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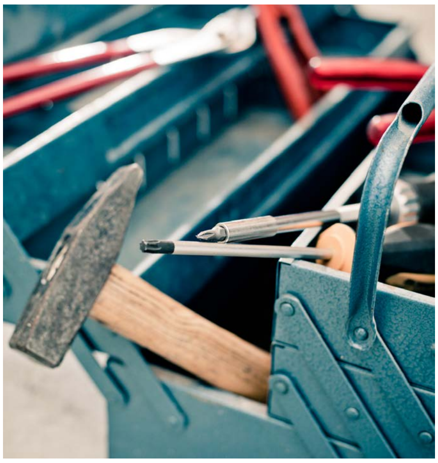

Countermeasures against dangerous use of communication devices while driving – a toolbox

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FINDING A BETTER WAY

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Countermeasures against dangerous use of communication devices while driving

Abstract

This report outlines possible means to reduce the dangerous usage of mobile phones and other communication devices while driving. An important aspect of this commission was to demonstrate alternatives to legislation.

The suggested countermeasures cover several areas. One is technical solutions, including countermeasures directed towards the infrastructure, the vehicle and the communication device. Another area includes education and information and describes different ways to increase knowledge and understanding. Furthermore, there are different possibilities for how society can influence the behaviour of individuals, both via bans, recommendations and incentives.

The usage of communication devices while driving has both advantages and disadvantages. How to deal with device usage is a complex problem, and it is unlikely that one single countermeasure can provide a complete solution. One countermeasure may even depend on the implementation of others. The exact effect of most countermeasures is hard to predict, and possible side effects may occur. It is therefore necessary to be pragmatic, meaning that countermeasures whose advantages outweigh their disadvantages should be implemented. Also, different countermeasures can reinforce each other which may attenuate negative side effects.

It is our opinion that a combination of different countermeasures – which educate and inform the driver while at the same time support him or her in a safe usage of communication devices – is preferable to a law against communication device usage while driving. Continuous follow-ups are necessary to ensure the outcome of implemented countermeasures.

Keywords:
telephone, communication, driver distraction, countermeasure

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Åtgärder mot trafikfarlig användning av kommunikationsutrustning under körning

Referat

Denna rapport behandlar tänkbara åtgärder för att reducera farligt användande av mobiltelefon och annan kommunikationsutrustning under körning. En viktig del i uppdraget var att belysa alternativ till lagstiftning om förbud. Åtgärdsförslagen täcker flera områden. Ett av dem är teknik, vilket innefattar både teknik i fordonet, teknik i kommunikationsutrustningen och en sammankoppling med infrastrukturen. Ett annat område handlar om utbildning och information och beskriver olika sätt att öka människans kunskap och förståelse. Ett tredje område belyser olika möjligheter som samhället har att påverka människans beteende, både via förbud och lagar och via incitament. En lista över samtliga åtgärdsförslag finns på rapportens baksida.

Det finns både för- och nackdelar med användandet av kommunikationsutrustning under körning. Hur användandet ska hanteras är ett komplext problem och det är osannolikt att en enskild åtgärd står för hela lösningen. En åtgärd kan till och med vara beroende av att andra åtgärder redan är implementerade. Många åtgärder har en baksida och man kan inte förvänta sig tydliga målbilder och rakt igenom positiva resultat. Man måste därför lyfta blicken och inse att om fördelarna överväger nackdelarna så är åtgärden värd att genomföra. Olika åtgärder kan dock stärka varandra och delvis fånga upp möjliga negativa sidoeffekter.

Vi anser att en kombination av olika åtgärder som dels utbildar och informerar och dels stöttar föraren i att kunna hantera kommunikation på ett säkert sätt är att föredra över ett förbud av användningen av kommunikationsutrustning under färd likt det som idag finns i andra europeiska länder. En kontinuerlig uppföljning och utvärdering krävs för att säkerställa att åtgärderna har förväntad effekt.

Nyckelord:
mobiltelefon, kommunikation, förardistraktion, åtgärd

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Preface

In October 2011, the Swedish National Road and Transport Research Institute (VTI) presented a literature review on usage of mobile telephones and other communication devices while driving. One of the main findings was that it has not been possible to show that there has been any long-term effect on road safety in the countries that have statutory requirements for hands-free devices. In November 2011, VTI was therefore commissioned by the Swedish government to investigate possible alternatives to a ban on using mobile communication devices while driving and its consequences.

The project leaders wish to thank all of those who have contributed to the report by writing parts of it, discussing possible alternative countermeasures and reviewing early drafts. We would like to particularly thank the reference group for its work. We also wish to thank the government for giving us this task.

The reference group consisted of:

Magdalena Bonde	*Eniro Sverige AB*
Ruggero Ceci	*Swedish Transport Administration*
Anders Fagerholt	*Ericsson AB*
Peder Fast	*Volvo Car Corporation*
Martin Miljeteig	*Swedish Transport Workers Union*
Fridulv Sagberg	*Norwegian Institute of Transport Economics (TØI)*
Trent Victor	*Volvo Technology AB*

Linköping, April 2012

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Omslag: Katja Kircher

Kvalitetsgranskning

Extern peer review har genomförts 31 mars 2012 av Magdalena Bonde (Eniro Sverige AB), Ruggero Ceci (Trafikverket), Anders Fagerholt (Ericsson AB), Peder Fast (Volvo Car Corporation), Martin Miljeteig (Svenska Transportarbetareförbundet), Fridulv Sagberg (TØI) och Trent Victor (Volvo Technology AB). Författargruppen har genomfört justeringar av slutligt rapportmanus. Projektledarens närmaste chef Jan Andersson, VTI, har därefter granskat och godkänt publikationen för publicering 13 december 2012.

External peer review was performed on 31 March 2012 by Magdalena Bonde (Eniro Sverige AB), Ruggero Ceci (Swedish Transport Administration), Anders Fagerholt (Ericsson AB), Peder Fast (Volvo Car Corporation), Martin Miljeteig (Swedish Transport Workers Union), Fridulv Sagberg (TØI) and Trent Victor (Volvo Technology AB). The author group has made alterations to the final manuscript of the report. The research director of the project manager Jan Andersson examined and approved the report for publication on 13 December 2012.

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Countermeasures against dangerous use of communication devices while driving – a toolbox

by Katja Kircher, Christer Ahlström , Carina Fors, Sonja Forward, Nils Petter Gregersen, Magnus Hjälmdahl, Jonas Jansson, Gunnar Lindberg, Lena Nilsson and Christopher Patten
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Summary

This report outlines possible means to reduce the dangerous usage of mobile phones and other communication devices while driving, while at the same time preserve the positive effects. The suggested countermeasures cover several areas and are intended to function as alternatives to banning device usage. One is technical solutions, including countermeasures directed towards the infrastructure, the vehicle and the communication device. Another area includes education and information and describes different ways to increase knowledge and understanding. Furthermore, there are different possibilities for how society can influence the behaviour of individuals, both via bans, recommendations and incentives.

We want to point out that the usage of communication devices while driving has both advantages and disadvantages. How to deal with device usage is a complex problem, and it is unlikely that one single countermeasure can provide a complete solution. One countermeasure may even depend on the implementation of others. The exact effect of most countermeasures is hard to predict, and possible side effects may occur. It is therefore necessary to be pragmatic, meaning that countermeasures whose advantages outweigh their disadvantages should be implemented. Also, different countermeasures can reinforce each other which may attenuate negative side effects.

The individual countermeasures use different approaches to reduce the dangerous usage of communication devices. Education and information mainly aim at changing the attitude and opinion about communication device usage while driving, both on a societal and an individual level. Another goal is to eradicate misconceptions and to increase the knowledge about which behaviour can be dangerous in which situations.

Financial incentives can strengthen the driver's motivation to adopt safer behavioural strategies with respect to communication device usage while driving. A financial profit may lead to sustained behavioural changes. This is a good complement to the changes in attitude brought about by education and information. Technical solutions are needed in order to couple for example insurance rates to individual communication device usage.

Technical solutions can facilitate other countermeasures, but they also have a great potential to support and help the driver directly. Countermeasures include situation based adaptation of device functionality, real-time distraction warnings, safety nets and features built into the vehicle and into the infra-structure, and automatic information exchange between infrastructure, vehicles and communication devices to facilitate the driver's ability to foresee critical situations. Many research and development projects are already initiated, and especially for the technical sector guidance in the right direction is important. This can only be achieved with continuous evaluation of technical achievements. Legal initiatives need to be phrased such that it addresses negligent behaviour rather than the usage of a certain device. Such a formulation can be normative and provide clearer rules and standards to deal with dangerous

communication device usage. Legislation can also be used to promote safe systems, a safe infrastructure, safe users and therefore safe communication.

To be able to implement the suggested countermeasures successfully it is important to consider possible issues and problems already in the planning phase:

- *Responsibility* | Currently it is not clear who should be responsible for the information delivered by independent suppliers, which is presented on the interface of the vehicle.
- *Business case* | The motivation to introduce new technologies is coupled to the possibility to earn money.
- *Ethical issues* | A number of the presented countermeasures will violate data privacy.
- *Legal issues* | Currently the driver is responsible for steering the vehicle, according to the Vienna Convention, which represents a conflict with the goals of autonomous driving.
- *Globality* | Technical solutions should preferably be global, which can meet legal, cultural, economical and technical obstacles.
- *Behavioural adaptation* | Drivers can overestimate the capability of technical solutions or misuse them with other purposes than safety in mind.

It is our opinion that a combination of different countermeasures – which educate and inform the driver while at the same time support him or her in a safe usage of communication devices – is preferable to a law against communication device usage while driving. Continuous follow-ups are necessary to ensure the outcome of implemented countermeasures.

Åtgärder mot trafikfarlig användning av kommunikationsutrustning under körning

av Katja Kircher, Christer Ahlström , Carina Fors, Sonja Forward, Nils Petter Gregersen, Magnus Hjälmdahl, Jonas Jansson, Gunnar Lindberg, Lena Nilsson och Christopher Patten
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Sammanfattning

Rapporten kan ses som en verktygslåda av åtgärder med syfte att motverka de trafikfarliga aspekterna av kommunikation under körning och samtidigt bevara de positiva effekterna. Åtgärdsförslagen täcker flera områden och är tänkta som alternativ till lagstiftning om förbud. Ett av dem är *teknik*, vilket innefattar både teknik i fordonet, teknik i kommunikations-utrustningen och en sammankoppling med infrastrukturen. Ett annat område handlar om *utbildning och information* och beskriver olika sätt att öka människans kunskap och förståelse. Ett tredje område belyser olika möjligheter som *samhället* har att påverka människans beteende, både via förbud och lagar och via incitament. En lista över samtliga åtgärdsförslag finns på rapportens baksida.

Vi vill poängtera att det finns både för- och nackdelar med användandet av kommunikations-utrustning under körning. Hur användandet ska hanteras är ett komplext problem och det är osannolikt att en enskild åtgärd står för hela lösningen. En åtgärd kan till och med vara beroende av att andra åtgärder redan är implementerade. Många åtgärder har en baksida och man kan inte förvänta sig entydiga och rakt igenom positiva resultat. Man måste därför lyfta blicken och inse att om fördelarna överväger nackdelarna så är åtgärden värd att genomföra. Olika åtgärder kan dock stärka varandra och delvis fånga upp möjliga negativa sidoeffekter.

Åtgärderna har olika angreppssätt för att minska trafikfarlig användning av kommunikations-utrustning. Utbildning och information ska huvudsakligen ändra individernas och samhällets inställning och förhållningssätt till kommunikationsutrustning. Förståelsen för vad som är farligt och när det är farligt ska ökas och feluppfattningar ska motverkas.

Finansiella incitament kan förstärka förarens vilja att anamma ett säkrare beteende med avseende på kommunikation under körning. En finansiell vinst utgör en belöning som kan upprätthålla motivationen att bibehålla ett säkert beteende. För att kunna koppla försäkringspremier till hur föraren använder sig av kommunikationsutrustning under körning behövs tekniska lösningar.

Tekniken kan alltså bidra till att möjliggöra andra åtgärder, men den kan även i sig själv hjälpa och stötta föraren. Åtgärderna handlar om att anpassa vilken funktionalitet som finns tillgänglig för föraren baserat på den rådande trafiksituationen, att varna den distraherade föraren, att bygga hjälpmedel och skyddsnät i fordonet och i infrastrukturen, och att förbättra förarens möjlighet att tolka trafiksituationen genom informationsutbyte mellan infrastrukturen, fordonen och de mobila enheterna. Många forsknings- och utvecklingsinitiativ är redan på gång, och speciellt för den tekniska sektorn gäller det att kanalisera utvecklingen i rätt riktning.

En lagstiftning behöver vara teknikneutral och rikta sig mot det vårdslösa beteendet snarare än mot användandet i sig. En sådan lagstiftning kan vara normbildande och ger ett tydligare regelverk mot trafikfarlig användning av kommunikationsutrustning. Lagstiftning och krav på upphandling kan även användas för att främja säkra system, säker infrastruktur, säkra användare och därmed säker kommunikation.

För att på ett framgångsrikt sätt kunna införa åtgärderna är det mycket viktigt att redan i planeringsfasen ta hänsyn till möjliga problem som kan uppstå:

- *Ansvar* | Det är i dagsläget oklart vem som ska ta ansvar för information som tillhandahålls av tredjepartsleverantörer men som presenteras via fordonets gränssnitt.
- *Business case* | Viljan att införa en ny teknik hänger ihop med hur vinstgivande den är.
- *Etik* | Flera av åtgärderna innebär ett intrång i den personliga integriteten.
- *Juridik* | I dagsläget är föraren ansvarig för framförandet av fordonet enligt Wien-konventionen, vilket står i konflikt med målet för autonom körning.
- *Globalitet* | Teknikbaserade lösningar ska helst fungera globalt, vilket kan möta juridiska, kulturella, ekonomiska och tekniska hinder.
- *Beteendeanpassning* | Förare kan överskatta teknikens förmåga eller använda tekniken till andra syften än säkerhet.

Vi anser att en kombination av olika åtgärder som dels utbildar och informerar och dels stöttar föraren i att kunna hantera kommunikation på ett säkert sätt är att föredra över ett förbud av användningen av kommunikationsutrustning under färd likt det som i dag finns i andra europeiska länder. En kontinuerlig uppföljning och utvärdering krävs för att säkerställa att åtgärderna har förväntad effekt.

Summary of proposed countermeasures

Technology-related proposed countermeasures

- **General increase in road safety based on technology and infrastructure**
  A safety net that guards against, prevents or mitigates undesirable consequences of unsafe communication while driving.

- **Real-time measurement of attention**
  Warns distracted drivers and adjusts support systems based on the driver's current level of attention.

- **Architecture for dissemination of information between the infrastructure, the vehicle and mobile devices**
  Enables unimpeded exchange of information between different systems and thus binds together a number of the countermeasures.

- **Guidelines for good interaction design**
  Describes how communication devices should be designed to minimise distraction.

- **Objective test methods for communication systems**
  Serves as the basis for rating communication devices, such as Euro NCAP. The intention is to favor safer solutions.

- **Use adapted to time, the situation and individual use**
  Restricts access to communication in situations which are considered to demand the driver's undivided attention.

- **Cooperative systems**
  Reinforces a number of other countermeasures by improving and enriching the available information about the current traffic situation.

- **Personal assistant**
  Assists the driver to carry out secondary tasks, in this way reducing the time the driver uses for other activities.

- **Wholly or semi-autonomous driving**
  Takes over driving tasks from the driver and allows the driver to devote time and resources to, for example, communication without affecting road safety.

Education and information

- **Risk education in the driver's training**
  Provides knowledge and insights about the risks associated with use of communication devices while driving.

- **Support to company managements within companies and to personnel responsible for procurement of transport**
  Assists in providing a clear company policy for employees on communication while driving.

- **Risk education in the compulsory basic and further training for the certificate of professional competence, YKB**
  Trains professional drivers on how to handle communication while driving to increase safety.

- **General information campaign focusing on distractions**
  Changes a high-risk group's attitudes, norms and experienced control over behaviour.

- **Dialogue-based information campaign**
  Achieves changes in behaviour by information campaigns with the active participation of a particular target group.

Financial incentives

- **Penalty point systems, incentives and premiums**
  Enables more systematic action against repeated breaches of rules, which, for example, can lead to revocation of driving licences and more expensive insurance premiums.

- **Pay-as-you-talk insurance policies**
  Gives drivers a financial benefit for safe usage of communication devices while driving.

Legislation

- **Legislation on use of communication devices**
  Can be norm-building and provides a clearer regulatory framework against unsafe usage of communication devices.
- **Development facilitating legislation/procurement requirements**
  Affects and channels development to promote safe systems, safe infrastructure, safe users and thus safe communication.

The authors

This report has been produced by a group of researchers at the Swedish National Road and Transport Research Institute (VTI), who have contributed different parts. The authors are listed here in alphabetical order with a brief description of their contribution to the report.

Christer Ahlström has contributed the countermeasures *Guidelines for good interaction design, Architecture for the dissemination of information between the infrastructure, the vehicle and mobile devices, Real-time measurement of attention* and *Adaptation of use to time, the situation and the individual*. He and Katja Kircher have compiled the section on technology and are the principal authors of the introduction and the concluding chapters.

Carina Fors has contributed the countermeasure *General increase in road safety based on technology and infrastructure*.

Sonja Forward has contributed countermeasures for information and campaigns. She has also, together with Nils Petter Gregersen, written the introduction to the section on education and information.

Nils Petter Gregersen has been joint project leader of the assignment. As well as his tasks as project leader, he has contributed countermeasures on education of different groups of road users. Together with Sonja Forward, he has written the introduction to the section on education and information.

Magnus Hjälmdahl has contributed to the countermeasure *Guidelines for good interaction design*.

Jonas Jansson has contributed to the introduction of the section on technology and with the countermeasure *Fully- and semi-autonomous driving*.

Katja Kircher has been project leader of the assignment. She has contributed with the countermeasures *Objective test methods for communication systems*, *Cooperative systems* and *Legislation that facilitates development*, as well as inspecting and contributing to the other countermeasures in the section on technology and to a certain extent to the other countermeasures. She and Christer Ahlström have compiled the section on technology and have been the principal authors of the introduction and the concluding chapter.

Gunnar Lindberg has contributed the sections on financial incentives.

Lena Nilsson has examined the whole report and contributed many valuable comments and points of view.

Christopher Patten has contributed the countermeasure on legislation.

We would also like to thank the following colleagues, who have made suggestions, contributions or points of view on the report: Anna Anund, Roya Elyasi-Pour, Mats Gustafsson, Kerstin Robertson, Lars Eriksson and Gunilla Sjöberg.

Countermeasures against dangerous use of communication devices while driving.

Glossary

App
Abbreviation of application, a piece of software which the user can easily install on a mobile device.

Autonomous systems
Driver support and information systems which only use information that can be received via sensors in a vehicle. A fully autonomous car can travel safely from point A to point B without assistance from the driver.

Crowdsourcing
Used here to illustrate how many drivers contribute small pieces of information to build up a larger picture of the traffic situation.

Euro NCAP
The European New Car Assessment Programme, a road safety collaboration between many European states, car manufacturers and NGOs. Crash tests are carried out, which lead to the car being rated on a five-grade scale (1-5 stars) according to how well it protects passengers and pedestrians.

Embedded systems
Driver support and information systems which the manufacturer has embedded in the vehicle and which are thus integrated with the other functions of the vehicle.

Cooperative systems
Driver support and information systems where a number of actors (vehicle, infrastructure etc.), share information to improve individual performance.

Meta analysis
A systematic review of a number of studies that have investigated the same subject.

Nomadic devices
Telephones, navigation systems, tablets and similar, which can be taken along in the car. Most of these are not at present synchronized with the car's other functions although there is some possibility of synchronisation.

V2I Vehicle to Infrastructure Communication
Wireless communication between vehicle and infrastructure and vice-versa (I2V)

V2M Vehicle to Mobile Communication
Wireless communication between vehicle and mobile devices.

V2V Vehicle to Vehicle Communication
Wireless communication directly between different vehicles. This is a basic prerequisite for cooperative systems.

1 Introduction

Initially a brief summary is provided of the connections between driver capacity, attention and the traffic situation. This is followed by an overview of current technical development in the vehicle and communication industry. The concept “communication” is used in a broad sense in this report. It includes both the driver’s communication with other people through communication devices and the exchange of information that may take place between the vehicle and technology or with the driver through various channels. It will be clear from the context what kind of communication is referred to in each particular case.

Quote from the directives for the assignment:

“The swift development of technology, both of communication devices and vehicles, makes it difficult to point to particular devices or usage while driving as particularly dangerous. This makes it even important to adopt a technically-neutral perspective and to also take into consideration the positive effects of having communication devices in the vehicle. In the light of the report, VTI should analyse the alternatives to a ban that may exist. The aim is to identify conceivable countermeasures that can effectively influence the driver to avoid unsafe use of technology, for, for instance, communication, information and entertainment while driving. It is also important to analyse the consequences of different countermeasures of this kind. Quality assurance should take place through use of an external reference group, including researchers from outside VTI”.

This report is detailed while at the same time being very limited. To enable the reader to obtain a quick overview of the report, each countermeasure is described on three levels – as a sentence (see the summary of proposed countermeasures in the beginning of this report), as a short summary and by a rather longer description. The limited nature of the report means, among other things, that there are always more aspects to take into account and that each countermeasure should therefore be regarded as a stimulant for further discussion rather than a definitive proposal.

1.1 Overview of the current state of knowledge

In October 2011, VTI submitted a report [63] to the Government, which shed light on how use of mobile phones and other communication devices affect drivers while driving, whether there is a correlation with traffic accidents, the effect of legislation on behaviour, and the impact of legislation on the number of accidents. To sum up, it can be noted that use of communication devices had an overall negative impact on driving. However, the effect on the risk of accidents is not clear, partly because the data is not sufficiently good to draw clear conclusions, and probably also because drivers are flexible and adapt their behaviour according to the situation and their ability. The extent of compliance with laws that prohibit hand-held use of mobile telephones is poor in Europe, and it has not been possible to show that the accident rate has decreased as a result of legislation. In this context, it is important to note that no country in Europe has a total ban on mobile phone use while driving, there is only a requirement for hands-free use, the design of which differs from country to country in Europe. A number of countries have also introduced specific prohibitions against writing text messages while driving.

Technological development is proceeding rapidly – today’s mobile phones do not have much in common with those in use ten years ago – and all indications point to development escalating. Because of the wording of the law, it may be difficult for police to determine whether a telephone has been used in an illegal way or not. At the same time, technical devices are increasingly connected together in different networks, not just telephones and computers but also cars, household technology, and infrastructure. Communication between technology in all its forms will become increasing important for different functions, both for the individual and society, and it will become increasingly difficult to make a distinction between “harmful” and “useful” communication. It must therefore be emphasised that it is important for countermeasures to be drafted in a technologically neutral way in order for them to be appropriate for a longer period, despite rapid development.

A clear finding in the last report, together with the expected development of technology and its consequences, is that banning hand-held telephones cannot be the only solution for reducing dangerous usage of communication devices. This has also been taken up in a number of other reports [68, 81, 97, 98], which also draw attention to the importance of evaluating the effects of countermeasures.

Multifaceted communication

Modern smart phones and similar devices make it possible to communicate in many ways. As well as making and receiving “traditional” phone calls, one can receive and send messages, write and read e-mail, keep updated via social networks, surf on the net among many other things. With the aid of a large number of applications, communication equipment may also be used to drive with good fuel economy, navigate correctly, warn about crashes with the aid of the embedded camera (for example, www.ionroad.com), keep the driver awake with quizzes about trivia. In the United States, in particular, apps that parents can download to their teenagers’ phones to monitor their driving have started to become widespread (for example, *www.guardianteen.com*).

Displays and touchscreens have started to replace physical controls in cars as well. The information that can be shown there is, of course, a lot more flexible and may include range from speed and rpm to route information, radio stations or fuel usage. As it is possible to connect external devices, in principle, anything can be shown, and the distinction between the vehicle’s information system and nomadic communication devices is being erased.

Some applications which are well intended probably actually also have a distraction potential, although it is important not to fall into the trap of directly condemning everything new that communication technology has to offer as distracting and dangerous in traffic. Automated communication between vehicles, as well as between vehicles and infrastructure can improve safety and accessibility as well as reducing the environmental impact [31]. This has also been shown in the EU project SAFESPOT [84], Coopers [16], CVIS [18] and in projects such as CoCAR and CoCarX in Germany [13]. Communication in which the driver also participates can also have positive effects in traffic. For example, the Swedish Transport Administration requests drivers to call a particular number to report obstacles on longer single-lane sections where road works are taking place. Another example is that it is possible for a driver to call and notify a delay to avoid the stress of having to drive as quickly as possible. A driver can also receive a call to request that they bring something home with them, which reduces the number of car trips.

A lot of the communication that takes place on the roads today is, however, not directly related to the task of driving, but either related to a person’s occupation or entirely private. The benefit in this case is thus not linked to expected improved road safety but rather financial or relating to improved quality of life. For the communicating driver, the communication is in most cases perceived as being so valuable that it takes place despite awareness of the risks [36, 37, 58, 96].

Certain occupational groups would have difficulty in performing their work in the same way as today if communication was not possible while driving. Professional drivers perform a number of tasks in the vehicle which involve communicating with the outside world, for example, navigation, customer contacts, contacts with distribution centres and with other drivers. In our society which demands ever greater efficiency, the possibilities of communication means that it is possible to use the time spent driving for work conversations [67] or for stimulation when bored.

The driver's resources and driving

The strain experienced by a driver depends on the complexity of the traffic situation, the driver's experience and the state of the driver, for instance, whether the driver is tired or ill. A current summary of different theories relating to distraction, inattention, and workload is contained in a doctoral thesis by Engström [27].

For most drivers, the major part of the period spent driving consists of routine situations. The driver's visual and mental resources can either be focused completely on driving or on a combination of driving and other activities, without driver overload occurring. This is related to the large parts of the traffic system having embedded safety margins, which are essential to enable a person to drive for a longer uninterrupted period of time without becoming exhausted.

Some groups of drivers are exposed to overload to a greater extent than others. These include, for example, young, inexperienced drivers. For inexperienced drivers, the task of driving requires a lot of mental capacity and additional tasks while driving easily create a mental overload. This is an important partial explanation as to why inexperienced drivers have a greatly increased risk of accidents [25]. A corresponding reasoning on increased overload can also be applied to older drivers, but in this case mostly as a result of ageing as such and the accompanying reduced sensory ability and mental flexibility [48].

It is seldom the case that the driver's maximum attention is required to cope with an ordinary traffic situation and the driver therefore seldom experiences communication as distracting in a way that they cannot control and compensate for. It is very common that drivers will increase safety margins by, for example, reducing speed and overtaking less [63]. Many traffic situations, especially on motorways and major trunk roads are of fairly low complexity and do not require maximum concentration by the driver. This can even become a considerable problem with drivers becoming so bored that they need other stimulation to avoid "switching off" or even falling asleep. In such situations such as on long transcontinental routes in Australia or in the United States, but also in long tunnels as in Norway or China, "unnecessary" information is deliberately embedded to keep drivers awake and interested. This may take place, for example, through attractive design in tunnels [60]. Research has been initiated on stimulating drivers through apps and communication. The correlation between the complexity of the external environment, the resources necessary to cope with the traffic situation depending on the driver's experience and the driver's available resources are illustrated in Figure 1.

If the driver has free (unused) resources for a longer period, there will be an increased probability of the driver seeking stimulation, which may lead to the driver initiating activities that are not related to driving.

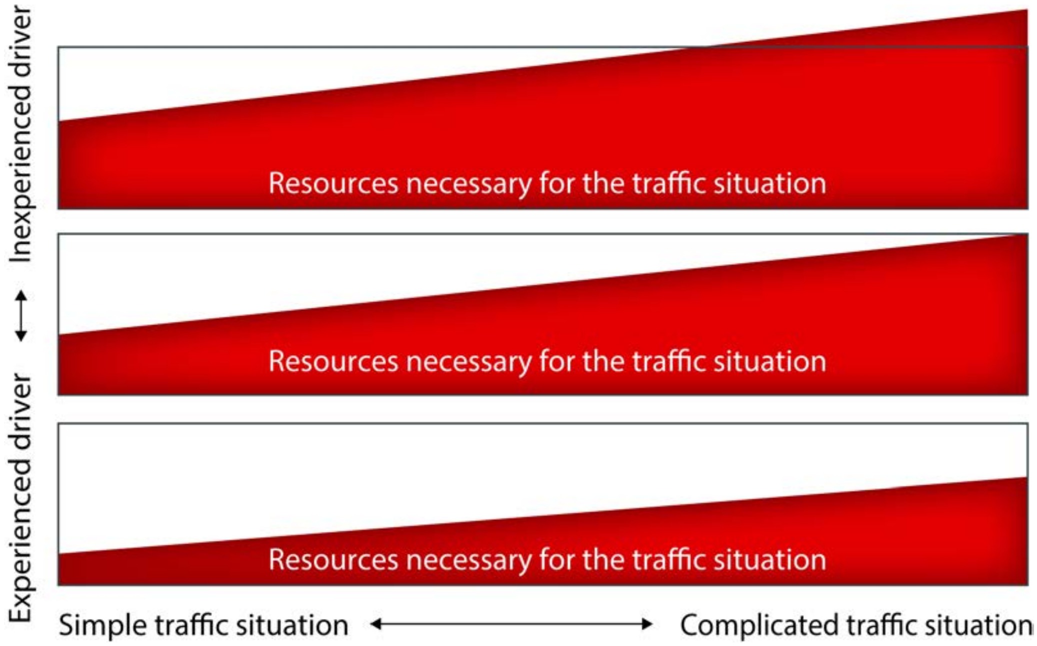


Figure 1 A simplified model on the connection between traffic complexity, the driver's available resources at a particular moment (black line), the driver's experience and the resources necessary to cope with the traffic situation in a good way (red area). Complicated traffic situations require more resources from the same driver, and newly qualified drivers need more resources than experienced drivers in the same traffic situation. All of these factors affect the amount of free resources the driver has available (white area).

Different types of safety-critical situations

Critical situations and problems that can arise for a number of reasons: the demands of the traffic situation may exceed the driver's capability, the driver may be using too many resources for something other than driving, the driver may be concentrating on the wrong thing at the wrong time, or that the situation is changing so rapidly that it is beyond the driver's control (similar to force majeure). Some examples are given below:

The driver may be overloaded by the situation, and therefore does not manage to (re)act sufficiently well despite focusing completely on driving. A situation of this kind may, for example, arise for an inexperienced driver in a city that the driver is not familiar and where there is high traffic intensity. Overload may also arise by the general state of the driver being temporarily reduced by, for example, tiredness, illness, the effect of alcohol or other factors, when full attention is not sufficient to cope with the situation [51, 102].

The driver concentrates on the wrong thing at the wrong time. This can also happen without there being overload and may be caused by a mismatch between the driver's expectations and the concrete development of the situation, or when the attraction of a secondary task is too strong. It is particularly noticeable when the driver looks away from the road too long or too often. A number of studies point out that looking away from the road for more than two seconds is associated with an increased number of accidents [65, 66]. Both the driver's own speed and the movements of other road users lead to rapid changes in the traffic situation.

The driver therefore needs to continuously take in new information to update his or her picture of the traffic environment. If this is not done sufficiently often, it will be impossible to foresee the development of the traffic situation and prepare driving, and as the update largely takes place through the visual channel [87], it can be disastrous to look away. Even if a person is only mentally occupied with something else, at the same time as looking at the road, the resources for processing the visual information are reduced, which can lead to information being missed [88]. This phenomenon is referred to "looking but failing to see".

In common for these critical types of situations is that the resources that the driver has available, or focuses on traffic, are insufficient to deal with the situation safely. This does not mean that there will necessarily be an accident as other road users may prevent this happening, or the driver may be "lucky" that there is no one in the way if, for example, he drifts over into the oncoming lane. What happens is that the risk of an accident increases, as the driver is not processing all of the existing information which is necessary to adjust to changes in the traffic situation.

The situation changes so quickly as to be beyond the driver's control. In addition to the events which to some extent can be foreseen due to their being "triggered", for example, by a brake light being lit [39] or by a car further forward in the queue starting to slow down, wholly unexpected events that are difficult to anticipate may happen. An animal or a child might run out into the street, a stone be thrown down from a bridge, or a piece of rock fall down from a nearby slope. In this case the situation need not entail a workload at all to start with. The faster such an event is noticed, in other words if the driver is looking in the right direction, the greater the chance that the driver will have time to react. It has been possible to show that variations in the mental load do not change the average response time for such events [50, 70]. There are indications that basal reactions to objects that approach very rapidly function almost as reflexes ("looming"), both for the visual [61] and the auditory channel [40]. Accordingly, there is a short cut past mental processing – the brain endeavours the whole time to take the shortest path from perception to action [35].

Requirement for a useable definition of inattention

It is common in the literature for all of the situations described above to be summarised by the concept inattention, at the same time as distraction is usually described as "insufficient or no attention to activities which are critical for safe driving". [82]. It is unfortunate that "(un)safe driving" is used as a measure for determining whether the driver was distracted as it may lead to distraction being stated as the cause of almost every accident that takes place. This development would be disastrous for a constructive discussion of the situation as it easily leads to guilt being placed only on the driver.

It is important that distraction is defined in a way that does not assume safe driving. The concept of distraction is undermined when the same behaviour can be described as distracted or not, depending on whether anything critical has happened or not. An example is a driver who looks at the speed meter or the telephone in heavy traffic. In the one case, the queue of cars continues at the same speed and nothing happens, and in the other case, the vehicle in front brakes and a critical situation arises. A good definition here would facilitate the assessment of whether a driver was actually distracted or not, regardless of whether anything critical happened or not. There is a US-European co-operation group which is currently working on a taxonomy of inattention while driving, which is to be used for accident analysis and development of safety systems. An introductory problem formulation has been published [93].

Dangerous use of communication devices in traffic

With this theoretical background, the question is thus what may be considered to be dangerous use of communication devices in traffic in contrast to use that does not affect or which even increases road safety. The report only takes into consideration the direct effect of the usage, without taking up indirect effects such as being able to quickly reportaccidents, obstacles in the road and the like. These aspects must, of course, be taken into account in a more comprehensive cost-benefit analysis.

Usage that is dangerous in traffic may be unaware or deliberate and, in the latter case, planned or unplanned. Different types of countermeasures are required to meet these different uses. In general, it can be said that a planned unsafe usage needs countermeasures that change the individual's attitude to achieve sustainable effects, while the occurrence of unplanned and, in particular, of unaware dangerous usage can be reduced with the aid of driver support systems.

1.2 Purpose

The purpose of the commission is to "*obtain conceivable countermeasures which can effectively influence the driver to avoid dangerous use of technical devices for, among other things, communication, information and entertainment while driving*" – in other words a toolbox of countermeasures aimed to counteract the dangerous aspects of communication while driving and, at the same time, retain the positive effects. Accordingly, the countermeasures may not necessarily diminish the use of communication devices as long as this usage takes place in a safe way. What is important is that dangerous usage is reduced to the greatest possible extent. On this basis, we have made a summary of the countermeasures that can have one or more of the following consequences:

- increase road safety in general
- increase road safety specifically when the driver uses communication devices
- reduces the frequency of use of communication devices
- reduces use of communication devices in particular situations
- shifts use of communication devices from dangerous to less dangerous situations
- simplifies use of communication devices
- reduces/removes dangerous components in use of communication devices.

The main focus of the countermeasures is on communication which has no direct relationship to driving, for example, private or work-related phone calls, text messages, status updates on social networks and the like.

2 Methods

Countermeasures for safe use of communication devices in vehicles can be undertaken in many different areas, and, in an initial stage, we wish to make sure that we do not miss any important aspects. To obtain a picture of the extent of different alternative countermeasures against dangerous use of communication devices in traffic, we therefore urged all VTI employees to submit proposed solutions. At the same time, research leaders and specialists at VTI were contacted and requested to participate in writing this document. A reference group of researchers and actors from other organisations was appointed to further increase the breadth in collection of alternative countermeasures.

Where possible, reference has been made to existing literature. Possible countermeasures have also been dealt with in a freer approach to shed light on aspects not taken up in the literature. In the sections describing proposed countermeasures, references are given where there is a scientific foundation while other countermeasures are more of the nature of creative proposals from an expert panel or take up solutions in process of development which have not yet been published.

A template has been produced to report on the proposed countermeasures. The template used to describe each countermeasure consists of the following headings:

- Summary
- Description
- Implementation
- Potential risks and side-effects
- Supplementary information

The working group and the reference group met at a workshop on 26 January 2012. At the workshop, the findings of the previous government commission [63] were presented and various identified areas of countermeasures discussed in plenary sessions as well as in smaller working groups with active participation of the reference group. A template was produced for reporting on the proposed countermeasures.

The researchers in the working group were then asked to describe proposed countermeasures which fell within their areas of expertise with the aid of the template. The drafts were subsequently examined and reworked. After a final examination by the reference group, the final version of the report was written.

3 Countermeasures

The proposed countermeasures are categorised in different areas. One of these is technology, which includes both technology in the vehicle, technology in the communication devices and a link with the infrastructure. Another area concerns education and information and describes different ways of achieving knowledge and understanding. The third area sheds light on different possibilities that society has to affect individual behaviour, through prohibitions and laws and by incentives.

As many countermeasures are dependent on one another, the distinction between them is not always obvious (see Figure 2). To be able to keep every description of a countermeasure distinct, there will be some repetition of details among the proposed countermeasures.

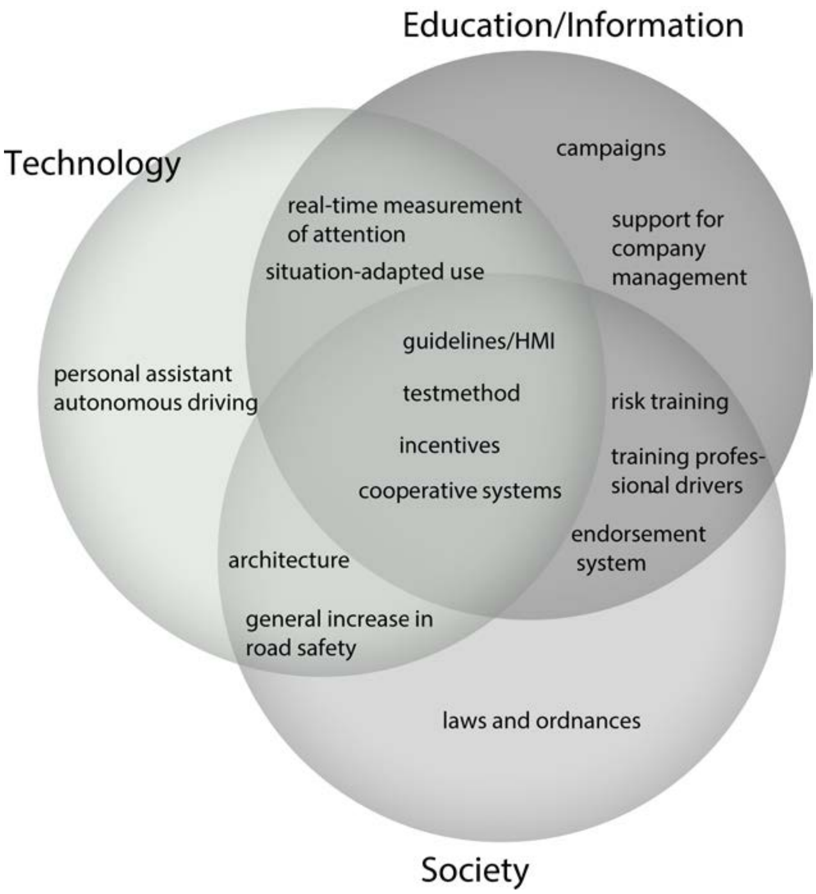


Figure 2 Clarification of the link between proposed countermeasures

A short summary of the description of how the countermeasure is intended to function is presented for every countermeasure. This is followed by a more detailed description, followed by points of view on implementation, which are developed in accordance with Table 1. Finally, conceivable risks and side-effects of the countermeasure are taken up, and, in some cases, the countermeasure is complemented with additional information.

Table 1 Structure of the "Implementation" section for countermeasures

Purpose	The purpose of the countermeasure with respect to how (dangerous) use of communication devices is to be reduced.
Recipient	The primary target for the countermeasures.
Early adopters	The end users who will probably be the first to be affected by the countermeasure This may be important for planning evaluation of the countermeasure.
Responsibility	The instance or instances that are proposed to be responsible for the countermeasure.
Sustainability	Some measures are expected to only require one application while others need to be followed up or repeated to maintain the effect.
Combinations	Countermeasures may be freestanding or dependent on other measures which must be implemented at the same time or subsequently.
Costs	Proposals are made on who is to bear the costs for countermeasures associated with costs.

3.1 Technology-related proposed countermeasures

To address driver distraction and to make driving more comfortable and safer in general, the car industry, together with researchers, has developed a large number of driver support systems. These include all types of support, from automatic intervention to warnings and information systems. These systems are expected to have a great potential for mitigating or preventing, amongst other things, distraction-related accidents, by warning, supporting, intervening or preventing critical situations.

The "Automotive Handbook" [83] contains a description of some of these systems and their effects at an overarching level. Specifically, the systems can assist in the case of distraction caused by communication devices, although the potential total road safety benefit is considerably greater as the systems, in different ways, address deficient driving ability in a much broader sense.

Driver support systems which have been considered to be most relevant for reducing the negative effects of use of communication systems while driving can be divided into three categories:

- *Preventive measures.* Assist the driver not to get into a critical situation, for example, by "workload managers" [8, 81], which adapt the functionality/information available to the driver to the situation, through improved interfaces that make handling the device easier, or, by cooperative systems that improve the ability to anticipate future events.
- *Warning measures*. Measure driver distraction and warn the driver, or adapt other driver support systems based on the state of the driver before a critical situation arises.

- *Mitigating measures*. Warn/intervene when there is a risk of collision/lane departure or mitigate the consequences of an accident.

An interesting development in the market is that it is not only the vehicle manufacturer that develops this type of system. Retro-fitted systems are available for, for example, lane departure and distraction warnings, and apps are also starting to appear with, for example, collision warnings and lane departure warnings. A requirement for embedded systems is that it should be possible to use the device in a safe way in traffic [71] but there are no such requirements at present for nomadic devices. This can be seen as a competitive disadvantage for embedded systems, both because there are more restrictions on them and because development and thus the sales price are more expensive owing to the requirements made.

Driver support systems can also be used to provide the driver with traffic information. Nomadic devices have a great advantage in this market, mainly for communication and navigation, but new areas of use are being introduced at a fast pace, with greater integration with the car.

There is still scope for improvement of different driver support systems, in among other ways, through their interacting and obtaining better external environment information via communication with the driver and with the infrastructure, and through their obtaining information about the state of the driver. It is therefore important to continue to support development and research on the support systems, both as regards technology and machine-machine interaction. An important aspect of this technical development is that it is actually used in the intended way.

The limits of the capacity of the various systems must be clear at the same time as the possibilities for using the systems for other purposes than safety is restricted. It is also important that a distinction can be made between systems that have a major impact on reducing damage and those that are less effective or directly counterproductive. As part of this, improved accident follow-up is required to be able to establish links between systems and accidents/statistics.

3.1.1 Countermeasure: General increase in road safety based on technology and infrastructure

Active safety systems serve as a safety net for the driver and warn or intervene if there is a risk of a collision or lane departure.

A general increase in road safety contributes to mitigating the effects of or completely preventing distraction-related accidents. Countermeasures can be implemented in the infrastructure (for example, rumble strips, lane departure warnings), both in individual vehicles (for example, systems that warn/intervene in the risk of collision/lane departure). These countermeasures are not specifically targeted on accidents caused by communication devices but also mitigate/prevent such accidents.

Description

Road safety on Swedish roads has improved continuously since the 1970s, which is reflected in statistics on the number of fatalities and serious injuries in traffic. The increased road safety is largely owing to safety improvements of both roads and vehicles.

Countermeasures to improve road safety in the infrastructure – such as three-lane roads, lane departure zones and speed-reducing countermeasures – are intended both to prevent accidents taking place and to mitigate the consequences of the accidents that still occur [91]. Road equipment that aims to draw the driver's attention to the surroundings is particularly relevant to the use of communication devices when driving. This includes, for example, rumble strips and various speed-reducing countermeasures such as humps and transverse rumble strips [55]. It is also possible that the design of the road may have a preventive effect on the use of communication devices. The surrounding traffic environment can also affect the driver's workload level, where the quantity of visual information has a negative impact on the risk of accidents. Above all, it has been seen that visually irrelevant information from, for example, advertising signs make it more difficult to focus on the information that is relevant for traffic [24]. The situation becomes even worse if an additional distracting factor is added on – use of communication devices at the same time – in an already demanding traffic environment.

A concept that has become increasingly important in traffic research is "self-explanatory road", which means that roads should be designed in such a way that road users understand intuitively what they are to do, for example, as regards choice of speed and level of attention. Self-explanatory roads could contribute to safer use of communication devices by making it easier to assess the risks in a given situation. An infrastructure countermeasure which could be implemented is special "lay bys" where drivers can stop when they need to use communication devices. If these are designated by a special symbol, they will at the same time serve as a reminder that inattentive communication can be dangerous.

Safety systems in the vehicle – for example, anti-lock brakes, electronic stability control, collision warning, automatic brakes and lane departure warnings - are intended to serve as a safety net for the driver in a critical situation. Neither in this case is the technology specifically targeted on use of communication devices but the systems can mitigate the consequences of inattentive use. An automatic braking system, which reacts to pedestrians can be crucially important if the driver is inattentive at the wrong moment. The same thing applies for systems that warn/correct steering if the driver is in the course of leaving the road.

Implementation

Purpose

The purpose is a general improvement of road safety, including use of communication devices. The countermeasures may be preventive – to inform the driver when it may be suitable or unsuitable to use communication devices, warning – to help distracted drivers be attentive, or correcting – to mitigate/avoid a potential accident.

Recipient

The countermeasure is targeted on all road users.

Early adopters

Infrastructure-based countermeasures are implemented in principle for all road users to the same extent. Advanced active and passive safety systems are often first found in premium models.

Responsible

The Swedish Transport Administration and the municipalities are responsible for implementation of countermeasures in the road environment to improve road safety. Guidelines for where and how a particular measure should be used are given in most cases in the publication "Vågor och gators utformning" [Design of Roads and Streets, in Swedish] [92].

Advanced active and passive safety systems are introduced by vehicle manufacturers, but their introduction can be speeded up by statutory requirements and incentives.

Lead time/Sustainability

It is probable that certain types of countermeasures in the road environment, for example, rumble strips and barriers, produce a swift effect when they are introduced and that the effect persists over time. It is more difficult to predict the length of time before the measure produces an effect in the case of countermeasures that produce a smaller and less direct effect on road users, such as self-explanatory roads. A self-explanatory road should ideally be understood by the road user directly but the concept also may include a certain type of road being associated with a particular attribute (for example, that all 2+1 roads should have a 100 km/h speed limit), which may require a period of learning.

Combinations

Countermeasures in the road environment can probably not alone prevent dangerous use of communication devices in traffic. When it comes to drawing the attention of a distracted driver to potentially dangerous situations, various autonomous forms of driver support (collision warning, lane departure warning, etc.) may be a good complement to, for example, rumble strips. Likewise, systems where the vehicle communicates with other vehicles and with the infrastructure (*Cooperative systems*) are a complement to the information that the driver obtains directly from the traffic environment as well as helping the driver assess if and when it is appropriate to use communication devices (*Adaptation to situation*).

Cost

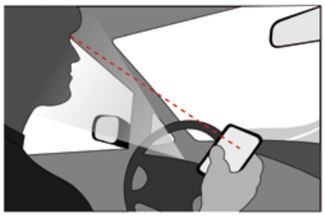
All countermeasures in the road environment entail costs for purchasing, installation, and maintenance, which the road authority must meet. Consideration must be given in each case to whether the benefit exceeds the costs. Safety systems in the vehicle are paid for by the customer.

Potential risks and side-effects

A potential risk of countermeasures that are expected to increase safety is that they may lead to a riskier behaviour on the part of road users, which in turn can lead to a deterioration in overall safety. Usually, most countermeasures are evaluated before they are used to any greater extent. There is therefore relatively little risk of a countermeasure, intended to increase road safety, having the opposite effect instead.

In this summary, it may be worth pointing out that it may be a good idea in the future to take into account the effects of use of communication devices in the evaluation and introduction of new road safety countermeasures.

3.1.2 Countermeasure: Real-time measurement of attention



Eye movements can be measured to ensure that the driver does not look away from the road for too long or too often.

Use of communication devices while driving sometimes leads to the driver paying insufficient attention to traffic – insufficient scanning of the traffic environment, the driver looks away from the road too many times and for too long, poorer ability to respond to information. By continuously measuring the level of attention and warning the driver about insufficient attention, it is possible to get the driver to pay more attention to traffic in these situations. The warning threshold for other support systems can also be adapted to the current level of attention of the driver.

Description

It is difficult to measure the level of attention. Currently, it is attempted to estimate the level either by measuring different physiological parameters such as eye movements, facial expression and heart rhythm, or by measuring driving behaviour in the form of staying in lane and maintaining distance. Eye movements are perhaps the measure that is simplest to relate to distraction; when sending text messages, a person looks away from the road a number of times and sometimes for a very long time and in a telephone call which demands attention scanning of the traffic environment deteriorates and a person’s glance can fasten on a distant object. There are a number of algorithms that attempt to quantify when the driver looks away too often or too long in order to provide a warning when this happens. The intention is to provide direct feedback to the driver when the driver needs to refocus attention back to the traffic, which seems to have very positive effects [22]. It is also conceivable to have a delayed feedback for educational reasons. Feedback is then given in the form of a summary of the day’s driving in terms of how often the driver has been inattentive. A summary of this kind could also be sent to parents, employers or insurance companies in order to be able to follow up unsuitable driving behaviour in various ways. An advantage with delayed feedback is that the message can be reversed and highlight the positive instead of always criticising what is wrong.

A number of distraction warning systems are still at the prototype stage and rigorous testing is essential before they can be taken into use [21]. Combining a number of different sensors and data sources is often highlighted as the best way forward.

Toyota has launched a “Driver Monitoring System” which measures head direction and eyelid activity to detect sleepiness and other dangerous states of the driver. Mercedes “Attention Assist” uses the driver’s manipulation of the car’s controls to detect tiredness, and Volvo’s “Driver Alert Control” measures discrepancies in the car’s movements to detect sleepiness. There are also a number of other companies (for example, Tobii Technology, Seeing Machines, SmartEye and Attention Technology) which try to measure the driver’s state by measuring eye movements and blinking behaviour.

Implementation

Purpose

The purpose of real time measurement of the driver's level of attention is to be able to reduce the incidence and effect of driver distraction by warnings and information.

Recipient

The countermeasure is targeted on the individual driver.

Early adopters

Implementation will take place gradually. The available commercial solutions have been introduced in premium models or as retrofitted systems. Apace with the systems becoming more stable, the technology will undoubtedly become more widespread in cheaper models. At present, the main consumers of retrofitted systems are hauliers and the mining industry where drivers risk becoming exhausted.

Responsibility

The greatest responsibility is to create a demand, which can be reinforced both by authorities and for example, by the mass media. The vehicle industry and subcontractors are responsible for development of the technology.

Lead time

There are already some simpler systems on the market. Some kind of Incentive may be necessary for more widespread use of the technology. Vehicles equipped with the technology could be given prominence in Euro NCAP as safer alternatives. It will become a competitive advantage for vehicle manufacturers to offer the system when consumers start to make a demand for it. A Statutory Requirement could hasten introduction (compare with the requirement for lane departure warnings for heavy goods vehicles) but the technology needs to mature before this can happen.

Sustainability

The sustainability depends on the perceived benefit of the system and public acceptance of the system.

Combinations

Co-ordinations with other measures could be a great benefit. Information about surrounding traffic (the countermeasures *Cooperative Systems* and *Adaption to situation*) and integration with nomadic communication devices (*Guidelines* countermeasure) would reinforce the possibilities for providing correct feedback to the driver. Distraction warnings could be, for example, suppressed when it is certain that incorrect behaviour will not lead to a critical situation. Being able to link deviant behaviour with simultaneous telephone use would also strengthen the feedback given to the driver.

Cost

The manufacturers bear the cost of development. Ultimately the product is paid for by the consumer.

Potential risks and side-effects

The industry has presented ready-made solutions to measure and warn about both tiredness and distraction. It is interesting that they present complete solutions bearing in mind that the research community has still not succeeded in measuring either tiredness or distraction in a satisfactory way [3].

How should one get drivers to take warnings seriously? Even if a driver receives a warning of tiredness, it is not probable that he or she will stop, especially if there are only a few kilometres left. It could even be the case that drivers use the system like an alarm clock. The same applies for distraction warnings where a driver could get used to looking away until the system provides a warning. Even if it is possible to monitor and warn about various diminished driver capacity, it is thus not certain that this will have an effect in accident statistics. One conceivable way that has proved to work better is to give feedback to the driver in a more general way than simply to present warnings at the time of distraction. A summary could be presented at the end of the journey. Reports could be sent to employers for professional drivers and training in safe driving could be adapted to the driver's actual behaviour [98].

3.1.3 Countermeasure: Architecture for dissemination of information between the infrastructure, the vehicle and mobile devices

At present, there are a number of different solutions for, for example, connecting the telephone with the car or vehicle and the surroundings, but there is no standard that describes or regulates how this is to take place. An architecture is needed for communication between infrastructure, vehicle, embedded systems and nomadic devices and this is most easily co-ordinated by international standards. This countermeasure is a prerequisite for a number of the other countermeasures to be realised.

A standardised architecture for communication between architecture and mobile devices serves as the basic framework for other devices.

Description

Transferring information between mobile devices, the vehicle and the infrastructure has many advantages, see the countermeasure *Cooperative systems*. The interaction between vehicles is usually referred to as "vehicle to vehicle" [V2V], between vehicle and surrounding environment "vehicle to infrastructure [V2I], and between vehicle and mobile device "vehicle to mobile" [V2M]. When all vehicles/users assist in keeping information updated, it is referred to as "crowdsurfing". An international standard is required to promote compatibility between vehicles, infrastructure and nomadic devices, which specifies the way in which the exchange of communication is to take place.

It is becoming increasingly common that the car itself is able to communicate with its surroundings. Some examples are Ford Sync and GM OnStar, which offer services such as reading out messages, voice-controlled calls, navigation and automatic calls to an alarm centre. There are also political directives, which drive forward these solutions. One example is the eCall project which aims for all new cars, at the latest by 2015, to be equipped with a device that automatically notifies the location of the vehicle to an alarm centre in the event of an accident [90].

Nomadic devices can also be included as complete link in the system. An important aspect of this is that they can be synchronised with the driver's own vehicle, which entails an integration of the nomadic device with the car's controls and displays. A number of important actors have joined together in the Car Connectivity Consortium [10] with the aim of realising and standardising such integration (see also the *Guidelines* countermeasure).

An important aspect is the communication channel used for transferring information. It can be expensive if different authorities are to build up an infrastructure required for a dedicated protocol. One conceivable alternative is to make use of the existing telecommunications network [13]. This is an apparently simple solution but one that requires coordination between the operators as well as coverage along all roads. Capacity and performance in the networks is also crucial for the applications that are possible. V2V communication has been demonstrated with a maximum delay of 0.5 seconds in the 3G network in the projects CoCar and CoCarX [13]. This is appropriate for sending warnings and information (Figure 3). However, it cannot be expected that very time-critical safety functions or functions where the car takes an active role in decision-making (*Autonomous driving*) will be able to function using the telephone network.

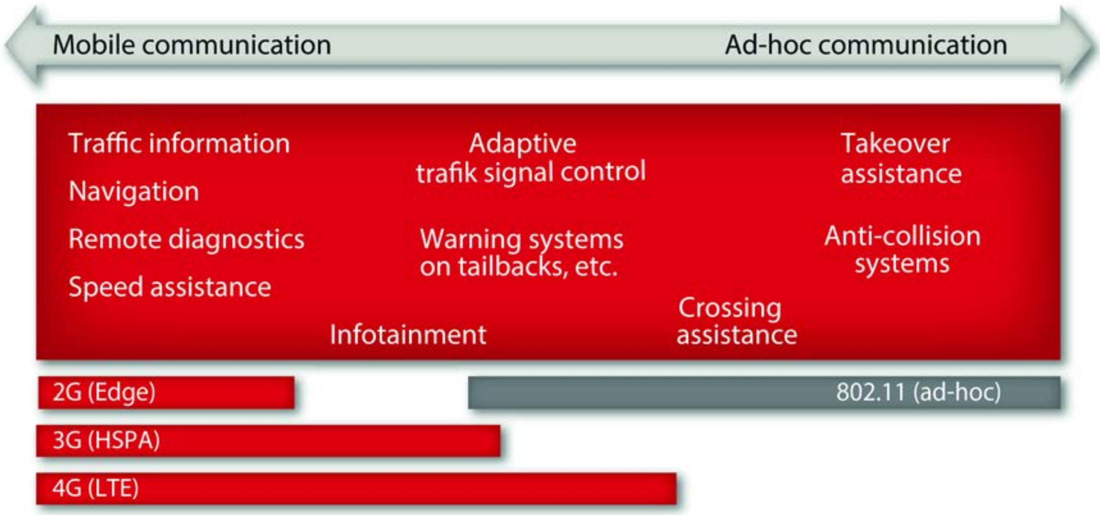


Figure 3 Areas of application where it is conceivable to use different types of telecommunications network versus ad-hoc networks [13].

Implementation

Purpose

The purpose of the measures is to obtain the standards required for the vehicle and the nomadic device to be able to communicate with one another and with the surrounding world leading to an integration of nomadic units with the car and to an opening for new safety-enhancing functions. The introduction of new technology and new functions is simplified.

Recipient

The countermeasure is targeted on a number of recipients including vehicle manufacturers, the IT industry, service suppliers and public authorities. What is important is to create good interaction between the different players. Working for synchronisation between communication equipment and vehicle is not nationally limited but must be done in the international arena and in collaboration with industry.

Early adopters

Different categories of drivers will undoubtedly use different parts of the countermeasure. Many will benefit from the car knowing that it is icy and the suggested maximum speed, where there are areas that require maximum attention and that the active safety systems can collaborate.

Responsibility

Different parties will be responsible for implementation. When the technology is installed in vehicles it will produce added value for consumers so that the market will probably take care of this.

Lead time

The time it takes before the countermeasure has an effect extends from weeks to years. There are already applications for mobile telephones that use crowdsourcing to collect information about tailbacks and access. Implementing similar solutions for spreading information about “dangerous” places would rapidly spread if it was a service that people wanted. Building up the infrastructure required for all vehicles to be able to keep a check on surrounding traffic is, of course, more complicated and will take a very long time.

Combinations

The standard can best be seen as a basis for countermeasures such as *Adaptation to the situation*, *Cooperative systems* and to a certain extent for *Autonomous driving* and *Personal assistant*.

Cost

The costs will probably be more in implementation of the architecture than in production. It is important to invest from the start in an architecture/standard that is international and forward-looking to achieve the greatest possible compatibility.

Potential risks and side-effects

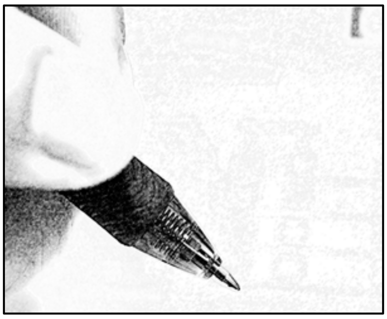
The risk of unsuccessful standards and guidelines is that they are impediments to technology and counteract the original purpose which is to speed up the introduction of new safety technology and new services. A standard for communication between vehicles and nomadic devices opens new markets for a number of services. Such services may be focused on comfort, tourism, entertainment etc. and can both be good and bad for safety. They can also have a considerable impact and importance for the effectiveness of the transport system and for energy-efficient driving.

Personal integrity will be restricted as a number of actors will always know where the vehicle is. This is a difference to the existing storage by the telephone operators of the position and communication of mobile telephones as the information about the vehicles is used and send to a number of other actors. court order is required at present to obtain access to information about the location of mobile telephones. It is thus important to be able to guarantee personal integrity in a credible way in connection with the spread of information. Although it is theoretically possible to use anonymity services for data traffic, there is a great risk that this will not be the case. There is a lot to win from increased information about people’s travel habits and patterns of movement. Risk and exposure-based insurance, position-based direct advertising, accident reconstruction and continuous monitoring of speeding are examples of contentious issues which not everyone may wish to see solutions for.

One positive effect may be that communication device can also be used for position-related and customised traffic and tourist information. Newer, as yet unpublished, projects even investigate whether position-related entertainment, such as tourist information about sights in the vicinity and other trivia, can contribute to road safety in monotonous traffic situations where there is otherwise a risk that the driver will be tired out with an increased risk of falling asleep.

3.1.4 Countermeasure: Guidelines for good interaction design

Interfaces that simplify manipulation and adapt functionality to current circumstances would reduce the risk of distraction when using communication devices while driving. The introduction of a countermeasure of this kind would be simplified if there were guidelines that describe how applications and nomadic devices should be designed. Linked to a rating system, such as Euro NCAP, the guidelines would provide guidance for both consumers and manufacturers. It is important that the guidelines achieve international acceptance, that they are formulated in a technologically neutral way and that they can be adjusted to different groups of drivers.



A "description protocol" intended to guide both consumers and manufacturers in their endeavour to find safer products.

Description

When the driver has decided to interact with a communication device, it is important that this can take place as easily as possible. Displays, interface and manipulation shall therefore be designed in such a way as to keep distraction from interaction to a minimum. To promote good interaction design, guidelines are needed for development of communication devices intended for use while driving. Of course, the guidelines should also apply to software and apps.

The guidelines should be linked to testing and rating similar to Euro NCAP [29]. Clear requirements combined with a simple rating scale should provide guidance both for the developer of technology and for the individual consumer. At present, it's not possible to specify exactly how the guidelines should be designed and how extensive they should be but in general:

- Visual distraction should be kept to a minimum (it should not take too long to perform each particular task. The driver should not have to look away from the road for more than short periods, information should be provided based as needed by the driver etc.) and large demands on working memory should be avoided. Conceivable solutions are voice- and speech-based interfaces, haptic interfaces, head-up displays and similar.

- Communication both to and from the driver should be adapted to the current traffic situation (see countermeasure *Adaptation to the situation*).

- Nomadic devices need to be integrated with the car manufacturer's own systems. In the same way that the vehicle manufacturer must comply with certain guidelines, the manufacturer of nomadic devices should also comply with guidelines that facilitate safe usage [81].

- If a driver has a phone in the car for use while driving, it should be located appropriately (easily visible and within reach if the telephone is completely freestanding from the vehicle and out of sight if the telephone is integrated/synchronised with the vehicle). Accordingly, there should be a suitable location in the car for the phone. If the driver sees advantages in having the phone in this location, for example, by the phone being charged and connected to the car, there will be greater readiness to actually use this location for the phone.

- Guidelines should be adjusted to different categories of drivers. For example, professional drivers have other requirements than private drivers, new drivers have other needs than experienced drivers, older drivers need adaptation to age-related deterioration in sight/hearing and technically knowledgeable users can be dealt with in another way than those who have not grown up in today's connected society.

The EU has in the European Statement of Principles (ESoP [28]) summarised recommendations on the design of safe and effective vehicle systems. Similar recommendations have also been presented by the Alliance of Automobile Manufacturers (AAM [23]), the Japan Automotive Manufacturers Association (JAMA [59]), the Society of Automotive Engineers (SAE [43]) and the International Organization for Standardization [ISO]. A more concrete proposal has recently been presented by the National Highway Traffic Safety Administration (NHTSA [71]). This proposal is still in the process of being circulated for comment. In common for these guidelines is that they concern how the systems are to be located in the car, how information is to be presented to the driver, how interaction is to take place with the system, what services are to be made available and when they should be made available. These guidelines are not statutory requirements but recommendations and most vehicle manufacturers are very familiar with them. However, for manufacturers of communication devices, the guidelines are probably less well known as the equipment is often not primarily intended for use in vehicles. Guidelines for external devices are, however, being developed by NHTSA [71].

From a commercial quarter, a relatively newly established consortium Car Connectivity Consortium [10] is in the process of developing standards and guidelines for how mobile telephones and other devices that the driver takes into the car should be integrated with the vehicle, see also the countermeasure *Architecture*. The idea is for the technology that the driver takes into the car to be automatically connected with the car's embedded systems. Services available in the phone (music, GPS, contact book, internet and similar) will then be directly accessible via the car's embedded systems. The advantage of that is that the car's controls and displays are designed for use in a car while in motion. They are therefore better located and designed for this purpose. Products that comply with the guidelines drawn up may be marked with the MirrorLink certification. This certification entails, besides it being simple to connect the car and the phone in purely technical terms, also that interaction with the device/application should be kept to a minimum, the quantity of information presented to the driver should be limited, voice control should be preferred etc. However, it must be borne in mind that the restrictions in the guidelines have been developed on the assumption that the driver should be allowed to use communication equipment while driving.

Implementation

Purpose

The purpose of the countermeasures is to create guidelines that assist manufacturers to design products that minimise distraction when they are used while driving. Just as there is an aircraft setting in most phones today, there could be a car setting where functionality is adapted to safe driving.

Recipient

The countermeasure is targeted, inter alia, on the manufacturers who need to produce products that are adapted for use while driving, and to consumers, who have a choice whether to buy these products or not, and also to independent institutions/authorities which should participate in drafting guidelines as well as to those responsible for testing and certification.

Early adopters

The manufacturers will be the first to use the guidelines. Their feedback is therefore important for updates and adaptations of the guidelines.

Responsibility

The manufacturer of the device, regardless of whether it is embedded in the car or nomadic, are responsible for implementation. Statutory requirements, advertising campaigns and guidelines can, however, speed up the process either by direct requirements on design or by ensuring that consumers begin to demand improved solutions.

Lead time

It is important that both the vehicle industry and electronic manufacturers support the guidelines and certification. Mobile telephones are replaced about every other year so that the first step could have an effect within a very short time span. A complete integration of communication devices taken into cars requires, however, that the vehicle fleet is updated or replaced.

Sustainability

Evaluations of design guidelines are necessary to be able to make continuous improvements and adaptations in order for a positive effect to be ensured and maintained.

Combinations

There are clear connections to a number of other countermeasures. Suggestions on how the design of different guidelines can be obtained in *Adaptation to situation*, *Architecture*, *Personal Assistant* and *Real time measurement*. The test describes how certification can take place in accordance with current guidelines.

Cost

The costs for production of the guidelines are difficult to assess as many actors are involved (legal responsibility, development costs, international collaboration, etc.).

Potential risks and side-effects

The interface to the user is a critical point in the guidelines. Visual components in an interface will always require that the driver looks away from the road. Even if the picture is projected on to the windscreen by infinity-optics (the focus will be far away instead of on the wind-screen), the driver will focus attention on the projected message [17]. The same applies for cognitive components in the interface which will always place a mental load on the driver (in particular, when they do not work perfectly). This includes, for example, interfaces based on speech synthesis/voice recognition. Currently there is a problem with voice recognition (translating speech to text) and also with interpretation of what has been said (artificial intelligence which interprets the text and answers the driver's questions). The level of sound in the car reinforces the existing difficulties. It may also be a problem that Swedish is seldom a prioritised language. Before these areas have matured at a level which is in principle fault-free, there is a great risk that users will be frustrated that the voice-controlled support system does not understand them. In the event of frustration about not being able to make themselves understood, it is also probable that the driver seeks eye contact with the phone/voice/machine. There is then a risk that the benefit of the voice-controlled control system, namely that it is not necessary to look away from the road, will be lost.

There is a risk in letting commercial actors produce guidelines and, in particular, certifications.

Euro NCAP is funded by the European Commission, inter alia, and the test is carried out by independent research institutions: TNO in the Netherlands and TRL in the U.K. [50]. A similar solution would have been desirable for rating communications equipment intended for use while driving. MirrorLink is a promising initiative although its main focus is on seamless communication between communication devices taken into the car and the car's embedded systems. Although minimisation of distraction is an explicit goal for the products certified by MirrorLink, the organisation is none the less controlled by market forces.

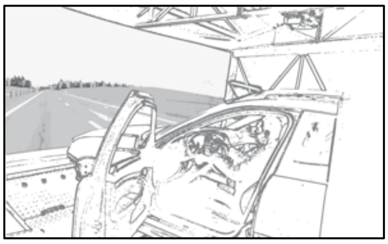
It is probably impossible to produce guidelines that wholly counteract the problem of distraction. Instead, it is a case of making the best of the situation and striking a reasonable balance between road safety and the driver's requirements to be able to make effective use of time spent on the road.

Additional information

Research in the HMI area is at present undergoing a minor revolution and it is important that the guidelines do not hinder development. In order to feed in information, the technology for voice- and gesture-control (on touch screens or in the air) is gradually starting to mature and, in parallel with the purely technological development, major advances are now being made in how to use technology in the best way. Instead of command-based voice control, we are now seeing dialogue systems where it is possible to talk to the machine without having to remember exact phrases. It is also starting to become possible to ask for information and simpler services, see further the countermeasure *Personal assistant*. Apace with the increasing popularity of touch screens, inputting through these screens has started to mature and here as well, it can be seen that the command-based and sometimes artificial gestures are started to give way to more intuitive sign language. The interfaces are becoming better adapted to situations. When a driver is talking with a passenger, for example, the tempo of the conversation changes according to how demanding driving is [12]. If an automatic voice-based dialogue system is to be used while driving, it is thus an advantage if the system pauses or changes the rhythm of speech if the situation becomes demanding. A newly-started EU project, GetHomeSafe [38] has just started to investigate how voice-based interfaces should be designed.

If it is possible to improve a function, it often leads to an increase in usage. This could thus mean that a device is used more and in situations where this has not previously been the case. This can reduce the positive effect. However, it is difficult in the current situation to see whether this would cancel the whole of the positive effect or change it into something negative.

3.1.5 Countermeasure: Objective test methods for communication systems



A technologically-neutral testing method is needed to be able to evaluate how safe a particular product is.

Every device/software conceived for use while driving needs to be tested and evaluated in terms of road safety – mainly the extent to which driving ability deteriorates and in which traffic situations such deterioration is acceptable. At present, there is no such test. The test should be technologically neutral in order to function with future solutions as well. It should function regardless of whether the system tested is embedded in the car, or whether it is retro-fitted, whether it is nomadic or third-party software. The optimal design of the test protocol is related to the countermeasure *Guidelines*, and the result of the test is the core of the rating awarded to the product.

Description

There is at present no perfect test that can be used to evaluate how distracting different embedded, retrofitted or nomadic communication and entertainment systems are. However, there are a number of proposed in traffic test methods, including the 15-second rule [42], the occlusion method [94] and the lane change test [69]). The tests assess how driving ability is affected when the driver uses communication devices at the same time. During the actual test, the driver’s ability is measured in terms of lateral and longitudinal control of the vehicle, glance behaviour, and subjective estimates. To make repetition of the tests possible, during as realistic conditions as possible, it has been proposed that the tests should be carried out in driving simulators [71]. Despite this, there are a number of known difficulties. A number of factors lead to varying test results. Individual differences between test subjects, differences between different simulators, and the complexity of the traffic situation in question determine whether it is possible to combine driving with a secondary task. The driver’s overall experience and experience of the system to be tested must be taken into account, and the interaction between road safety and changes in different performance measures must be clarified.

To evaluate communication and other devices in the car with respect to road safety, a simulator-based test method is required which takes the above-mentioned difficulties into account. The degree of difficulty in the traffic environment needs to be varied to be able to differentiate between functions that are wholly unsuitable while driving and those which, for example, may be used outside city traffic. The degree of complexity must be established with as objective a rating as possible, for example, in accordance with the method developed at UMTRI [86]. The performance measure with appurtenant limit values should not reflect the average but rather be based on how many drivers succeed or fail to keep within a particular safety interval, for example, how many who drive over the edge line, exceed the speed limit, come too close to other vehicles or miss signals in traffic. Glance-direction-based measures have also proven to be successful and should be used. Examples of suggested threshold values for glance behaviour are contained in draft guidelines by NHTSA [71, p.90]: “For at least 21 of the 24 test participants, no more than 15 per cent of the total number of eye glances away from the forward road scene should have durations of greater than 2.0 seconds while performing the secondary task”. Based on the margin by which the criteria are complied with, a rating system can be produced which makes it possible for consumers to choose distraction-minimising products. The number of test subjects, the population they are selected from, and their familiarity with the equipment which is to be evaluated need, however, to be given serious consideration for the test to be accurate.

The method can be based on proposals developed by NHTSA [71], ESoP [28] and JAMA [59], see also Guidelines. A pilot trial has just been carried out at VTI to test the suitability of different performance measures and the results will be published in the near future [64].

As regards test procedure, it is suggested that drivers be encouraged to make maximum effort to succeed with their secondary task, in order to ensure that motivation to carry out the secondary task is comparable among test subjects and that the “worst-case scenario is investigated”.

Implementation

Purpose

The countermeasures are intended to enable evaluation of how communication and other devices affect driving performance in traffic situations of varying complexity with as objective methods as possible. It should be possible to use the results of this evaluation to rate embedded, retro-fitted and nomadic devices in an easy way. This in turn can lead to well-anchored possibilities of affecting insurance premiums, restrictions for use during driving, purchasing propensity, etc.

Recipient

The countermeasure is targeted on both vehicle manufacturers and manufacturers of communication systems as well as consumers. The first two need to develop systems that can cope with the test and the last to obtain information about the product characteristics with respect to road safety and thus can make informed decisions at the time of the next purchase. Independent researchers should be tasked with testing the products before they are released on the market.

Early adopters

Depending on possible combinations with other countermeasures, such as legislatory requirements, insurance incentives or other, the user group of most interest may vary. Initially, it is probable that those who are already safety-conscious will use the evaluation results to choose their devices, but if other incentives are included, it is very probable that other groups of drivers can be reached.

Responsibility

The test method should preferably be a global standard design and must therefore be developed in collaboration with authorities in other countries.

Lead time

The earlier the test method is available, and the greater propensity there is to use and accept it in conjunction with the development of embedded and nomadic systems, the more quickly spread the tested equipment will be. This also means that the test method must be easily available for manufacturers and that evaluation is swift and effective to avoid delays in the product development process.

Sustainability

If the test method is used and if consumers are made aware of the content of rating, it is probable that the method will have a long-term impact (compare marking of energy consumption of white goods or the Euro NCAP ratings for collision safety). It is very important that rating is clear and not confusing. To enable the method to be used in the long term, it must not be customised according to current technology but rather designed in a technologically neutral way.

Combinations

The test method is suitable for combining with other countermeasures, for example, *Insurance incentives* for devices with a minimum distraction potential, automatic shutting down of unsuitable functions. Campaigns to encourage consumer only to purchase products with a high safety rating etc. *Information campaigns* about the test method and its introduction are necessary to "wake up" consumers.

Cost

The development costs of a suitable test method should be borne by authorities and research funding bodies. Evaluation of the products can either be voluntary or compulsory and the costs can reasonably be borne by the manufacturers. In the case of voluntary testing, a good result can be used in marketing, while a compulsory testing requires the same financial input from all competitors.

Potential risks and side-effects

The method can be overvalued in a way that confidence in the ratings exceeds the accuracy of the ratings. It is possible that products which have obtained a good rating will be used more often and with less "common sense" than they are designed for so that overconfidence in the tested products reduces the safety margin. Information and education are needed to prevent this. Expensive tests can also lead to smaller manufacturers not entering the market as they cannot cope with financing the testing. This must be taken into account when the regulatory framework for testing is created. This is especially important bearing in mind that modern phones are largely defined by the software (apps) that users download. Testing should in other words not be limited to the device itself but also include third party software.

Additional information

In the United States, guidelines are about to be published for evaluation of embedded electronic devices which require visual attention and manual handling [71, 79, 78]. Subsequently, voice-based systems and nomadic devices will also be dealt with. In its detailed report on the requirements on these evaluation guidelines, NHTSA clarifies many questions which are directly relevant for evaluation of communication devices intended for use while driving regardless of whether the device is embedded or nomadic, and whether it entails a visual, manual or cognitively workload. Many of the points taken up above are dealt with in greater detail in other sections of the report. It is very important to take into consideration these guidelines as well as ESoP, JAMA and ISO for success in the international market.

3.1.6 Countermeasure: Use adapted to time, the situation and individual use

Today, there is an enormous flow of information and more and more channels make continuous demands on our attention. By adapting both the incoming and outgoing flow of information according to the current traffic situation, the driver can be assisted to avoid unnecessary distraction. This may be as easy as delaying incoming text messages until the driver has passed a school. In this way, the drivers can avoid moments when they unfortunately take their eyes off the road and/or focus on something other than driving on the "wrong" occasion.

By prioritising and scheduling information, access to communication can be restricted in situations which require the driver's undivided attention.

Description

Whether it goes well or not to use communication devices while driving depends to a large degree on external circumstances. By controlling when, where and how communication with the driver is permitted/allowed access, usage can be avoided when it is unsuitable to do anything other than drive. These technologies are sometimes referred to as "workload managers", information scheduling and similar, and have been shown to work well both in simulator studies [100] and in the field [77]. For the driver, the restrictions will be marginal. It may be as easy as an incoming text message being delayed until the driver has passed an area where attention is required, for example, a school, a home for the elderly, or a city centre with a lot of unprotected road users.

Both Volvo and Saab were early out in including similar systems in their cars. As early as 1998, a dialogue manager was introduced in Saab 9-5 which delayed presentation of information if the driver was considered to be under mental strain, and in 2002 the concept was expanded to include incoming telephone calls etc. Volvo has also introduced a similar information management system [Volvo Intelligent Driver Information System). See Green [41] or Engström and Victor [26] for a summary of the research carried out in the industry.

With the aid of accident databases, maps can be produced showing particularly accident-prone areas. Incoming messages can be delayed or blocked in these areas. In the same way, areas zones can be added where the driver's undivided attention is required such as crossroads, pedestrian crossings, and school areas. Different authorities can provide information about, for example, schools, day care centres and pedestrian crossings, while car manufacturers in collaboration with the electronic industry can use crowdsourcing to provide dynamic information about, for example, the state of the road and the traffic situation. Using statistical information is a good beginning, which is considerably improved if it is linked to the time of the day. Even better results may be anticipated if the zones are adapted dynamically in accordance with current traffic circumstances. If, for example, a person is in the process of catching up with slow-moving traffic on a motorway, it is unsuitable for the person to be disturbed by a communication device. The same applies when the weather or state of the road is bad.

Adaptations may also be made based on the individual, both as regards more long-term conditions such as experience and age and more temporary conditions such as distraction, tiredness and stress. The current state and characteristics of the individual driver may then be weighed into the assessment of the extent of the driver's workload in the particular situation. In this way, the individual's characteristics and abilities are combined with the demands of the traffic situation to arrive at a final assessment of which communication functions the driver can deal with in the current circumstances. Research is in process both to relate measurable situation characteristics to perceived situation complexity [33, 86, 102] and to assess the current state of the driver (read more under the countermeasure *Real time measurement*). There are also proposals as to how different functions should be treated depending on the degree of complexity of the traffic situation [102], which do not, however, take into account the driver's characteristics.

There are a lot of applications (TXTBlocker, IZUP, ZoomSafer, DriveSafely, Textecution, CellSafety) which shut down text functionality in mobile phones when the car is being driven above a particular speed. These products are targeted on parents and companies that wish to prevent their teenagers/employees from sending text messages while driving. Certain of these applications can also send automatic messages to callers notifying them that the recipient of the call is at present driving a car and is therefore unable to answer. There are also solutions which automatically read incoming messages so that the driver does not have to read the messages on the display and voice recognition software which can send text messages, update social networks etc. with the aid of the voice. However, it is important that voice-based systems as well also cope with the requirements made in the proposed *Guidelines* to avoid cognitive overload.

It is not only incoming messages that can be adapted to the situation. The interface itself can also be varied according to the traffic situation.

Implementation

Purpose

The intention of the countermeasure is to reduce the negative effects of using communication devices while driving by ensuring that drivers are not disturbed in (certain of) the situations when they need to be particularly attentive to driving, at the same time as not all use of communication devices should be blocked. A better adaptation to the situation of use is considered to have a great effect on safety, with only minor restrictions on the freedom to communicate that are acceptable to the driver.

Recipient

The countermeasure is targeted on all those who communicate with the outside world while driving, to employers and parents, and to the opposite party in a conversation. However, the countermeasure needs to be adapted based on who is driving (professional/private driver, beginner, experienced driver etc.).

Early adopters

It is probable that the safety conscious drivers are the first who will demand and use this technology. To reach as many drivers as possible, financial incentives, education, information and social influence in the form of positive group pressure may all be necessary to create insight and acceptance of limitations introduced.

Responsibility

It is desirable that there is an explicit political will as an incentive to industry to develop the technology.

Lead time

Prototypes have been tested and there are many applications for smart phones.

Sustainability

The better adaptation to the individual and the situation is, the more probable it is that a countermeasure will be accepted, which will in turn affect its sustainability.

Combinations

A combination with countermeasures for real time detection of road layout, the traffic situation, the driver, the condition of the driver, etc. is required to create reasonable distinctions and to limit functionality at different levels. Cooperative functions can improve the dynamic assessment of the situation considerably. An *Architecture*/standard for the dissemination of information facilitates the exchange of information in this case.

Cost

The manufacturers will pay for the cost of development. Ultimately the product will be paid for by consumers.

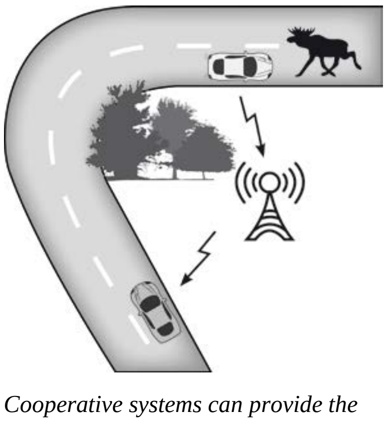
Potential risks and side-effects

One evident risk of the countermeasure is that the user will be lulled into a sense of false security that it is wholly without risk to use communication devices in every situation where they are available. However, the intention is to assist the driver not to use the device in demanding situations rather than helping the driver to find “safe” situations.

It is difficult to introduce restrictions on something that was previously allowed. As a majority of the population consider that they are better than the average driver [99], there is a risk of not everyone accepting the restrictions in the freedom to communicate.

3.1.7 Countermeasure: Cooperative systems

Cooperative systems reinforce a number of the other countermeasures by improving and enriching the information required to be able to determine where and when it is directly unsuitable to use communication devices.



Cooperative systems can provide the driver with information about critical events at an early stage. This makes it easier to foresee future events, thus improving the prerequisites for a workload manager, for example.

Description

Cooperative systems are based on transfer of information in real time between different vehicles, between the vehicle and the infrastructure, and from the infrastructure to another infrastructure. What is special about cooperative systems is the mutual exchange of information in real time. It is thus more than only downloading of saved information from different databases. In general terms, it is conceivable that the driver is provided with information which improves strategic and tactical choices while driving, for example, up-to-date information about tailbacks, weather, icy roads, approaching emergency vehicles, accidents, animals on the road etc. and that navigation devices are continuously updated so that the driver is automatically guided into alternative roads to avoid traffic jams, accident locations, etc. Systems for automatic braking could also intervene earlier and in this way lead to gentler braking, and vehicles on a collision course could work together to avoid a collision. A lot of the information required can be collected by crowdsourcing, but certain basic information needs to be provided by different authorities, for example, weather, type of road, current speed limit, “dangerous” places, etc.

The development of cooperative systems is made possible as flexibility is increasing in information and communication technology at the same time as costs are decreasing. In time, it is very probable that nomadic communication devices will also be connected to the cooperative network to enable seamless integration of functions. There have been and are a number of major EU projects for research and development of different types of cooperative solutions. Some of these projects are CVIS, SAFESPOT, Coopers and CoCarX [16, 18, 84, 13].

The greatest benefit of cooperative communication compared with autonomous sensors is that the information about vehicles in the vicinity is a lot more accurate. A connecting together with map-based information can improve assessment of the situation and advance planning considerably. Different cooperative functionalities are conceivable if the focus is on the problems relating to the driver’s use of communication devices. For example, the car can recognise that the driver is speaking on the phone and can then itself send signals to surrounding vehicles, which can in turn adapt their warning strategies or even actively increase the distance from the vehicle in question. It is also conceivable that certain vehicles (such as buses at bus stops), or temporarily dangerous locations in the infrastructure (such as mobile roadworks areas) can inform traffic in the vicinity of their presence so that drivers passing by can adjust their communication. The latter could profitably be integrated as part of a “workload manager”, see countermeasure *Adaptation to situation*.

Implementation

Purpose

The intention of using cooperative systems, within the framework of safe communication, is to provide every vehicle with a detailed picture of the current traffic situation. In this way, it will be easier to adapt where, when and how it is more or less appropriate to use communication devices while driving.

Recipient

The measure is primarily targeted on drivers to increase safety, but will also affect manufacturers of vehicles, communication devices and active and passive safety systems, as the available information increases. The more that comply with the communication protocol, the more can benefit from it. Road maintenance authorities and other actors can also use cooperative information to improve their services.

Early adopters

In order to ensure that early adopters as well benefit from cooperative systems, a possible implementation system is an asymmetric rolling out. Nomadic devices, which already exist in (in principle) every vehicle can receive cooperative traffic warnings and information with the aid of an application via the mobile system. Even with relatively few information providers, this could still have an effect on the whole traffic environment at a reasonable cost. The public sector can take a lead here by equipping its vehicles with the right technology, in particular blue-light and yellow-light vehicles that are often located at dangerous places or which can be a danger in themselves.

Responsibility

Politicians can drive demand forward and facilitate the creation of the necessary infrastructure by guidelines and requirements. Manufacturers are responsible for the technological development.

Lead time

Both the technological development and how the cooperative systems are introduced affect the time when the systems can really achieve an impact. Although research is in process in Europe, the US and Japan, there may be a delay before the technology is launched on a broad front. The impact also depends on the platform adopted for communication transfer in the cooperative systems. – the car fleet is replaced at a considerably slower pace than, for example, mobile telephones. Information, which is not extremely time-critical, could beneficially use the existing telecommunications system to send information as the infrastructure already exists.

Sustainability

When a degree of spread is achieved and the systems function according to expectations, it is probable that the effects will be long term. Cooperative systems risk not being sustainable if the information is not perceived as being useful and valuable and if intrusion into personal integrity is feared.

Combinations

Cooperative systems can and should be combined in a meaningful way with a large number of other countermeasures. A prerequisite for cooperative systems is a standardised communication protocol (*Architecture*) and a willingness to collaborate and share information, which is perhaps not directly beneficial for the disseminator of the information. Political incentives can facilitate here. Requirements that new cars are equipped with communication possibilities according to a common standard increase the possibilities for faster spread in the future.

Cost

The costs are large to start with both for research and for development, but also for creating the infrastructure required and to coordinate the information which is to be handled. One alternative is to subsidise the costs when the technology is introduced. Apace with the number of users increasing, the system can begin to bear its costs.

Potential risks and side-effects

To really be able to benefit from cooperative systems, a large number of participants must transmit information. Initially, it is not meaningful for individuals to invest as nothing will be received until a critical mass of users has been reached. Without incentive or long-term investments, there is thus a risk that the technology will not be spread. Incentives should be created, possibly by letting the public sector take the lead, to reach the critical mass required for the benefit to exceed the costs for most users.

The disadvantages of cooperative systems are not so much to with the technology as such but more about acceptance, integrity, opened/closed systems, who is responsible if anything goes wrong, the need for common standards, who is to pay the high initial cost and the like. Unless everything works, cooperative systems will not achieve a breakthrough on a wide front. Even if cooperative systems do become successful, it is probable that a certain number of vehicles will not be linked into the communication. This must be taken into account, especially during a transitional phase. It is particularly important that these vehicles can be handled by the communication in a way that does not create conflicts between equipped and non-equipped vehicles. There is a correlation with possible overconfidence in the technology, which has already been described in conjunction with other countermeasures, for example, *Test* or *Adaptation to situation*), and which can also be anticipated here.

The fundamental idea of cooperative systems is communication. As certain of the examples have shown, the transition is fluid between communication only taking place between vehicles and also including the driver. It is not either self-evident which is good communication that increases road safety and which is bad that reduces road safety. No overload is placed on the driver if the driver is not included in the flow of information owing to the car automatically adapting to the situation. At the same time, many misunderstandings and critical situations may arise if the driver does not have full control over the vehicle.

3.1.8 Countermeasure: Personal assistant

A personal assistant, human or digital can assist with everyday errands.

Drivers use communication devices to obtain access to the information that they need for the moment – even while driving. It is therefore important that the services drivers consider that they need are made available as safely as possible. Examples of how this could be done are through personal assistants, accordingly that a digital or human assistant is used to assist with the service that the driver needs at the moment. The measures are expected to reduce the time that the driver looks away from the road, but it is difficult to foresee the consequences of the increased cognitive load, in particular for digital assistants, which are still beset with technical problems.

Description

A personal assistant can help with many everyday tasks, for example finding the closest restaurant, booking a hotel room or sending an urgent e-mail to a colleague. Of course, not everyone can have their own private secretary, so the appearance of the assistant may vary. Already today, it is possible to obtain help with route information, opening hours, timetables, hotel booking, etc. by calling a personal search service. Similar functionality is also starting to be available on mobile phones, where a voice-controlled digital assistant can assist with simple tasks.

Implementation

Purpose

The intention of the measure is to simplify use of the different services with the aid of a personal assistant enabling the driver to keep an eye on the road and hands on the wheel for the major part of the journey.

Recipient

The countermeasure is targeted on everyone who at any time uses a communication device while driving. Professional drivers may very well have a central organisation providing customised service, while private drivers can use the services available to the general public.

Early adopters

As every call to a human personal assistant costs money, it is probable that users are primarily people who use the assistant for work purposes. Apace with the digital assistants becoming more common and better, use will spread to larger groups.

Responsibility

In the first place, the countermeasure will be implemented by private companies, for example telephone operators, service companies or technology companies.

Lead time

Eniro and similar telephone directory companies already offer a large range of services with personal service. Demand will drive forward development of more advanced services.

Sustainability

The sustainability of the countermeasure will be determined by the market.

Combinations

The countermeasure is per se self-going but *Guidelines* as well as *Time, situation and* individual *Adaptation* can contribute to taking care of the cognitive workload.

Cost

The customer will bear the cost. Just as at present there is often a fixed charge for data traffic regardless of the extent of use (flat rate), it is conceivable that subscriptions will become available for assistant services to avoid having to pay for every individual call. The subscription can possibly be linked to reduced insurance premiums, or the employer could purchase the service to demonstrate that the company is concerned for the employee’s safety in traffic.

Potential risks and side-effects

The interaction with the assistant must take place in accordance with Guidelines for good interaction design. Regardless of whether it is a digital or a human assistant, it is possible that use of the communication device will increase apace with assistance being available to perform more and more tasks while driving. Bearing in mind all research showing that it is dangerous to talk on the phone due to the cognitive load, regardless of whether one uses hands-free or not [57, 62, 74, 75], this is perhaps not a desirable development.

Increased cognitive workload during the conversation, deteriorated scanning ability, and frustration over the assistant not understanding what one wants are factors that can result in a deterioration in driving ability. However, it should lead to a clear improvement compared with taking one’s eyes off the road for a longer period [4]. In combination with the countermeasure *Adaptation to situation*, it is, however, possible to adapt usage of the services to the current circumstances.

3.1.9 Countermeasure: Wholly or semi-autonomous driving

Wholly-autonomous driving enables the driver can lie and sleep in the back seat while the car is moving. This sounds futuristic but semi-autonomous technology such as adjustable governors and parking assistants are already on the market.

Moving control over the vehicle from the driver and allowing the vehicle to take over driving is a future scenario that is probably the only technical solution to wholly eliminate the problem of distraction. The road there is a long one, which will be traversed in a number of small steps via, for example, automatic speed governors and semi-automatic vehicle convoys. There are a number of reasons for introducing autonomous driving, including increased road safety, improved transport efficiency, less burden on the environment, but also increased comfort for the driver. Depending on the driver's role in the system, the K:_Publikationer\Eva - pågående\Rapport 770A Katja Kircher\Bilder\In the situations where the driver is released from responsibility for driving the car, all communication is not dangerous for traffic.

Description

Autonomous driving means that the vehicle takes over the longitudinal and lateral control so that the driver in principle is relieved of all operational and most tactical elements, while strategic decisions remain with the driver, at least to some extent. This means that the driver chooses the destination and can influence the route, while the vehicle takes care of keeping the vehicle on the road, the speed, and interaction with other traffic in the vicinity. It is most probable that support systems offer the driver more and more general support (see Figure 4) and that there is thereby a gradual shift towards more and more autonomous driving where an intermediary step may be some form of semi-autonomous driving, for example, a number of vehicles that follow one another only on certain stretches of road or in a specifically delimited environment such as a tunnel, only within an organisation, etc. We are now in a transitional period, where certain automation for driving is being introduced. Examples of such systems are adaptive speed governors, and lane retention assistance. For the type of systems, it is still expected that the driver will be responsible for driving in critical situations. Distraction and the use of communication devices are still a potential danger here then.

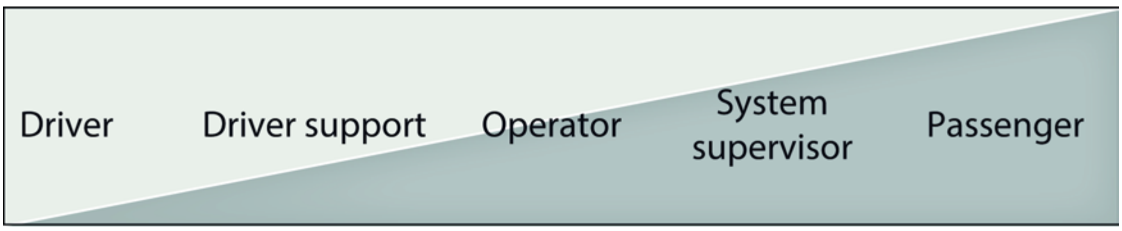


Figure 4 The driver's role when driving becomes more and more autonomous. The scale goes from the driver having full control (manual/conventional driving) to the vehicle being wholly autonomous and the driver in principle being a passenger in the car [34].

With the introduction of autonomous driving functionality in the vehicle, the role of communication technology will be changed in a number of ways:

1. The driver has fewer or no tasks relating to driving, which releases capacity for other tasks. The requirements of being able to communicate and perform various types of tasks will increase markedly.
2. In convoy driving, communication between the drivers of the respective vehicle may be important for the system to function and for drivers to accept the situation.
3. Communication between drivers, vehicles and other roadusers can be an important component to be able to leave and resume control of the vehicle in a safe way.

Semi-autonomous and autonomous driving has the potential to offer very great benefits for the individual and for the transport system. However, there are a number of questions that require further study before this can be a reality. The most important measure associated with autonomous driving is therefore to engage in research and investigation in this area relating to technology, the human being in the system and laws and ordinances.

An example of an ongoing research project is the SARTRE project [85] where convoy driving is studied. A professional driver with special training leads a convoy of vehicles and the following vehicles follow the lead vehicle without the driver needing to do anything. A list of a number of projects in process is presented on http://en.wikipedia.org/wiki/Autonomous_car.

Implementation

Purpose

The purpose of autonomous driving is to relieve the driver, ultimately taking completely over manoeuvring of the vehicle. In this way, the usage of communication devices will be of no danger as the vehicle manoeuvres itself.

Recipient

Well-functioning autonomous driving is in the interests of both professional and private drivers. It offers major possibilities for increased safety and increased effectiveness in the transport system.

Early adopters

Early adopters of autonomous driving may be professional traffic, for example, heavy goods vehicles from the same firm of hauliers who drive in a convoy.

Responsibility

To prepare the way for autonomous driving, the authorities must together with other actors make decisions about the allocation of responsibility while driving.

Lead time

It is not possible today to say exactly when wholly automatic driving functions will be introduced on the road network, but it is most probable that there will be a gradual development from today's adjustable governor to an increasing extent of automation.

Sustainability

It is very probable that autonomous driving will be self-sustaining.

Combinations

The countermeasure can function autonomously, but can be improved in combination with *Architecture* and *Cooperative systems*. Information to the public is also important to obtain acceptance.

Cost

Substantial investments in adaptation of the infrastructure will be required for a well-functioning transport system.

Potential risks and side-effects

The consequences of the introduction of autonomous driving will be very great in a number of areas. Questions requiring additional research are how to handle the handover and resumption of control between driver and system, if the driver still needs to have a supervisory function during autonomous driving and allocation of responsibility in the event of accidents. At present, discussions are in process within, inter alia, UN ECE WP 29 [56] concerning a proposal dealing with autonomous driving and the need to review the requirements of the Vienna Convention for driver control, that is that the driver is responsible for always having full control of the vehicle.

The less the driver has to do, and the more reliable the autonomous driving functions, the greater is the probability that the driver will direct attention to other tasks, such as communication with other people. It is very important to integrate this natural behaviour of the driver in development. In the event of planned resumption of control, the driver needs to be informed in good time so that any communication can be terminated in a good way and the driver can obtain a picture of the traffic situation by being aware of information provided by the support system and by comprehending the traffic situation. As long as there is a risk of a driver spontaneously needing to resume control, countermeasures must be taken to guarantee that the driver continuously monitors driving. In these circumstances, the same requirements apply to safe communication in traffic as apply when the driver is in full personal control of the car.

Increased automation entails that the driver must hand over control of the course of events to technology. Many drivers may find this difficult to accept. Norm changes and new perspectives on traffic and transport must be created for this development to take place.

3.2 Education and information

In the work on road safety, the purpose of education and information is most often to influence the motive behind the action (such as attitudes and norms) which in turn is expected to affect the behaviour in question. The purpose of the countermeasure sets the demands on its implementation; skills usually demand practical training while insights require experiences and help in drawing the correct conclusions. As an introduction to the concrete education and information countermeasures, a short outline of the latest research on this subject is given below.

Information

Information campaigns are useful for making road-users adopt safe behaviour in the long term, not least regarding the safe use of communication devices. Meta-analyses are often used to examine the results of different campaigns. In a study by Delhomme et al. [20] it was found that campaigns could reduce the number of accidents by 15 per cent. A later meta-analysis that included 437 campaigns from 14 different countries showed similar results. The driver’s perception of risk increased by 16 per cent, speed was reduced by 16 per cent, seat belt use increased by 25 per cent and accidents were reduced by 9 per cent [76].

In connection with the latest meta-analysis from 2009 it became clear that previous campaigns had not always drawn upon important research findings. This implies that there is still a potential for further improvements. More specifically, campaigns have an increased chance of becoming successful if they use existing knowledge about the message's formulation, target group adaptation and connection to theoretical models concerning people's decision-making and behaviour. It was therefore an important task for the European project CAST to produce a manual with concrete advice and instructions about the appropriate practices to achieve the best results. This covers, among other things, problem formulation, target group selection, message design and formulation, choice of methods for communication and several other important aspects [11].

A few examples of the type of knowledge that should provide the basis for the creation of information campaigns are given below [11].

It is of great importance that an information campaign about communication device usage while driving focuses on a single well-defined subject and is directed towards a specific target group. By targeting the message on a specific group, its formulation can be based on the specific conditions and interests of the group's members. The message should be formulated in such a way so as to speak not only to the intellect but also to the emotions. Another important condition is that change occurs over time and that different individuals have reached different levels of this development process. The information should therefore be adapted to the location of the target group in the process of change. Two different types of message may be used, the first aims to increase an individual's knowledge about the problem while the second regards changing norms in society or in different subgroups and thus requires a broad exposure of the message.

There are also certain general guidelines that the message should comply with. Some of the key concepts for these guidelines are:

- Dissatisfaction with one's own perspective
- Understanding (transparency and clarity)
- Credibility
- Attractiveness
- Relevance and conviction

Dissatisfaction with one's own perspective can be achieved by presenting information that counters previous conceptions. Increased understanding can be gained if the message is relevant and if it can be associated with something that the individual already knows. Credibility implies that the message should be based on knowledge and that it is possible to implement. A failure in this respect is associated with great risks as the individual's trust in the message is undermined. As an example, if the purpose is to reduce the use of communication devices while driving, the message must be perceived as attractive and inviting.

A problem that occurs as we attempt to change attitudes to communication devices is that the existing information is unclear and in many cases contradictory. As an example, when legislation prohibits only hand-held phones, some will understand this as meaning that it is safe to use a hands-free device [97], while others understand that there is no safe way to make calls while driving. More recent results [49, 73] have even been presented by the media as implying that phoning while driving can increase safety, as long as one keeps one's eyes on the road.

Before a message is formulated it is therefore necessary to design a thorough plan. In some cases it may be appropriate to first counter earlier assertions before introducing new ideas. The campaign can subsequently be designed according to the existing knowledge about the desired behaviour and the target group.

How to communicate with the target group is related to the choice of communication channels. Media and communication channels can be personal or non-personal.

- Personal communication channels include personal meetings, social media online and by phone or interviews with opinion leaders.
- Non-personal channels include the traditional mass media (press, radio, television, internet etc.) and events.

Within traffic-related research, frightening propaganda has been used to try and scare the drivers into behaving in a law-abiding way. It is assumed that the tension created makes the individual more responsive to the message. However, research has shown that the effects of frightening propaganda are more complex than that. Insufficient fear does not create the necessary tension and excessive fear can lead to an inability to act. Studies have also shown that scaring can have the opposite effect, meaning that a negative behaviour is strengthened as it is perceived as more attractive [11]. In conclusion, the effects of scare campaigns have arguably been overrated, but they may be effective if the message clearly states how to avoid the situation occurring.

Education

As with information activities, education needs to be adapted to the target group and purpose. There are, for example, great differences in how education should be conducted for young people who are about to get their driving licences and for older, more experienced drivers. The structure and choice of pedagogical methods are also different depending on whether an individual is, for example, learning to control a vehicle in critical situations or if the aim is to provide an understanding of the risks and one's own limited skills behind the wheel. Research also indicates that the choice of appropriate education messages and methods varies between women and men, younger and older persons, between beginners and more experienced drivers and between persons with different personalities [25]. It has been known for a long time that experience leads to proficiency and that this is also true for driving. A number of different methods have therefore been developed to ensure that the driver's education builds experience, some examples are the 16-year age limit for driving instruction for a Swedish class B licence (for a car), practical exercises in moped training and workplace-based learning (APL) for heavy vehicle licences in the upper secondary school.

The importance of individual and social conditions for a person's behaviour as a driver and to road safety has also recently been increasingly understood. These conditions include gender, lifestyle, profession, personality, group affiliation, health, goals and ambitions in life or ethnic background. Many such aspects of an individual's life influence the decisions taken in the traffic, the motivation to maintain a safe distance while driving, the importance of driving according to group norms, workplace culture and peer pressure etc. Research has shown that regarding road safety, it is often more important to work on these types of mechanisms rather than the knowledge about rules or the skills in manoeuvring the vehicle. This perspective, i.e. prioritising awareness, understanding and motivation rather than skills in handling a vehicle has to an increased extent permeated driver's training for different vehicles and at different levels, in Sweden as well as in other countries [25]. Awareness-generating education is well adapted to contexts related to safe communication device usage while driving, both at a basic level and in further training.

There are a number of important psychological, physiological and social differences between younger and older as well as between male and female drivers. For example, it is evident that group norms and peer pressure are more important during early years than later in life. There are also several important physiological mechanisms that differentiate younger from older and men from women. Some examples are hormonal processes and the development of certain functions in the brain. It has been established that the functions in the frontal lobe regulating reflection on the consequences of an action, control of emotions and impulses and prioritisation between short-term and long-term goals are not completely developed until around 25 years of age and that this development is faster in women than in men. These differences are of essential importance in the choice of education methods for increasing risk awareness and for safer behaviour [25, 45].

Evaluation

In the implementation of education and information, as well as in other road safety countermeasures, it is very important to evaluate the countermeasure using different scientific methods. There are several reasons for this: the most important and most obvious is that an evaluation presents the results of a countermeasure which may in turn contribute to future initiatives. This is true regardless of whether the results are positive or negative. It is important to talk about why countermeasures succeed or fail, how to improve them next time and which recommendations and warnings can be given to others who wish to try similar methods. Evaluations based on scientific principles are the only way to ensure that the conclusions drawn are correct.

Countermeasures that specifically target education and information have often been considered difficult to evaluate. This is one reason for the relative rarity of carrying out such evaluations [11]. Another is that insufficient funds are allocated to cover such an evaluation. In some cases, when evaluations have been carried out, it has been impossible to prove any positive effect. This has in turn been used as an argument against investing in education and information [72]. The reason for this may, of course, be that the countermeasures evaluated were inefficient but to a very high degree these results are dependent on the evaluation methods used to demonstrate the outcome of various investments. Three examples are given below of frequent mistakes that must be eliminated in a methodologically correct evaluation [72].

- A basic problem is that the evaluation concerns an effect on individuals. People are affected by a great number of different phenomena in society and the development of norms achieved by a countermeasure is quickly mixed with other norms in society. This is a systemic effect that makes it more difficult to isolate and measure the effectiveness of a countermeasure.
- Very large groups of people are generally required in order to prove statistically guaranteed changes in accident involvement. It is relatively uncommon to conduct education and information campaigns in very large groups of people while at the same time having the opportunity to follow them during a longer period of time.
- In meta-analyses of countermeasures the focus often lies on the effects on accidents. For many countermeasures this is not the primary target but rather they instead aim to influence understanding, attitudes or behaviour. In this case, the wrong effects are therefore evaluated.

3.2.1 Countermeasure: Risk education in the driver's training

One way to reach out to all future drivers is through compulsory risk education in the driver's education for licence class B, C and D. This training shall focus specifically on distractions and communication device usage in cars. It should also be pedagogically adapted to modern knowledge about the skills that a safe driver needs. This education takes place at a centre for hazardous road conditions driving practice since it combines theory with practical exercises in a car designed to generate awareness.

Education and information can be used to influence attitudes, norms, awareness and ultimately also the targeted behaviour.

Description

Driver's education is an important arena for increasing risk awareness among car drivers. Today, the education covers the risks of mobile phone use in the compulsory risk education, part 1. However, this education includes a number of different components during a short period of time and is therefore not adapted to achieving a safe device usage [6].

In order to be meaningful, risk education about distractions and communication devices in a car is judged to require at least two hours of training that combines practical and theoretical components.

We know today that young people are dependent on group affiliations and social norms. We also know that the brain's functions for assessing risks, controlling emotions and impulses as well as evaluating the consequences of an action are still developing in young drivers. Young drivers also have the highest accident risk on the road. It is therefore important that the right pedagogical methods are used, taking advantage of the existing knowledge of young people's physiological, psychological and social development. The pedagogical methods should contribute to a positive development, which requires that the young persons themselves are active in generating knowledge and awareness [1, 25, 45].

There is an ongoing development in which a student-centred pedagogy using experience-based, awareness-generating, investigative and problem-based techniques are increasingly used in the driver's education. It is of essential importance that the students themselves are active in defining problems and solutions, that group dynamic methods are used and that assistance is given in drawing the right conclusions.

Because practical, awareness-generating exercises in a car must include simulated risk situations while using communication devices, the education is most suitably conducted at a centre for hazardous road conditions driving practice or other restricted area. Simulator-based education components may also potentially be considered [32].

Implementation

Purpose

The purpose of this countermeasure is to generate awareness among driving licence students about the risks associated with the use of mobile phones and other communication devices while driving. The purpose is furthermore that this awareness should lead students to refrain from using the devices in a way that increases risks.

Recipient

The countermeasure is compulsory and is targeted on all those obtaining a licence class B, C or D. The compulsory education ensures that all new drivers are reached by the message. If the education is conducted in a good way the message can lead to a change in norms and make drivers refrain from using mobile phones etc. while driving.

Early adopters

Young drivers are expected to draw the most profit from the countermeasure since the majority of persons obtain their driving licence between 18-24 years of age. This is a group that commonly talks on their mobile phones, writes text messages and browses the internet while driving. It can be predicted that it is more difficult to achieve awareness and change behaviour in certain groups unless a tailored pedagogy is used, for example regarding persons with a risk-taking personality or those who are firmly based in social norms that counteract the message.

Responsibility

The countermeasure requires an extension of the compulsory part of the driver's education, something that is likely to require a change in legislation. A responsibility is also demanded from the educational organisations through further training of driving instructors in order to increase their knowledge, both of the subject in question but also about new pedagogical methods. Development and testing of both theoretical and practical components is also necessary. The actors required to design the countermeasure are therefore the Swedish Government/the Riksdag, the Swedish Transport Agency and the driving instruction schools/centres for hazardous road conditions driving practice.

Lead time

The countermeasure in itself takes around two hours to carry out. On completion the countermeasure is expected to have a direct effect on the participating driving licence students.

Sustainability

On implementation the countermeasure is expected to have a direct effect on new drivers. The effect will increase as more people participate in the training and get their driving licences. It is probable that the countermeasure has greatest effect during a limited time but keeping in mind that young people are frequent users of communication devices, the countermeasure will be of considerable importance to decrease risks within these groups.

Combinations

As for all types of pedagogical countermeasures it is to be expected that the effects are strengthened in combination with other measures or alternative solutions, for example a reward system or technical solutions that ensure safe device usage.

Costs

Two hours of education in a group and individually costs the same as two hours of the compulsory risk education part 2 in a centre for hazardous road conditions driving practice. Who will pay for the cost is a political issue.

Potential risks and side-effects

There are several risks associated with this type of education initiative. Most importantly, a false trust in one's own capacity to handle the communication devices while driving can be instilled. It is therefore very important to choose the right pedagogical methods and to ensure that the instructors are able to help students in drawing the correct conclusions from the education. If the wrong pedagogical models are used, or if the instructor does not have the right competence, there is a significant risk of the message not being understood and accepted or that it will be counteracted by the social norms that the participants are confronted with when they return to their social group.

Additional information

Knowledge about younger persons' driving and risks in the traffic has developed significantly during the last ten years. This has led to an understanding that safe driving is not mainly associated with knowledge of rules and the technical handling of the vehicle. We know today that the most important factors behind how a person uses their vehicle are related to lifestyle, goals in life, group affiliation, gender, age and other such qualities that are carried into the role as a car driver. These qualities affect the choices made and how motivated one is to behave in a safe way. This knowledge must therefore be the starting point for formulating messages and pedagogical methods in the road safety education. This process is today under way in the driver's education but the formal driving licence system is not adapted to this new knowledge.

3.2.2 Countermeasure: Support to company managements within companies and to personnel responsible for procurement of transport

Support to company managements and to personnel responsible for the procurement of transport can help responsible managers convey a company policy regarding communication to employees while driving.

The employer has an important influence on how professional drivers act in the traffic, for example by drawing up policies for speed, sobriety, working hours, use of communication devices etc. By providing the management and the trade union representatives with support and tools for adopting an appropriate company approach to employees' use of communication devices it is possible to shift an influential group of road users to a safer traffic attitude. This support can also be provided to companies that wish to include road safety as a part of the working environment for its employed personnel, for example in travel to and from the workplace. Companies with a distinct policy for the use of communication devices can advantageously be preferred in procurements, for example in municipality procurement of the mobility service, waste disposal or school transportation.

Description

Company managements take a large part of the decisions relating to the type of work tasks that drivers are to perform while driving and in which way. It is also they who set requirements for the procurement of transport. Trade union representatives for the persons who carry out transport are also an important actor. This is true both for private and public operations. The individuals who hold this responsibility are not always well educated about road safety issues and therefore lack the motivation or knowledge to take correct and important decisions about how, for example, communication devices should be used while driving in order to limit accident risk. These key actors for road safety need support and tools in order to take the correct decisions. Organisations that conduct this type of support activity already exist today but the operations could become significantly more important. In order to achieve this, some kind of catalyst or incentive is needed, for example a certification of safe traffic principles, connection to insurance premiums or a clearer legislation concerning the responsibility for the working environment and road safety. There are currently certification systems for procurement through the organisation Q3 and for companies with a road safety policy through the Swedish National Society for Road Safety (NTF) and Säker Trafik AB. In the near future the new standard for road safety, ISO 39001, will serve as certification.

The support to company managements and procurement staff can include education, cost-benefit calculations, follow-up observations or surveys and tools for the development of road safety policy and procurement criteria. The support can cover many different aspects of road safety, for example speed, sobriety, fatigue and seat belt use but also distraction and use of communication devices while driving.

The effects of the countermeasure will be greater as the operations grow more extensive and it reaches more companies and procurers. If the education is conducted in a good way the message could lead to a change in norms and company culture, an increased refraining from using mobile phones etc while driving and the development of new ways to handle the necessary communication tasks performed by professional drivers.

Implementation

Purpose

The purpose of the countermeasure is to engage company managers, trade union representatives and personnel responsible for procurement of transport and to develop concrete preventive road safety operations, including use of mobile phones and other communication devices while driving. The purpose is also for the countermeasure to encourage companies to introduce countermeasures or set procurement criteria that prevent dangerous device usage. This can be achieved by for example using technical solutions, awareness-generating education or other countermeasures presented in this report.

Recipient

The countermeasure is voluntary and directed to all interested personnel in company managements as well as personnel responsible for procurement of transport.

Early adopters

Professional drivers employed by companies that take an interest in road safety issues and introduce a road safety policy in their operations. Hauliers are procured with road safety criteria.

Responsibility

The company management and the trade unions are important for changing their drivers' behaviour as it is they who generally design requirements and rules and decide which countermeasures are adopted. By setting rules and principles for the use of communication devices while driving they can also greatly influence the conditions for reducing distractions and accident risk. This type of countermeasure is expected to reach a large proportion of the professional drivers. A similar role is held by the person responsible for setting procurement criteria on road safety when procuring transport. How drivers behave in their work is largely defined by the requirements on communication device usage while driving.

Lead time

The support process for a company may take a few months of work. The implementation of new rules, education of drivers etc. can require a few more months. On implementation, the countermeasure is expected to have a direct effect among the professional drivers concerned.

Sustainability

The effect will increase over time as more persons participate in the education. There could be a lag for groups of drivers that have developed a culture that is not necessarily beneficial to road safety and that will not necessarily change as a direct consequence of management directives.

Combinations

To achieve optimal outcome, countermeasures also need to motivate the drivers themselves, for example by education or different types of incentive. As for all types of pedagogical countermeasures it is to be expected that the effects are strengthened in combination with other countermeasures or alternative solutions, such as a certification system, connection to insurance premiums, education of drivers, reward systems for drivers or technical solutions and messenger services.

Costs

The countermeasure is voluntary and paid for by the recipient.

Potential risks and side-effects

There are risks associated with countermeasures of this type. One such risk is that the countermeasure is directed towards company managements and that it is they who, in turn, decide how their employees should act. In order for such decisions to be accepted and implemented in a positive way it is necessary for employees to participate in the decision-making, for example through trade unions. Aspects relating to employees' integrity also need to be carefully considered together with employee representatives. The positive effects may completely or partly disappear if the company managements set too many rules or if the rules infringe on the employees' own liberty to make decisions.

The systems used to control/supervise employees may be abused by the company management. ISA systems (a system that tells drivers what the speed limit is) are an example of this since they are used to penalise employees or monitor their performance. From the employees' perspective the positive effects of the system (safer speed choice) will be wholly or partly overshadowed by the controlling aspects of the system. Part of the support/procurement should therefore be spent on guaranteeing the personal integrity of the employees' and on ensuring that only the aspects of the system that promote road safety are used.

Additional information

There is considerable knowledge about the role of professional transport in the transportation system for movement of goods and people. It covers accessibility, logistics, environmental impact, working environment and road safety. There is a great need to convey this knowledge to transport suppliers. Countermeasures that convey knowledge, tools and support to suppliers and procurers of transport may therefore be important in many different areas, not only road safety and use of communication devices.

The proposed countermeasure may, in an adapted form, also be used in other sectors. In this case, the employees' role is not primarily as a driver but instead a company management can show that they wish to invest in the employees' safety when travelling to and from work. The company management could for example purchase certain features for the employees or offer courses during working hours.

3.2.3 Countermeasure: Risk education in the compulsory basic and further training for the certificate of professional competence, YKB.

All professional drivers must attend a course in order to receive the certificate of professional competences, YKB. The YKB includes both basic and recurrent further training with components focused on road safety. The proposed countermeasure is to make the components that concern risks of using mobile phones or other devices and distractions compulsory within both basic and further training.

Education on handling communication devices while driving for increased safety could be included in the compulsory basic and further training for the certificate of professional competence, YKB.

Description

The driver's education is an important arena for generating awareness about risks among professional drivers. It is therefore important that the basic training for heavy vehicle licences class C and D raises the issue of risks associated with dangerous device usage while driving. Another proposed countermeasure (see section 5.2.1 above) suggests a compulsory education on communication devices within the driver's training for heavy vehicle licences. Professional drivers use many different communication tools beside mobile phones, for example CB radios and tailored logistics products. If used inappropriately, these devices easily create distractions and increase the accident risk. An increased accident risk is especially dangerous with heavy vehicle traffic as these vehicles cause a larger collision impact in accidents and thereby cause more serious injuries.

By adding a compulsory component in the YKB training on distraction and use of communication devices while driving, drivers get an opportunity to directly connect the risks and their own behaviour with the devices used in their professional role.

In order to be meaningful, risk education on communication devices in the YKB is judged to require at least two hours in the basic training combining both practical and theoretical components, as well as recurrent reminders about road safety during further training. Simulator-based training could be used for specific components.

Culture and norms are an important part of the professional role for many professional drivers, just like for young drivers. It is therefore important that the right pedagogical methods are used, taking advantage of the existing knowledge about risk consciousness and the factors that influence the motivation to drive safely. The pedagogical methods should contribute to a positive development, which requires that the professional drivers themselves are active in generating knowledge and awareness (see further discussion on pedagogy in section 4.2.1).

Because practical, awareness-generating exercises in a car must include simulated risk situations while using communication devices, the training most suitably takes place at a centre for hazardous road conditions driving practice or other restricted area. Simulator-based training components may potentially be considered.

Implementation

Purpose

The purpose of the countermeasure is to generate awareness among professional drivers of the risks associated with the use of mobile phones and other communication devices while driving. The purpose is furthermore that this insight should lead participants to refrain from using the equipment in a way that increases risks.

Recipient

The countermeasure is compulsory and is directed to all the participants in the basic and further training for the certificate of professional competence, YKB.

Early adopters

Professional drivers are expected to draw the most profit from the countermeasure since they are required to participate in the YKB training. These drivers often speak in their mobile phones and use other types of communication devices while driving. It can be predicted that it will be harder to generate awareness and behavioural changes within certain groups unless a tailored pedagogy is used, for example among those who have a risk-taking personality or those who are firmly based in cultures and social norms that counteract the message.

Responsibility

The countermeasure requires changes in the curriculum for the YKB, and this affects the regulations. The Swedish Transport Agency is the responsible authority. Further training of teachers is also required to increase knowledge, both of the subject in question as of the appropriate pedagogical methods. Development and testing of both theoretical and practical components are also necessary. The actors required to design the countermeasure are therefore the Swedish Transport Agency and the organisations that are responsible for the training.

Lead time

The actual training only takes a few hours per driver. Since the further training is recurrent, all professional drivers will in time be reached by the measure

Sustainability

If the training is conducted in a good way the message can lead to changed norms, a greater willingness to refrain from using mobile phones etc while driving and development of new ways to handle the necessary communication tasks performed by professional drivers.

On implementation, the countermeasure is expected to have some direct effect on professional drivers. The effect will increase as more and more drivers participate in the training.

Combinations

As for all types of pedagogical countermeasures it is to be expected that the effects are strengthened in combination with other countermeasures or alternative solutions, such as support from the company management, a company policy, procurement criteria, reward systems or technical solutions and a messenger service.

Costs

The training is already included in a compulsory component and is paid by the person who pays for the entire YKB training.

Potential risks and side-effects

See the section on possible side-effects for the countermeasure *Risk education* in the driver's education, on page 50. Note that in this instance the company is an important part of the social group.

Additional information

See the section on additional information for the countermeasure Risk education in the driver's education, on page 50. Note that this is also highly relevant to the road safety education in the YKB.

3.2.4 Countermeasure: General information campaign focusing on distractions

Information campaigns can change society's norms and attitudes on communication while driving.

Since new technology is constantly being launched this countermeasure intends to focus on the underlying problem, namely distractions, rather than treating each device separately. The goal of this information campaign is to change attitudes, norms and perceived control of the behaviour in order to decrease dangerous device usage while driving. The perception of one's own behaviour varies between those who often and those who less often use communication devices while driving [95]. This countermeasure is mainly targeted on those who use communication devices often since this is generally a group with road safety issues. To achieve a high penetration rate and reach out to many drivers it is important that the campaign is launched through different channels.

Description

The countermeasure is a public road safety campaign in which the message is designed to change attitudes to using communication devices while driving. This means that the message will counter the driver's attitudes and norms regarding the behaviour but also their perceived control. The last part is included since these drivers do not feel that their own behaviour is risky as they see themselves as skilled car drivers. A norm-changing message can be expected to have a great effect on the behaviour since the target group will experience an increased peer pressure.

A public campaign should focus on the dangerous use of communication devices in general and not restrict itself to, for example, mobile phones. The main theme is to in a clear, transparent and credible way present what is meant by distractions and how to avoid dangerous device usage. According to the established practice the message is based on the target group's perceptions of the behaviour that have been thoroughly examined before the message is formulated and the campaign can start. Since a behaviour is often well established it is necessary to monitor the campaign over a longer period of time.

Based on the perception in the target group that they themselves are not at risk while using communication devices, a first campaign investment can focus on making them think about their perceptions without creating any change in behaviour. The following parts of the campaign can then aim to keep these thoughts alive and suggest other ways of behaving. In some cases, a focus on positive effects of the new behaviour can have a greater effect than a focus on negative effects of the unwanted behaviour.

A concrete example could be using a concept similar to the intensive campaign weeks conducted in Sweden on the compliance with speed limitations and seat belt use. This structure allows public information campaigns in different channels to be combined with increased police surveillance, observation studies and local and national media reports of the outcome of these surveys.

To achieve a high penetration rate and reach out to many different types of driver it is important that public campaigns are launched through different channels.

Implementation

Purpose

The purpose of a public information campaign on distractions is to change the perception of what is considered a safe use of communication devices in a car.

Recipient

The target group is persons who regularly use communication devices in cars.

Early adopters

It is easiest to convince those who already agree with the message. The more influential these persons are and the more support they get through the campaign, the easier it will become for them to convince others.

Responsibility

A relevant authority, such as the Swedish Transport Administration, the Swedish Civil Contingencies Agency (MSB), or the Swedish Transport Agency should be responsible for initiating a campaign of this type. However, other groups, such as non-profit organisations, trade associations or trade unions should be responsible for implementing the campaign. The evaluation is to be done by an independent research supplier.

Lead time

A certain effect, such as a change in attitudes, can be achieved relatively quickly but as the final objective is to create a lasting change in norms and behaviour there should also be a more long-term campaign plan.

Sustainability

Effects can be seen relatively quickly but the countermeasures need to be repeated as the effect usually subsides.

Combinations

Combinations of countermeasures usually give the best outcome, for example information, surveillance, education and different types of rewards. Some such combinations require that a larger public campaign can be connected to local countermeasures such as *Targeted campaigns* and local countermeasures at different workplaces.

Costs

The costs depend on how many and which different media are to be used. TV-time is expensive while the internet is considerably cheaper. A cost that is also important to calculate is the evaluation cost. An evaluation is invaluable in this context and does not only concern observational studies of behaviour but also whether the driver's attitudes, norms and perceived control of the behaviour have changed. Without an evaluation it is impossible to know if, or why, the campaign has had a particular outcome. The responsible authority will pay for the evaluation costs.

Potential risks and side-effects

A possible risk is that the campaign does not have any effect. This risk is higher if a thorough examination has not been done of the motives that affect the behaviour. The risk is also higher if the message is not properly tested before it is launched. Another possible risk that is harder to influence is if something that contradicts the message happens in the society at the same time. An example could be a message that claims that using mobile phones while driving is not dangerous, something that would make the campaign look less credible. Even if the sender of this message does not have the same status it can have a negative effect since persons who do not wish to change their behaviour will listen more to messages that strengthen their own opinions, regardless of where they come from.

3.2.5 Countermeasure: Dialogue-based information campaign

A targeted information campaign aims to change the behaviour with anctive involvement of specific target groups.

An information campaign aims to increase the understanding of the potential dangers and accident risk of the inappropriate use of communication devices while driving. The campaign is a combination of information through target group-oriented mass media, direct information to selected target groups through an appropriate information channel, for example through their companies, a participatory initiative where the target group can affect the further countermeasures that may be implemented, evaluation with measurement/registration of the driver's behaviour and a reward system for the safe use of communication devices.

Description

An example of the countermeasure is shown by describing how a campaign directed to professional drivers of heavy vehicles would be designed. Professional drivers use communication devices while driving for a number of different tasks. This is often necessary in order to carry out work tasks in an efficient way. An information campaign should therefore not aim to prevent communication but rather to change the conditions and the behaviour in order for communication to occur in a safe way. As the campaign consists of a combination of information and several other actions the outcome is expected to be significant.

Two different types of message can be used. The first aims to increase the individual's awareness of the problem. The second, requiring broad exposure of the message, regards changing norms in society or in different subgroups. The first message is expected to make drivers more aware that they are themselves running an increased risk and that their different strategies for avoiding accidents are not ideal. The second focuses on norms and the message is that using communication devices while driving is inacceptable. This message is expected to have a significant influence on the behaviour since the target group will experience an increased peer pressure. The messages are otherwise designed according to the general knowledge about adaptation to different target groups and in such a way so as to harmonise the messages with other parts of the campaign [11].

How to communicate the message depends on the target group. Results can be achieved within specific companies through a local design and size while a group such as young drivers requires a high penetration rate as the important aim is to change norms. Since the target group often does not experience that they are themselves at risk while using communication devices a first campaign investment can focus on making them think about their perceptions without any change in behaviour. The following parts of the campaign can then aim to keep these thoughts alive and suggest other ways of behaving.

The mass media part of information campaigns is spread through channels that reach professional drivers, for example magazines from trade associations or the transport trade unions.

The messages are designed according to general knowledge about adaptation to different target groups and in order for them to harmonise with the messages of other parts of the campaign. One of these campaign actions regards direct information to drivers in their workplace. This can be implemented through group meetings with drivers where discussions or lectures are held. Information folders and posters or videos can also be used in a way that ensures that the messages enforce each other. A method that has proven effective is to let drivers discuss road safety in a group with the purpose of making suggestions to the management about investments that can improve the drivers' conditions while the drivers themselves define how they can contribute through changed behaviour [44]. At the same time, the company management has to show that they are interested in receiving ideas and taking actions. An important part in this type of campaign is to follow up, monitor and provide feedback. There are different methods for this, for example self-reporting, technical measurements or observational studies. The purpose can be both to give feedback to the drivers and to use this as the basis of a reward system where good drivers receive some kind of benefit.

Examples of another group that a targeted information campaign could focus on are new, young drivers, a group that often uses their mobile phones etc while driving although they have not developed sufficient experience and routine for driving.

Implementation

Purpose

The purpose of the campaign is to convey messages that generate awareness about the risks of inappropriate use of communication devices while driving, as well as to show alternative ways to solve transport and communication issures. A resulting effect of the campaign is expected to be that individuals will adapt their behaviour, the use of communication devices, to a safe usage.

Recipient

The campaign targets different groups of communication device users with specially designed messages and methods. These groups may be, for example, young drivers or different kinds of professional drivers, for example lorry, bus, taxi or emergency service drivers.

Responsibility

A related authority, such as the Swedish Transport Administration, the Swedish Civil Contingencies Agency (MSB) or the Swedish Transport Agency should be responsible for initiating a campaign of this type. However, other groups, such as nonprofit organisations, trade associations or trade unions should be responsible for implementing the campaign. The evaluation is to be done by an independent research supplier.

Lead time/Sustainability

Results can be seen relatively quickly but the countermeasures need to be repeated or followed up.

Combinations

Studies have shown that the combination of surveillance and campaigns have particularly good results. However, since use of mobile phones while driving is not a breach of the law, surveillance cannot be followed by legal consequences. The only exception is if the usage leads to reckless driving. On the other hand, feedback from the surveillance can make a driver aware of a situation where he/she is acting in an inappropriate way. This means that a larger campaign can be connected to local countermeasures, for example in different workplaces.

Costs

The costs depend on how many and which different media are to be used. TV-time is expensive while the internet is considerably cheaper. A cost that is also important to calculate is the evaluation cost. An evaluation is invaluable in this context and does not only concern observational studies of behaviour but also whether the driver’s attitudes, norms and perceived control of the behaviour have changed. Without an evaluation it is impossible to know if, or why, the campaign has had a particular outcome. The responsible authority will pay for the evaluation costs.

Potential risks and side-effects

See the section on possible side-effects for the countermeasure *General information campaign*, page 57.

3.3 Financial incentives

In order to delve deeper into the regulatory and economic perspective, we ask the question why the behaviour of individuals is or needs to be regulated in the first place.

There are four different answers to that question:

a) The individual only takes into account their own individual risks. This is a persistent problem, causing problems such as the continued increase in the weight of the vehicle fleet, or that too many cars crowd into the same place at the same time, creating congestion, etc. This is also one of the most common causes for regulatory intervention either in the form of corrective tariffs (e.g. congestion charges) or quantitative regulation (such as emission limits and to some extent, speed limits).

b) Parts of individual risks are external. While this may be regarded as a part of the answer above, this aspect concerns more closely effects on the individuals themselves. This includes for example when the individual's own healthcare costs and loss of income after an accident are covered by public finances (i.e. financed without direct relation to the behaviour which caused the accident). Once again, any countermeasures would concern corrective tariffs or quantitative regulation.

c) Individuals are unaware of the risks that their behaviour brings. The individual underestimates costs in comparison to benefits, in this case the risks inherent in certain behaviour, such as sending text messages while driving on the motorway. This individual will take greater risks than they intend to. Regulatory solutions in this aspect are mostly related to providing information, similar to informing about the dangers of smoking or about the reasons for speed limits (such as signs or other notifications about road quality ahead of drivers).

d) The intentions of society at large differ from the individual. For some reason, the government has an interest in offering the individual greater safety than the individuals themselves would want. Various forms of altruistic preferences might lead to such solutions.

With these aspects as a basis for discussion, one could either implement quantitative regulations or some more market-oriented reform.

A ban on hand-held mobile phones is one form of quantitative regulation. The individual's benefit of using the technology remains, however, meaning that such regulation requires monitoring in tandem with punishment for individuals who violate the regulation, which is stronger than the benefits gained. Otherwise, the regulation won't be adhered to. There would possibly be a certain learning curve as individuals start to have a perception of the size of fines, in which case regulation might have an initial effect in spite of a lack of sufficient sanctions.

The other possibility involves internalising the external risk costs (as in a or b above) with a tax or fee. Such fees could either be in the form of an ex ante fee (e.g. a per-minute charge as individuals behave in ways that may decrease their alertness) or an ex post fee which is collected if something were to happen. The former has high requirements of observability and surveillance, which is here considered to be impracticable. The other method is a form of punishment, meaning that one causes an accident and at the same time was fiddling with technical equipment, the punishment would be more severe than otherwise. As long as the individual isn't subject to c) above this will regress to constituting a cost of behaviour. Neither of these, however, is particularly simple to implement in practice.

However, it is not necessarily the case that there are grounds for regulation. Today's behaviour could be the optimal balance between the individual and societal benefit from technical equipment, versus the increased risk costs. The countermeasures we then look at taking would include regular road safety measures comparable, in terms of effectiveness, to investment into road systems, airbags etc. In the absence of the problems delineated above, any such products or services would be a regular marketed product which, if offered, would be offered to the consumer as an add-on to the car. There is then no reason for regulation. One could possibly contemplate some sort of industrial incentive to companies developing this sort of product.

There is also the possibility that insurance companies would be interested in more accurately controlling for insurance-holders' risk levels and behaviour. If there is a correlation between the use of communication devices and risks, the insurance companies have reason to adjust their premiums on that basis. This also necessitates controls of compliance. Once again, this becomes a question for private companies where competition between different actors should drive differences in premiums. That said, we have observed that the insurance industry tends to be cautious about experimenting with premiums.

3.3.1 Countermeasure: Penalty point systems, incentives and premiums

Many countries have introduced systems with penalty points connected to the driving licence. Drivers accumulate a standardised amount of penalty points for traffic violations. Reckless use of communication devices could be a violation in such a system, burdening the driver with penalty points. The points are accumulated over time and may result in licence recall, mandatory further training and more expensive insurance premiums, while good behaviour reduces the number of points and is rewarded with lower insurance premiums.

A penalty-point system makes it possible to act against repeated traffic-code violations more systematically, and may lead, for to licence revocation or higher insurance premiums.

Description

It has been seen that the way in which consequences of a code violation are designed affects the behaviour of drivers. Fines do affect road-safety behaviour, but the threat of revocation of a licence is perhaps even more effective. The current Swedish system for licence revocation has had the same philosophy since the 1977 Driving Licence Act, in which such revocation is a matter of individual assessment.

Many countries, including the Nordic countries, have introduced penalty-point systems, as standardised consequences for certain traffic code violations. Most commonly, drivers are punished for speeding, but also usage of seatbelts, careless driving and failure to stop at red lights are included. Some countries also punish usage of mobile phones without a hands-free kit. A violation burdens drivers with penalty points, which are accumulated until the licence is revoked at some limit. In some countries, points are also given if a driver has been involved in causing an accident. The accumulation of points can be decreased over time with good behaviour, as well as after some further training or rehabilitation.

Studies show initially positive road-safety effects following the introduction of a penalty-point system. These studies also indicate that such benefits decrease over time. The standardisation of certain violations also leads to decreased workload for police. [101] In 2008, Vägtrafikinspektionen [Traffic Inspectorate] recommended further studies to investigate a potential introduction of a Swedish penalty-point system. [101]

There is one additional aspect to penalty-point systems, concerning the connection to the insurance market and policy pricing. If, as research indicates, the penalty points provide an indicator for drivers with a high risk of accident, it would be relevant for insurance companies to price their policies on that basis. There are reasons to believe that such developments would make the benefits of penalty-point systems more sustainable. It is common in many countries that insurance companies use the penalty points in their pricing.

Today, information about any consequence of traffic-code violations in Sweden are reserved for the judicial system, and the insurance companies do not have access to such information, unless insurance costs are involved. Even then, those details are not generally provided to all companies in the industry, creating information asymmetries between the driver committing the violation and insurance companies. The driver is not required to share such information when changing insurance company. By introducing a penalty-point system with a connection to the driving licence, this kind of information can be generalised, be stored and as such be part of the pricing at insurance companies.

By creating a connection between reckless usage of communication devices and a penalty-point system, such device usage would become a basis for insurance pricing and thus affect drivers' behaviour in both the short and the long term. Exactly how such a standardised association, and the system in general, would be designed is a topic that requires further investigation. In principle, however, two separate forms are probable. In one form, the cause of an accident involves the reckless use of communication devices. This kind of accident in combination with such device usage gives the violating driver a certain amount of penalty points. As such, an association to behaviour is only made once an accident has happened. In the second form, there could be a system where the reckless device usage gives penalty points even if an accident has yet to happen. The latter form requires complicated monitoring to assess reckless use in a legally secure way.

A system in which penalty points are associated with insurance premiums requires a link between the driver and the insurance. In Sweden presently, only the vehicle is insured, not the driver. This is, in particular, the case for professional drivers, where the company holds the insurance and the driver is completely separated from the system. Possible solutions to this problem may require further investigation.

Implementation

Purpose

There are two main purposes to implement a penalty-point system: in part, there is a clearer connection between behaviour and licence revocation, which drivers consider a significant consequence; and in part, the system makes available more information to the insurance market about expected future risks. Hence the penalty-point system is connected to a premium differentiation, which could be expected to affect drivers. A driver who has collected points could through good behaviour reduce the accumulation of points and thus also the size of their premium.

Recipient

This action is directed toward drivers. The intervention could be segmented for different groups, such as new licence holders (as in the Netherlands), professional drivers etc., if there is reason to focus on a particular group.

Responsibility

The introduction of a penalty-point system is the responsibility of the state. One interesting aspect is whether a standardised penalty-point system may reduce the workload of the police force.

Lead time, Sustainability, Combinations

The intervention should provide benefits immediately, but its sustainability is a question for further studies. One assumption is that the association with premium pricing in the insurance market could increase the longevity of the system.

The system is very conducive to being connected to a “pay as you drive” system, where drivers can “prove” good behaviour by voluntary monitoring equipment.

Cost

The cost of a penalty-point system has not been analysed. There are many examples of these systems around the world, which is why a cost-benefit analysis should be able to be quite accurate. In terms of benefits, besides effects on road safety, there are also potential savings within the police force. If the system is then combined with a regress of public costs of traffic accidents toward third-party liability insurance, the burden on public finances is reduced while the costs for drivers increase via increased insurance premiums. The costs increase the most for drivers exhibiting dangerous traffic behaviour.

Potential risks and side-effects

As with all countermeasures that involve increased costs of insurance premiums, the penalty-point system risks increasing the number of uninsured drivers. As long as third-party liability insurance remains mandatory in Sweden, this does not need to constitute a drawback, as one possible consequence is that drivers with an uninsured vehicle drive more carefully. Other risks that could be considered with the system include a decreased sense of legal security as a result of the standardised application, as well as possibly increased administrative cost.

3.3.2 Countermeasure: Pay-as-you-talk insurance policies

By adapting insurance premiums, drivers can be provided with financial incentives to secure handling of communication devices in traffic.

In the traditional Swedish third-party liability insurance, premiums are usually based on rough categorisations of the distance driven. In some countries, this has been further developed into pay-as-you-drive insurance, where the premium is based on actual distance driven, and “pay-as-you-speed” policies where the premium is based on risky behaviour such as speeding. These systems could be further developed to include usage of communication devices. For those who voluntarily purchase insurance under such policies, good behaviour in traffic brings rewards in terms of a smaller insurance premium.

Description

Road-safety issues can be analysed as an externality in economic terms, i.e. where a decision-maker fails to include all relevant consequences in their decision. In the case of a negative externality the decision-maker, when unregulated, will choose an excessive consumption of the activity connected to the negative externality. In traffic, examples of such externalities usually include vehicle emissions,noise or congestion. To regulate externalities, the regulator either has to use quantitative regulation or market-oriented instruments. The latter have become more common through different forms of environmental fees, carbon-emissions taxation or congestion charges, and have often proven to be more effective. Let us consider the road-safety problem as an externality, where in the unregulated scenario drivers will prefer excessive consumption of risk.

In order to keep the cost of an accident from becoming unmanageable for the individual, the Swedish traffic code requires mandatory third-party liability insurance. The premium covers the average costs incurred by an individual and is charged to the driver in annual intervals or shorter. Meanwhile, the connection to actual distance driven is too vague for the premiums to reflect the risk level of the individual. The premium is also sometimes differentiated by type of car, age, or other variables that show a correlation to that risk [14, 19, 52-54].

Insurance premiums are thus already an extant example of a market-based instrument to regulate individual traffic behaviour. Insurance companies and researchers have for some time been experimenting with more advanced premium structures. An initial step would be “pay-as-you-drive” where the premium is connected to actual distance driven, with the assistance of geopositioning technology [2, 7 9]. The individual pays a variable premium based on how much and where they use the vehicle. A further step involves the introduction of “pay-as-you-speed” premiums. In this model, the premiums are associated with the individual’s behaviour in traffic and, in the initial efforts, to speeding. Research indicates that with relatively simple pricing methods, individuals can be effectively encouraged to stay within the speed limits. Technical advances should also make it possible to monitor the usage of communication devices. If the insurance business finds that handling communication devices significantly incurs future accident-related costs, premium pricing would be differentiated on that basis. Reckless usage of communication devices will be punished with a higher premium.

The introduction of “pay-as-you-drive” and “pay-as-you-speed” can be done in a market-oriented, voluntary manner. Individuals with good behaviour, or with little benefit to lose from changing their behaviour, will switch to such policies as it results in lowered premiums. The benefits of a voluntary introduction are that the integrity-related problems and the risk of manipulation of the system are reduced. As policies increase in market share, a gradually increasing premium in the remaining group encourages even more to switch policies.

Drivers do not pay the full costs incurred in an accident. In part, public finances are burdened with the cost of medical care, medicine and parts of lost income, and in part costs of grief and suffering are not included to any greater extent. At present, insurance premiums are taxed in Sweden at 32 per cent, and can be seen as a way to include societal costs in insurance premiums. An alternate way of increasing the extent of societal costs includes a regress toward the public finances for, for example, healthcare costs to third-party liability insurance. At the same time the burden on public finances is thus reduced, the degree of internalisation increases through the insurance. Through new “pay as you…” systems, road safety is further improved: from initially having burdened the public, to being transferred onto the community of drivers, to finally mostly burdening the individuals with the highest risk levels.

A system connecting individual behaviour to insurance premiums does, however, require a link between driver and insurance. In Sweden, it is currently the vehicle that is insured, and not the driver. This becomes a particularly notable question in terms of professional traffic, where a company is the insurance-holder and the driver is completely removed from the system. Possible further solutions to this problem require further investigation.

Implementation

Purpose

The purpose of this system is to provide an incentive to individuals to reduce their risk traffic behaviour. With a functional system of incentives, the usage will fall to an optimal level, meaning that in some cases using communication devices is a rational choice, while in other cases it is too expensive.

Recipient

The final recipient here is the individual driver. Public responsibilities are still delegated to the actions of the insurance market.

Early adopters

Through the insurance market, the system will initially attract careful drivers with road-safe behaviour. As the market matures, however, more drivers will enter the system. Issues regarding uninsured drivers still require further action.

Responsibility

Insurance companies are primarily responsible for the implementation of the premium structure. However, the responsibility for implementing the necessary technical infrastructure could potentially be connected to the traditional responsibilities of road maintenance authorities, of which the Swedish Transport Administration is the dominant actor.

Lead time, Combinations, Cost

“Pay-as-you-drive” systems are presently readily implementable while “pay-as-you-speed” systems primarily have been used within research projects. Some further technical development is required to find systems where the usage of communication devices can be logged, and sent with complementary information to insurance companies. Provided that the systems are there, the implementation can be relatively rapid, but is subject to market dynamics. The implementation assumes that there is such competition that some companies benefit from segmenting into this niche.

Sustainability

As long as insurance companies differentiate their premiums, the system can be reasonably expected to develop further over time and would have a long-term effect. Nothing appears to indicate that these effects would weaken once the technical infrastructure is in place.

Potential risks and side-effects

The costs of these systems likely exceed the benefits they bring to any individual insurance company at the present. The cost mass incurred toward the insurance, without increased tax or regress, is too low, and the costs of developing the system for an individual company are too high. In that regard, it could be argued that a technical infrastructure provided by the state is more suited to obtaining benefit from the collective nature of the technology.

As noted above, the system can pose threats to personal integrity. To some extent, this problem is handled through the voluntary nature of the insurance form. We assess, however, that as the system over time acquires larger market share, the status of voluntariness becomes less clear.

Those who choose not to accept the policies would be affected by higher premiums and would eventually be identifiable. One advantage is that other measures then can be targeted toward this group in particular. Another obvious risk is that the number of uninsured drivers may increase. The problems incurred by an increasing number of people driving without basic third-party liability insurance are obvious, but should fewer drivers choose additional insurance only the individual's finances are affected.

Additional information

Technical development within the financial area could very well be linked to innovations within the car industry and as such also include a growth perspective.

3.4 Legislation

Sweden is relatively alone on not having legislation specifically targeted on using mobile phones while driving. In a previous review of the effect on road safety [63], it was noted that legislation has not had the expected effect in other countries.

3.4.1 Countermeasure: Legislation on use of communication devices

Previous studies have not succeeded in showing that general bans on the use of hand-held mobile phones reduce usage or the incidence of accidents. In the light of this, proposals are made here for a clarification of the text in Chapter 2, section 1, and Chapter 3, section 1 (Careless driving) of the Traffic Ordinance. A law should be technologically neutral and focus on careless behaviour rather than usage as such.

A clarification of the current wording of the law on carelessness driving is aimed at risky behaviour rather than a total ban on a particular technology.

Description

Legislation against the use of communication devices while driving can be formulated (i) as a general regulation that drivers must be attentive in traffic, (ii) as a total ban against use for all drivers or for specific groups of drivers or (iii) as a ban with exceptions if certain conditions are met. Today, Sweden applies a general law. According to Chapter 2, section 1, of the Road Traffic Ordinance, "To avoid road accidents, a road user shall take the care and caution required taking into account the circumstances" and according to Chapter 3, section 1, "Vehicles may not be driven by a person, who, owing to illness, tiredness, the effect of alcohol, other stimulating or anaesthetic substances, cannot drive the vehicle in a safe way." In principle, these regulations can be considered to include risky usage of mobile phones and other communication devices while driving, i.e. usage which leads to such pronounced distraction that it entails a danger (see *Section 3.1* of this report).

In many other countries, it has been decided to target the mobile phone specifically. Laws against text messages are often drafted as a total prohibition while mobile telephone laws require hands-free equipment. Previous studies have not shown that a general ban on hand-held mobile phones reduces usage or accidents [58]. Statutory requirements for hands-free devices are considered to be without interest as hands-free mobile phone use has not proven to be safer than hand-held use [57].

A change in the law is one way of clarifying the danger in using communication devices in an incorrect way while driving. It would lead, for example, to a telephone call being identified as a driver activity or a condition of the driver that could legally be compared with driving while tired or under the influence of alcohol.

Regardless of the method chosen – a total ban, a ban with certain exceptions or a general rule against careless driving – it is important that the law is technologically neutral. The focus here should not be on banning or regulating use of a particular device, but rather on preventing the dangerous behaviour in traffic which it can give rise to. The law should not either be restricted to communication devices in terms of mobile telephony or similar but should also include navigation systems, and so-called infotainment systems. If one thing is prohibited, a lot of other things are permitted at the same time. One clear example is the law against hand-held mobile phones which has led to many believing that communication using hands-free phones is not dangerous.

In the light of the knowledge about effects of legislation, no countermeasure is proposed with general legislation against usage of communication devices while driving. Instead, we recommend a clarification of Chapter 2, section 1, and/or Chapter 3, section 1, of the Road Traffic Ordinance by adding formulations concerning distraction or rather self-caused overload and also include examples of dangerous usage of mobile phones or other communication devices. It is important that it is exactly the "dangerous" or "risk" usage of communication devices that is emphasised so that not all usage is prohibited in this way. A similar proposal has previously been made by the National Road Administration (*Vägverket*) to the Ministry of Enterprise, Energy and Communications in 2008.

Implementation

Purpose

The purpose of the law is to clarify what is dangerous in using communication devices in an incorrect way while driving. It also becomes clearer for those in authority to monitor and sanction a particular behaviour.

Recipient

The countermeasure is targeted on all drivers. If special rules apply for certain groups of drivers, the target group is expanded to company managements and procurers of transport for commercial transport. Road safety in commercial traffic entail responsibility for the working environment, and company managements are accordingly also included.

Responsibility

The government is responsible for implementation.

Lead time

The lead time for implementation depends on the time required for legislation.

Sustainability

There is probably an introduction effect on road users' behaviour which is greatest to start with due to the legal clarification of incorrect usage being dangerous, the news effect, information campaigns, etc.

If we consider the countermeasure as a way of driving forward development and a foundation for other measures, the effect could be long-term.

Combinations

Clearer legislation is not considered to have any great effect in itself but it may have a substantial effect in combination with, or as a basis for other countermeasures, which aim at voluntary adaptation of usage. Such countermeasures include the countermeasures mentioned above, for example, development of technical solutions, educational initiatives, information activity, procurement requirements, development of company policy and the introduction of insurance incentives.

Cost

The costs of legislation cannot be estimated.

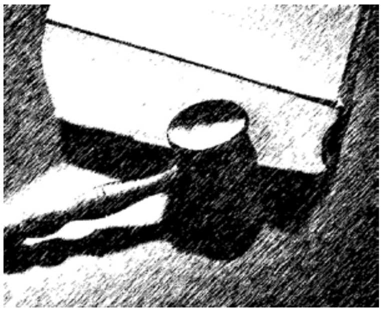
Potential risks and side-effects

A general risk of new legislation in general and mobile/technology-related legislation in particular is the effect of legislation on individuals' behaviour and on road safety being short-lived due to decreasing compliance with the law. It is often said that legislation has a poor effect if supervision cannot take place effectively. In this case, the legislation does not prohibit use generally but only dangerous use. Monitoring a prohibition of this kind would be almost impossible. One should therefore consider whether legislation may primarily have a norm-building effect by emphasising the unsuitability of behaviour.

As mentioned above, it is difficult or impossible to determine in an objective way whether a driver is using a communication device in a way that is dangerous in traffic, and the limit when a particular driver is overloaded is diffuse. This means that the proposed countermeasure, like the legislation against illness and tiredness, is very blunt. Everyone knows that the consequences of falling asleep at the wheel are serious. None the less, a large number of tiredness-related accidents occur precisely because it is so difficult to determine where the limit is when a person gets tired. In the same way, it is difficult, both for the driver and for an external observer, to know where the limit is for too much distraction.

3.4.2 Countermeasure: Development facilitating legislation/procurement requirements

Legislation does not only concern prohibition but can also entail proactive requirements which promote development and introduction of safe systems, safe infrastructure and safe users. Legislation or procurement requirements can then be used to influence and channel development and thus promote safe communication while driving.



Laws and directives can be used to hasten the introduction of new solutions in the market. Development can in this way be channelled to promote safe systems, safe infrastructure, and thus safe communication.

Description

Instead of laws that prohibit use of communication devices for all drivers or for certain groups of drivers, it is also conceivable for legislation that promotes development of safe systems, safe infrastructure, and safe users. One example is the European Parliament and Council's Regulation (EC) no. 661/2009 [30] on type-approval requirements for the general safety of motor vehicles, according to which all new vehicles shall be equipped with electronic stability control systems from 2014 and all new heavy duty vehicles should have lane departure warning systems and advanced emergency brake system from 2015.

Government authorities, municipalities and many companies have safety and environmental requirements that apply for purchase of new vehicles. This includes the vehicle having to have a rating of at least 32.5 in a crash test according to Euro NCAP, that the car must be equipped with an anti-skid system, that a certain kerb weight has to be achieved, and that the vehicle should be equipped with an alcolock and ISA systems. [89].

In the same way, requirements can be made or legislation introduced that vehicles and communication devices which are used while the vehicle is moving shall comply with certain Guidelines. This may entail requirements on the interface and on communication standards (Architecture) for new systems. The idea of legislation of this kind is not to impede technology which is in process of development but to channel and lead development in the right direction.

Implementation

Purpose

The purpose of the countermeasure is to promote development of safe technology. The expected effect is for development to move more swiftly in the right direction than if rules had not been established.

Recipient

The countermeasure can be targeted on procurers, which affects the market in this way. In the course of time, it will also have an effect on the supply, so that private consumers in turn can benefit from the improved technology. The countermeasure can also be targeted directly on developers in the form of legislation.

Early adopters

If progress is made through procurement, the drivers of the procured vehicles will probably be the first to use the technology on a broad front.

Responsibility

The government and public authorities that formulate the procurement requirements for authorities or as legislatory bodies are responsible for the countermeasure. Private companies may also make requirements, of course, on vehicles that are to be used as company vehicles.

Lead time, Sustainability, Combinations, Cost

The countermeasure as such shall only stimulate other countermeasures. Accordingly, the effects, lead time, sustainability and costs of the countermeasure are different. See the different technical countermeasures.

Potential risks and side-effects

The risk of a development promoting legislation is that it is sometimes not easy to foresee where development is going, which can lead to legislation being an obstacle. A parallel may be drawn with autonomous driving, which ultimately should allow the driver to do other things than driving the car. Legislation requiring that the driver is to be responsible for driving the vehicle at all times can then create problems. It is very important to ensure that development is not impeded. Here requirements and guidelines for procurement can be a better alternative as they are simpler to change and adapt.

4 Combinations of countermeasures

Certain of the countermeasures described need to be combined with other countermeasures to have any effect at all, while others are more independent. In general, however, it is considered important to attack distraction while driving on a broad front with a combination of countermeasures. This is particularly important as certain measures have a swift impact while others need more development or a higher extent of penetration to achieve a noticeable impact.

Some examples are shown below where collaboration is needed between countermeasures:

- In the event of *legislation* against communication devices while driving, it is important that the law is accompanied by both *education* and recurrent *information campaigns*. It is also required that compliance with the law is followed up in different ways. This need not only take place with severe sanctions and a high probability of being prosecuted but can also be achieved by safety-adapted *incentives* or *insurance premiums*, which in turn require continuous monitoring of use of communication devices.

- *Educational countermeasures* need to be complemented by continuous *feedback* for a driver not to relapse to previous behaviour. Feedback can either be given directly at the time of distraction with the aid of various driver support systems, via individually compiled feedback reports based on measured actual behaviour after every run, via sporadic information campaigns, via raised/lowered *insurance premiums* or similar. An individually compiled report should include both praise and criticism. In this way, the circle can be completed and a link back to the education is made.

- Improved interfaces *(HMI)* depend on there being standardised *tests* to evaluate the interface but also *guidelines* to abide by. A safe HMI also adapts the quantity of information and how the information is presented depending on the situation. The quantity of information may mean no information at all here. To be able to *adapt the HMI to the situation* in a good way, knowledge of the external traffic environment is required, which is updated in real time, which requires standardised communication protocols and other *IT architecture*.

- The number of infotainment systems, both embedded and freestanding, is increasing by leaps and bounds in modern vehicles. Although there are tests and guidelines, which make all these individual systems minimally distracting, it is important that the aggregate load from all systems does not exceed the driver's ability. To avoid overload, all systems, including nomadic systems such as mobile phones, must be *synchronised* and *coordinated*, for example, by a *workload manager*.

- For a number of the countermeasures described relating to possible *support systems* for increased safety in cars, a number of potential problems and side-effects have been pointed out. These include overrating the possibilities of the support systems, use of systems for other purposes than safety, and conflict creation where systems and drivers interpret the course of events differently. To come to grips with this type of side-effects, it is required that the introduction of technology is combined with changed *driver education* where the focus is placed on insights into limitations and motivation to use systems for increased safety.

- *Countermeasures to increase road safety* in the infrastructure (for example, rumble strips) both in the individual vehicle (for example, ABS, ESC, collision warning), also assist in preventing or alleviating communication-related accidents. These systems can be made even more effective when different vehicles can communicate with one another and together prevent critical events *(cooperative systems).*

A structured implementation and countermeasure plan should be developed immediately. This plan should already from the beginning include and prepare the way for the more technologically advanced proposed countermeasures. This is particularly important as it is difficult both technically and politically to reach agreement on standards, guidelines, test procedures, laws, etc. Clear information about expected effects and advantages is necessary, not least to be able to achieve credible proposed solutions of how possible threats to personal integrity are to be dealt with.

It appears clear that certain of the countermeasures are not mature enough for rapid implementation while others can be introduced immediately. It is important here to see the correlation between countermeasures to be able to sketch an optimal and broad implementation plan. The technological development, in particular with regard to mobile telephony, is fast and rather uncontrolled. A faster production of guidelines and test methods could contribute to guiding development in the right direction. The earlier there are clear guidelines, possibly connected to reward systems, the greater is the probability that one will not end up in the situation that certain “unsafe” applications have already become established and need to be removed or changed with considerable effort.

Possible collaboration with NHTSA and similar foreign organisations on this matter can also be beneficial, as similar ideas are sometimes proposed for the US market.

5 Discussion

First and foremost, we wish to emphasise that we consider that safety is a very important aspect of the transport system.

The overarching transport policy objective is to ensure a socio-economically effective and long-term sustainable provision of transport for citizens and business throughout the country. The functionality objective of creating accessibility and the impact objectives of safety, environment, and health shall contribute to the long-term sustainability of the transport system (www.regeringen.se/sb/d/11771).

In certain cases, it is possible to combine all the transport policy objectives but compromises are often required to achieve solutions that are practically possible. One natural example is accessibility and safety [46]. If safety were to have top priority in every respect, car driving and modern traffic would not have been possible. Possibilities for communication may be a means to both achieve the impact objective of safety and counteract it. It is exactly therefore that striking a balance between stimulating and restrictive measures is so delicate.

From an economic perspective, the issue has been raised of how the costs of mobile communication compare with the benefit [15, 47, 80]. Two of the studies considered that the benefit of the communication far exceeded the costs, while the third study concluded that the cost-benefit balance was close to zero for traffic in the United States. According to a US study, there are good arguments against legislation prohibiting mobile communications when driving – laws and ordinances come at a price and the price for maintaining legislation on mobile phones is that monitoring of other crimes would have to be given a lower priority [67].

Communication is a prerequisite for continued road safety improvements for many of the countermeasures described in this report. Here it is often about automatic communication between different vehicles and the infrastructure. In these cases as well, information needs to be presented to the driver in a safe way. The more the vehicle and the surrounding world can communicate and make decisions without the driver being involved in the process, the greater risk there is of the driver's assessment of the situation diverging from the vehicle's or systems' assessment, which results in the vehicle behaving in a way that the driver does not expect. These can in turn entail misunderstanding and inappropriate reactions on the part of the driver. As long as the driver has a controlling or at least a supervisory role, it is thus of great importance that the driver's picture of the situation is updated by appropriate information. Of course, it could be argued that this type of communication is relevant for safety and should not be therefore be prevented or reduced but information that is relevant for traffic also needs to be presented in a safe way.

The main focus in this report is, however, on communication devices which are not directly linked to driving, for example, private or work-related telephone calls, text messages, status updates of social networks and the like. For many drivers there is a great perceived benefit in being able to communicate when travelling. This benefit may be wholly dissociated from the actual driving but it need not be. Drivers ring telephone calls to stimulate themselves when they are bored, and it has also been reported that drivers can use calls to keep awake [49]. Of course, it is not lawful to drive when tired and using the telephone as a means to keep awake is not recommended. The benefit of stimulation must, however, be included in the calculation as it, as described in the introduction, is a natural behaviour of people to seek entertainment when they are bored.

In the Swedish work on the zero vision, the systemic perspective has been advanced as being of key importance, a view that has been successful in reducing the number of injured and dead. People are part of this system where the focus has been on designing the road traffic system in order to avoid people being subjected to more violence in collisions than the body can withstand. In many contexts, there is a great potential for taking greater consideration to the human being as an active part of the traffic system, with varying skills and motivation to make safe choices and thus affecting his or her own safety. It is therefore, as a complement to the more technologically focused countermeasures, of crucial importance with pedagogical countermeasures, where drivers obtain an insight on both dangers of incorrect use and advantages of safe use of communication devices while driving.

When discussing road safety improvement countermeasures in connection with communication, it has to be borne in mind that the standard cannot be the perfect driver who remains concentrated on traffic without interruption for a long time. Instead, it is necessary to compare with the present situation where drivers during the journey use the telephone, eat, comfort their children, think about their family situation and solve work-related problems.

Certain of the countermeasures described may have a slightly futuristic character but research is under way on a number of fronts and it is difficult to predict how much may be realised in the next 10-20 years. It is to be expected, however, that the technology described will be available on the market. What makes some of our proposals speculative is rather the fact that very few of them have been evaluated. We do not know therefore if and how much the countermeasures will increase road safety. Long-term effects may differ from short-term effects and unforeseen or possibly undesirable consequences may arise. One example of such a side-effect is that wholly autonomous driving may lead to an increase in car traffic as it is no longer necessary to take the train to work on the journey. Instead, work can be taken care of in one's own car while travelling comfortably and without change to one's destination.

There are a number of important questions which may make implementation of the majority of countermeasures difficult:

- *Responsibility*. It is at present unclear who is to take responsibility for information provided by third-party suppliers but which is presented via the vehicle's interface.
- *Business case*. Willingness to introduce new technology combined with how profitable it is
- *Ethical aspects*. A number of the countermeasures entail an encroachment into personal integrity.
- *Legal aspects.* At present, the driver is responsible for driving the car according to the Vienna Convention, which conflicts with the objective of autonomous driving.
- *Globality.* Technology-based solutions shall preferably function globally which can meet legal, cultural, financial and technical obstacles.
- *Behaviour adaptation*. Drivers can overrate the ability of the technology or use technology for other purposes than safety.

In conclusion, one can wonder about different future scenarios, either where authorities intervene or where they refrain from doing so. The current situation corresponds roughly to the latter case – the authorities do not regulate usage of communication devices – but there are many initiatives, both in research and in development, which raise this issue. Another scenario is that authorities, either by direct prohibitions and demands, or through a plan for future usage of communication devices, steer development and implementation in a particular direction. Besides control by authorities, valuations and norms in society will affect peoples' and thus also drivers' view of communication. It is difficult to foresee how these norms will develop but it is not inconceivable that current demands for people to be contactable everywhere will change to not being reachable having a high status. This could be made use of to market the car as a calm oasis where external requirements can be avoided. As an illustration of the fact that there may be several ways to achieve a safe traffic system, where the drivers' communication needs are met, we conclude the report with three future scenarios, which differ greatly from one another.

The luxury of silence	**Safe communications**	**Wholly autonomous driving**
Not being able to be contacted has a high status, which has led to the car being marketed as a "calm oasis". It is accepted in society that a person does not need to be contactable when they are driving, and that communication devices are used much less while driving than at present. As people refrain from communication voluntarily and in mutual understanding with society's norms, road users are contented and the effect is long term.	Technological development and change in attitudes in society have made it possible for communication devices to be used in the car without threatening road safety. At the same time, the activating and stress-relieving effects of communication while driving have been integrated. Drivers accept that certain limitations are made in the free communications to achieve as high a safety standard as possible. Benefits are high with only small concessions.	The car is able to drive wholly autonomously. The driver is relieved from having to drive and only drives manually if he wishes to do so or in very special circumstances. All that is required is for the destination of the journey to be specified at the start of the journey. All of the driver's resources can be used for other things, the driver can just as easily sleep during the journey or work. As almost all driving is automated, the issue of the extent to which one can communicate while driving is a problem that has almost completely disappeared.

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