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The Use of Mobile Phones in Road Traffic

SNRA inquiry into the use of mobile phones and other IT systems while driving

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Preface

The final report was written by the following authors: Christopher Patten, Ruggero Ceci, Therese Malmström and Klas Rehnberg.

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Abstract

In connection with its 2002 Letter of Appropriations, the Swedish National Road Administration (SNRA) was commissioned by Sweden's Ministry of Industry, Employment and Communications to study more closely the safety problems associated with the use of mobile phones and other information technology in road traffic. The assignment resulted in this inquiry which encompasses a total of 14 separate studies, the majority of which have been carried out as surveys applying various scientific methods. These methods include experimental studies carried out both in real traffic environments and in driving simulators, interview and questionnaire surveys, literature studies and ethnographic studies on the use of mobile phones in actual road traffic. The results of a project to chart legislation concerning the use of mobile phones in other countries in Europe are also presented. All these studies are discussed in this report, and lead ultimately to a number of conclusions and recommendations.

These recommendations thus form the substance of the analysis carried out by the SNRA research group, which takes its point of departure from the problems and opportunities linked to the use of mobile phones and IT in road traffic. Following extensive consideration and exhaustive examination of the research results, our conclusion, in part, is that it is not justifiable to introduce legislation that only prohibits the use of mobile phone systems that require the use of the driver's hands. This is because research clearly shows that it is primarily the conversation *per se* and its complexity that burden and thereby distract the driver.

1. Background

The issue of mobile phones in road traffic has been under debate in Sweden for several years. A number of organisations and members of the Swedish parliament have submitted a motion to ban drivers from using hand-held mobile phones while driving in road traffic, as they regard this as incompatible with safe driving. Like many other countries in Europe, several organisations want to campaign for a law stating that the driver must use handsfree equipment when using a mobile phone in road traffic. The issue has consequently been handled by several different bodies and authorities, most recently the parliamentary Committee on Transport and Communications, which highlighted the need for an inquiry. The committee's comment was prompted by a seminar held by the SNRA in spring 2001 in Stockholm. A number of invited experts and decision-makers met to discuss the use of mobile phones in road traffic based on the latest findings, on people's ability and limitations as drivers in road traffic, and on industrial development projects.

In connection with its 2002 Letter of Appropriations, the SNRA was therefore commissioned by the Ministry of Industry, Employment and Communications to study more closely the safety problems associated with the use of mobile phones in road traffic. More specifically, the assignment reads as follows (in translation): *"The SNRA shall report on safety problems as well as opportunities linked to the use of mobile phones while driving, by 30 June 2003 at the latest. The assignment also includes proposing possible measures to restrict various kinds of car equipment from causing road traffic safety problems while driving."*

From an international perspective (EU recommendations etc.), however, mobile phones today are considered a type of In-Vehicle Information System (IVIS). Like in-car PCs, navigation systems and video/DVD, etc., these systems are deemed to constitute a distraction risk for the vehicle driver. Mobile phones in road traffic do however differ in two important respects from the above-mentioned in-vehicle systems:
1) Their extensive distribution and widespread use, both in society as a whole and in road traffic.
2) The fact that a mobile phone conversation in road traffic requires more or less continuous attention and intermittent operation during the call/driving.

Operating a phone while driving can affect both the cognitive (thought) and motor functions (steering, changing gear, signalling, etc.) required to drive a vehicle. This is why the use of mobile phones is the main issue in the present inquiry, which also addresses the use of other IT systems in road traffic.

2. Objectives and anticipated effects

The inquiry's objective

The objective of the inquiry is to lay the foundations for safe driving in road traffic. This will be achieved by studying vehicle drivers' ability to perform the task of driving in a typical road traffic situation, while being distracted by operating other technical systems. According to the Ministry of Industry, Employment and Communications' request, the inquiry must take into account the multitude of technical systems that can be used in vehicles, as well as the technical developments taking place in the field of mobile technology.

The main objective of the inquiry is to outline safety problems, but it must also highlight opportunities linked to the use of a mobile phone while driving a car. Furthermore, the inquiry must, if possible, propose measures that could limit the risk of different kinds of vehicle system causing road traffic safety problems when used during driving.

Connection to the overall goal in transport policy

The inquiry's goal is in line with the transport policy goal for increased road traffic safety. A decrease in the factors that contribute to drivers being subjected to high mental workloads and distractions in road traffic serves to ensure safer, more attentive drivers. Calculations in other countries (e.g. the USA) show that a large proportion of road traffic accidents are caused by the driver being distracted. Distraction can be caused by many different factors, but in-vehicle technical systems comprise no insignificant proportion of these factors. How large this proportion is, however, is very difficult to calculate as details relating to this are not often included in the police reports. There is only limited opportunity to monitor and evaluate accidents that are directly or indirectly caused by the use of IT systems while driving.

Sub-goals

The following sub-goals have been set for the inquiry:

- to study the effects of mobile phone conversations while driving in different road environments (basic vs. more complex) and the effects of conversations with varying degrees of complexity (simple vs. complex conversations).
- to study the effects of mobile phone systems (comparison of handsfree vs. hand-held) while driving in different road environments.
- to study the effects of other in-vehicle systems (e.g. DVD, SMS, navigation systems) while driving in different road environments.
- to examine previous scientific studies about the use of mobile phones and other in-vehicle systems, to serve as a basis and complement the inquiry.
- to indicate possible measures which could be used to limit the risks associated with using mobile phones and other in-vehicle systems in road traffic.

3. General description of methods

This report includes results from several studies which, in various ways, look into the use of mobile phones in connection with driving a car. The studies partly comprise previous research, both national and international, as well as previously unpublished research within the area. The main results are obtained from the simulator study initiated by the SNRA and carried out at the Swedish National Road and Transport Research Institute (VTI) during autumn 2002, which thus forms part of the new research. The simulator study was designed to make it possible to study any differences between the use of hand-held and handsfree mobile phones while driving. It was also of interest to study how using a phone worked in connection with various situations in built-up and rural road environments. The two groups that form the basis for the comparison, i.e. hand-held and handsfree, each comprised 24 individuals who all undertook a drive of just over 1.5 hours, through a number of situations of varying nature (e.g. traffic lights in a built-up area at 50 km/h, or a motorcycle pulling out from a junction on a rural road environment at 70 km/h, etc.). All subjects of the study were called on their mobile phone around a dozen times during the simulator drive, whereby they had to perform an addition and memory task that was assumed to correspond to a complex mobile phone conversation.

The simulator exercise also included three smaller sub-studies which focused on making a call, receiving an SMS (text message) and watching a DVD film. The measurements taken during the study were primarily objective in nature, although subjective information was also collected. Of the objective measurements gathered, i.e. driving performance values, the primary parameters measured were the vehicle's distance, speed, road position, forward acceleration, sideways acceleration and reaction time in a specific situation. The surveys conducted with all subjects of the study in connection with the simulator exercise analysed the subjects' attitude and experiences of using a mobile phone (hand-held or handsfree), text messages and DVD while driving a car. For a more detailed description of the method and structure of the simulator study, refer to Kircher et al. 2003.

PDT – peripheral detection task

Many of the results from the simulator study are PDT measurements. PDT (peripheral detection task) is a method used to indirectly measure the driver's mental workload based on his reaction time. In the simulator study this meant that the driver would react to a visual signal (a light-emitting diode) presented in the peripheral field of vision in the windscreen while driving. However, reacting to this visual signal was not the driver's primary task but a secondary task, which did not burden the driver's mental ability appreciably. The driver's primary task, and the most important factor during the simulator drive, was to manoeuvre the vehicle. A small button was placed on the driver's index finger, and the driver had to press it when the signal was presented. The signal appeared randomly throughout the simulator test and it was presented for a maximum of two seconds or until the driver had reacted to the signal, i.e. pressed the button. Long reaction times and missed signals are assumed to be a result of a high mental workload according to current theories in this field. The point of departure for the method is that human mental capacity is limited and that difficult or concentration-demanding tasks burden the mental resources more than routine simple tasks. When the individual is subject to tasks that are mentally straining in some way, a phenomenon

called cognitive tunnelling can occur. This means that the individual's field of vision is reduced and that peripherally located information is missed. Therefore, by measuring the individual's reaction time from when the light-emitting diode is presented at the side of the windscreen to when the driver reacts, it is possible to see whether, and if so to what extent, the task was mentally straining, in this case talking on a mobile phone while driving. For a more detailed description of PDT, refer to Kircher et al. 2003, section 1.7.

4. Knowledge background based on previous research

Having access to a mobile phone in the car can have both a positive and a negative impact on the driver. On the positive side, there is the mobile phone's communication function: it can be used to issue an alarm, make emergency calls and reduce the length or number of journeys, for example. Negative effects include a deterioration in the driver's comprehension and perception, and impaired driving caused by the motor activity required.

The positive effects of the communicative function are obvious and immediate, which is why mobile phones have become so popular both in cars and in everyday life over the past decade.To benefit from the advantages of a mobile phone in an emergency situation, the driver simply has to have access to a phone in the car. It does not necessarily have to be used while driving. In an emergency situation the driver can stop the car and then ring for help. Moreover, the positive effect a mobile phone conversation can have on the driver's vigilance during long, monotonous car journeys should not be ignored. Finally, there are professional and financial benefits in being able to use travelling time productively, which is an important socio-economic factor.

The negative effects are (1) the driver's perceptive intake (e.g. detecting a pedestrian on the road), (2) central cognitive (thought) processes (e.g. planning a journey) and (3) driver behaviour (e.g. braking). According to empirical results and theoretical knowledge, mobile phones have the following effects on driving a car (for information about references and source material for the text below, see Svenson and Patten 2003).

<u>The effect of the mobile phone on the driver's sensory and perceptive intake</u>
When a driver speaks on the phone and drives a car at the same time, each glance at the road lasts longer and the covered area decreases. This gives rise to tunnel vision, whereby the central area of the field of vision is given proportionally more attention, and the outer areas proportionally less. The number of saccadic (eye) movements can decrease from around 90 per minute during normal driving to around 80 per minute when the driver is talking on the phone. Inexperienced drivers pay less attention to the main task, i.e. driving the car, for longer periods than experienced drivers.

The reaction time for detecting road traffic phenomena such as emergency vehicles, other road users, wild animals, road signs, etc., increases from around 50 to 400 milliseconds, and the probability of the driver missing a traffic phenomenon completely is greater during a mobile phone conversation. The more demanding the conversation, the more the reaction time and ability to detect different road traffic phenomena is impaired.

Making a phone call includes the process of dialling a phone number. The actual operation of the phone means that the driver's attention is divided for approximately 10-40 seconds. Looking for the phone or a phone number is a process that competes for the driver's attention and has an adverse impact on driving performance.

<u>Effect on central cognition and the thought process</u>
Talking on a mobile phone demands extra mental and psychomotor resources, and in many studies this has manifested itself in both physiological and subjective

measurements. The effect of this is that simultaneous thought processes can be disturbed, delayed or eliminated. For example, complex phone calls that require extensive mental resources are extremely destructive to other thought processes that affect tangible tasks, such as planning or checking the route, thinking about the location of a lay-by or a place to park, or assessing whether the car will fit into an empty parking space.

Effect on the driver's external behaviour

When a driver speaks on a mobile phone, the steering movements become more frequent and more dramatic than if the driver concentrates exclusively on driving. How well a driver keeps to his lane can be measured by the lateral position in relation to the general direction of the vehicle. During mobile phone calls, the standard deviation from the lateral position (i.e. during calls approximately 30% of the lateral positions are outside of the ideal position during a car journey) usually increases from approximately 0.2 metres to approximately 0.3 metres.

The reaction time for detecting that a vehicle ahead is slowing down has been measured to increase by approximately 600 milliseconds, which means that the time until the speed of the driver's own vehicle is adapted to the vehicle in front is extended by an equivalent amount. It is also evident that drivers brake harder when reacting to something in the road traffic environment when they are talking on the phone than when they are not. The harder braking may (in good weather conditions at least) compensate for the longer braking reaction time when the driver is speaking on the phone. However, it is also evident that longer braking distances are a result of speaking on the phone and driving a car at the same time, and that in these cases the drivers have been unable to adapt their speed or brake sufficiently to compensate for the impaired reaction time. As a result, the braking distance is longer during a call on a mobile phone. Generally speaking, older drivers react more slowly than younger drivers. Moreover, they are adversely affected by complex phone calls, although not necessarily by very simple conversations.

The driver's psychomotor control activities (steering, changing gear, dipping headlights etc.) compete with finding a phone number, dialling it, holding the phone etc. This competition for resources is more distracting in, for example, heavy traffic and difficult driving conditions than on a straight motorway where the effects are normally relatively small or non-existent, according to existing research literature. Experienced car drivers (with over 10,000 hours of driving experience) are less distracted by additional activities, because the driving itself requires less of their cognitive and motor capacity than with other drivers. Many professional drivers also have knowledge of using different IT functions.

Conclusions about mobile phones and driving from previous research

Mobile phone calls impair driving – whether or not the driver is aware of the fact. Driving a car and being involved in a demanding mobile phone conversation at the same time disturb or eliminate other thought processes, such as planning the route.

Making a phone call disturbs the driver's cognitive and psychomotor processes, which are required to control the car and drive safely. To what degree the psychomotor responses are impaired depends on the phone system, but the disruptive effect cannot be fully eliminated by using a handsfree system, for example.

A driver who speaks on the phone uses the information needed for driving less frequently, and control of the car becomes less smooth. It is possible to compensate for the attention and control lost during a conversation by, for example, reducing speed and increasing the distance to the vehicle in front. However, current research shows that this compensation cannot be expected to be sufficient to counterbalance the impaired driving performance that arises when a driver is speaking on the phone and driving at the same time – particularly in unexpected critical road traffic situations.

Experimental and simulated studies, as well as field studies, show that driving performance is impaired considerably when the driver speaks on a mobile phone while he or she is driving a car. This is substantiated by the results of accident surveys which show that mobile phone calls are a contributory cause in accidents.

The use of a mobile phone and other activities in the car

Subjective assessments – Drivers understand that driving is impaired by performing other tasks at the same time. They even adapt their own behaviour to a distracting activity. They may reduce speed when they receive a call or delay answering if the road traffic conditions are too demanding.

A number of studies have gathered subjective information on how demanding or distracting various activities are perceived by the driver. This makes it possible to compare the use of a mobile phone with using the car stereo or reading a map. The results show that drivers consider dialling a phone number quite demanding and more distracting than using the car stereo or talking to a passenger. Reading a map or writing something down is generally regarded as more demanding than making a call, while lighting a cigarette or taking change from a pocket is seen as roughly equally demanding as dialling a phone number. Generally speaking, most people think that driving is less safe when the driver uses a mobile phone, and there is no general resistance to restrictions on the use of mobile phones in cars.

Objective measurements – There are also studies that have compared the effects of talking on a mobile phone while driving a car with the effects of other activities in the car. The most common other activity has been controlling or adjusting the car stereo, and the results indicate that the distracting effect is roughly the same for, e.g. a difficult radio setting manoeuvre as for a demanding phone call. A very simple phone conversation impairs driving to approximately the same degree as listening attentively to the radio. Looking for a number in the phone book and dialling a phone number manually are demanding activities and impair driving performance considerably.

One study equated the impaired driving performance from using a mobile phone with the effects of driving under the influence of alcohol (at the upper limit of the permitted blood alcohol level in the UK). The effects of alcohol, however, last for the entire car journey, while a normal phone call only lasts for a fraction of the total driving time. In accident analyses, mobile phones appear as a contributory factor in ‘distraction accidents’, but interaction with passengers or adjusting the car stereo come into the picture more often.

Driving a car and IT systems other than mobile phones

The distracting effect of mobile phones on driving a car is at the same level as using other IT systems in the car. Simultaneous use of different IT systems, including mobile phones, while driving a car is assumed to impair driving performance more than using

one system at a time. The IT systems in question are systems that require the driver's attention. Automatic systems that work without driver input normally relieve the driver of cognitive workload, but in critical situations when the automatic system does not work or requires correction, the workload increases.

A number of studies have attempted to estimate to what degree events not linked with the actual driving but which still distract the driver's attention contribute to accidents. Epidemiological *post hoc* data is always difficult to interpret, particularly when it comes to assessing how great an influence different contributory factors have had. Existing epidemiological studies do however show that distraction is an important contributory cause in accidents. Distraction can be assumed to occur in approximately 2-6 per cent of the accidents reported to the police, and in at least 0.5 per cent of the accidents the distraction comes from a fellow passenger. These figures are in all probability lower than the actual figures.

Experienced professional drivers probably handle additional routine tasks better than the average driver. Note that real driver expertise is not achieved until after at least 10,000 hours of driving, and that working as a professional driver is not enough *per se* to produce genuine driving experience. If older drivers try to carry out additional activities in the same way as younger drivers, they are expected to perform less well. *However, older drivers can be expected to take fewer risks than younger drivers and not to carry out additional activities as often or as suddenly. Accident statistics tend to show that despite the younger drivers' shorter reaction time, they are more likely to have accidents than older drivers. Mobile phones occupy a unique position among modern IT systems in that they require that the driver continuously answers during a conversation. This is why driving a car is impaired regardless of how complex the driving situation is.*

5. The effect of the conversation on the driver while driving

This section describes the effects of the actual conversation on driving performance and how performance is affected depending on the complexity of the conversation.

The inquiry's studies of the actual conversation and its influence on the driver's attentiveness and driving performance have produced results are largely consistent with those of previously presented research. This applies both to the field study in actual road traffic (Patten et al. 2003) and the driving simulator study carried out in autumn 2002 (Kircher et al. 2003).

The main results of the field study (Patten et al. 2003) showed that there are differences in the mental workload between simple and complex conversations while driving. The complex conversation brought about significantly longer reaction times, and thereby a longer stopping distance to a given object than the simpler conversation.

In the driving simulator study it was found that mobile phone conversations affected the speed regardless of the type of system while driving on rural roads at 90 km/h and in complex built-up areas at 50 km/h. The speed was reduced, particularly when a hand-held phone was used, which has been interpreted as the subjects compensating for the increased mental workload of the phone call. Moreover, the variations in speed decreased in these traffic conditions. This is interpreted in the simulator study as a kind of 'locking' at a certain speed due to reduced external attention. This can also be construed as a compensatory effect caused by the difficulty of adapting speed to the demands presented in the external environment while having a phone conversation. Clear effects of the conversation are thus evident here, which is thought to be linked to mental performances by the drivers and the need to compensate for insufficient attention functions.

The PDT measurement has indicated dramatic effects as a result of the mobile phone conversation *per se*. This was true whether the driver used hand-held or handsfree equipment. *One general result is that the ability to react gauged according to PDT was significantly impaired in connection with a phone conversation while driving. This deterioration manifested itself both in a longer reaction time and in a higher number of missed signals. This result is easy to translate into performance during actual driving, e.g. a driver misses road signs, or fails to look in the wing mirror when overtaking or changing lane, which can have serious consequences.*

In other studies (Esbjörnsson & Juhlin 2003, Salo & Svenson 2003) the authors have indicated the drivers' ability to adapt conversations and the use of IT systems to the demands of the road traffic situation. This has applied in particular to drivers who are very experienced in using a phone and IT in road traffic, such as taxi drivers and other professional drivers who have been interviewed and studied in real traffic. The experimental studies carried out both in Sweden and other countries, however, show that drivers who are engaged in phone calls while driving have significantly fewer mental resources at their disposal, and thereby less opportunity to react sufficiently quickly and in the right way when a serious road traffic situation arises. This is probably the explanation why accidents occur as a result of using a mobile phone and using other IT systems in road traffic.

6. Using a mobile phone while driving in built-up areas and on rural roads

It is difficult to study the use of mobile phones in built-up areas. Research carried out previously has been of a *post hoc* nature and mainly comprises epidemiological studies, i.e. studies of accidents that have already happened. The SNRA, together with the Swedish National Road and Transport Research Institute (VTI), has therefore carried out a driving simulator study that also includes driving in a simulated built-up area. The main issues were to examine by means of experiments what happens when a mobile phone is used while driving in a built-up area, and also to compare handsfree and hand-held phone systems (for information about references and source material for the text below, see Svenson & Patten 2003, Patten et al. 2003 and Kircher et al. 2003).

The simulator study's results are not to be regarded as the last word in the issue of using a mobile phone in built-up areas, rather as its opening chapter. However, it is possible to discern certain trends.

The average speed of drivers with hand-held mobile phones was significantly lower in the study than for those who used handsfree phones. This was true both in built-up areas and on rural roads. The result therefore confirms the results of previous field studies into rural road environments.

The simulator study shows a clear, significant effect of using a phone in the simulated rural roads and in built-up areas in the analysis of PDT. Reaction times were measured using the PDT method. This method involves the driver reacting to visual impressions presented in the peripheral field of vision while driving. The study does not, however, reveal any significant difference in reaction times owing to whether the driver has used a hand-held or handsfree phone. The drivers performed equally poorly regardless of the mobile phone system.

The analysis of the comparison between the different traffic environments indicates that the simulated road traffic environments can be placed on a scale according to Fastenmeier's (1995) taxonomy of complexity. According to the reaction times based on PDT, the mental workload on rural roads is equally high as on simple roads in built-up areas. In Figure 1 below, a statistically significant upward trend can be seen which shows that a more complex simulated road traffic environment leads to longer reaction times.

/diagram – decimaltal anges med punkter i den engelska texten/
Simulator study – mobile phones
(from Kircher et al. 2003)
Hand-held (HH)
Handsfree (HF)
No conversation

PDT reaction time (s)
Road Traffic environments
Rural road
Built-up SIMPLE

Built-up MEDIUM
Built-up COMPLEX

Fig. 1: PDT reaction times in seconds in four simulated road traffic environments including base line measurements (no conversation) from the VTI's simulated study (Kircher et al. 2003).

The study also indicates that the mental workload is just as high driving on a rural road as on simple roads in built-up areas. Clearly, however, the road traffic environment in a built-up area is generally far more complex than on a rural road or motorway. The built-up environment includes pedestrians, crossings, traffic lights, higher traffic intensity and other factors within a smaller area than on rural roads. On rural roads too, the phone call causes an increased mental workload which means that the driver can miss information, in particular in the peripheral field of vision, such as road signs. Consequently, there are significant differences in the effects of using a mobile phone while driving depending on the road traffic environment, although the differences are not that extensive. The greatest effect is that which the actual conversation has on driving.

7. The use of hand-held and handsfree mobile phones – differences in the effect on driving

Literature study, simulator studies and a field study

One of the main issues this inquiry has investigated is if there are differences in how driving is affected depending on whether the driver uses a hand-held mobile phone or a mobile phone equipped with a handsfree system. The issue has been studied by investigating international research literature on the subject (Svenson & Patten 2003), and by carrying out an extensive driving simulator study at the VTI in autumn 2002 (Kircher et al. 2003). In autumn 2001, a study was also carried out in real traffic (Patten et al. 2003) using a specially equipped test car. Among other things, this study compared how driving was affected by phone calls using handsfree and hand-held mobile phones during simple and complex conversations.

The majority of the results presented in this section come from the driving simulator study. The study was structured as a direct comparison of how driving is affected by calls on hand-held and handsfree phones respectively (see Table 1). This has made it possible to draw conclusions about the mental and psychomotor demands that the different types of equipment entail during simulated driving (various situations in built-up and rural environments).

The drivers also had to dial a particular number while driving, the number being given to them immediately before they had to dial it. To do this they used the buttons on the mobile phone that was used in the trial to dial the number. This study too created opportunities for a direct comparison between the different types of system in terms of mental demands and how the practical procedure affects driving in a number of defined environments (rural roads only).

The question of hand-held versus handsfree mobile phones in road traffic was also raised in a survey, whereby the subjects reported their subjective assessments after driving in the simulator. These answers are discussed in the same report as the objective measurements taken during the driving simulator tests (Kircher et al. 2003). Furthermore, polls and interviews have been conducted with larger groups (just over 24,000 and 3,000 respectively) of private individuals in Sweden (Thulin 2003).

The mobile phone systems used in the study

In their report, Svenson and Patten (2003) describe the different types of hand-held mobile phones and handsfree systems used in studies into using a mobile phone and its effects on driving (see Table 1).

Table 1: A description of existing systems for hand-held and handsfree mobile phones which are relevant to conversations while driving.

Hand-held:		
1a. Receiver unit held to ear, keys used to make, end or receive a call.	1b. Receiver unit held to ear, keys used only to make a call.	1c. Receiver unit held to ear, keys used only to receive a call.
1d. Receiver unit held to ear,		

but without keying in a number
(e.g. hand-held voice-activated receiver unit).

Handsfree:

2a. Keys used to end, receive and make a call.	2b. Keys used to receive a call .	2c. No keys used (e.g. handsfree voice-activated receiver unit).

In the simulator study, type 1a hand-held mobile phones and type 2a handsfree mobile phones were used. All subjects of the study had to receive calls and make calls based on a pre-determined procedure. These different stages (making and receiving a call respectively) were, however, carried out in two separate studies with varied traffic environments. In the field study (real traffic) calls were only received on type 1b hand-held and type 2b handsfree systems.

The main difference between conversations and non-conversations

The main results of the field study showed that there are differences in the mental workload between simple and complex conversations while driving. However, no difference emerged between hand-held and handsfree equipment in terms of mental workload when driving on rural roads (based on PDT measurements). The average driving speed, however, decreased during conversations on hand-held mobile phones.

The results of the driving simulator study show that the main effect that emerged during the study arose from differences between conversations and non-conversations, i.e. when the subjects were driving while having a conversation, and when they were driving along the same stretches without having a conversation. These effects are consistently very strong and indicate that the mental influence caused by using a mobile phone while driving is extremely clear. This result also substantiates several earlier studies carried out in various countries (see Svenson and Patten, 2003 for references).

In the simulator study, differences between hand-held and handsfree equipment were only detected in a few individual situations and for a few variables. The main result revealed a marked similarity in the effects that could be expected in the direct comparison between the different types of system. There were no significant differences in reaction time between the different types of system in any situation according to the PDT measurements. This also applies for a number of the other measurements used (road position, time and distance measurements, braking, time to collision (TTC)). The only difference to emerge was that the speed was reduced by 3-5 km/h when the subject of the study had a conversation on a hand-held mobile phone, which did not happen when the driver spoke on a handsfree phone in the same situation (at both 70 and 90 km/h on rural roads and 50 km/h in built-up areas).

These results correspond with previous results from rural driving in real traffic. One interpretation is that a driver holding a phone in his hand while driving perceives a conscious or subconscious mental workload that leads him to increase or decrease speed in line with the flow of information. The driver therefore regulates the speed himself so that it corresponds to a reasonable mental workload for the individual in relation to the visual and cognitive demands that arise in connection with the task of driving. The results of the subjective measurements taken in the form of a survey after the test partially substantiate this interpretation (see below).

Perceptions about hand-held versus handsfree mobile phones

The majority (60 per cent) of the subjects involved in the simulator study questioned preferred handsfree systems, while only 29 per cent thought that hand-held mobile phones were preferable. However, there seems to be a general perception that handsfree equipment entails a clear improvement while driving. According to a survey, however, only 12 per cent of those asked (of a total of 24,300 respondents) have access to a handsfree system of some kind. Roughly half of those asked (approximately 3,000 respondents) in another survey think that hand-held mobile phones should be banned while driving. It was also thought that hand-held mobile phones increase the risk of accidents (Thulin & Gustafsson 2003).

The results of the surveys reflect the perception that handsfree equipment is better when a driver has to handle the vehicle and the systems at the same time. This probably applies to a greater degree if the vehicle, for example, has manual transmission and is being driven in more complex traffic environments where the driver needs to use the vehicle's controls and systems more often, and where there are greater demands on both the sensory and cognitive resources (scanning, interpretation and planning, etc.).

The conclusions drawn from the studies presented is that handsfree equipment does not solve the most critical problem while driving, i.e. that the conversation itself places demands on concentration, and that a phone call has an adverse effect on the driver's attention while driving. Notwithstanding, a large number of countries in Europe (and other parts of the world) have introduced legislation prohibiting the use of hand-held mobile phones while driving. Such legislation has likely arisen as a result of attitudes based on factors that are not purely scientific.

Unclear whether handsfree systems are less mentally straining

It is therefore still unclear as to whether the physical demands decrease with handsfree systems and whether this in turn reduces the total mental workload while driving. It is possible that the driving situations in the simulator study did not put high enough demands on manoeuvring the vehicle while the drivers were engaged in mobile phone call tasks. The entire simulated route is, however, based on real streets and roads in the city of Linköping, southern Sweden. Most of the situations could be steered through with one hand on the wheel and braking at the same time. The situations also had a relatively short duration, which meant that they had less of an effect on the PDT measurement, i.e. the reaction time to phenomena in the periphery (secondary task?) and the conversation task (tertiary task?). PDT was otherwise measured on a continuous basis during the entire simulator drive (1 hr 15 min). It is also difficult to determine which are the secondary and tertiary tasks in this context. It can be assumed that in most cases the driving task was the primary task (in particular when something in the road traffic environment required greater attention). How the subjects of the study then prioritised between the other tasks is not absolutely clear, but the results do indicate that the call had a high priority while it was taking place. There is no evident difference here between hand-held and handsfree systems, rather the subjects coped with the conversation task equally 'well' regardless of the system.

The following conclusions have been drawn from this results analysis:

1. There are no major differences in the effect of using a hand-held mobile phone or a mobile phone with handsfree equipment while driving according to the experimental studies carried out in both the driving simulator and on rural roads.

2. The reduction in speed observed when using a hand-held mobile phone while driving is relatively small, but it may be important to the driver's mental capacity. However, it remains to be seen whether or not it is of significance to road traffic safety.

8. Operating a vehicle together with a mobile phone and other IT systems while driving

Operating mobile phone equipment in the vehicle encompasses everything from positioning and holding the equipment to keying in details and commands, for example. The main emphasis of this section is on mobile phones, although SMS (text messaging systems using a mobile phone) and GPS (global positioning) will also be discussed. Navigation and DVD systems (scanners for digital movies) displayed in the driver environment entail less physical management and operation, and are therefore less of a problem in this context. These systems are more closely related to problems with visual and auditory attention demands.

Firstly, it is important to define in more detail what physical distraction entails and how it is related to driving and road traffic safety. Talking on a mobile phone while driving requires extra mental and psychomotor resources. The control activities required of the driver while driving (steering, changing gear, indicating, dipping headlights, etc.) compete for the driver's mental and psychomotor resources with activities required to use a mobile phone or another system: finding a phone number (in the unit or in some other way), keying in a number and using a hand-held mobile phone, for example. This competition causes a greater distraction in intensive, demanding built-up road traffic than on a straight rural road or motorway. This has been established in research literature. However, professional drivers, with more than 10,000 driving hours, are thought to be affected to a lesser extent by extra tasks (using a phone, navigation etc.) as their ordinary driving performance requires less of their mental and physical resources compared with other drivers. It is also assumed that they can learn to use various types of IT system in such a way that it minimises the disruptive effect on their attention while driving. The next section presents further results from a number of different surveys and an interpretation of their relevance to this inquiry.

Making a mobile phone call while driving disrupts the driver's attention for an average of 10 to 40 seconds, depending on the type of system (voice activated, etc.). This time includes both the actual keying in, and operation of the mobile phone. Furthermore, the task of looking for the actual phone and/or the phone number seriously competes with the driving task, in terms of both attention and driving performance (Svenson & Patten, 2003).

In another study that examined how drivers enter the final destination in a navigation system for vehicles, three visual-manual (conventional hand-eye co-ordination) systems were compared with a voice-activated system (Tijerina et al. 1998). As a comparison, the study also examined dialling a mobile phone number and tuning in a radio frequency. It emerged that the three visual-manual navigation systems worked on average far worse than the voice-activated system in several ways. For instance, they required more and longer glances at the display and affected driving performance to a higher degree. It was also noted that all the navigation systems took longer to use than it took to call a mobile phone number (10 digits) or tune the radio.

The inquiry's driving simulator study also looked into making a call while driving. As mentioned before, no differences emerged between hand-held and handsfree systems. However, there was a significant increase in the variation of the simulator vehicle's road

position for the subjects using handsfree equipment. It has been interpreted that this result is linked to the drivers' positioning of the mobile phone while making the call. The drivers with handsfree systems had to stretch forward to the dashboard where the phone was positioned, which required more of the driver's hand-eye co-ordination. Drivers using hand-held mobile phones placed them on the upper part of the steering wheel while driving and keyed in the number with the same hand that held the phone, and this placed less of a demand on co-ordination ability.

International studies show that drivers engaged in mobile phone calls make more frequent and more dramatic movements of the steering wheel than when driving and not engaged in phone calls. It has also been observed that drivers engaged in mobile phone calls brake more sharply in connection with different road traffic situations, which is considered a sign of impaired reaction time. Quite simply, they detect any obstacles and signals too late and are therefore forced to brake harder. In general, the distance during the braking reaction time is, however, longer for drivers speaking on a mobile phone.

The results of international studies can also be corroborated by performance data from the simulator test. The data showed that the subjects of the study in several test situations (mobile phone call, reading a text message) showed impaired braking reaction times, which indicates diminished mental preparedness for the road traffic events included in the test (Kircher et al. 2003). It can also be noted that the more systems the driver has to operate simultaneously while driving, the greater the negative impact. This is equally true whether the system is for communication/information purposes (phone, navigation, radio, etc.) or is a driver aid (e.g. ISA, distance warning, adaptive cruise control, etc.). The challenge lies in adapting and automating these systems in the optimal way for the driver – a challenge essentially in the hands of the vehicle developers.

9. Effects of other IT-based systems (navigation, DVD, SMS, etc.)

The following section deals with the use of Short Message Services (SMS or text messaging), navigation systems and DVD systems while driving a car.

Short Message Services (SMS)

Ten people – seven men and three women – participated in the section of the simulator study examining the effects of receiving text messages. The subjects received 10 text messages over the course of the simulated drive. The messages comprised short questions along the lines of 'What day comes after Wednesday?'. The questions were read aloud by the subjects of the study and then answered verbally. The phone was positioned on the passenger seat which meant that the subjects had to pick up the phone in order to read the message.

The simulator study did not show any clear results about how receiving text messages influences driving performance (speed, reaction time, etc.). This could partly be because the results are only based on 10 individuals. The differences between the individuals were relatively large in terms of the time they needed to read the messages and the different strategies they used to read the messages. Examining how text messages are received in a realistic way is therefore a complicated process as it is something that the user controls himself to a large extent. Further research is required to increase knowledge of how the use of text messages can influence cognitive workload and driving performance.

Navigation systems

Navigation systems can reduce the need for the driver both to look for information in the road traffic environment and devote his attention to reading maps in paper format. This can reduce the mental workload, if the system is designed in a user-friendly way. If this is not the case, i.e. if the information does not correspond to the prevailing road traffic environment or if the navigation system is complicated for the driver to use, the system may instead distract the driver. The probable result then is a greater mental workload and impaired driving performance.

The design of the navigation system therefore plays a very important role in how the driver's driving performance is affected by the equipment. Studies have shown that auditory navigation systems, i.e. with spoken information, provide faster reaction times than navigation systems that present the information visually, i.e. as an image or text (Svenson & Patten 2003). Other benefits of auditory systems are that we remember information we receive by hearing for slightly longer than information we receive visually. Moreover, our ability to perceive sound is not as limited as our ability to see, because we do not need to focus on the source to perceive the sound. Our field of vision is however limited and is burdened to a greater extent than our hearing while driving a car. However, most navigation systems present a lot of the information visually, which means that for long or short periods of time the driver has to look away from the road environment to the navigation display. This can result in the driver missing important events in the road environment.

A study into road accidents in Japan showed that cars with some kind of information system are over-represented among cars that drive into a car in front. 60 per cent of

accidents reported to the police involving cars with such systems are rear-end collisions, while this type of accident accounts for just over 30 per cent of all accidents (Takubo et al. unpublished). The reason for these accidents is assumed to be that the driver's attention was focused on the display, and the driver was therefore unable to perceive that the car in front had slowed down or stopped. The length of time the driver looks away from the road environment depends partly on the reason for looking at the display, and partly on the driver's assessment of the road traffic situation. In a calm road traffic situation, such as a traffic jam where the flow of traffic is slow, the driver probably does not consider it particularly dangerous to focus his attention on the navigation display for a slightly longer time, while in a stressful built-up environment it may be considered more dangerous to look away from the road environment.

DVD systems

As mentioned before, the subjects' driving performance was also studied while a movie was being shown on DVD. Eight people completed the simulator experiment. For 40 minutes of the total driving distance a DVD movie was shown, which the subjects were asked to follow while driving. The subjects were asked to verbally confirm when a number of selected events took place in the film. They never had to operate the DVD player, rather their task was to drive the car and follow the content of the film to a certain extent.

The results showed that the subjects' reaction time using PDT measurements was longer in most of the traffic environments where the DVD film was on. Watching a movie is therefore assumed to increase the mental workload on the driver. On stretches with a 90 km/h speed limit the subjects' reaction time was 135 milliseconds slower on average when the film was being shown than when it was not being shown. During this time the vehicle could move 3.38 metres. When the speed limit was 50 km/h, which was when the reaction time deteriorated the most, the vehicle could move 2.25 metres before the driver reacted to the signal in question.

The results also showed that the subjects varied their speed less when the film was on than when they drove without DVD equipment. Moreover, it emerged that the subjects increased the distance to the car ahead on stretches with 90 km/h speed limits when the film was being shown. The increase in the distance was 15.4 metres. However, the subjects managed to stop at a red traffic light, for a cyclist and for a bus to the same extent as when they were not watching a DVD. The results are, however, based solely on data collected from eight people and the individual differences were relatively large. It is also important to bear in mind that the results are produced from an experimental situation, which lacks a fair equivalent in reality. It is unlikely that particularly many of the subjects had watched a DVD while driving a car before, which may have affected the results. The mental workload tends to increase when a situation or task is unfamiliar. During the course of the film, the subjects were also asked to follow the film closely enough that they could answer a number of questions related to certain events, which probably does not happen in reality.

It is not likely that the increased distance to the car in front and the decrease in speed variations have a direct impact on road traffic safety. However, if these changes are an indication that the driver does not have time to take in other information from the traffic system, it may influence road traffic safety.

However, as mentioned before, the results of the simulator study, relating both to the use of DVDs and text messages, are very limited. More research is therefore required in order to draw any general conclusions about the use of these IT-based systems while driving a car. The results from the DVD study also indicate, however, that watching a movie influences the mental workload and impairs the driver's reaction time, which may well have an extensive effect on road traffic safety. The use of these types of system also means that the driver frequently directs his attention on something other than the road, which means that he risks missing vital events in the surrounding area – resulting in a higher risk of an accident. However, some car drivers attempt to adapt their use of SMS, navigation and other systems to their driving by, for example, waiting before answering incoming text messages and only looking at the navigation display when the road traffic situation is perceived as sufficiently calm. Even though this kind of adaptive behaviour in mentally demanding situations is positive, it hardly eliminates the risk of incidents. The road traffic system is an eventful phenomenon, and what may seem like a calm situation one second can turn into a near-accident the next.

10. Subjective measurements of the use of mobile phones while driving

Below follows a compilation of studies conducted with the aim of examining people's subjective approach to and experience of using a mobile phone in connection with driving a car.

The use of a mobile phone

A number of studies have examined people's approaches and attitudes to using a mobile phone in connection with driving a car. It is clear that many people perceive a clear risk in talking on a mobile phone while driving a car. Many also think that driving performance is impaired when the driver is talking on a mobile phone while driving the car (Thulin & Gustafsson 2003, Salo & Svenson 2003, Kircher et al. 2003). In a survey of approximately 3,000 respondents, almost half thought that a ban on using a hand-held mobile phone while driving should be introduced (Thulin & Gustafsson 2003). At the same time, many say that they always or nearly always have their mobile phone switched on when they drive and, thereby, probably also use it.

The fact that drivers are aware of the possible risk therefore does not mean that they completely avoid using their mobile phones while driving. A study of taxi drivers (Salo & Svenson, 2003) also showed that awareness of the risk did not influence drivers' own mobile phone use while driving. The perceived risk does, however, lead many people to try to avoid or reduce the risk in various ways by taking certain precautionary measures.

According to Thulin and Gustafsson's results (2003), a quarter of drivers refrained from using a mobile phone while driving in the dark, and 30 per cent claimed that they always or nearly always stopped the car when making a call. One in ten respondents in the same survey said that they never answered the mobile phone if it rang while they were driving. It was also relatively common for them to reduce their speed when they spoke on a mobile phone, or to make a call when the road traffic situation was calm, i.e. little or slow-moving traffic. A full 70 per cent avoided overtaking while talking on a mobile phone. Other precautionary measures taken by the subjects included minimising call times, asking a passenger to answer, asking to ring back at a more suitable time or asking the person who called to ring back.

Esbjörnsson and Juhlin (2003) also detected these types of precautionary measure in their observation study into users of mobile phones. Drivers adapted their mobile phone calls and their driving to each other extensively by, for example, reducing speed and making calls when the traffic rhythm was slow. The task of dividing attention between talking on a mobile phone and driving a car is, according to Esbjörnsson and Juhlin (2003), not a particularly major problem. According to them, this task is no more difficult than dividing attention between driving a car and other tasks such as changing gear and looking at the speedometer – an opinion contradicted by many other studies (Svenson & Patten, 2003). It should, however, be added that this is a subjective assumption on the part of Esbjörnsson and Juhlin. The fact that the driver and the person he is speaking to on the mobile phone do not share the same situation, is compensated for by the driver informing the other party about the prevailing road traffic situation. This information can be passed on consciously by the driver referring to the current road traffic situation, or subconsciously through the driver's way of speaking, such as changes in tempo and changes in who speaks. According to Esbjörnsson and Juhlin, this

indicates how the driver successfully adapts his behaviour to the situation. Moreover, they maintain that the difference between the low number of reported accidents assumed to be due to mobile phone calls and the high theoretical risk shown in certain experiments and studies, may be linked to this adaptation between talking on a mobile phone and driving.

It is, however, not always possible to avoid the potential risk that talking on a mobile phone while driving can entail. After all, it is not easy to assess the mental workload in a specific situation. While a situation may not be perceived as particularly mentally taxing, it could still demand a great deal of attention.

Perceived risk of accident

According to Thulin and Gustafsson's results (2003), a remarkably high number – 10 per cent – say they have been close to driving off the road during a mobile phone call. In the study, 18 per cent also say that they have on at least one occasion concentrated so closely on a mobile phone call that they have almost collided with another road user or object. The task seems to constitute a particular problem and high risk for younger drivers. As many as 40 per cent of the younger male drivers claim that they have on at least one occasion concentrated so closely on a mobile phone call that they have almost collided with someone or something, or that they have been close to driving off the road. The corresponding figure for the oldest group (both men and women) was 4 per cent.

It was also fairly common for drivers on one or more occasion to have concentrated so closely on a mobile phone call that they missed a turning, failed to observe a traffic signal or a stop sign, or were driving at an unsuitable speed in relation to the circumstances. This was also more common among younger than older drivers, with 62 per cent of the younger and 24 per cent of the older drivers. The figures are generally higher among men than women. A number of the respondents also said that they had ended up in the wrong lane or on the wrong side of the road when they had spoken on a mobile phone. In the survey carried out in connection with the simulator study, the subjects report that the task of talking on a mobile phone while driving a car is perceived as mentally straining (Kircher et al. 2003).

The results also revealed that of the car drivers who had been involved in accidents reported to the police or an insurance company, or which led to personal injury, 6 per cent had spoken on a mobile phone in connection with the accident (Thulin & Gustafsson 2003). In two cases, the respondents answered that using a mobile phone contributed to the accident, and in seven cases they answered that it may perhaps have been a factor. Mobile phones have, however, also been a help in many accidents. In the region of 100,000 car drivers per year use their mobile phone to summon the police or an ambulance to the scene of an accident (Thulin & Gustafsson 2003).

Perceptions about handsfree and hand-held mobile phones

The majority of those participating in the survey conducted by Thulin and Gustafsson (2003) had a more positive attitude towards mobile phones with handsfree equipment, and they also felt that hand-held mobile phones increased the risk of accidents more than handsfree phones. The survey conducted in connection with the simulator study did not, however, show that the type of mobile phone influenced the perceived mental workload (Kircher et al. 2003). Neither did the type of phone used affect what the subjects perceived they devoted the most attention to – driving or the phone call.

Change in driving behaviour

As mentioned before, the majority of the drivers, primarily those who used handsfree phones, claimed that they reduced their speed while speaking on the phone (Kircher et al. 2003). The objective results from the simulator study, however, show that this was not the case. Both test groups, especially those who used hand-held mobile phones, felt that they drove worse than normal when speaking on the phone. It was also perceived as easier to talk on a mobile phone in rural traffic than in traffic in built-up areas.

SMS and DVDs

In connection with the simulator test where one test group was given the task of receiving text messages and another group of watching a DVD, participants were asked to complete a questionnaire about their experiences of using this type of equipment while driving. Due to the limited number of test subjects, it is not possible to draw any general conclusions from the results, instead the results should be viewed as possible tendencies. Drivers who received text messages while driving were generally negative towards sending text messages while driving. Receiving text messages while driving was not perceived as equally negative. Seven out of 10 said that they reduced their speed when they read the message and generally felt that their driving performance was impaired slightly when they were reading the message. The test subjects were negative about watching a DVD while driving and also said that this impaired their driving performance. The perceived mental workload was estimated higher by the subjects who watched a DVD while driving than those who received text messages and phone calls.

11. Using a mobile phone in connection with driving

TSU92 is a road traffic safety survey conducted by the SNRA and the Swedish National Road and Transport Research Institute (VTI) based on daily dispatches of questionnaires to randomly selected members of the Swedish population. The results relating to access to mobile phones and using a mobile phone in connection with driving during the period April 1998 – March 2001 inclusive, have formed the basis for the VTI report entitled *Användning av mobiltelefon vid bilkörning* (Using a mobile phone while driving, Thulin & Gustafsson 2003). The material comprises answers from a total of 24,926 people.

TSU92 showed that approximately 70 per cent of car drivers in 2001 had access to a mobile phone while driving. Of these, 30 per cent used the mobile phones in connection with driving. Younger car drivers had access to mobile phones to a greater extent than older drivers and they also used their mobile phones more often. Moreover, it emerged that men used mobile phones more often than women. The average call time was 10 minutes a day. In privately owned cars, the average call time was 7 minutes a day. 17 per cent of the mobile phones were equipped with handsfree systems. The results showed that the drivers who had this kind of equipment used their mobile phones more while driving than drivers who used hand-held mobile phones. Their calls were also slightly longer than drivers using hand-held mobile phones.

It also emerged in Thulin and Gustafsson's survey that car drivers made and received an average of 7.4 calls a week, and that each call lasted 2 minutes on average. Sending and receiving text messages while driving was most common among the youngest test subjects, who said that they sent or received 3.7 text messages a week while driving on average. The corresponding figure for the entire body of participants in the survey was 1.2. Hand-held mobile phones without extra equipment were used by 73 per cent of the drivers, headsets were used by 17 per cent, and 5 per cent used a mounted phone with microphone and loudspeaker.

Information about the use of mobile phones in accidents

Thulin and Gustafsson (2003) note that surveys of the proportion of accidents involving drivers who have been speaking on a mobile phone at the time of an accident have shown varying results. The results of a survey of all accidents reported to the police between 1992 and 1995 in the state of Oklahoma, USA, showed that in 0.2 per cent of the accidents the driver had been using a mobile phone when the accident occurred. Since 1992, the Oklahoma police now note whether a mobile phone was involved as a matter of routine. Despite this, the number of unreported cases is presumably relatively high, and the proportion of accidents where a mobile phone has been used is probably underestimated. In comparisons of the causes of accidents in which a mobile phone has been accessible with accidents in which there has been no mobile phone, it emerged that inattention was clearly in evidence as a cause of the accident. Other causes linked to the driver's access to a mobile phone were driving at too high a speed, driving on the wrong side of the road, and changing lanes. The percentage of accidents in built-up areas was also significantly higher among drivers with mobile phone access.

In a Norwegian study, the proportion of accidents reported to insurance companies which involved drivers speaking on a mobile phone was estimated at 0.82 per cent. A

Finnish survey carried out into fatal accidents between 1997 and 1998 estimated the number of accidents involving drivers talking on a mobile phone at 1.4 per cent. In general, however, it is likely that there is a high number of unrecorded cases in the statistics regarding the proportion of accidents where drivers have spoken on a mobile phone at the time of the accident.

Information about the causes of accidents for all categories of accident is generally not covered by the SNRA's accident statistics. The lack of statistical information about causes of accidents (pre-crash or active safety aspects) in Sweden is regarded as a shortcoming. Even the SNRA's in-depth studies of fatal accidents chiefly only look at the aspects of the accidents that aggravate injury, i.e. passive safety aspects or the post-crash phase. Consequently, information about mobile phones, for example, is completely excluded from official accident statistics in Sweden. Neighbouring Finland, however, has analysed its fatal accidents in the pre-crash phase, which has consequently provided an information basis about mobile phones in road traffic. In Finland, Luukkanen et al. (2001) found that in 1 per cent of the fatal accidents between 1991 and 1998, mobile phones were a contributory cause of the accident.

/diagram/
Deaths in road traffic and mobile phone subscriptions in Sweden (1972-2002)
No. deaths in road traffic
Mobile phone subscriptions (inc. pay-as-you-go)
Year

Deaths in traffic
Mobile phone subscriptions

Source: SNRA, Post and Telecom Agency

r=-0.661 p=<0.01 (2 tailed)

Fig. 2: The figure outlines the statistics for deaths in road traffic in Sweden between 1972 and 2002 on the left y-axis. The right y-axis shows the number of mobile phone subscriptions, including pay-as-you-go subscriptions, in Sweden since 1990.

The number of mobile phone subscriptions in Sweden has increased approximately 11 times in the past 10 years, while the number of deaths in traffic has had a downward trend for 30 years (see Figure 2). It is interesting to note that despite the dramatic increase in the number of mobile phone subscriptions in recent years, the number of fatal accidents has continued to decrease. Figure 2 shows a negative link, but causality cannot be proved. There has been speculation in, for example, the media that mobile phones cause a great many fatal accidents. The statistics in Figure 2 above give no such indication. Nevertheless, it can be assumed that there are many unreported statistics.

12. Socio-economic estimates

Thulin and Ljungblad (2001) estimated that phone calls were present in approximately 2 per cent of Sweden's annual total road traffic mileage (based on measurements of the number of kilometres driven by all vehicles in a year). This means that 98 per cent of all journeys are made without phone calls in traffic. Their estimate may, however, enable us to calculate the social gain, by viewing the travel time used for phone calls as productive rather than non-productive time (i.e. only a consumption of time) according to the norm used in the SNRA's socio-economic calculations. Travel time per se is conventionally counted as non-productive time, and thereby an economic 'loss' to society. This 'loss' varies depending on the type of journey undertaken, such as a business trip, private travel or commuting to and from work. Travel time is conventionally counted as unproductive time and, as a rule, the greatest gain from a new road lies in being able to reach the destination more quickly. New technology and the extensive availability of mobile phones means that to some extent people can work while travelling, although to date this has not been noted in cost/benefit calculations.

Assuming that 2 per cent of the total annual traffic mileage (Thulin and Ljungblad 2001), is 'productive', in that the driver talks while he drives, the 'gain' is as follows:

According to the SNRA's 2001 Annual Report, travel time is 560 million hours on state roads and 430 million hours on the municipal road network. Two per cent of this is 20 million hours. With a time value of SEK 120/h according to a standard model, the theoretical 'gain' to society is 20 million x SEK 120 = MSEK 2,400/year.

A fatality in road traffic 'costs' society MSEK 14.3 according to current socio-economic calculations in Sweden. It is likely that there are unreported cases in which mobile phones are the cause of fatal accidents, but the level is thought to be around 1 per cent of fatal accidents in, for example, Finland (Luukkanen et al. 2001). We have no reason to believe that Sweden differs significantly from Finnish road traffic conditions. One per cent of deaths in road traffic in Sweden amounts to around 6, which provides a theoretical socio-economic cost of MSEK 14.3 x 6 = approx. MSEK 86/year.

The actual costs of the calls are not included in the above calculations. In this context the cost of the calls to the subscriber is also significant. An assumed rate of SEK 2 a minute equals SEK 120/hour, i.e. SEK 120/hour x (20 million hours/2) generates a turnover of MSEK 1,200/year. This cost is paid to the phone operators and normally benefits the national economy.

The reader should be aware that the figures above are based on a number of assumptions and estimates about usage and significance, which affect the outcome of the 'gains' and 'losses' to society. The calculations should therefore be considered educated estimates rather than definitive figures.

13. Legislation on the use of mobile phones in other countries

Legislation on the use of mobile phones may assume varying degrees of detail. At the one extreme there could be a single, universal regulation generally prohibiting any behaviour that draws attention away from driving; and at the other extreme is a rule stating that mobile phones may be used under certain specific circumstances. For example, it has been discussed whether it should be stipulated that the driver should not need to use his hands to speak on the phone. Swedish legislation on the use of phones while driving is to a large extent restricted by the general caution requirement in Chapter 2, Section 1 of the Road Traffic Ordinance.

> To avoid road accidents, road users shall observe the care and attention that the circumstances demand. Road users shall show particular consideration towards children, the elderly, school road-crossing patrols and persons perceived to have a functional disability or an illness that impedes their progress in traffic.
>
> Road users shall act in such a way as not to impede or disturb other road users unduly.
>
> Road users shall show due regard for those who live or go about their business beside the road.
>
> Those travelling off-road shall ensure that their route, speed and mode of travel do not disturb people or animals unduly or damage land, plants or crops belonging to others.

Chapter 2, Section 1 of the Road Traffic Ordinance.

There is no penalty clause in Chapter 2, Section 1 of the Swedish Road Traffic Ordinance. This means that anyone who does not observe the rules in this section are punishable when the lack of care and attention is so severe that the action can be punished as negligence in traffic in accordance with Section 1 of the act (1951:649) on punishments for certain road traffic offences (Road Traffic Offence Act).

The Road Traffic Ordinance is based on regulations in the Convention on Road Traffic (Vienna, 8 November 1968). The regulation in the convention which most closely corresponds to Chapter 2, Section 1 of the Road Traffic Ordinance is article 7. 1.

English convention text	***French convention text***	***Swedish translation***
1. Road users shall avoid any behaviour likely to endanger or obstruct traffic, to endanger persons, or to cause damage to public or private property.	1. Les usagers de la route doivent éviter tout comporte, ment susceptible de constituer un danger ou un obstacle pour la circulation, de mettre en danger des personnes ou de causer un dommage, à des propriétés publiques ou privées.	1. Vägtrafkanter skall undvika varje beteende som är ägnat att vålla fara eller hinder i trafiken eller fara för personer eller skada på allmän eller enskild egendom.

Several countries have legislation on the use of mobile phones while driving. There follows a compilation of information about various countries' legislation, according to information provided following a request from the SNRA to a number of European countries.

<u>Belgium:</u>

Since 1 July 2000, the use of a mobile phone while driving is prohibited in Belgium unless the vehicle is stationary or has been parked. The regulation is in Article 8.4 of the Belgian road traffic ordinance (Arrêté royal du 1er décembre 1975 portant règlement general sur la police de la circulation routière/ Koninklijk besluit van 1 december 1975 houdende algemen regelement om de politie vad het wegverkeer). The ban only applies to drivers using a hand-held phone. According to the survey response, the regulations in Article 8.4 are viewed as a formal expression of the more general regulations in Article 8.3 which stipulate that the driver must have constant control over the vehicle.

Legislative texts		**Translation**
French	**Flemish**	
8.3. Tout conducteur doit être en état de conduire, présenter les qualités physiques requises et posséder les connaissances et l'habileté nécessaires.	8.3. Elke bestuurder moet in staat zijn te sturen, en de vereiste lichaamsgeschiktheid en de nodige kennis en rijvaardigheid bezitten.	Drivers must have the necessary physical and mental ability and the necessary knowledge and skill to drive the vehicle.
Il doit être constamment en mesure d'effectuer toutes les manœuvres qui lui incombent et doit avoir constamment le contrôle du véhicule ou des animaux qu'il conduit.	Hij moet steeds in staat zijn alle nodige rijbewegingen uit te voeren en voortdurend zijn voertuig of zijn dieren goed in de hand hebben.	On any occasion the driver must be capable of implementing all the manoeuvres incumbent upon him and have control of the vehicle or animals he is driving.
8.4. Sauf si son véhicule est à l'arrêt ou en stationnement, le conducteur ne peut faire usage d'un téléphone portable en le tenant en main.	8.4. Behalve wanneer zijn voertuig stilstaat of geparkeerd is, mag de bestuurder geen gebruik maken van een draagbare telefoon die hij in de hand houdt.	Other than when the vehicle is stationary or has been parked, the driver is not permitted to use a phone held in the hand.

Denmark[1]:

As of 1 July 1998, it is prohibited in Denmark to talk on a hand-held mobile phone while driving. Regulations on the use of mobile phones are provided in § 55 of the Road Traffic Act. The regulations are formulated as follows (in translation):

The use of mobile phones and other telecom equipment

§ 55 a. Drivers of vehicles are prohibited from using hand-held mobile phones while driving.

Subsection 2. The Minister for Transport may establish additional rules about the use of other telecom equipment and the like while driving.

Finland

Finland has, by means of the act (FFS 2002:423) regarding amendments to road traffic legislation, introduced a ban on communication equipment being used in such a way during driving that it can have a detrimental effect on the use of the vehicle's manoeuvring devices. The same act has also been used to introduce a ban on drivers of motorised vehicles using mobile phones held in the hand while driving. The regulations can be found in § 24 a of the road traffic act. The regulations came into force on 1 January 2003, with the exception of some taxi services and public transport. The amendment to the road traffic legislation was proposed in Finland's government bill

[1] Details of Danish legislation have been taken from the Retsin??formation legal database.

(219/2001) to the parliament with a proposal for an act on the amendment of road traffic legislation. The legal regulation is formulated as follows (in translation):

24 a § *The use of communication equipment while driving*

Radio or television receivers, other audiovisual reproduction equipment or communication equipment are prohibited from being used in such a way while driving that they can have a detrimental effect on the use of the vehicle's manoeuvring devices or in some other way disturb the driver's concentration on road traffic.

Drivers of motorised vehicles may not use mobile phones that are held in the hand while driving.

The act came into force on 1 January 2003. For drivers operating in passenger traffic under a taxi licence who do not have access to a central radio taxi ordering service, and for drivers in hail-based public transport, the law comes into force on 1 January 2005.

France

France has no legislation directly regulating the use of mobile phones. The constitution text in France regulating the use of mobile phones is in article R 412-6 II of the *Code de la Route*. The regulation corresponds most closely to Article 8 of the Convention on Road Traffic. According to the survey response, the constitution text is perceived as a total ban on using a mobile phone while driving.

Constitution text	**Translation**
II. - Tout conducteur doit se tenir constamment en état et en position d'exécuter commodément et sans délai toutes les manoeuvres qui lui incombent. Ses possibilités de mouvement et son champ de vision ne doivent pas être réduits par le nombre ou la position des passagers, par les objets transportés ou par l'apposition d'objets non transparents sur les vitres.	Each driver must keep himself in such a condition and position that he can simply and without delay perform the manoeuvres required. His possibilities and field of vision must not be restricted by the number or positioning of passengers, of objects being transported, or by the placement of objects or the occurrence of opaque objects on the windows.

Luxembourg

In Luxembourg, mobile phones may only be used if the driver can use the phone and hold the steering wheel or controls with both hands. The regulations can be found in Article 170 Paragraph 2 of the *Code de la Route*.

Constitution text	**Translation**
Art. 170bis. 1. Il est interdit ..... 2. Tout équipement téléphonique à l'usage du conducteur doit être fixé solidement dans le véhicule ou être intégré au casque de protection porté par le conducteur. Cet équipement doit répondre aux conditions d'utilisation du deuxième alinéa.	**Art. 170 Para. 1.** 1. It is prohibited… 2. All telephone equipment which is intended to be used by the driver must be firmly attached to the vehicle or be part of a protective helmet worn by the driver. The equipment must fulfil the terms of use in the second paragraph.
En ce qui concerne l'utilisation de cet équipement le conducteur n'est autorisé, dès que le véhicule conduit est en mouvement, à lâcher le volant ou le guidon d'une main que pour les seules opérations demise en	As regards the use of the equipment, the driver may release the wheel or controls with one hand only to switch on or off the equipment and he must not change his driving position

service et d'arrêt de cet équipement; pour ce faire il ne doit pas changer sensiblement sa position de conduite. Par ailleurs, l'écoute et la communication doivent lui permettre de garder les deux mains au volant ou au guidon.	significantly to do this. Moreover, the conversation or phone connection must allow him to keep both hands on the steering wheel or controls.

The Netherlands

According to Dutch traffic legislation, the driver of a motor vehicle, moped or vehicle designed for people with a disability, is not permitted to hold a mobile phone when the vehicle is in motion. The regulation is designed so that it is the holding of the phone itself that is forbidden to the driver of the vehicle. The formulation of the regulation also means that the driver can use a phone when the vehicle is stationary, for example at traffic lights.

The regulation is part of Article 61 a *Reglement verkeersregels en verkeerstekens*.

Constitution text	**Translation**
§ 30. Gebruik van mobiele telecommunicatieapparatuur Artikel 61a	**§ 30 The use of mobile phone equipment Article 61 a**
Het is degene die een motorvoertuig, bromfiets of invalidenvoertuig bestuurt verboden tijdens het rijden een mobiele telefoon vast te houden.	The driver of a motor vehicle, moped or vehicle designed for people with a disability, is not permitted to hold a mobile phone when the vehicle is in motion.

Norway

The Norwegian Ministry of Transport and Communications has ruled on a ban on drivers using a mobile phone while driving a motor vehicle. The ban refers to the use of a mobile phone which, during use, is not placed in or on a holder installed in the vehicle. The regulations were announced in 1999, came into force on 15 March 2000 and are translated below.

Regulation on the ban on drivers using hand-held mobile phones while driving a motor vehicle:

Established by the Ministry of Transport and Communications on 17 December 1999, authorised in road traffic legislation on 18 June 1965 no. 4 § 23b.

§ 1. *Drivers' use of a mobile phone while driving a motor vehicle*
Drivers of motor vehicles may not use a mobile phone while driving, unless, during use, the mobile phone is placed in or on a holder that is securely installed in the motor vehicle. The holder must be installed within easy reach of the steering wheel and as close to the driver's ordinary field of vision while driving as practically possible, unless the holder is an integrated part of the vehicle's original fittings.

§ 2. *Definitions*
In this regulation the following definitions are used:
a) *Mobile phone:* radio equipment for communication over public networks.
b) *Driving:* motor vehicle in motion.

c) *The use of a mobile phone:* All uses, including all use of the mobile phone's keys, conversations, receipt of calls, receipt or sending of messages or text.

Portugal

In Portugal it is forbidden for car drivers to use equipment for receiving sound, or radio telephone equipment in the vehicle when it is in motion. The ban does not apply if the equipment has an earphone or a microphone with a loudspeaker system, which means the driver does not need to use his hands all the time. The regulation on this is in Article 84 of the Portuguese equivalent of the Swedish road traffic ordinance, *Código da Estrada*.

Spain

Since 2001, Spain has had a specific regulation prohibiting the use of mobile phones while driving. The constitutional regulation on this is found in Article 11, paragraph 3 of the Spanish equivalent of the road traffic ordinance, *La ley sobre tráfico, Circulation de véhiculosa Motor y Seguridad Vial*.

Constitution text	**Translation**
Se prohibe la utilizacion durante la conducción de dispositivos de telefonia movil y cualquier otro medio o sistema de comunicación, excepto cuando el desarollo de la comunicación tenga lugar sin emplear las manos, ni usar casco, auriculares o instrumentos necesarios.	The use of a mobile phone and other means or systems for communication is banned while driving, except when the call takes place without the use of hands, or with the use of a helmet, earphones or other necessary device. .....

The UK

As in Sweden, the UK currently has only general legislation (that the driver must have control over the vehicle) regulating the use of mobile phones.

In autumn 2002, the Department of Transport submitted a motion to introduce a new offence regarding the use of hand-held mobile phones while driving. It is noted in the motion that the use of handsfree phones also increases the risk of accidents. A penalty regulation on handsfree phones would, however, be difficult to monitor, and the Department of Transport therefore does not think it would be practical for the regulation to also include the use of handsfree phone equipment. On the whole, the response to the submission has been positive about the motion. Since 1 December 2003 it has been forbidden to use systems other than handsfree systems while driving.

Germany

The German equivalent to the Swedish road traffic ordinance, *Straßenverkehrs-Ordnung* (StVO), includes a ban on the use of hand-held mobile phones. The regulation has been introduced by the German equivalent of the Swedish Ministry of Industry, Employment and Communications in co-operation with the federal council.

Constitution text	**Translationc**
§ 23 Sonstige Pflichten des Fahrzeugführers . . .. . (1a) Dem Fahrzeugführer ist die Benutzung eines	**§ 23 Other obligations of vehicle drivers** ..... (1a) A vehicle driver may not use a mobile phone

Mobil- oder Autotelefons untersagt, wenn er hierfür das Mobiltelefon oder den Hörer des Autotelefons aufnimmt oder hält. Dies gilt nicht, wenn das Fahrzeug steht und bei Kraftfahrzeugen der Motor ausgeschaltet ist	or car phone if he must pull out or lift the mobile phone or car phone's receiver. This does not apply if the vehicle is stationary or, in the case of motor vehicles, if the engine is switched off.

14. Aspects based on the vehicle regulations

The vehicle regulations are there to regulate all aspects of design, construction, function and quality in newly produced vehicles. The aim is usually to establish requirements for achieving greater road traffic safety. The vehicle regulations are established either at EC level or within international standardisation, such as ISO, which is global. Vehicle regulations for IT equipment presuppose that equipment is originally installed by the car manufacture or integrated in the vehicle (such as the dashboard) in order to satisfy safety requirements.

Equipment installed subsequently often does not satisfy the safety requirements for internal safety and attachment – with a risk of components coming loose and 'flying around' in a collision. Mounting holders for mobile phones in the factory is problematic as there are many different models and brands. Vehicle owners may, however, be able to buy an extra SIM card for the GSM phone, although this probably requires that the handsfree equipment is factory-mounted.

Nevertheless, it is possible to install a handsfree system subsequently that follows the regulations, but in modern vehicles there is often not enough space on the dashboard for such installations. Moreover, the equipment is split into several parts, some parts having to be fitted in a different place in the car. When installing the holder at a later stage, it can also be difficult – due to a lack of space – to position the equipment so that the demand on readability is fulfilled.

Some types of equipment should not be able to be used while driving, and there may be certain connection requirements and demands on technical solutions to prevent this. There are also guidelines on how the system should interact with the driver, the human machine interface (HMI). These guidelines differ from other vehicle regulations in that they stipulate instructions on driver behaviour and demands on the IT systems in addition.

It is not possible to change the demands on vehicle design and function exclusively through Swedish 'national' legislation. This is regarded as an obstacle to trade within the EU. Instead, change takes place through international agreements such as the EC and ECE. The vehicle regulations develop and change continuously, which is why the reader is recommended to contact the SNRA or other equivalent authority for more detailed and up-to-date information.

15. Conclusions and recommendations

First, it should be pointed out that the availability of a mobile phone in a car is of great value in emergencies and accidents. However, the results from many different studies show that using a mobile phone while driving impairs driving performance significantly. This is because a driver's attention to surrounding traffic and traffic information is impaired and his control of the car becomes less precise and smooth when talking on the phone. Not only the physical fine motor-responses needed for phoning disturb driving, but also the conversation itself, and in particular, demanding conversations impair both attention and manoeuvring performance significantly. Therefore, handsfree mobile phone systems will not solve the safety problem of phoning and driving. Analyses of accidents have shown that the impairment of driving while phoning leads to an increased risk of having an accident both for hand-held and handsfree phones.

It is possible to view mobile phones in traffic as a narrow, isolated problem area, one without a broader traffic-related and social perspective. Based on that assumption, the only reasonable measure would be a total ban. However, the SNRA considers it both desirable and necessary to view mobile phones in a wider context, and therefore does not recommend a total ban.

However, the SNRA does want to advise drivers against simultaneous phoning and driving, as the activity does involve a higher risk both for the driver and other road users. If using a mobile phone is necessary, the driver must take the utmost care and be aware of the impairment in driving performance that a distraction such as a phone conversation represents for the driver in a road traffic situation.

The inquiry has to date found no clear advantages in using handsfree mobile phone systems while driving. What is clear is that it is the conversation and its complexity *per se* that give rise to adverse changes in the driver's ability to drive due to increased mental workload and distraction, rather than the type of phone system being used. We are therefore unable to suggest requirements on handsfree systems for mobile phones, as there is no scientific evidence to support the idea that they would lead to an improvement in road traffic safety. On the contrary, empirical studies have shown that drivers using hand-held phones have adapted (reduced) their speed, whereas those using handsfree phones have not. The lack of a behaviour to compensate for the effect of a phone call, such as a reduction in speed, is seen in the study as detrimental to road traffic safety. However, according to the subjective reports drivers using handsfree systems generally believed that they did reduce (adapt) their speed, even though in actual fact they did not. The precise reason behind this (mis-)conception is uncertain, but there is unarguably reason to believe that a driver using a handsfree system can be led into a false sense of security.

Therefore, the SNRA does not wish to advise drivers against using mobile phones equipped for handsfree usage. They generally have the advantage of being easy to find as they are fixed in place, so the driver avoids having to search around for the phone in his/her pocket, bag or some other unspecific place. Moreover, handsfree equipment can provide a greater flexibility for the driver in the handling of the vehicle e.g. in changing

gear or indicating. Nevertheless, the driver must always be aware of the distraction that using any type of mobile phone can represent.

One potential premise might be to distinguish between phoning while driving on rural roads, and phoning while driving in built-up areas. However, the simulator study has not been able to identify any advantage between handsfree and hand-held mobile phones in this context either: the drivers' performance was equally 'poor' regardless of system type. Clearly, the traffic environment in an urban area is generally far more complex than on a rural road or motorway. This means that the increased mental workload which causes a driver simply to 'miss' information, particularly peripherally presented information such as road markings, is affected to a lesser extent in the relatively low complexity of a rural road.

We can with great certainty state that the driver's ability to drive safely on the roads is adversely affected when speaking on the phone. Even other activities can distract or impair the driver such as conversing with passengers, eating, smoking, adjusting the car stereo, sending text messages, watching a movie, etc.

Recommendations

1. Following extensive consideration and exhaustive examination of results from the inquiry's research and other international studies, our conclusion is that it is not justifiable to introduce legislation that **only** forbids the use of mobile phone systems that require the use of the driver's hands. This is because research clearly shows that it is primarily the conversation *per se* and its complexity that burden and thereby distract the driver. The actual level of mental workload and distraction depends on the complexity of the conversation, the driver's experience, and the prevailing traffic situation. The level of distraction is not palpably affected by which type of phone system is being used (e.g. hand-held or handsfree).

2. In its in-depth studies of fatal accidents, the SNRA only routinely studies primarily the aspects that aggravate injury in the crash phase. The inquiry therefore recommends that when studying fatal accidents, in future the SNRA should itself systematically look into the causes of accidents in the pre-crash phase, as far as such relevant information is available. It is in line with the Swedish Parliament's Vision Zero for road traffic safety to gather any information about the causes of accidents that may provide a basis for possible road traffic safety measures in the future.

3. The SNRA recommends that the Police and the SNRA's in-depth study programme be given the authority and opportunity to more easily check whether a mobile phone has been used in a fatal accident. Such a check would only involve knowing if and when a phone was used (incoming or outgoing call), without needing to verify other, more detailed information that may impact on the individual's integrity.

4. The SNRA recommends that using a mobile phone while driving be defined in legal terms, in a separate regulation, as a driver activity or a driver condition on a par with the effects of tiredness or alcohol. For example, in accidents where using the phone is the actual cause of the accident, the sentence would be harsher for offenders found guilty based on the capacity-impairing effect of

phoning on the driver's mental abilities. The law could classify using the phone in an accident context as a seriously aggravating circumstance, and it could therefore be defined as a careless act in accordance with current traffic laws and sentencing practice in Sweden.

5. The SNRA recommends that drivers be informed of how driving and driving performance is affected by using mobile phones and other equipment in the vehicle while driving. This information should not only target current licence-holders, but also learner drivers as part of their driver training. An information plan should be drawn up for information regarding what distracting activities in traffic actually involve. A distraction involves not being able to devote as much mental capacity to the task of driving due to a higher mental workload. The higher the mental workload a driver has, the smaller the field of vision from which a driver can perceive information from the traffic environment: a kind of mental 'tunnel vision' arises. Moreover, the driver's ability to process and make decisions based on incoming (traffic) information becomes slower. This delaying effect on the human decision-making process could be of greater significance to those driving in built-up areas, where other traffic and other traffic events can be more intensive.

6. The SNRA recommends that equipment such as DVD, TV and other visual information and entertainment systems be positioned where the driver cannot be visually distracted while driving. This applies equally to systems installed subsequently, as to integrated and factory-mounted systems. It would seem inappropriate to allow the use of equipment (with moving pictures) that does not support the driving process, such as DVD, TV, video, visual telecommunication systems (which may exist in e.g. 3G phones), PDAs and other infotainment applications, as the system's display can be seen by the driver. However, such systems may be beneficial in certain contexts, such as entertaining children in the rear seats. Navigation equipment should, however, be permitted as a system intended to support driving. However, these driver-support systems (e.g. navigation equipment) must be user-friendly, and comply with the European Statement of Principles on Human Machine Interface (HMI) for In-vehicle Information and Communication Systems (1998), including all related documentation.

7. Finally, the SNRA recommends further support for the development of intelligent driver-support systems that use high technology to improve the driver's conditions for travelling safely and efficiently in the traffic system.

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Appendix 1

Swedish translations are available for the second to the fifth abstracts inclusive at the time of printing. The reports that form part of the inquiry's compilation of scientific reports are:

1. Mobile telephone simulator study. Albert Kircher, Jan Törnros, Katja Vogel, Lena Nilsson, Anne Bolling, Christopher Patten, Therese Malmström, Ruggero Ceci.
2. Information technology in the car: Mobile phones and traffic safety – a review of contemporary research. Ola Svenson and Christopher Patten.
3. Using mobile telephones: Cognitive Workload and Attention Resource Allocation. Christopher Patten, Albert Kircher, Joakim Östlund, Lena Nilsson.
4. Combining mobile phone conversation and driving – studying a mundane activity in its naturalistic setting. Mattias Esbjörnsson and Oskar Juhlin.
5. Mobile Phone Use while Driving. Hans Thulin and Susanne Gustafsson.
6. Mobile phoning and driving: The professional driver's perspective. Ilkka Salo and Ola Svenson.
7. Kombinationen IT baserade stödsystem i bil och nya unga förare. Nils-Petter Gregersen.

The above reports can be found in a compilation of reports by the SNRA, Publication 2003:92.

2. INFORMATION TECHNOLOGY IN THE CAR: MOBILE PHONES AND TRAFFIC SAFETY – A REVIEW OF CONTEMPORARY RESEARCH

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ABSTRACT

This study reviews contemporary research on the effects of using a mobile phone when driving. First, it should be pointed out that the availability of a mobile phone in a car is of great value in emergencies and accidents. However, the results from over 80 studies show that using a mobile phone in a car while driving impairs driving performance significantly. This is because a driver's attention to traffic and traffic information is impaired and the control of the car becomes less precise and smooth when talking on the phone. Not only the motor activities needed for phoning disturb driving, but also the conversation in itself, and in particular, demanding conversations impair both attention and manoeuvring performance significantly. Therefore, handsfree mobile phones will not solve the safety problem of phoning and driving. Analyses of accidents have shown that the impairment of driving while phoning leads to an increased risk of having an accident both for hand-held and handsfree mobile phones. One important characteristic of a phone conversation in relation to most other in-car activities is that the pace and content of the phone conversation cannot be controlled as well by the driver. This

makes a phone conversation more distracting than other equally demanding in-car activities that can be distributed in time and adapted to prevailing traffic and driving conditions.

3. USING MOBILE TELEPHONES: COGNITIVE WORKLOAD AND ATTENTION RESOURCE ALLOCATION

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ABSTRACT
Driver distraction is recognized as being one of the central causes of road traffic incidents and mobile telephones are tangible devices (among many other electrical devices) that can distract the driver through changes in workload. Forty participants completed a motorway route characterized by a low level of road complexity in the form of vehicle handling and information processing. A peripheral detection task (PDT) was employed to gauge mental workload. We compared effects of conversation type (simple versus complex) and telephone mode (hands-free versus handheld) to baseline conditions. The participants' reaction times increased significantly when conversing but no benefit of hands-free units over handheld units on rural roads/motorways were found. Thus, in regard to mobile telephones, the content of the conversation was far more important for driving and driver distraction than the type of telephone when driving on a motorway or similar type of road. The more difficult and complex the conversation, the greater the possible negative effect on driver distraction.

4. COMBINING MOBILE PHONE CONVERSATION AND DRIVING – STUDYING A MUNDANE ACTIVITY IN ITS NATURALISTIC SETTING

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ABSTRACT
Talking on a mobile phone is becoming increasingly common while driving a car. This increase is a matter that concerns the state, which traditionally has played an active role in road traffic safety. However, it is also an issue that affects car drivers themselves, both in terms of demands on safety and support for easily accessible phone conversations. In the search for understanding of the safety aspect for this activity, scientists are discussing how they can explain the difference between the lower number of reported accidents where a mobile phone call is involved, and the high theoretical risk calculated through controlled experiments. This study, with field work surrounding mobile phone calls linked to driving a car, addresses this issue by reporting how car drivers combine driving with mobile phone conversation and adapt them to each other. We think that the low proportion of reported accidents may be explained by drivers' endeavours to make the mobile phone conversations as smooth as possible.

5. MOBILE PHONE USE WHILE DRIVING

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ABSTRACT
In this research, requested by the Swedish National Road Administration, the purpose was to give a picture of drivers' use of mobile phones while driving and their attitudes to the use of mobile phones while driving. In addition, the purpose was to get some idea of the number of traffic accidents, along with injuries and deaths, which were caused by drivers using their mobile phones.

The research includes three sub-studies. One study is based on data from the national questionnaire-based Traffic Safety Survey TSU92 regarding car drivers' access to and use of mobile phones while driving. This sub-study also includes a short literary review. The second sub-study comprises focus group discussions. The results from the discussions are partly the basis for the questionnaire used in sub-study three, the purpose of which is to highlight the behaviour and attitudes regarding drivers' use of mobile phones while driving a car. In addition, the purpose was to highlight the safety aspect.

The number of mobile phone users has increased heavily and accelerated in the last ten years. This increase is reflected in drivers' use of mobile phones while driving. 73% of all drivers had access to a mobile phone in 2001. These drivers accounted for 85% of all yearly mileage. Of the mobile phones, 75% were hand-held without extra add-on equipment. Hand-held mobiles were most common among younger and older drivers. 30% of all drivers with mobile phones used them daily while driving. The respondents in the questionnaire survey considered handsfree equipment significantly less risky to use than hand-held mobile phones. A third of the respondents favoured a law against use of mobile phones while driving, regardless of the type of mobile phone equipment. Half of all respondents thought that hand-held mobile phones should be forbidden to use during driving. The accident risk associated with the use of hand-held mobile phones was perceived as much higher than for handsfree equipment. The drivers who generally use hands-free equipment especially pointed out this risk factor.

The dominant reason for the driver to have a mobile phone in the car was the security of always being able to contact or be contacted by someone else. According to our estimates, 100,000 drivers each year use the mobile phone to contact the police or call an ambulance after an accident. According to our theoretical estimates, 10-20 people die in traffic accidents in Sweden each year as a consequence of drivers' use of mobile phones while driving.

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