalls to a different number than 112 [41]. Another point raised by Telenor, one of the leading MNOs in Norway, is the routeing of the calls. They have already implemented the routeing to 112 as stated in the standards from the EU and warn the government about the use of other numbers. If the government decides to go for another solution than 112, Telenor says that it is unclear whether they can, or potentially how they can, accommodate this [42]. Some of these uncertainties are discussed later in this chapter.

In Norway, 75% of all fatal traffic accidents from 2010 to 2014 happened in rural areas [9]. At the same time, most studies conclude that the eCall system will have the greatest effect in rural areas, so this is at least one good indication that the effects of the system might be positive for Norwegian conditions.

5.2 EC IA calculations for Norway

In this section, the suitability of the benefit-cost analysis in the European Commission's Impact Assessment on eCall (EC IA) is evaluated for Norway. First, the average EU country is looked at, and then the analysis is adjusted with Norwegian parameter values. Below only summaries of the analyses are presented, the full calculation tables are found in Appendix B.

5.2.1 Recap of the most significant parameters

When considering the model used in the EC IA, some parameters affect the results more than others. A few of these parameters were presented in the previous chapter, but a recap will follow below. Since the following considerations are for Norway, the values given in euros are also converted into Norwegian kroner (NOK). The exchange rate used is the one from 2011, when the values were set by the EC IA, of 7.79 [43].

General parameters The general parameters utilised in the EC IA is the discount rate of 4%, since this is the recommendation from the EU. The projected penetration rate of eCall, as presented in Chapter 4 were also used. The same was the estimated evolution of the number of fatalities, injuries, and accidents in the years to come, represented by the reduction rates presented in Table 5.1.

Table 5.1: Annual reduction rate of events utilised in the EC IA.

Accidents	1.46%
Fatalities	3.50%
Severe injuries	1.90%
Light injuries	1.71%

In-vehicle system costs Most studies have concluded that the In-Vehicle System (IVS) costs estimated in the EC IA are reasonable. Table 5.2 presents the values together with the conversions into NOK.

Table 5.2: IVS costs per vehicle for policy option 3, regulatory introduction, in the EC IA.

	Euro (€)	**NOK**
Initial cost	180	1 403
Cost after 6 years	125	974

Cost of public safety answering point Regarding the costs of the PSAPs for the different European countries, they might differ vastly depending on the type of implementation chosen. It is up to each country to decide which entity should act as PSAP, as long as it follows the regulations set by the EU. For an average EU country, the implementation costs are estimated to be 1.1 million €.

5.2.2 EU average

Even though there are vast differences in the EU, an average of the benefits and costs can be a sound basis for a comparison. When presenting the eCall system, these are the values the Norwegian government has used as a base [14].

Table 5.3: Resulting values for the EU average [2015 NOK/€]. Based on [2].

Total discounted benefits	1 429 655 225 €	11 140 731 307 NOK
Average discounted yearly benefits	75 245 012 €	586 354 279 NOK
Total discounted costs	822 726 648 €	6 411 179 679 NOK
Average discounted yearly costs	43 301 403 €	337 430 509 NOK
Net value (2015-2033)	606 928 557 €	4 729 551 628 NOK
BCR	1.74	1.74

The resulting BCR shown in Table 5.3 is the conclusion of the EC IA and the value used by the EC when presenting eCall to Europe. However, as stated at the beginning of this chapter, Norway already has very high traffic safety, so a general average might not be so realistic.

5.2.3 Applying the EC IA model to Norwegian conditions

To make the above estimates more accurate Norwegian statistics are used to adjust the model.

Norwegian parameters Norwegian statistics are the basis for some of the parameters utilised in this analysis. Firstly, the vehicle fleet in Norway was 3 040 219 in 2015 and includes passenger cars and vans [44]. Secondly, the Norwegian accident statistics are shown in Table 5.4.

Table 5.4: Traffic accident statistics with casualties in Norway in 2014. Source: [3]

Type	Number (2014)
Fatalities	147
Severly injured	674

Another parameter unique to Norway is the monetary value of accidents, Table 5.5. These values build on a willingness-to-pay perspective, which means that the values are not just set based on different costs related to an accident, but also the population's willingness to pay to reduce the risks in traffic that can lead to fatalities or injuries.

Table 5.5: Monetary values for traffic accidents with casualties. Source: [4, 5]

Accident type	**Monetary value (2009 NOK)**	**Monetary value (2011 NOK)**
Fatality	30 220 000	31 350 228
Severe injury	22 930 00	23 787 582
Serious injury	8 140 000	8 444 436

Results Based on the parameters above and the EC IA model the result is a discounted BCR of 2.41. Table 5.6 presents the summary of the calculations, for the detailed version see Appendix B.

Table 5.6: Resulting values for Norwegian conditions utilising the EC IA model with Norwegian statistics. [2015 NOK]

Total discounted benefits	4 695 444 547
Average discounted yearly benefits	247 128 660
Total discounted costs	1 952 077 834
Average discounted yearly costs	102 740 939
Net value (2015-2033)	1 510 330 016
BCR	2.41

For Norway, the EU average would result in a BCR which is much higher than the general EU average. Of the costs, the IVS part stands for over 70%, and it is clearly the largest cost component. For the benefits, the casualty cost savings stand for almost 70% the initial year and then decreases until 65% in 2033. However, even though it decreases, it is still the main benefit component throughout the analysis period. When it comes to the reduction of accident severity, in the year 2036 3.23 fatalities will be avoided and 23.25 severe injuries mitigated. The question is then, how accurate are these results? Traffic safety in Norway is very good compared to the European average, thus is this estimate too optimistic? Take for example the congestion cost parameter; that average is calculated based on values ranging from 3% to 17%. Is it likely that Norway resembles the EU average? In the next section, possible changes to the model will be presented to improve the estimations.

5.3 Potential changes in model and parameters

In the two estimates done so far, some general European parameters are utilised even though they might not fit the reality in Norway and Europe. Next, two types of changes are presented to make the model more realistic. The first changes are general adjustments to the model, and the second are parameter adjustments.

At the publication time of the EC IA, the plan was to have an operational eCall service in 2015. Due to lack of progress, this has been postponed until 2018. To take this into consideration the analysis period will be changed from 2008-2033 to 2015-2036.

In the model, the annual reductions of accidents and casualties are at a European average, but for Norway the statistics are different. Table 5.7 shows the estimated Norwegian average annual reduction rates, based on the annual reduction of casualties in the period 2007-2014, which will be used in the improved model.

Table 5.7: Estimated annual reduction in accidents with casualties in Norway based on statistics from 2007 to 2014. Source: [3]

Type	**Annual reduction**
Fatalities	5.20%
Severe injuries	4.60%

As mentioned in the previous chapter, there are uncertainties regarding the calculations of cost savings and the monetary values used. When a fatality is avoided, what is estimated to be the severity of the injuries? In the Norwegian Traffic Safety Handbook, the estimation for eCall is that 33% of the avoided fatalities will be reduced to severe injuries, and 66% reduced to serious injures. For the mitigated severe injuries, all are estimated to be reduced to serious injuries [38].

There are three critical parameters in the EC IA model, the percentage reduction of fatalities, severe injuries, and congestion that affect the result of the benefit-cost calculation.

For the EU average presented above, the values of the reduction parameters are shown in Table 5.8. This is the average of the percentage values of all the EU countries, not the average of the pessimistic and optimistic view of the EC IA.

Table 5.8: Estimated percentage of avoided casualties and reduced congestion by eCall for the EU average, assuming 100% penetration, utilised in the EC IA.

Fatalities	4.80%
Severe injuries	5.26%
Congestion	13%

As discussed, a general European average might not be the most realistic estimation for Norway. So, which countries are similar to Norway? In the following, values from four countries are presented and then discussed with regards to their suitability for comparison to Norway.

5.3.1 Using Swedish and Finnish estimates

By considering the neighbouring countries, the similarities to Norway are higher than if it is compared to Europe in general. When it comes to the Norwegian vehicle fleet Finland is the country that the Norwegian Ministry of Transport and Communications compare the fleet with [14]. Moreover, Sweden resembles Norway in terms of geography and emergency service situation. Sweden and Finland are also considered to resemble since the EC IA put them in the same cluster.

Reduction parameters Based on national studies the estimated reduction in fatalities for Sweden and Finland differ a great deal. So, three sets of reduction parameter values are presented in this section; the estimates from the Swedish national study, the estimates from the Finnish national study, and the average of the previous two, which might be deemed the most realistic scenario of the three. In this analysis, an unweighted average has been used not to give larger countries more weight than smaller. The basis of most national studies conducted is a sample of accidents or some other estimations and with a weighted average, inaccurate studies might count too much.

Table 5.9: Swedish and Finnish estimates for reduction of casualties and congestion, assuming 100% penetration, utilised in the EC IA.

Type	**Swedish estimates**	**Finnish estimates**	**Average**
Fatalities	3.50%	6.00%	4.75%
Severe injuries	4.00%	4.00%	4.00%
Congestion	10%	10%	10%

Results These calculations are conducted with the new model with the analysis period now being 2015-2036, and with the Swedish and Finnish estimates. In what might be the most realistic of the three cases, using the average of the Finnish and Swedish estimates, the resulting BCR is 1.54. For the detailed calculations see Appendix B.

Table 5.10: Resulting values for Norwegian conditions utilising the improved EC IA model with Swedish and Finnish reduction estimates.

[2018 NOK]	**Swedish estimates**	**Finnish estimates**	**Average**
Total discounted benefits	2 901 932 506	3 123 711 409	3 012 821 957
Average discounted yearly benefits	152 733 290	164 405 864	158 569 577
Total discounted costs	1 952 077 834	1 952 077 834	1 952 077 834
Average discounted yearly costs	102 740 939	102 740 939	102 740 939
Net value (2018-2036)	949 854 672	1 171 633 575	1 060 744 124
BCR	1.49	1.60	1.54

This result is much more pessimistic than the EU average for Norway. The reason for this is the lower values for the reduction parameters. This change is also reflected in the main benefit components which still is the casualty cost savings. However, now this part decreases from 68% to 51% since the estimated congestion reduction is still quite high. For the cost components, the situation is the same as for the previous calculation since the same estimates are still utilised. No new estimates of the costs for Norway have been made because of the decision process described earlier.

When comparing the Swedish and Finnish results, there is only one aspect that differs, the number of avoided fatalities. However, the difference is not substantial with 1.16 lives in 2036. For the average, the estimated number of avoided fatalities are 2.20 in 2036 and 9.84 for severe injuries. Even though these results are more pessimistic than the EU average, they still indicate that the eCall system will be beneficial to the Norwegian society.

5.3.2 Using UK and Dutch estimates

Two other countries the Norwegian Public Road Administration often compare with when it comes to traffic safety, are the United Kingdom and the Netherlands.

Reduction parameters The UK and the Netherlands are the countries in the EC IA with the lowest estimates for reduction of fatalities and severe injuries. Their values are presented in the table below. Again an unweighted average is used for the same reasons as with the previous calculation.

Table 5.11: UK and Dutch estimates for reduction of casualties and congestion, assuming 100% penetration, utilised in the EC IA.

Type	**UK estimates**	**Dutch estimates**	**Average**
Fatalities	2.00%	2.00%	2.00%
Severe injuries	1.50%	1.00%	1.25%
Congestion	3.00%	17%	10%

Results Considering the average of the UK and Dutch reduction parameter values the resulting BCR is 0.86 for Norwegian conditions. In comparison, the most significant difference between the UK and Dutch estimates is the congestion savings. While the UK has the lowest estimate, the Netherlands has one of the highest. This point is discussed further later in this chapter.

Table 5.12: Resulting values for Norwegian conditions utilising the improved EC IA model with UK and Dutch reduction estimates.

[2018 NOK]	**UK estimates**	**Dutch estimates**	**Average**
Total discounted benefits	1 073 125 028	2 296 334 931	1 684 729 979
Average discounted yearly benefits	56 480 265	120 859 733	88 699 999
Total discounted costs	1 952 077 834	1 952 077 834	1 952 077 834
Average discounted yearly costs	102 740 939	102 740 939	102 740 939
Net value (2018-2036)	- 878 952 806	344 257 097	- 267 347 854
BCR	0.55	1.18	0.86

Again, the main cost component is the IVS costs since the cost estimate has not changed. However, looking at the benefit components of the average, the main one is now the congestion cost saving. With the low casualty reduction estimates utilised their share of the benefits are reduced to 40%-26%.

For all three scenarios in this calculation, the estimated number of avoided fatalities in 2036 is 0.93 while the estimated mitigated severe injuries differ a bit with the average being 3.08. The results of the two scenarios, UK estimates and the average, shows that the eCall system is not beneficial for the Norway. The benefits are too low compared to the costs.

5.3.3 Discussion

So far the results of the benefit-cost calculations with the different critical parameters, reduction in fatalities, severe injuries, and congestion costs have been presented. However, which of the results are the most realistic ones? This is discussed next.

As previously mentioned, there are vast differences between countries in Europe when it comes to traffic safety, and Norway is at the top. Hence, using the EU average as an estimate for Norway is not very realistic. Recognising this is easy when evaluating the number of fatalities for a given year. In 2014, there were 28.5 fatalities per 1 million inhabitants on Norwegian roads, while the EC IA estimated an EU average of 58 fatalities per 1 million inhabitants. That is more than the double.

So, if the EU average is not a good comparison to Norway, which countries are? The Norwegian Public Roads Administration most often use Sweden or other Nordic countries, alternatively other countries in Europe with high traffic safety, like the United Kingdom or the Netherlands. However, for the latter two, there are substantial differences that need to be considered, e.g. population and geography [10]. The Norwegian Ministry of Transport and Communications has used Finland as a comparison. These are the reasons why the estimates for these four countries have been chosen for this analysis to be transferred to Norway.

As mentioned, through all the calculations the cost components have not changed. The basis of the IVS costs is the Norwegian vehicle fleet and the estimated penetration rate of the EC IA for all. For the PSAP costs the EU average has been utilised. The reason for this choice is that the penetration rate is very challenging to estimate, and for Norway no decision has been made about which entity should be the PSAP. However, one interesting aspect of main cost component, the IVS cost, is that the vehicle owners will take this cost, and not the government. This means that from the government perspective if the costs of the users are excluded, eCall will be very beneficial.

Coming back to this analysis, considering all costs, the most interesting aspect of it is the benefits. A summary of the relevant values from the analysis is presented in

Table 5.13: Summary of important values from the calculated estimates.

	Finnish estimates	**Swedish estimates**	**UK estimates**	**Dutch estimates**
BCR	1.60	1.49	0.55	1.18
BCR in 2036	3.42	3.19	1.17	2.63
Avoided fatalities in year 2036	2.78	1.62	0.93	0.93
Mitigated severe injuries in year 2036	9.84	9.84	3.69	2.46
Break even year	2029	2030	>2036	2034

Table 5.13.

Of the four estimates, the calculation with Finnish values is the most optimistic with a BCR of 1.60 and 2.78 avoided fatalities in 2036. On the other hand, the calculation using UK estimates have the most pessimistic with a BCR of 0.55 and 0.93 avoided fatalities in 2036.

This work concludes with three scenarios, a pessimistic view, an optimistic view, and the average of the two, to achieve the most realistic estimates for Norway. For the pessimistic scenario, the UK estimates are used and the Finnish for the optimistic. In Table 5.14, the reduction parameters for the average scenario are presented.

Table 5.14: Norwegian estimates for reduction of casualties and congestion for the average scenario, assuming 100% penetration.

	Average scenario
Fatalities	4.00%
Severe injuries	2.75%
Congestion	6.50%

5.4 Estimates for Norway

Given the parameters above, the results for the average view of the effect of eCall for Norwegian conditions are displayed in Tables 5.15 and 5.16. As mentioned in the discussion, the values for the PSAP costs used are the average of the EU since no decision has been made in Norway. This aspect will be evaluated in the sensitivity analysis later in this section.

Table 5.15: Resulting values for Norwegian conditions utilising the improved EC IA model with the average of the pessimistic and optimistic scenario for Norway.

[2018 NOK]	**Average scenario**
Total discounted benefits	2 098 418 218
Average discounted yearly benefits	146 340 384
Total discounted costs	1 952 077 834
Average discounted yearly costs	102 740 939
Net value (2018-2036)	146 340 384
BCR	1.07

Table 5.16: Summary of important values from the average scenario of the Norwegian estimates.

	Average scenario
BCR	1.07
BCR in 2036	2.30
Avoided fatalities in year 2036	1.85
Mitigated severe injuries in year 2036	6.77
Break even year	2035

According to this analysis, 1.85 lives will be saved by eCall in 2036, and 6.77 severe injuries will be mitigated with the average scenario. This estimate is considered the most realistic one for the effects of eCall given Norwegian conditions with a BCR of 1.07. The main benefit component, in this case, is the casualty cost saving starting with a share of 69% which decreases throughout the analysis period down to 53%. If the trend continues the congestion cost savings will become the main benefit component from 2040. However, the resulting BCR is very close to the border of 1, which symbolises the line between a measure being beneficial or not. Since the parameters utilised are just estimates a sensitivity analysis will be reviewed next.

5.4.1 Sensitivity analysis

To assess the different parameter's impact on the benefit-cost analysis a sensitivity analysis has been performed. The various scenarios chosen for the analysis are selected based on the most uncertain estimates and parameters regarding Norway and the decision process for the eCall implementation so far, i.e. the estimated reduction of fatalities, severe injuries and congestion. Table 5.17 below displays the results.

Table 5.17: Sensitivity analysis of the estimates for Norway.

	BCR discounted	BCR in year 2036	Avoided fatalities in year 2036	Mitigated severe injuries in year 2036	Break even year
Norwegian estimates	1.07	2.30	1.85	6.77	2035
Fatalities/ injuries +1%	1.32	2.81	2.31	9.23	2031
Fatalities/ injuries +2%	1.57	3.32	2.78	11.69	2029
Fatalities/ injuries -1%	0.83	1.78	1.39	4.31	>2036
Without traffic safety handbook estimates	0.97	2.09	1.85	6.77	>2036
PSAP costs +50%	1.07	2.29	1.85	6.77	2035
0% congestion savings	0.74	1.52	1.85	6.77	>2036

Looking at the sensitivity analysis, with the Norwegian estimation as a basis, it is evident that small changes to the estimated reductions in fatalities and injuries can tip the BCR further above or below the beneficial limit. This indicates that the eCall system is an uncertain investment. The measure could become beneficial to society, but it could also become a cost.

Looking back at the improvements done to the model, one change was concerning the reduction in severity when a fatality is avoided or a severe injury mitigated. The Norwegian Traffic Safety Handbook has made some estimations, 33% of the avoided fatalities will be reduced to severe injuries, and 66% reduced to serious injures, which were used in the improved model. However, in the calculations of the EC IA, it was estimated that all avoided fatalities become severe injuries, and not both severe and serious injuries. If this improvement is ignored the BCR drops with 0.2, and the eCall system is, again, no longer considered beneficial as shown in the fifth row in the sensitivity results table.

As mentioned before, the decision of who should be PSAP in Norway has not been taken, and therefore the PSAP costs are still uncertain, not just concerning the PSAP upgrades but also the potential costs for routeing the eCalls. The results of the sensitivity analysis show that these costs do not impact the resulting BCR much compared to the IVS costs. Even with a 50% increase in the PSAP costs the discounted BCR will still be 1.07.

So far one parameter has almost been ignored, the congestion savings. Of all the critical parameters this can be said to be the most uncertain one. Chapter 4 discussed the reasons for this. However, the UK report which states that it is unlikely for eCall to create any congestion savings, is not the only one that is sceptical about this point [10], which is why this has been included in the sensitivity analysis. The average scenario made for Norway above, also use much larger estimates than the ones presented in the Norwegian report from 2006. The 2006 report estimated a congestion saving of 2.5 to 5 million 2018 NOK each year [38]. Also, looking at the results from the sensitivity analysis this parameter has a significant impact on the degree of benefit created by eCall. The net value in 2036 in Table 5.15 will drop from the estimated 146 340 384 NOK to -513 096 405 NOK for the Norwegian estimate if the congestion saving is set to 0%. The relationship between the estimated congestion reduction, the discounted BCR, and the net value is presented i Figure 5.1.

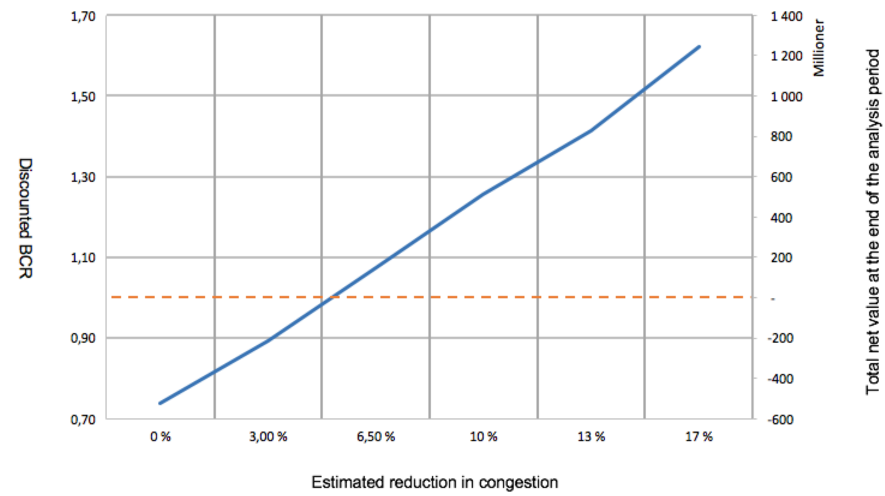

Figure 5.1: The relationship between the estimated reduction of congestion, the total discounted benefit-cost ratio, and the total net value of the eCall system at the end of the analysis period in 2018 NOK.

5.4.2 Break even analysis

Another important aspect when evaluating a new system is how long it takes before the system is beneficial. For this reason, a break-even analysis has been completed. The results can be seen in Table 5.17, together with the sensitivity analysis. The break-even year of the Norwegian estimation is 2035, which is almost the end of the analysis period. Removing the congestion savings as discussed above, will raise the break-even year to about 2045, given that the total net value of the eCall service continues to increase at the same rate each year as in the analysis period.

5.5 Non-quantified parameters

The success of the eCall system does not only depend on the parameters used in the calculations. However, it is not easy to put a price on these other aspects. One example is the maintenance cost of the IVS, which has been excluded from almost all the reports reviewed in this thesis. It is hard to make an estimate for the maintenance cost when the system has not been developed yet. For this reason, and the fact that this cost is considered to be marginal compared to the others, the cost has been excluded.

Network coverage is also one aspect mentioned in the review of the EC IA. For Europe, the GSM Association Europe stated in 2011 a geographical coverage of 99%. For Norway, the population coverage of Telenor and Telia, the two leading MNOs, are 99% while the geographical coverage is 84% for Telenor [45, 46]. So, there might be parts of the Norwegian road system that does not have coverage, but Telenor and Telia have no numbers on this.

Another point mentioned at the beginning of this chapter is the number of false calls, which is a big concern for the emergency centres in Norway. There are 19 medical emergency centres, and these have been considered as the preferred PSAPs. However, some of these centres are already under enormous pressure with problems of understaffing [39]. The introduction of eCall can lead to an increased number of false calls. Even though the expected number of false automatic calls are small, it is hard to estimate the expected number of false manual calls. Today the PSAPs in Europe work with a percentage of 60% of all calls to emergency numbers being false/hoax [2]. The percentage for eCall will depend on awareness and education about the system.

When it comes to the expected number of calls in general, the EC IA has made an estimation of two automatic and 19 manual eCalls per 1000 vehicle per year when the system is fully deployed. For Norway, that would mean an increase of calls equal to 7.49% each year if we exclude the calls that eCalls most likely will replace [47].

The reason for the exclusion is that no estimates concerning the number of replaced calls have been done. Table 5.18 presents the exact numbers.

Table 5.18: Estimated number of eCalls in Norway when penetration reaches 100%.

Vehicle fleet 2015	3 040 219
Estimated automatic eCalls per year	6 080
Estimated manual eCalls per year	57 764
Estimated eCalls per day	175

Chapter 6

Evaluation of the ITS Tool "Verktøy for virkningsberegningere av ITS-tiltak" Developed by TØI

In this chapter, an evaluation of the usability of the ITS tool, "Verktøy for virkningsberegninger av ITS-tiltak" in regards to the eCall system is done [8]. The Norwegian Public Roads Administration (Statens Vegvesen) commissioned the tool, and the Institute of Transport Economics Norwegian Centre for Transport Research (TØI) developed it. The tool's purpose is to evaluate measures described in the Norwegian ITS-handbook by a benefit-cost analysis.

6.1 The tool and its parameters

The Excel tool provides a simplified way of calculating the socio-economic benefits for users without much economic background or MS Excel knowledge. The focus of the tool is on the implications of the measures on traffic safety, mobility, and the environment, on a given stretch of road. There are two questions that the tool is supposed to answer: Will the ITS measure be beneficial under the given circumstances? What conditions must be met for the measure to be beneficial? To answer these questions the Excel tool consists of six spreadsheets for the different ITS measures presented in Table 6.1.

The benefit-cost analyses in the spreadsheets are based on different parameters depending on the measures, but they all present the same calculations, which are:

- Net benefit (the measure's benefits minus the costs over the whole analysis period)
- Net benefit per ITS budget NOK (net benefit divided by costs in present value)
- Benefit-cost ratio (the measures positive benefit divided by the sum of the costs and potential negative benefit components)
- Traffic safety effect per mill. NOK (expected number of accidents avoided per mill. NOK of measure cost)

Table 6.1: Overview of the spreadsheets in the ITS tool and their purpose.

Spreadsheet	**Examples of measures**
1- Speed regulating measure with effect on average speed and the share driving over 120 km/t	Variable speed limits, speed measuring boards, speed limit reminding information, automatic traffic control
2- Speed regulating measures with effects on accident risk and the speed distribution	Traffic flow control, Variable speed limit
3- Congestion alert with or without additional information, travel time information	Congestion alert, travel time information or other information
4- Alert for pedestrian or bicycle near pedestrian crossing	Alerts near pedestrian crossing
5- Prioritisation of public transport in traffic lights	Prioritisation of public transport in traffic lights
6- Real time information about public transport	Real time information about public transport

Some of the general parameters in the tool are already set, like the discount rate and the index adjustment. The utilised discount rate is 4%, the same value as in the EC IA. The rest of the parameters are up to the user to provide, such as background information about the road and traffic on the road, as well as information about the measures costs and information about its benefits on e.g. accidents, average speed, and speed distribution. The tool presents guiding values for most of the measures' effects based on empirical studies of the measures to help the user.

6.1.1 Benefit and cost parameters

To calculate the benefits of the different measures, the Excel tool focuses on the benefits for the traffic safety, the environment, and the mobility.

- For the traffic safety, the primary parameter is the estimated change in the number of accidents. This is either estimated based on empirical studies or calculated based on the change in average speed.
- For the environmental effect, the main parameters are the changes in speed distribution and congestion distribution.
- For the mobility benefit, the expected change in travel time is calculated based on average speed, speed distribution, and the length of the road.

In the tool, the costs of the measures are investment costs, which occur in year 1, and the yearly operation and maintenance costs. If the operation and maintenance costs are not yearly, they have to be recalculated into yearly sums before they are entered into the tool.

6.2 Usability of the tool in regards to eCall

At a first glance, the second spreadsheet “Speed regulating measures with effects on accident risk and the speed distribution” looks to be the most appropriate one for the eCall system. The reason for this is that the spreadsheet includes the number of avoided accidents. However, several challenges were identified after analysing the Excel tool in its current version with eCall as a possible measure;

- Unable to define avoided fatalities and reduction in severity of injuries, only number of avoided accidents as a parameter.
- Unable to specify the IVS costs
- Difficult to define the benefits and costs of eCall for a specific stretch of road

These aspects and suggestions for changes to incorporate the issues above are discussed in more detail in the sections below.

6.2.1 Inability to define reduction in fatalities and severe injuries

As mentioned above, the tool calculates the benefit to traffic safety based on the number of avoided accidents. However, the eCall system does not avoid accidents; it only reduces the severity of them. This is the smallest challenge identified with the tool because it uses the estimated number of avoided accidents to calculate the expected change in casualty costs. The benefit-cost analysis in Chapter 5 used the same casualty cost savings, so it should be possible to modify the calculation to use the number of avoided fatalities and severe injuries instead of avoided accidents.

6.2.2 Inability to specify the IVS costs

One distinctive aspect of the eCall system is that the installation costs of the measure are spread over several years since the implementation of the system in vehicles start with new type approved vehicles. These costs will vary from year to year depending on the number of vehicles equipped, in line with the penetration rate. For the other costs, the PSAP and GSM network upgrades, the two categories for costs in the tool fits with the investment cost the first year, and the operation and maintenance cost the following years. However, for the IVS there are two uncertainties. Firstly, the maintenance costs have not been quantified in any studies yet, they have just been excluded based on the lack of information, or assumed zero. Secondly, the cost of the IVS equipment varies as mentioned. So, there are two options to try to include the IVS costs into the tool, either they can be recalculated into equal yearly costs and combined with the maintenance costs, or they can be discounted to year 0 and added to the investment costs.

Unfortunately, there are downsides with the two options. For the first option, if the average yearly IVS cost is calculated, the estimates will be even more imprecise than the ones used in the EC IA already are. The tool is created to set an annual fixed cost which is then discounted through the analysis period. A potential solution is to change the tool so that different annual costs through the analysis period could be specified. However, this would impair the purpose of the tool to be easy to use for people with limited knowledge of economics and MS Excel. Regarding the second option, the IVS costs could be converted into an investment cost by discounting the costs for each year to year 0 and then summarise them. However, once more the purpose of the tool would be impaired.

6.2.3 Specifying the benefits and costs of eCall on a given stretch of road

One category of parameters that is needed for the calculations in the tool is details about the road considered for a measure. These parameters are used in the benefit calculations in the model. All measures presented in the tool are specific things that can be carried out at a given position along a road and thus will improve traffic safety, mobility and/or the environment. eCall is different; it is not a local measure; it cannot be spotted along the road. Moreover, to calculate the benefits and cost along a specific stretch of road is impossible.

However, is it possible to change the tool to include all of Norway instead of a specific road? The challenge here becomes evident in the analysis of the benefit calculations. There are three benefit aspects, which were presented earlier. For traffic safety, it should be possible to change the tool to include all accident in Norway, not just the ones on a specific road. The information of road type is used to estimate the normal severity of accidents and injury costs for the road considered. These estimates could also be altered to include all roads in Norway by utilising the accident statistics available.

For the other two aspects, environmental effect and mobility benefit, the detailed road information about the type of area, the share of congestion, heavy traffic, free flowing, and average speed are used to calculate the environmental impact and emissions and impact on navigability. Considering Norway as a whole, these details would be difficult to estimate, and some of the accuracies that the tool achieves will disappear.

6.3 Summary

When looking at the challenges mentioned above, and especially the last one, it is hard to see how the tool in the current version can be used in the case of eCall. For the benefits part of the analysis, calculations could have been done for the different types of road, instead of a given stretch. However, the costs of the whole eCall system cannot be divided into costs per road, more naturally would be years as was done in Chapter 4.

Several other measures in the Norwegian ITS Handbook were also excluded from the tool for similar types of reasons, like the lack of information available, and that the measure will affect more than one stretch of road.

Going through the identified challenges and solutions several changes in the tool are needed to be able to use it for the eCall service. However, the underlying model in the tool is a discounted benefit-cost analysis similar to the one utilised in the previous chapter which can be used on eCall. The only thing which might be a disadvantage with the changes needed is the loss of accuracy and detailed benefits which the tool provides.

Chapter 7 Concluding Remarks and Further Work

In 2018, the eCall system will be implemented in the European Union (EU), and European Economic Area (EEA). The process of reaching this decision has been long, and many studies have been conducted to determine the implementation method and the socio-economic benefit of the system. This thesis has reviewed several studies and compared their methods and results. Many of these studies were conducted many years ago before the framework of the service had been decided. The results are therefore not that accurate, especially when it comes to the estimated penetration rates.

The decision to make the implementation of eCall mandatory was based on the European Commission's Impact Assessment on eCall (EC IA) from 2011. This study showed that regulatory measures were the only way for eCall to become beneficial for society. When reviewing the model and assumptions utilised in the EC IA, some aspects were discovered to be uncertain. The study used a clustering methodology to make the analysis more accurate for the different European countries. The problem with this method was that only the EU average of the various parameters was presented in the report, but in the calculation completely different, country-specific, values were applied. Even though the results of the EC IA are more pessimistic than the earlier studies, some parameters still seem too optimistic. One of these parameters is the congestion reduction. The EC IA estimated the reduction value to be between 3% and 17% for the different clusters which several studies and stakeholders deem too high. Another parameter that might be too optimistic is the casualty reduction. This parameter is challenging to estimate, and the EC IA has included all traffic casualties even though only passenger cars and vans will be equipped with the eCall service.

As part of the EEA, Norway is also obligated to implement eCall. However, no analysis of the service for Norwegian conditions has been conducted in 10 years. This thesis modified the model used in the EC IA to fit Norway, and the result was a Benefit-Cost Ratio of 1.07 which is very close to the beneficial limit. The estimated reduction parameter values were 4% for fatalities, 2.75% for severe injuries, and 6.50% for congestion. The last value is the most uncertain one, as mentioned above. Therefore, a sensitivity analysis was conducted. If there is no reduction in congestion the benefit-cost ratio will drop to 0.74 and the eCall service will not be beneficial to society. Another interesting thing is the main cost component, in all the analyses this is the IVS-cost, which will be paid by the vehicle owners. So, from a governmental perspective, only looking at their benefits and costs, eCall is very beneficial, but considering the big picture the effect is more unclear.

In 2013 the Institute of Transport Economics Norwegian Centre for Transport Research (TØI) made an ITS tool to estimate the effects of different measures described in the Norwegian ITS Handbook. The measures for which the tool was created would all have an effect on the road where they were placed. The eCall service is not road specific, the benefits and costs can not be calculated for a given road. The ITS tool in its current version is therefore not applicable to eCall. However, generalisations to the model could be made to consider all of Norway instead of a given stretch of road, but accuracy and detailed calculation of benefits would most likely be lost.

7.1 Further work

Several areas can be suitable for further work:

- **A more detailed analysis of the benefit of eCall for Norway:** When the decision of which entity should act as PSAP is taken estimates for the PSAP costs can be made, and more precise benefit-cost analyses can be conducted. Another point is to do a more thorough analysis of the effect of eCall on Norwegian traffic accidents similar to what has been done in Finland.
- **Develop the modified version of the ITS tool:** Complete the changes proposed to adapt the ITS tool to the eCall service.

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Appendix A

Detailed overview of reviewed reports

In this appendix, an overview of the reviewed studies on eCall is presented in more detail.

A.1 E-MERGE - Pan-European Harmonisation of Vehicle Emergency Call Service Chain

Goal “Develop, test and validate common specifications for the vehicle emergency call at all levels along the service chain as well as to produce parts of the necessary technical, organisational and business structures for a Europe-wide take-up of the solution.”

Details/basics

Release year	**Made by**	**Project time**
June 2004	ERTICO - ITS Europe	April 2002 - March 2004

Based on	**Partner from**	**Metohds**
Various studies in e.g. Germany, Netherlands and the UK	The car industry, public authorities, emergency call centres, service providers	Laboratory tests, integration tests, real-life testing at 6 EU locations, survey for participating PSAPs

Parameters “For the E-MERGE validation the following impacts were selected:

- Reduction of medical costs
- Reduction of rescue costs
- Business opportunities for service organisations
- More effective management of road network - less traffic jams

- Pan-European coverage, better safety
- Quality of response
- Timelines of response"

Benefits "Major quantified benefits and stakeholders:

- Vehicle Manufacturer: Additional value to the market, 400-600 Euro per vehicle
- Public Authorities: Lower costs for social security and saving tax income
- Insurance Companies: Less payments on claims
- Individual Drivers: Less payment on on-covered costs
- Public Authorities: Lower medical costs
- Equipment manufacturer: Create a new 1.2 to 1.5 BLN Euro market on IVS
- Telco Operators: Increased penetration of handset subscriptions and dual SIM-subscriptions"

Costs "Major Cost areas:

- Individual driver: Buying and Installing the IVS
- PSAP, Emergency Authorities and Service Providers: Adjusting the call centres
- Vehicle Manufacturer, Insurance Companies and Service Providers: Adjusting the back-offices
- Vehicle Manufacturer, PSAP, EA, SP: Training of staff"

Results "Five main results:

- Tested and validated specifications for the interface between in-vehicle eCall system and PSAP at a pan-European level
- Tested and validated specifications for the interface between PSAP and Service Provider at a pan-European level
- Specifications for the MSD
- Specifications for the transmit MSD as data in the 112 voice channel
- Recommendations on related issues such as IVS design, PSAP system design, SP design and FSD."

Conclusion Potentially cutting fatalities by 5%, injuries by 10% and associated costs by 4 billion €each year. No positive effect foreseen for light injuries. An improvement of 5-10% in the response time is generally expected by the PSAPs when the MSD information is available to them immediately after the crash.

A.2 SEiSS - Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles

Goal "The primary objective of the eCall case study is to work out the benefits and costs of eCall implementation at a European level." A secondary objective was also to work out the effects of different monetary terms on the benefit-cost result. The reason for this is that previous benefit estimations for eCall were carried within the E-MERGE project and the eSafety Driving Group as well as this report with major differences in accident unit cost rates.

Details/basics

Release year	Made by	Project time
Januray 2005	VDI/VDE/IT for eSafety/ EU Commission	-

Based on	Metohds
E-MERGE and The Golden Hour Principle	Desk research, expert opinion, and quantitative and qualitative data have been applied: the bibliographic analysis, scanning existing literature, a series of expert interviews and workshops with representatives.

Assumptions

- 5% to 15% of road fatalities can be reduced to severe injuries
- 10% to 15% of severe injuries can be reduced to slight injuries
- A reduction in congestion time of 10% in the low-impact case and 20% reduction in the high-impact case
- 3% annual discount rate

Parameters

- Effects of eCall on Accident Severity and Congestion Time - low and high impact from E-MERGE
- Number of Road Accidents, Fatalities and Severe Injuries in EU-25 for 2002 from CARE and IRTAD
- European Cost Unit Rates for Accident Evaluation in Euros per accident
- International Cost Unit Rates for Accident Evaluation in Euro per Accident

Benefits

Annual Benefits	**Low impact**	**High impact**
Accident Cost Savings	5 700 Million €	21 900 Million €
Congestion Cost Savings	170 Million €	4 000 Million €
Total Benefits	5 870 Million €	25 900 Million €

Sensitivity analysis for the benefits:

Benefit Components	**European Cost-Unit Rate**	**International Cost-Unit Rates**	**Difference between International and European Cost-Unit Rates**
Avoided Fatality	865 000 €	474 891 €	-45.1%
Avoided Severe Injury	120 000 €	408 563 €	+240.5%
Arithmetic Mean	492 500 €	441 727 €	-10.3%

Costs

Annual Costs	**Pessimistic**	**Optimistic**
System Costs	4 500 Million €	3 000 Million €
PSAP Equipment Costs	5 Million €	3 Million €
Training Costs	45 Million €	27 Million €
Total Costs	4 550 Million €	3 030 Million €

Results The main outcome of this project is a methodology for assessing the socio-economic Impact of IVSS. "A key element of the methodology is the benefit-cost analysis, which allows us to determine the extent to which a society would profit from the introduction of an IVSS to the market."

Conclusion A range of attainable benefit-cost ratios of between 1.3 and 8.5, which represents the combined consideration of the "pessimistic view" and the "optimistic view" for the final recommendation of eCall was the conclusion of this study.

A.3 Ekonomisk värdering av eCall i Sverige

Goal To evaluate the effect of eCall for Sweden.

Details/basics Release year: 2006

Based on	Partner from	Metohds
STORM, E-MERGE, SEiSS, and E-Safety Driving Group	Swedish stakeholders	Benefit-cost analysis

Assumptions

- 5-15% reduction in fatalities to severe injury
- 10-15% reduction in severe to light injury

Benefits 8 persons per year is estimated that could have survived with a 100% penetration of eCall. Swedish safety experts thought this number was optimistic, and adjusted the estimate to a reduction in fatalities with eCall of 2-4%, and 3-4% for severely injured. With a fully equipped fleet the benefit of eCall were estimated to be between 550 - 830 MSEK.

Costs With a 100% penetration rate approximately 4.9 million vehicles need to be equipped. SOS Alarm AB has given a cost estimate of 3.5 MSEK per year.

Conclusion The calculations resulted in a BCR of 1.1-4.2.

A.4 AINO - Impact of an automatic emergency call system on accident consequences

Goal "The aim of the study was to estimate the impacts of an automatic emergency call system (eCall) on accident consequences in Finland."

Details/basics

Release year	Made by	Project time
January 2006	AINO, VVT Techincal Research Centre of Finland	-

Based on	**Partner from**	**Metohds**
Swedish study, case reports of Road Accident Investigation Teams in the period 2001-2003	eSafety Forum, Ministry of Transport and Communications Finland	Case study of traffic accident fatalities and a survey to all Finnish emergency response centres

Assumptions Two wheel vehicles and snowmobiles will be equipped with eCall in the future and accidents related to these vehicles were eCall could have an effect are therefore included in the analysis.

Parameters

- 3% annual discount rate
- Service life of IVS estimated to be 8 years

Benefits "In the study the very likely fatality reducing impact of eCall was calculated as 3.6%.[..] If the eCall system had been operational 20% of the fatalities would instead have been permanent injuries, temporary severe injuries for 40% and temporary mild injuries for 40%."This gives an annual savings of 22-44 million euros with regards to fatality savings.

Based on Swedish estimates the annual possible savings in Finland would be 32-42 million euros for severe injuries. Moreover, the decreased travel time would correspond to 0.3-0.5 million euros annually. In total this gives an annual socio-economic direct benefits of the eCall system of 55-88 million euros.

Costs Two prices were used when calculating the equipment costs. "The first estimate assumed that the eCall terminal would be retrofitted to all vehicles": 150 euros because this is the price consumers are willing to pay for the equipment + installation costs of 50 euros per terminal. "The other estimate assumed that the eCall terminal would be standard equipment for the vehicles": 75 euros.

"With the above presumptions the total costs of retrofittable eCall terminals are 99 million euros and the total cost of standard equipment eCall terminals are 37 million euros if the terminals were installed to all registered vehicles." When it comes to the cost of the eCall system for emergency centres this has not been estimated yet. Therefore, Swedish estimates of 0.37 million euros/year were used.

Conclusion “The eCall system was estimated to be able to reduce 5-10% of motor vehicle fatalities and 4-8% of all road fatalities in Finland.[..] The benefit-cost ratio of the eCall system examined in the study was estimated to be in the range of 0.5-2.3.[..] Based on the main findings of the study, the eCall system was recommended for immediate and widespread implementation in Finland.”

A.5 eIMPACT - Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe - Deliverable D6: Cost-Benefit Analyses for stand-alone and co-operative Intelligent Vehicle Safety Systems

Goal The objective of this report was to present the economic assessment of the twelve IVSS considered in eIMPACT on the societal level.

Details/basics

Release year	Made by	Project time
August 2008	The eIMPACT project	-

Based on	Partner from	Metohds
AINO, E-MERGE, SEiSS, Swedish study	The car industry, public authorities, research organisations	Benefit-Cost analysis and sensitivity analysis

Parameters

- 3% annual discount rate
- 2% inflation rate
- Economies of scale effects are not considered

Benefits

	Safety effect	Indirect traffic effect
Low impact: 2010	10.5 mill €	0
High impact: 2010	24.9 mill €	0.1 mill €
Low impact: 2020	1 626.2 mill €	3.4 mill €
High impact: 2020	2 206.4 mill €	4.6 mill €

Costs Cost of infrastructure equipment 29.4 mill. €per year, and system costs including installation 61 €per vehicle in 2010 and 60 €in 2020.

Results For 2010 the BCR was not calculated because penetration rate too low. However, for 2020 the penetration rates are estimated above 30% resulting in a BCR of 2.4 for the low impact case, and 2.3 for the high impact case. However, since eCall has infrastructure costs related to the establishment or adaptation of Public Safety Answering Point (PSAP), the potential case is the only relevant issue. Which means using a penetration rate of 100% in the calculations.

The new BCR was estimated to be 2.7 in 2010, and 1.9 in 2020. From this it can be seen that the BCR of eCall decreases with the time. This is due to the fact that there are less accidents and, therewith, less casualties.

Conclusion "Considering the pessimistic and the optimistic scenario, the BCR of the potential case is between 1.5 and 3.6 in the year 2010 and between 1.1 and 2.5 in the year 2020. Changing the safety parameter leads to a significant change of the BCR. Thus, there is the need for further safety analyses". However, eCall is considered an acceptable IVSS.

A.6 SMART - Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/legal issues

Goal "The specific objectives of the work are to:

- Assess all impacts and benefits of eCall, also fully covering the indirect benefits due to lessened congestion, fewer secondary accidents, improved operations of rescue services, traffic management, national economy, etc;
- Assess all costs of eCall
- Assess all other key deployment issues related to eCall; and
- To compare the three scenarios of do nothing/voluntary agreement/mandatory instalment with regard to their socio-economic profitability."

Details/basics

Release year	Made by	Project time
November 2009	TRL (UK), Inter-utXXI (HU), TNO (NL), VTT (FI), ERTICO (BE), eSafetyAware (BE), Vrije Universitet (NL)	-

Based on	Partner from	Metohds
STORM, E-MERGE, SEiSS, AINO, eIMPACT, Swedish study, and others	European Commission, PSAP experts	Snapshot Benefit-Cost analysis with the use of clusters

Parameters In 2020 the penetration rates are estimated to be:

- 6% for the 'do nothing' scenario
- 23% for the voluntary approach
- 42% for the mandatory introduction

For this study the average fleet of vehicles, including passenger cars, trucks, and buses, was estimated to be around 330 million vehicles between 2014 and 2020.

Benefits "Estimated reduction in casualties for the different clusters:

- Cluster 1: Fatalities 2%, severe injuries 1%
- Cluster 2: Fatalities 2%, severe injuries 1% (according to Netherlands case study)
- Cluster 3: Fatalities 1%, severe injuries 0.5% (according to UK case study)
- Cluster 4: Fatalities 6%, severe injuries 2% (according to Finnish case study)
- Cluster 5: Fatalities 3%, severe injuries 1% (according to Hungary case study)
- Cluster 6: Fatalities 3%, severe injuries 1%"

"Estimated reduction in accident related congestion costs:

- Cluster 1: 17%
- Cluster 2: 17% (according to Netherlands case study)
- Cluster 3: 3% (according to UK case study)
- Cluster 4: 10% (according to Finnish case study)
- Cluster 5: 15-20% (according to Hungary case study), 17% used in calculations
- Cluster 6: 15-20%, 17% used in calculations"

Costs For eCall the main cost component is the in-vehicle equipment; other costs was not considered in this study. The 'cost price' or cost to the supplier, with a small mark-up for implementation costs, was considered to be the most appropriate.

Results Three interesting results from this study were that:

- “The socio-economic profitability of eCall is quite sensitive to the magnitude of its safety effects because of the large number of vehicles to be equipped.”
- “All studies in which safety effects were estimated reported reductions in the number of fatalities.”
- “The cost side of the equation is most sensitive to the unit cost of eCall in-vehicle system.”

Conclusion

BCR/Year	**2020**	**2030**
’Do nothing’ scenario	0.06	0.08
Voluntary approach	0.15	0.15
Mandatory introduction	0.53	1.31

Appendix B
Details of the benefit-cost analysis for Norway

This appendix includes all calculation tables for the benefit-cost analysis for Norwegian conditions. As presented in Chapter 5, the model of the European Commission's Impact Assessment on eCall (EC IA) is the basis for the analysis.This model will be presented in detail, together with the mathematical results.

The model and general parameters

Table B.1: Assumptions for the model utilised in the EC IA

Analysis period	**Rates**	**Penetration rate**	**Exchange rate EUR/NOK**
2012-2033 and 2015-2036	Discount: 4%, Inflation: 2.2%	Matches new type approval from 2015, Figure 4.1	7.79

Table B.2: IVS costs for policy option 3 in the EC IA.

	Euro (€)	**NOK**
Initial cost	180	1 403
Cost after 6 years	125	974

The parameters

Table B.3: Annual reduction rate of events in the EC IA and in Norway.

Type	**Annual reduction - EU**	**Annual reduction - Norway**
Fatalities	-3.50%	-5.20%
Severe injuries	-1.90%	-4.60%

Table B.4: Calculation table for the EU average. Based on [2]

Year	New cars equipped with eCall	Number of equipped cars	Number of equipped cars, including private eCall	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2008			22 222	0,26 %			1 441		10 305		87 753				
2009			26 667	0,31 %			1 278		10 155		104 226				
2010			31 600	0,36 %			1 233		10 006		122 245				
2011			37 421	0,43 %			1 190		9 860		143 283				
2012			44 291	0,51 %			1 148		9 716		167 850				
2013			15 359	0,18 %			1 108		9 574		196 537				
2014			61 961	0,71 %			1 070		9 434		230 035				
2015	85185,19	85 185	158 432	1,83 %	15 333 333	1 323 484	1 032	0,81	9 297	6,93	582 177	16 656 817	4 544 169	- 12 112 648	0,2728
2016	170 370	255 556	342 120	3,95 %	30 666 667	26 448	996	1,74	9 161	14,63	1 244 298	29 512 610	9 397 325	- 20 115 285	0,3184
2017	255 556	511 111	613 391	7,08 %	46 000 000	27 030	961	3,00	9 027	25,74	2 208 089	42 554 577	16 136 241	- 26 418 335	0,3792
2018	340 741	851 852	972 675	11,22 %	61 333 333	27 625	928	4,56	8 895	40,04	3 465 620	54 549 668	24 507 441	- 30 042 227	0,4493
2019	429 630	1 281 481	1 424 187	16,43 %	77 333 333	28 232	895	6,44	8 765	57,52	5 022 427	66 128 991	34 370 608	- 31 758 383	0,5198
2020	522 222	1 803 704	1 972 229	22,75 %	94 000 000	28 853	864	8,63	8 637	78,15	6 883 952	77 284 863	45 592 469	- 31 692 394	0,5899
2021	522 222	2 325 926	2 524 919	29,12 %	65 277 778	29 488	834	10,67	8 511	98,11	8 722 916	51 613 281	55 914 414	4 301 133	1,0833
2022	522 222	2 848 148	3 083 094	35,56 %	65 277 778	30 137	805	12,56	8 387	117,52	10 542 282	49 628 648	65 407 650	15 779 003	1,3179
2023	522 222	3 370 370	3 647 739	42,08 %	65 277 778	30 800	776	14,33	8 264	136,41	12 345 408	47 720 338	74 140 604	26 420 266	1,5536
2024	522 222	3 892 593	4 220 021	48,68 %	65 277 778	31 478	749	16,00	8 144	154,81	14 136 113	45 885 417	82 179 274	36 293 857	1,7910
2025	522 222	4 414 815	4 801 314	55,38 %	65 277 778	32 170	723	17,59	8 025	172,78	15 918 760	44 121 061	89 587 591	45 466 531	2,0305
2026	522 222	4 937 037	5 393 239	62,21 %	65 277 778	32 878	698	19,04	7 907	190,41	17 698 340	42 424 557	96 427 791	54 003 234	2,2729
2027	522 222	5 459 259	5 997 711	69,18 %	65 277 778	33 601	673	20,44	7 792	207,70	19 480 592	40 793 295	102 760 789	61 967 494	2,5191
2028	522 222	5 981 481	6 616 988	76,32 %	65 277 778	34 340	650	21,78	7 678	224,78	21 272 115	39 224 766	108 646 583	69 421 817	2,7698
2029	522 222	6 503 704	7 253 735	83,67 %	65 277 778	35 096	627	23,04	7 566	241,70	23 080 528	37 716 557	114 144 666	76 428 109	3,0264
2030	522 222	7 025 926	7 911 096	91,25 %	65 277 778	35 868	605	24,26	7 455	258,59	24 914 630	36 266 349	119 314 472	83 048 123	3,2899
2031	522 222	7 548 148	8 592 782	99,11 %	65 277 778	36 657	584	25,41	7 347	275,56	26 784 610	34 871 911	124 215 842	89 343 931	3,5621
2032	522 222	8 070 370	9 303 172	107,31 %	65 277 778	37 464	564	26,56	7 239	292,63	28 702 273	33 531 097	128 909 532	95 378 435	3,8445
2033	522 222	8 592 593	10 047 432	115,89 %	65 277 778	38 288	544	27,67	7 133	310,04	30 681 321	32 241 847	133 457 763	101 215 917	4,1393
												822 726 648	**1 429 655 225**	**606 928 577**	**1,7377**

Estimated reduction in fatalities:	-4.80%
severe injuries:	-5.26%
congestion:	-13%

Table B.5: Calculation table for the EU average with Norwegian statistics

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2012			0,44 %			142		661		1 307 988				
2013			0,52 %			137		648		1 531 532				
2014			0,62 %			132		636		1 792 574				
2015	25 791	25 791	1,58 %	36 176 486	11 009 148	128	0,10	624	0,52	4 536 675	47 185 634	14 641 395	- 32 544 239	0,3103
2016	51 582	77 374	3,41 %	72 352 972	224 844	123	0,20	612	1,10	9 696 319	69 786 361	30 329 668	- 39 456 693	0,4346
2017	77 374	154 747	6,11 %	108 529 458	234 846	119	0,35	601	1,93	17 206 757	100 558 712	52 166 803	- 48 391 909	0,5188
2018	103 165	257 912	9,69 %	144 705 943	245 292	115	0,53	589	3,00	27 006 190	128 861 121	79 361 760	- 49 499 361	0,6159
2019	130 077	387 989	14,18 %	182 455 320	256 204	111	0,75	578	4,31	39 137 763	156 182 577	111 484 635	- 44 697 941	0,7138
2020	158 111	546 101	19,64 %	221 777 587	267 601	107	1,01	567	5,86	53 643 882	182 504 959	148 125 026	- 34 379 934	0,8116
2021	158 111	704 212	25,14 %	154 012 213	279 505	103	1,24	556	7,36	67 974 193	121 938 986	181 953 175	60 014 189	1,4922
2022	158 111	862 323	30,70 %	154 012 213	291 938	99	1,47	546	8,81	82 151 786	117 258 474	213 185 643	95 927 169	1,8181
2023	158 111	1 020 434	36,33 %	154 012 213	304 925	96	1,67	535	10,23	96 202 825	112 758 021	242 031 611	129 273 590	2,1465
2024	158 111	1 178 546	42,03 %	154 012 213	318 490	93	1,87	525	11,61	110 157 078	108 430 705	268 693 933	160 263 228	2,4780
2025	158 111	1 336 657	47,81 %	154 012 213	332 657	89	2,05	515	12,96	124 048 525	104 269 864	293 370 231	189 100 367	2,8136
2026	158 111	1 494 768	53,71 %	154 012 213	347 455	86	2,22	505	14,28	137 916 087	100 269 097	316 254 017	215 984 920	3,1541
2027	158 111	1 652 879	59,73 %	154 012 213	362 911	83	2,39	496	15,57	151 804 457	96 422 247	337 535 890	241 113 643	3,5006
2028	158 111	1 810 991	65,90 %	154 012 213	379 055	80	2,54	486	16,86	165 765 085	92 723 395	357 404 769	264 681 374	3,8545
2029	158 111	1 969 102	72,24 %	154 012 213	395 917	77	2,69	477	18,13	179 857 319	89 166 848	376 049 227	286 882 379	4,2174
2030	158 111	2 127 213	78,78 %	154 012 213	413 529	75	2,83	468	19,39	194 149 746	85 747 133	393 658 903	307 911 771	4,5909
2031	158 111	2 285 324	85,57 %	154 012 213	431 924	72	2,96	459	20,66	208 721 750	82 458 988	410 426 036	327 967 049	4,9773
2032	158 111	2 443 436	92,65 %	154 012 213	451 138	70	3,10	450	21,95	223 665 336	79 297 352	426 547 120	347 249 768	5,3791
2033	158 111	2 601 547	100,06 %	154 012 213	471 206	67	3,23	442	23,25	239 087 259	76 257 360	442 224 706	365 967 346	5,7991
											1 952 077 834	**4 695 444 547**	**2 743 366 713**	**2,4054**

Estimated reduction in fatalities: -4.80%

severe injuries: -5.26%

congestion: -13%

Table B.6: Calculation table for Norwegian conditions using Swedish reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		1 006 144				
2016			0,52 %			135		631		1 178 101				
2017			0,62 %			128		602		1 378 903				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,07	574	0,36	3 489 750	47 185 634	11 331 867	- 35 853 767	0,2402
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,14	548	0,75	7 458 707	69 786 361	23 030 152	- 46 756 209	0,3300
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,23	522	1,28	13 235 967	100 558 712	38 863 424	- 61 695 288	0,3865
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,35	498	1,93	20 773 992	128 861 121	58 007 423	- 70 853 697	0,4502
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,49	475	2,70	30 105 972	156 182 577	79 950 409	- 76 232 168	0,5119
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,64	454	3,56	41 264 525	182 504 959	104 225 891	- 78 279 068	0,5711
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	0,77	433	4,35	52 287 841	121 938 986	125 619 377	3 680 391	1,0302
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	0,89	413	5,07	63 193 681	117 258 474	144 415 320	27 156 846	1,2316
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	1,00	394	5,72	74 002 173	112 758 021	160 877 163	48 119 142	1,4267
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	1,10	376	6,31	84 736 214	108 430 705	175 249 190	66 818 485	1,6162
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	1,19	358	6,85	95 421 943	104 269 864	187 758 279	83 488 415	1,8007
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	1,26	342	7,34	106 089 298	100 269 097	198 615 536	98 346 439	1,9808
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	1,33	326	7,79	116 772 660	96 422 247	208 017 866	111 595 618	2,1574
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	1,39	311	8,20	127 511 604	92 723 395	216 149 436	123 426 041	2,3311
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	1,45	297	8,58	138 351 784	89 166 848	223 183 095	134 016 247	2,5030
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	1,50	283	8,92	149 345 959	85 747 133	229 281 719	143 534 586	2,6739
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	1,54	270	9,25	160 555 192	82 458 988	234 599 511	152 140 523	2,8450
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	1,58	258	9,55	172 050 258	79 297 352	239 283 263	159 985 911	3,0175
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	1,62	246	9,84	183 913 276	76 257 360	243 473 585	167 216 225	3,1928
											1 952 077 834	**2 901 932 506**	**949 854 672**	**1,4866**

Estimated reduction in fatalities:	-3.50%
severe injuries:	-4.00%
congestion:	-10%

Table B.7: Calculation table for Norwegian conditions using Finnish reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		1 006 144				
2016			0,52 %			135		631		1 178 101				
2017			0,62 %			128		602		1 378 903				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,11	574	0,36	3 489 750	47 185 634	12 310 684	- 34 874 950	0,2609
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,23	548	0,75	7 458 707	69 786 361	24 999 229	- 44 787 132	0,3582
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,40	522	1,28	13 235 967	100 558 712	42 152 296	- 58 406 416	0,4192
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,60	498	1,93	20 773 992	128 861 121	62 865 936	- 65 995 185	0,4879
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,83	475	2,70	30 105 972	156 182 577	86 577 580	- 69 604 996	0,5543
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	1,09	454	3,56	41 264 525	182 504 959	112 775 467	- 69 729 492	0,6179
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	1,32	433	4,35	52 287 841	121 938 986	135 816 100	13 877 113	1,1138
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	1,53	413	5,07	63 193 681	117 258 474	156 014 458	38 755 984	1,3305
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	1,72	394	5,72	74 002 173	112 758 021	173 661 808	60 903 787	1,5401
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	1,89	376	6,31	84 736 214	108 430 705	189 027 801	80 597 096	1,7433
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	2,03	358	6,85	95 421 943	104 269 864	202 362 446	98 092 582	1,9408
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	2,17	342	7,34	106 089 298	100 269 097	213 897 961	113 628 864	2,1332
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	2,28	326	7,79	116 772 660	96 422 247	223 850 531	127 428 284	2,3216
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	2,39	311	8,20	127 511 604	92 723 395	232 421 952	139 698 558	2,5066
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	2,48	297	8,58	138 351 784	89 166 848	239 801 217	150 634 369	2,6894
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	2,57	283	8,92	149 345 959	85 747 133	246 166 010	160 418 877	2,8708
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	2,64	270	9,25	160 555 192	82 458 988	251 684 152	169 225 164	3,0522
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	2,71	258	9,55	172 050 258	79 297 352	256 514 998	177 217 646	3,2348
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	2,78	246	9,84	183 913 276	76 257 360	260 810 783	184 553 423	3,4201
											1 952 077 834	**3 123 711 409**	**1 171 633 575**	**1,6002**

Estimated reduction in fatalities: -6.00%
severe injuries: -4.00%
congestion: -10%

Table B.8: Calculation table for Norwegian conditions using the average of Swedish and Finnish reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		1 006 144				
2016			0,52 %			135		631		1 178 101				
2017			0,62 %			128		602		1 378 903				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,09	574	0,36	3 489 750	47 185 634	11 821 275	- 35 364 358	0,2505
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,19	548	0,75	7 458 707	69 786 361	24 014 691	- 45 771 670	0,3441
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,32	522	1,28	13 235 967	100 558 712	40 507 860	- 60 050 852	0,4028
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,47	498	1,93	20 773 992	128 861 121	60 436 680	- 68 424 441	0,4690
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,66	475	2,70	30 105 972	156 182 577	83 263 994	- 72 918 582	0,5331
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,86	454	3,56	41 264 525	182 504 959	108 500 679	- 74 004 280	0,5945
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	1,05	433	4,35	52 287 841	121 938 986	130 717 739	8 778 752	1,0720
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	1,21	413	5,07	63 193 681	117 258 474	150 214 889	32 956 415	1,2811
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	1,36	394	5,72	74 002 173	112 758 021	167 269 486	54 511 464	1,4834
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	1,49	376	6,31	84 736 214	108 430 705	182 138 496	73 707 791	1,6798
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	1,61	358	6,85	95 421 943	104 269 864	195 060 363	90 790 499	1,8707
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	1,72	342	7,34	106 089 298	100 269 097	206 256 749	105 987 652	2,0570
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	1,81	326	7,79	116 772 660	96 422 247	215 934 198	119 511 951	2,2395
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	1,89	311	8,20	127 511 604	92 723 395	224 285 694	131 562 299	2,4189
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	1,97	297	8,58	138 351 784	89 166 848	231 492 156	142 325 308	2,5962
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	2,03	283	8,92	149 345 959	85 747 133	237 723 864	151 976 731	2,7724
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	2,09	270	9,25	160 555 192	82 458 988	243 141 831	160 682 843	2,9486
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	2,15	258	9,55	172 050 258	79 297 352	247 899 130	168 601 778	3,1262
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	2,20	246	9,84	183 913 276	76 257 360	252 142 184	175 884 824	3,3065
											1 952 077 834	**3 012 821 957**	**1 060 744 124**	**1,5434**

Estimated reduction in fatalities:	-4.75%
severe injuries:	-4.00%
congestion:	-10%

Table B.9: Calculation table for Norwegian conditions using UK reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		301 843				
2016			0,52 %			135		631		353 430				
2017			0,62 %			128		602		413 671				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,04	574	0,14	1 046 925	47 185 634	4 256 893	- 42 928 740	0,0902
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,08	548	0,28	2 237 612	69 786 361	8 639 916	- 61 146 445	0,1238
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,13	522	0,48	3 970 790	100 558 712	14 560 419	- 85 998 293	0,1448
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,20	498	0,72	6 232 198	128 861 121	21 703 775	- 107 157 346	0,1684
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,28	475	1,01	9 031 792	156 182 577	29 873 772	- 126 308 804	0,1913
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,36	454	1,34	12 379 357	182 504 959	38 892 110	- 143 612 849	0,2131
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	0,44	433	1,63	15 686 352	121 938 986	46 812 077	- 75 126 909	0,3839
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	0,51	413	1,90	18 958 104	117 258 474	53 743 858	- 63 514 616	0,4583
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	0,57	394	2,15	22 200 652	112 758 021	59 789 264	- 52 968 758	0,5302
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	0,63	376	2,37	25 420 864	108 430 705	65 042 474	- 43 388 231	0,5999
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	0,68	358	2,57	28 626 583	104 269 864	69 590 727	- 34 679 137	0,6674
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	0,72	342	2,75	31 826 789	100 269 097	73 514 974	- 26 754 123	0,7332
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	0,76	326	2,92	35 031 798	96 422 247	76 890 493	- 19 531 754	0,7974
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	0,80	311	3,08	38 253 481	92 723 395	79 787 468	- 12 935 927	0,8605
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	0,83	297	3,22	41 505 535	89 166 848	82 271 541	- 6 895 307	0,9227
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	0,86	283	3,35	44 803 788	85 747 133	84 404 336	- 1 342 797	0,9843
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	0,88	270	3,47	48 166 558	82 458 988	86 243 963	3 784 975	1,0459
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	0,90	258	3,58	51 615 078	79 297 352	87 845 501	8 548 149	1,1078
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	0,93	246	3,69	55 173 983	76 257 360	89 261 467	13 004 106	1,1705
											1 952 077 834	**1 073 125 028**	**- 878 952 806**	**0,5497**

Estimated reduction in fatalities: -2.00%

severe injuries: -1.50%

congestion: -3.00%

Table B.10: Calculation table for Norwegian conditions using Dutch reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		1 710 445				
2016			0,52 %			135		631		2 002 772				
2017			0,62 %			128		602		2 344 136				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,04	574	0,09	5 932 575	47 185 634	8 333 572	- 38 852 062	0,1766
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,08	548	0,19	12 679 801	69 786 361	17 042 781	- 52 743 580	0,2442
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,13	522	0,32	22 501 143	100 558 712	28 940 071	- 71 618 641	0,2878
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,20	498	0,48	35 315 786	128 861 121	43 466 791	- 85 394 330	0,3373
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,28	475	0,67	51 180 152	156 182 577	60 285 160	- 95 897 416	0,3860
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,36	454	0,89	70 149 692	182 504 959	79 082 607	- 103 422 352	0,4333
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	0,44	433	1,09	88 889 329	121 938 986	95 912 937	- 26 026 049	0,7866
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	0,51	413	1,27	107 429 258	117 258 474	110 955 348	- 6 303 126	0,9462
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	0,57	394	1,43	125 803 695	112 758 021	124 377 743	11 619 721	1,1031
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	0,63	376	1,58	144 051 563	108 430 705	136 337 755	27 907 050	1,2574
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	0,68	358	1,71	162 217 302	104 269 864	146 983 731	42 713 867	1,4096
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	0,72	342	1,84	180 351 806	100 269 097	156 455 673	56 186 576	1,5604
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	0,76	326	1,95	198 513 521	96 422 247	164 886 161	68 463 913	1,7100
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	0,80	311	2,05	216 769 726	92 723 395	172 401 231	79 677 836	1,8593
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	0,83	297	2,14	235 198 033	89 166 848	179 121 255	89 954 407	2,0088
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	0,86	283	2,23	253 888 130	85 747 133	185 161 799	99 414 666	2,1594
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	0,88	270	2,31	272 943 827	82 458 988	190 634 475	108 175 487	2,3119
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	0,90	258	2,39	292 485 439	79 297 352	195 647 796	116 350 444	2,4673
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	0,93	246	2,46	312 652 570	76 257 360	200 308 045	124 050 685	2,6267
											1 952 077 834	**2 296 334 931**	**344 257 097**	**1,1764**

Estimated reduction in fatalities:	-2.00%
severe injuries:	-1.00%
congestion:	-17%

Table B.11: Calculation table for Norwegian conditions using the average of UK and Dutch reduction estimates.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		1 006 144				
2016			0,52 %			135		631		1 178 101				
2017			0,62 %			128		602		1 378 903				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,04	574	0,11	3 489 750	47 185 634	6 295 233	- 40 890 401	0,1334
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,08	548	0,23	7 458 707	69 786 361	12 841 348	- 56 945 013	0,1840
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,13	522	0,40	13 235 967	100 558 712	21 750 245	- 78 808 467	0,2163
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,20	498	0,60	20 773 992	128 861 121	32 585 283	- 96 275 838	0,2529
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,28	475	0,84	30 105 972	156 182 577	45 079 466	- 111 103 110	0,2886
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,36	454	1,11	41 264 525	182 504 959	58 987 359	- 123 517 600	0,3232
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	0,44	433	1,36	52 287 841	121 938 986	71 362 507	- 50 576 479	0,5852
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	0,51	413	1,58	63 193 681	117 258 474	82 349 603	- 34 908 871	0,7023
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	0,57	394	1,79	74 002 173	112 758 021	92 083 503	- 20 674 518	0,8166
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	0,63	376	1,97	84 736 214	108 430 705	100 690 114	- 7 740 590	0,9286
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	0,68	358	2,14	95 421 943	104 269 864	108 287 229	4 017 365	1,0385
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	0,72	342	2,30	106 089 298	100 269 097	114 985 324	14 716 227	1,1468
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	0,76	326	2,44	116 772 660	96 422 247	120 888 327	24 466 080	1,2537
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	0,80	311	2,56	127 511 604	92 723 395	126 094 349	33 370 954	1,3599
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	0,83	297	2,68	138 351 784	89 166 848	130 696 398	41 529 550	1,4658
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	0,86	283	2,79	149 345 959	85 747 133	134 783 068	49 035 935	1,5719
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	0,88	270	2,89	160 555 192	82 458 988	138 439 219	55 980 231	1,6789
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	0,90	258	2,98	172 050 258	79 297 352	141 746 648	62 449 296	1,7875
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	0,93	246	3,08	183 913 276	76 257 360	144 784 756	68 527 395	1,8986
											1 952 077 834	**1 684 729 979**	**- 267 347 854**	**0,8630**

Estimated reduction in fatalities: -2.00%
severe injuries: -1.25%
congestion: -10%

Table B.12: Calculation table for the average scenario of the estimates for Norway.

Year	New cars equipped with eCall	Number of equipped cars	% over total number	IVS Costs	PSAPs costs	Estimated fatalities	Number fatalities Saved by eCall	Estimated Severe Injuries (SI)	No SI avoided by eCall	Congestion savings by eCall	Total Costs discounted	Total Benefits Discounted	Net Value	BCR discounted
2015			0,44 %			142		661		653 994				
2016			0,52 %			135		631		765 766				
2017			0,62 %			128		602		896 287				
2018	25 791	25 791	1,58 %	36 176 486	11 009 148	121	0,08	574	0,25	2 268 338	47 185 634	8 283 788	- 38 901 845	0,1756
2019	51 582	77 374	3,41 %	72 352 972	224 844	115	0,16	548	0,51	4 848 159	69 786 361	16 819 572	- 52 966 789	0,2410
2020	77 374	154 747	6,11 %	108 529 458	234 846	109	0,27	522	0,88	8 603 378	100 558 712	28 356 357	- 72 202 355	0,2820
2021	103 165	257 912	9,69 %	144 705 943	245 292	103	0,40	498	1,33	13 503 095	128 861 121	42 284 856	- 86 576 265	0,3281
2022	130 077	387 989	14,18 %	182 455 320	256 204	98	0,55	475	1,85	19 568 882	156 182 577	58 225 676	- 97 956 900	0,3728
2023	158 111	546 101	19,64 %	221 777 587	267 601	93	0,73	454	2,45	26 821 941	182 504 959	75 833 789	- 106 671 171	0,4155
2024	158 111	704 212	25,14 %	154 012 213	279 505	88	0,88	433	2,99	33 987 096	121 938 986	91 314 088	- 30 624 898	0,7489
2025	158 111	862 323	30,70 %	154 012 213	291 938	83	1,02	413	3,49	41 075 893	117 258 474	104 879 158	- 12 379 316	0,8944
2026	158 111	1 020 434	36,33 %	154 012 213	304 925	79	1,15	394	3,93	48 101 413	112 758 021	116 725 536	3 967 515	1,0352
2027	158 111	1 178 546	42,03 %	154 012 213	318 490	75	1,26	376	4,34	55 078 539	108 430 705	127 035 137	18 604 433	1,1716
2028	158 111	1 336 657	47,81 %	154 012 213	332 657	71	1,36	358	4,71	62 024 263	104 269 864	135 976 587	31 706 723	1,3041
2029	158 111	1 494 768	53,71 %	154 012 213	347 455	67	1,44	342	5,05	68 958 044	100 269 097	143 706 468	43 437 371	1,4332
2030	158 111	1 652 879	59,73 %	154 012 213	362 911	64	1,52	326	5,36	75 902 229	96 422 247	150 370 512	53 948 265	1,5595
2031	158 111	1 810 991	65,90 %	154 012 213	379 055	60	1,59	311	5,64	82 882 542	92 723 395	156 104 710	63 381 315	1,6836
2032	158 111	1 969 102	72,24 %	154 012 213	395 917	57	1,66	297	5,90	89 928 660	89 166 848	161 036 379	71 869 531	1,8060
2033	158 111	2 127 213	78,78 %	154 012 213	413 529	54	1,71	283	6,14	97 074 873	85 747 133	165 285 173	79 538 040	1,9276
2034	158 111	2 285 324	85,57 %	154 012 213	431 924	51	1,76	270	6,36	104 360 875	82 458 988	168 964 057	86 505 070	2,0491
2035	158 111	2 443 436	92,65 %	154 012 213	451 138	49	1,81	258	6,57	111 832 668	79 297 352	172 180 249	92 882 897	2,1713
2036	158 111	2 601 547	100,06 %	154 012 213	471 206	46	1,85	246	6,77	119 543 630	76 257 360	175 036 125	98 778 765	2,2953
											1 952 077 834	**2 098 418 218**	**146 340 384**	**1,07497**

Estimated reduction in fatalities:	-4.00%
severe injuries:	-2.75%
congestion:	-6.50%