

Master Thesis in Interaction Design

A Bluetooth User Interface in the Car

-A Design Proposal for the Volvo Car Environment

Maria Larsson

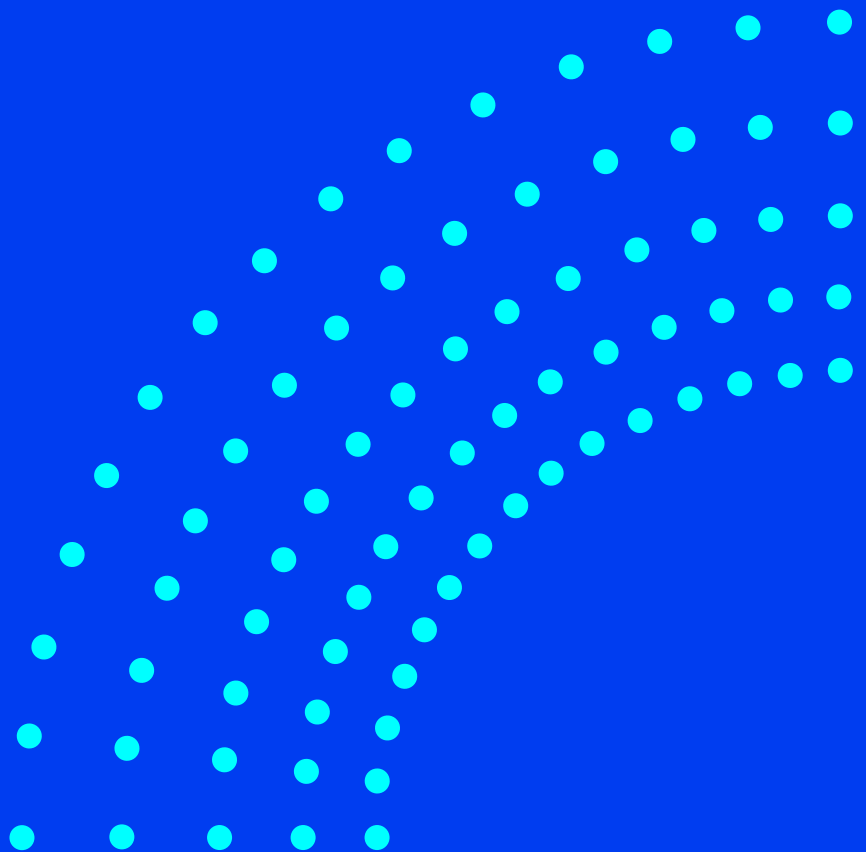
Gothenburg, Sweden 2004



IT University
of Göteborg

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Chalmers Department of Computer Science



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ABSTRACT

The automotive industry today is competitive and the car manufacturers try to attract customers with new technology. At the same time the everyday use of information technology is increasing and this technology will also be brought into the car. Bringing additional technology into the car that is not developed for the special car environment raises safety issues. For this reason, Volvo Car Corporation has chosen to investigate the possibilities of using Bluetooth for connection between different infotainment devices and the car network MOST. Earlier in this Bluetooth project hardware and software for such a Bluetooth node was developed by master students in computer science, but without any concern to the user interface. The purpose of this master thesis is to investigate what could be a suitable user interface for such a Bluetooth node, with special attention to when a cellular phone is connected to it.

A suitable user interface of course has to be adapted to the special context in the car and the task of using a cellular phone, therefore a user analysis and a task analysis was done to get valuable information about the context and its demands. It is also important that the interaction technique used is suitable for the driving context. Although the field of novel interaction techniques was explored, this did not result in finding a superior interaction technique for the car environment. A design proposal was developed and evaluated to find out in more detail what the requirements for a suitable Bluetooth node user interface are. The evaluation revealed some things that should be redesigned before the design proposal is a suitable user interface for a Bluetooth node.

Keywords: Bluetooth, Driving Context, User Interface

Ett Blåtands användargränssnitt för bilen

– ett designförslag för Volvo personvagnars bilmiljö

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Göteborg Universitet and Chalmers Tekniska Högskola

SAMMANFATTNING

I bilindustrin är det idag hård konkurrens och biltillverkarna försöker att locka kunder med ny teknik. Samtidigt ökar vårt dagliga användande av informationsteknik, vilken också tas med in i bilen. Att ta in extra teknik in i bilen som inte är utvecklad för den speciella bilmiljön väcker funderingar om hur säkert detta är. Av den anledningen har Volvo Personvagnar valt att undersöka möjligheterna för att använda blåtand i bilen för en koppling mellan olika underhållnings och informations apparater och MOST nätverket i bilen. Tidigare i detta blåtandsprojekt har magisterstudenter i datateknik utvecklat hårdvara och mjukvara för en sådan blåtandsnod, men utan tanke på användargränssnittet. Syftet med denna magister uppsats är att undersöka vad som skulle kunna vara ett lämpligt användargränssnitt för en sådan blåtandsnod, med särskild tanke på när en mobil telefon är uppkopplad mot den.

Ett lämpligt användargränssnitt måste förstås vara anpassat till den speciella kontexten och till uppgiften att använda en mobiltelefon, för den skull gjordes en användaranalys och en uppgiftsanalys för att få viktig information om kontexten och dess krav. Det är också viktigt att interaktionstekniken som används är anpassad till förarsituationen.

Även om interaktionstekniksområdet undersöktes resulterade det inte i någon självklar interaktionsteknik att använda i bilmiljön. Ett designförslag utvecklades och utvärderades för att ta reda på i mer detalj vad kraven för ett lämpligt användargränssnitt för blåtandsnoden är. Utvärderingen visade på några saker som behöver designas om innan designförslaget kan tjäna som ett exempel för ett lämpligt användargränssnitt för en blåtandsnod.

Rapporten är skriven på engelska.

Nyckelord: Användargränssnitt, Blåtand, Förarmiljö

Preface

This paper is a master thesis report in Human Computer Interaction and Interaction Design, written for the IT-University of Gothenburg, being a part of Chalmers University of Technology and Göteborg University. The master thesis was carried out by Maria Larsson at Volvo Car Corporation, Gothenburg from September 2003 to February 2004.

This thesis has its base in a Bluetooth project at Volvo Car Corporation, where software and hardware for Bluetooth was developed in two earlier Master Theses [Reinert 2003, Markman 2003]. The purpose of this project was to investigate the possibilities and constraints on using Bluetooth in the car for a wireless connection between different infotainment devices and the network MOST in the car. Included in the software part of the project was the task to suggest and construct a user interface for a hands-free telephone and other Bluetooth devices with a connection to the car. The purpose of this master thesis within this project was to suggest a suitable general user interface in the car for these Bluetooth devices and especially suggest a suitable user interface for a Bluetooth cellular phone.

I would like to thank my supervisors; Staffan Björk at the IT University for asking the right questions to get me further, and Niklas Adolfsson at Volvo Car Corporation for guidance and support during the project. Also thanks to Johannes Agardh and Anders Ivarsson at Volvo Car Corporation for answering all my questions. Not to forget are the test participants that gave me an hour of their valuable time, thank you.

Thanks also to those who helped me but whose names are not mentioned.



Maria Larsson

Gothenburg, February 2004

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APPENDIX E:
For Volvo Car Corporation only

1 Introduction

The history of the automobile is over a century long. The car was the workhorse of the 20th century and will mostly likely be of major importance in this (the 21st) century as well, not only as a way of transportation but as a field of research and technological advancements also. Car manufacturers compete by putting new technology into the car and there are a lot of different functions that can be realized in a car. The question is though if drivers really need and want all these functions, i.e. if they are willing to pay for it. For customers to be willing to pay for this new technology the benefit has to be clear.

At the same time the everyday use of information technology is increasing. For that reason, car manufacturers today increases their efforts in providing customer functions with entertainment and information giving character. Putting new technologies into the car raises the question about how much new technology drivers can handle and still be good drivers and not a danger for themselves, passengers and other road users. Is it possible to add these applications without distracting the driver to much in the primary task of driving?

Currently people have started to use their cellular phones more and more during driving and the accidents coupled to cellular phone use while driving is also increasing [Jacko 2003]. The use of a handheld cellular phone while driving is affecting the driving since interacting with the cellular phone (pressing the buttons) and holding it means one hand less for the driving and in some driving situations two hands are needed. Hence, applications not integrated into the car have to be considered as users bring them into the car anyway. This raises the question: wouldn't it be safer to integrate this with the car and develop one safe hands-free interface that suits the car environment? Exploring this, car manufacturers have mounted built-in phones in their cars, but some users think that is a hassle to have two different phones or to switch between the phones (when having a twin card¹) [Larsson 2003a]. It is also pretty expensive with a built-in phone. A better solution would be if the user's own cellular phone could be connected with the speakers and the microphone in the car to provide hands-free phoning, then it would be only one phone number and the technology would be much cheaper. One requirement however would be that the switch between the cellular phone and the hands-free interface could be done automatically. In a study made in the US [US-study1 2000] the most wanted function in the future vehicle was a docking for the cellular phone for hands-free operation. Also many countries (for example Germany and Denmark) have prohibitions against the use of handheld cellular phones while driving. Therefore, the development of a hands-free solution for the car is of interest for the car manufacturers.

The safety and competition issues also demands that this new technology has to be easy to use and understand for the user, otherwise it will either result in a lot of accidents or the user think it's to much effort to learn it and will not buy it. Therefore it is important that the user interface fit into the special driver situation and that the user see the new technology as easy to use.

The interface of a cellular phone is small when interacting with it in the driving situation; hence it would be great if the car could provide an interface that was adapted for interactions in the driving situation. To realize this solution a way to connect the cellular phone with the car is needed, it could be done by using a cable or a docking station or by using wireless technology. The disadvantage with a cable or a docking station is that every model of a cellular phone then has to have their own solution, which means that different cellular phones can not be used with the hands-free system. Hence a wireless technology is better for this connection. Volvo Car Corporation has chosen to study the constraints and possibilities with using the wireless technology Bluetooth in the car.

A benefit of having a Bluetooth connection is that the establishment of the connection will be automatic once the device is paired with the Bluetooth node in the car. Another advantage with the Bluetooth technology is that it is an open standard, which means that if the Bluetooth devices all follow this standard they should be compatible with each other. Other advantages with the Bluetooth technology that are especially good for the car environment are the small physical size and the small power consumption.

¹ Having a twin card refers to when a user has two SIM cards to the same phone number.

The purpose of the Bluetooth project at Volvo Car Corporation (which further on will be referred to as VCC) is to investigate the possibilities and constraints on using Bluetooth in the car for a wireless connection between different infotainment devices and the car network MOST, i.e. having a Bluetooth node that will be a part of the already existing infotainment system. The project consists of one software part and one hardware part. The software part is further divided into two parts, part one is to suggest and construct an interface between a hands-free telephone or other interesting Bluetooth devices and the car, the other part is to suggest and construct a general user interface for these Bluetooth devices. The second part is the scope for this master thesis.

The user interface-part consists of different steps. The user interfaces that are to be developed or modified are in priority order as follows:

1. General user interface for all Bluetooth devices (i.e. pairing and connecting the Bluetooth device with the car).
2. User interface for a cellular phone device.
3. User interface for another device (first part of the project gives device suggestion).

1.1 Research question

This thesis will deal mainly with the question:

"How can the car provide a suitable user interface for a cellular phone with a Bluetooth connection to the car?"

To be able to answer the research question, two question statements were identified:

1. What does the special context and the task mean for the design of such an interface and which interaction technique is suitable for this task in this context?
2. How can a user interface that takes the context, the task and the suitable interaction technique in consideration be designed?

The answer from the first question was planned to be used as a base for developing design proposals for a Bluetooth node user interface with focus on the connection to a cellular phone. The design proposals was also planned to be evaluated with users and these results and the development process were going to answer the second question and give additional information to answer the main question.

The goal is to provide documentation on the users and their tasks, and to present a design proposal for a user interface for a Bluetooth node in the car environment.

2 Background

Many different areas are relevant as background material to this master thesis. First, a brief overview of the Bluetooth technology is presented and thereafter follows a brief description of the human and its cognitive processes. Lastly related work is described.

2.1 Bluetooth, a brief Overview

This chapter is a short introduction to the Bluetooth technology. The facts presented are based on [Miller 2001] and [Brown 2002].

In 1994 Ericsson wanted to eliminate the cables between mobile phones and their accessories and therefore started a project to investigate a low-power and low-cost radio interface to do that. The project grew and in 1998 the Special Interest Group (SIG) was founded, where Ericsson was joined by companies such as IBM, Intel, Nokia and Toshiba. The SIG is responsible for the development of the standard for the open Bluetooth Specification.

The term Bluetooth refers to the open specification for a technology that enables short-range wireless voice and data communications anywhere in the world (it operates within a frequency spectrum that is unlicensed throughout the world). Bluetooth wireless communication uses radio waves to communicate through the air (radio frequency technology) in a way basically similar to broadcast radio or television. There are three different classes of Bluetooth: class 1 with a range of 100 meters, class 2 with range 10 meters and class 3 with a range below 5 meters. Class 2 is mainly used for cellular phones.

The Bluetooth technology operates within 79 channels in the free radio band (between 2.4 and 2.48 GHz) also called the Industrial, Scientific and Medical (ISM) band. This radio band is also used by Wireless LAN (and affected by microwave ovens). Bluetooth is a frequency-hopping spread spectrum (FHSS), which means that the wireless connection between two devices change frequencies at fixed time intervals, hopping around the channels in a special sequence 1600 times per second. The master device in the connection determines both the timing of the hopping and the selection and sequence of channels used. The channels change very quick hence the effect of an interference on one channel will not last that long. This technique provides high security and is often used in military systems for radio transmission.

When a Bluetooth link is established between two devices, one device acts as the master and the other as slave. A device may act as a master in one communication and as a slave for another. A master can connect to up to seven active slaves (and up to 255 parked slaves) at the same time, forming a piconet; this "point-to-multipoint" feature is what differentiates Bluetooth from other wireless technologies. In a "point-to multipoint" connection all the slaves share the same channel. If piconets overlap they form a scatternet.

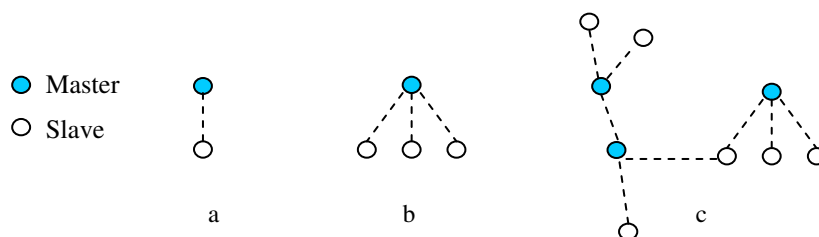


Figure 1 Piconets with a single slave operation (a), a multi-slave operation (b) and a scatternet (c).

For the Bluetooth devices to be able to work together the master-slave relationship is necessary in Bluetooth low-level communications. In general the devices operate in peers. When a Bluetooth link is established between two devices it is not important for the higher protocols and the user which device assume which role (master or slave). Therefore is this done automatically and the user does not have to do anything.

Bluetooth applications are built on profiles. The profiles are developed to standardize the transmission between the Bluetooth devices. Profiles describe the various services, such as dial-up-networking, file transfer and printing that the devices support. Two Bluetooth

devices that want to transmit a special kind of data both have to support the right kind of profile for that kind of transmission. If we take for example the cellular phone and a headset, they both have to support the Bluetooth Headset Profile; otherwise they will not work together.

The Bluetooth connection process contains four steps: Device Discovery, Name Discovery, Association and Service Discovery. To be able to do these steps the device has to be in discoverable mode. As a privacy feature some devices have a discoverable mode setting, hence when they are set in non-discoverable mode other Bluetooth devices in the range will not detect them. In some devices there is also a timer on how long the devices stay discoverable, since it takes more power from the battery to be in discoverable mode than in non-discoverable mode. If the device is in discoverable mode its electronic address will first be detected in the device discovery. The Device discovery step is tight followed by the name discovery, where the more "friendly name"², the Bluetooth device name, is discovered. The next step is the association step, also called pairing, bonding or joining by different vendors. When pairing two Bluetooth devices one often has to enter a shared PIN number, which serves as a security level. Not all devices require PIN number though, which means anyone can pair with these devices. The association is made once. Which means that the PIN number is only needed during the pairing process and do not have to be entered every time one uses the Bluetooth devices together. The Service discovery is the next step and there it is discovered which services (profiles) the device support consequently the devices knows which profiles they have in common and can use. If all these steps were successfully completed the Bluetooth devices can now perform Bluetooth operations together.

2.2 The Human

Knowledge about user capabilities is important when designing something for humans. General knowledge about humans and how they act are found in the area of cognitive psychology, whereas specific knowledge of a special kind of user group can be gathered in user analyses. Cognitive psychology is a complex subject and many pages could be written about that, but since that is not the subject of this master thesis only a very short introduction to this subject will follow here. More information can for example be found in [Eysenck 1996] and [Preece 1994], which are the references for this chapter (together with lecture notes from [MDI 2002]).

Within cognitive science there are different theories about how the human information processing is done. One model is the following:

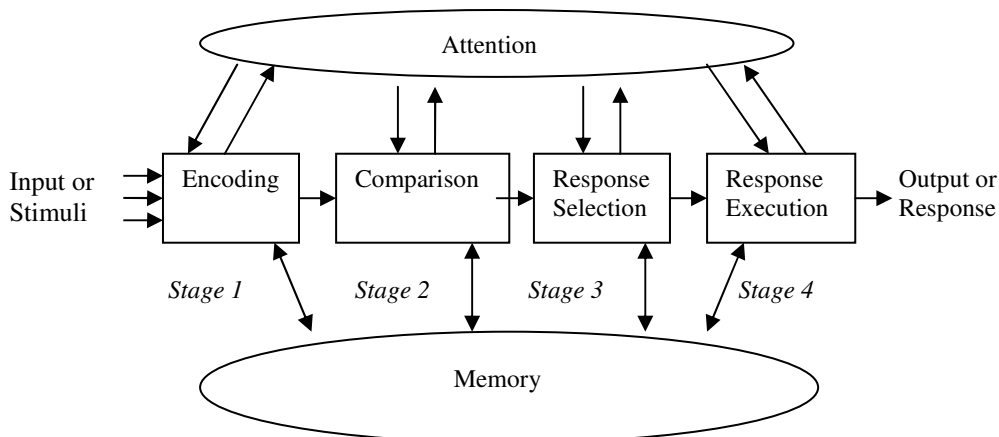


Figure 2 A model of the human information process.

In stage 1, information from the environment is encoded into an internal representation. Stage 2 compares the internal representation of the stimulus with memorized representations that are stored in the brain. In stage 3 it is decided which response should be given to the encoded stimulus. When such an appropriate response is found the process goes on to stage 4, which concerns the organization of the response and the necessary action.

² It is called "friendly name" because for humans it is easier to think of a device by name rather than by electronic address.

2 Background

In this model cognition is viewed in terms of three processes:

- How information is perceived by the perceptual processors (*perception*).
- How that information is attended to (*attention*).
- How that information is processed and stored in *memory*.

The multi-store model described below, describes more clearly how these three processes are connected.

Perception is to become aware of something with assistance of the human senses. Perception is often a combination of influences from different senses. In the design area it is most often the senses sight, hearing and touch that are interesting. Visual perception could for example be the organization of objects, perception of movements, spatial perception, perception of objects and pattern matching. The auditory perception is for example used in the design area to warn people or to create a certain atmosphere. An example of when tactile perception is used is when designing buttons or controls.

The core of **attention** is focalization, concentration and consciousness. Attention implies withdrawal from some things in order to deal effectively with others. The information that we choose to attend to are relevant in the context of our present activities and goals, although sometimes our attention is involuntarily captured by certain stimuli. Attention can be focused or divided. When several inputs reach us at the same time, but we are only focusing and responding to one input it is called focused attention. Divided attention is when several inputs not only reaches us, but also are attended to and responded to. Of course there is a limit of how many inputs we can handle at the same time before our attention is overloaded. How well we can divide our attention between different tasks are depending on the complexity of the tasks, the tasks similarity and how used to perform the tasks we are. For that reason it is easier to combine tasks that are simple, well-known and dissimilar than tasks that are similar, unknown and complex.

Performing tasks many times means that our performance improves; the improvement can go on to the point when the performance becomes automatic. When it is automatic we simply do it without thinking about it, examples of activities that can be automated are reading and writing. The automatic processes do not require attention and are not affected by the limited capacity of the brain; hence they do not decrease the ability for performing other tasks at the same time. The automatic processes are also unavoidable, which means they are difficult to change once they have been learned. While the non-automatic processes, the so-called controlled processes, require attention and conscious control, and can for that reason be more easily changed.

The **memory** process can be divided into three main stages, *encoding* (input), *storage* and *retrieval* (output). First of all there is the input stage where newly perceived information is being learned or encoded. Then it is the storage stage, where the information simply is held in preparation for some future occasion, i.e. representation of knowledge. Finally there is the output stage where the information is retrieved from storage.

There are a lot of different theories how the human memory is structured. A well-known model for how the human memory looks like is the multi-store model by Atkinson and Shiffrin (1968). In the following picture are also the three main stages of the memory process added to the model.

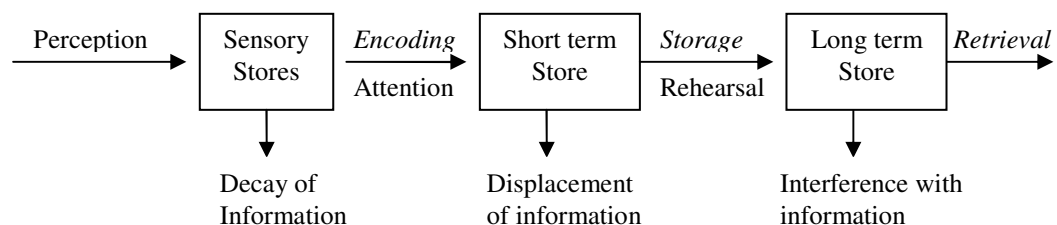


Figure 3 Atkinson and Shiffrins multi-store model.

Information from the external world first reaches the modality-specific sensory stores. There are different stores for visual, auditory and tactile material. Not all the information entering the sensory stores is attended to and therefore is some information lost in the sensory stores. The information that is attended to is further processed to the short term memory. In the sensory stores the information persists only for up to one or two seconds.

The information from the sensory stores then reaches the short term memory where it is processed. The short term memory is also sometimes called the working memory for the reason that information is here held temporarily for another processing activity for example handling inputs, planning and preparing outputs. The working memory capacity to hold information is limited in amount and time, which makes it fragile. This is apparent for example if one thinks of when one tries to remember a phone number when one dials it, it is very difficult to remember long phone numbers and a small distraction can cause one to forget the number completely. The working memory can hold between 5 and 9 chunks of information at one time. Through rehearsal the information in the short term memory is transported to the long term memory.

The long term memory has unlimited capacity when comparing with the short term memory. Information that enters the long term memory is assumed to be permanent. Atkinson and Shiffrin said that nearly all the forgetting from the long term memory is due to failure to find the appropriate memory trace rather than to the loss of the trace from the memory system. The knowledge that is stored in the long term memory can be declarative or procedural knowledge. Declarative knowledge is concerning general knowledge and personal experience, i.e. "Knowing that". Procedural knowledge concerns motor skills for example riding a bike or playing piano, i.e. "Knowing how".

2.3 Related work

2.3.1 Automotive industry

Other car manufacturers have developed Bluetooth systems for their cars and some of these systems will be described in this chapter. The systems described below were unfortunately not available to try out, hence this information comes from the companies own presentations of their systems and might therefore sound better than they are.

Daimler Chryslers UConnect

DaimlerChrysler has developed something called UConnect, which is an in-vehicle, hands-free and voice activated communication system, a Bluetooth-enabled automotive application [UConnect]. In the fall of 2003 they started to offer UConnect as a dealer-installed option and stated that a factory-installed version of the system will debut in Chrysler Pacifica early in the year of 2004. UConnect allows users to have only one communication device (their own cellular phone) with one telephone number and they can also use their current phone carrier.

How do the UConnect work? Using Bluetooth, the communication is driven through the user's personal cellular phone, and works both inside and outside the vehicle. (Calls may be linked to UConnect within 30 feet of the vehicle). UConnect uses Bluetooth radio frequencies to enable handheld cellular phones to communicate with the so-called "head unit" in the dashboard, which stores and processes simple voice recognition commands. The user only needs to bring his or her Bluetooth-enabled phone into the vehicle, and it will be recognized by the car's UConnect, allowing pre-programmed phone numbers to be dialed via voice commands during travel. The UConnect allows the audio to be heard through the radio speakers, and the driver is able to talk through a microphone located near the rear-view mirror, which makes phone conversations hands-free. The cellular phone itself can be placed anywhere in the vehicle during this time, meaning the users can leave it in their purse, pocket or in the briefcase (even when it's placed in the trunk). UConnect features the following:

- *Voice dialing* - Voice commands can be used to digit-dial the phone or access pre-stored voice tags; the user presses the control button that connects the cellular phone with the microphone. Then the user states the name or number of the person he or she wants to call and the system understands the request by using speech recognition. The system confirms the phone number, and then dials it. The phone number appears on the radio's display as it is being dialed. The voice recognition software recognizes speech generically; hence anyone in the vehicle can use it.
- *Audio address book* -The system can store up to 32 names in its address book and four destinations for each name, ranging from pager to home phone, which mean a total of 128 phone numbers. The phone numbers can be dialed automatically via

voice commands.

- *Audio system mute* -The system allows the user to mute the microphone for privacy. Hence if the user have passengers and want to keep the call private, the user can transfer the call to the handset and use it in the usual way.
- *Call transfer* - Allows the customer to transfer a call from the vehicle's system to the mobile phone.
- *Communicates in three languages* - French, Spanish, and English.
- *Multi-phone recognition* - UConnect can be programmed to recognize up to five phones that is flexible enough for an entire family. Priorities are set for the different phones, hence if there are multiple phones in the car which are paired it searches for the first phone set in the system to connect. If this phone is not found it searches for the next phone in the priority order.

When there is an incoming call or when the user begins to make a call the system also lowers the volume on the audio systems automatically. The Factory-installed UConnect shows the caller ID on the radio screen during an incoming call.

The phone conversations may be continued upon entering or exiting the car, without disrupting the call. That is, after the vehicle is parked and the driver departs, the phone conversation can continue, uninterrupted, via the user cellular phone.

The dealer-installed version of UConnect consists of a control pad, speaker, microphone, wiring harness, and a control module containing voice recognition software and the Bluetooth chipset. The control pad is mounted on the vehicle's instrument panel, and the microphone is attached to the overhead console. A hidden speaker transmits audio.



Figure 4 The dealer installed Uconnect [www.jeeplin.com]



The factory-installed version allows the audio to be heard through the vehicle's radio speakers, and the microphone placed in the vehicle's rearview mirror serves as the driver interface. The UConnect factory-installed version will have all functions built-in to the rear view mirror. The Grand Cherokee is to offer the mirror version during the 2nd half of the 2004 model year.

Figure 5 The factory installed Uconnect [www.wjjeeps.com]

The voice recognition software uses speech extraction technology to improve voice recognition under noisy conditions. The system reduces the effect of wind, echoes, feedback and multiple talkers by isolating speech properties. When reducing background noise, the system also reduces the bandwidth needed for transmission and can thereby increase the life of the cellular phone battery by 20%. The UConnect system costs around 275 US dollars today [UConnect].

Ford

Ford Motor Company's hands-free wireless communication system with Bluetooth technology is called "Mobile-Ease" and it will be available on all 2004 Lincoln cars and SUVs beginning in early November 2003. As with UConnect, "Mobile-Ease" is integrated into the vehicle's audio system, it uses the audio speakers and a microphone is mounted near the rear view mirror. The system have a control/button pad mounted on the dashboard, with for example a green status light that indicates if there is a connection between the system and a Bluetooth cellular phone. If the cellular phone is paired "Mobile-Ease" recognizes it immediately after it enters the vehicle and it is logged on to the system. Not paired cellular phones can be connected to the system by pressing the voice recognition button on the control pad and speaking some simple commands, up to five different phones can be linked. The user can also use voice commands to dial. The voice recognition recognizes commands in English, North American Spanish, and French Canadian. Also this system automatically mutes the radio when sending or receiving a call, and gives the user the possibility to mute the call. The user can also transfer calls between the vehicle and the wireless phone. The systems phonebook stores up to 32 names and four numbers per name. [Ford]

BMW

BMW calls their system ULF. Once the vehicle is started the system begins communicating with the vehicle and the calls will be routed through the car. As soon as the mobile phone is brought within the range of the Bluetooth chip installed in the vehicle, the system login is performed automatically. Only when activating the system for the first time is it necessary to enter a four digit code. Also this system uses the audio speakers in the vehicle and has a small microphone. The system also mutes the audio when receiving or placing calls. An incoming call can be answered via the phone button on the steering wheel or the phone icon on the dashboard or the pairing button. Calls can be made at the touch of a button on the multifunctional steering wheel or via voice activation. To place a call using voice recognition, the users say the phone number or use a voice tag that they have programmed for example: "home", "work" or "Bob's cell phone". The system also synchronise information stored in the cellular phone, such as phonebook entries, a list of the eight most important numbers, and numbers last called and display these on the onboard monitor. Hence the user can scroll through the cellular phone book and call a number from it. Calls can also be transferred in and out of the car, phone calls are only interrupted for a brief period while the system switches the call to the vehicle (getting into the vehicle) or to the personal cellular phone (leaving the vehicle). The system can be paired with up to four different phones but only one phone can be used on the system at one time [BMW].

Other Manufacturers

Similar Bluetooth systems as described above are also available in new models from Mercedes and Peugeot. Toyota (Lexus) also has a similar system as the ones above but also shows the strength of the Bluetooth connection: a good connection is indicated by blue and a connection that easily can be broken is indicated by yellow on the display, the yellow connection also has worse sound quality. No indication means no connection. One can register (pair) up to four phones but only one is functional. If more than one cellular phone is registered (paired) one need to choose the phone that one usually uses. When the ignition key is turned to "ACC" or "On" will the chosen Bluetooth phone automatically be connected and the connection result will show [Toyota].

2.3.2 Interacting models for other Bluetooth systems

What kind of interactions do other Bluetooth systems require? How have other systems that use Bluetooth connection, solved for example the pairing process? Here follows some examples on how the pairing is done. The examples are to give a brief overview, for details, such as menu alternatives in the cellular phone see the references. First are the pairing process between a cellular phone and a Bluetooth node in a car described to see how others have solved it in the same situation. Today we also have PCs and PDAs that can be connected to a cellular phone with Bluetooth. How the pairing process is made between these devices are also interesting for this design work. Therefore is thereafter the pairing process between a laptop and a cellular phone described and last is the pairing between a handheld computer and cellular phone described.

Pairing a Cellular Phone with Daimler Chryslers UConnect

To read more about this system see previous chapter. Important to know here is that this car system uses voice recognition.

- 1) To initiate system, press UConnect / Phone Button
- 2) After the System "BEEP" say, "Set-Up"
- 3) UConnect will offer the following Commands:
 - Phone Pairing
 - Confirmation
 - Prompts
 - Language
- 4) Say, "Phone Pairing"
- 5) UConnect will offer the following commands:
 - Pair a Phone
 - Delete Current Phone
- 6) Say, "Pair a Phone"

To complete the Pairing Process, follow the instructions in your Wireless Phone Owners Manual. For example, the 3 common Wireless Phone Commands to look for when Pairing a wireless phone are the following

- *Add / Search Device
- *Phone Initiated
- *Hands-Free / All Types [UConnect]

Pairing a Cellular Phone with Toyotas Bluetooth system

To pair a cellular phone in a Toyota the following steps are required (translated from Swedish):

1. Press "Info" to show the screen "Information menu".
2. Press "Phone" to show the screen "Phone".
3. Press "Settings" to show the screen "Settings", use arrow to scroll in the screen.
4. Press the button "Entry" and connect your cellular phone to the system. Before you use the phone you will give in your PIN code on the Screen. The manual for your cellular phone contains instructions for what to do on your cellular phone.
5. When the pairing is done the cellular phones name and Bluetooth address is shown on the screen [Toyota].

Pair/bond a device with a Notebook/Laptop computer (windows 98) with a BLUE card (e.g. Laptop and Ericsson T39mc) [Blue card]

The Blue card should be inserted in the computer and the Bluetooth operation mode should be set to "on" in the T39mc. Then the personal phone name has to be assigned on the T39 and then will the phone be in discoverable mode for 3 minutes. On the laptop is then the following steps made:

1. Tab on the Blue card icon in the Control Panel and then enter the Blue card Control Center.
2. The Address and Name will show up if all the setting is well configured.
3. Select Security in the "Settings" pull down menu and then enable in the "Require Authentication".
 - a. Select the Serial Ports in the "Settings" pull down menu.
 - b. Tab the "Search" to perform a Bluetooth inquiry to the Bluetooth devices in the effective coverage area.
 - c. The BD Address of the device will be shown up in the Devices pull down menu.
 - d. Tab the Name (button) to get the friendly name of the T39 mobile phone.
 - e. Then tab the "SDP" to look up the Bluetooth service provided by T39mc.
4.
 - a. As prompted in the screen enter the passkey and check the "Remember PIN-code setting". Tab OK.
 - b. The T39mc may automatically display a message "Add to paired devices?" press yes.
 - c. The T39mc will ask for your passkey. Enter the same passkey into your mobile phone.
 - d. Pairing succeeded will show up.

2 Background

- e. The Name tag edit box will show the Bluetooth Name of laptop PC, you can edit it and store it in the T39mc.
5. The service and server channel will be displayed after the pairing procedure. Tab “Back”.
6. Tab “Save” to store the settings and then message box “You must restart the PC before the new settings become active will pop-up.” Tab OK.
7.
 - a. Select security in the “Settings” pull down menu again.
 - b. Select disable in the “Require Authentication”.
 - c. Verify that the desired connected Bluetooth device BD address should be obtained in “Paired devices” (pull down menu).
 - d. Restart the PC, after restarting; two virtual Com-ports will be created.

Pairing the Palm Bluetooth Card with an Ericsson T39m (or Ericsson T68) [Palm]

After the Bluetooth card is installed and inserted in the Palm Handheld and the Bluetooth function is activated on the phone (that is the operation mode should be set to “on”) the following steps is needed.

1. Palm OS 4.x:
 - a. In the Launcher, tap on Prefs.
 - b. Choose Bluetooth.
 - c. Make sure the Bluetooth is enabled.
 - d. Tap the Trusted Devices button.
2. Ericsson T39m:
 - a. Make the T39 discoverable.
 - b. Make the T39 accept the pairing with a device.
3. Palm OS 4.x:
 - a. Tap Add Device.
 - b. The Palm is searching for Bluetooth devices and the T39 should be listed in the discovery Results window.
 - c. Select the T39.
 - d. Tap OK.
4. Ericsson T39m:
 - a. T39 displays: Add Palm to paired devices. Press YES.
 - b. Enter the passkey. Press YES.
5. Palm OS 4.x:
 - a. Enter the same passkey and Tap OK.
 - b. Make sure the T39 is now added in the list of “Trusted devices”.

3 Method

There are a lot of lifecycle models that shows how a development process within interaction design can be made. The models show which activities are included and how they are related to each other. Examples of models are: the waterfall model, star model, the usability engineering lifecycle [Preece 2002]. For the thesis, the user-centered system development [MDI 2002] was selected.



Figure 6 User Centred System development.

This model consists of four levels. The first level is the *Concept* level, where the concept for the product is decided, that is to what the product is going to be used, if it is needed and who will use it. Next level is the *Functionality* level where it is decided which functions the system is going to provide. At the *Interaction* level that comes next, it is decided how the user will interact with the system. In the final level, the *Surface* level, it is decided how the surface towards the user will look.

At each level there is a cycle of four basic activities: Analyze, Specify, Design and Evaluate. These activities are repeated in the cycle until a satisfying result is reached or the time or money is up.

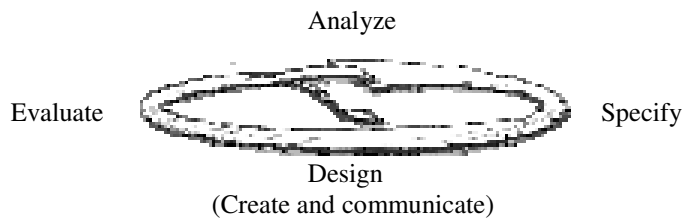


Figure 7 Basic activities at each level

The working process of the model is that one level is iterated until it is satisfying and then one proceeds with iterating next level until it is satisfying and so on. For this master thesis the concept and functionality levels are already made by VCC, which leaves the interaction and surface levels for this master thesis. It was decided to merge these two levels to one level, as this would only be a prototype for exploring the possibilities instead of a final product. The plan was to make one and a quarter cycle at this level, since that was what was reasonable in time.

The *analysis* phase should consist of a user analysis and a task analysis, since in this project it was important to understand the user and the user context and also what the task of using a cellular phone means. These analyses should also help to answer the first question statement. A requirement specification should then also be written with these analyses as a base.

The gathering of information about the user and how the user perform the task can be done in a lot of different ways, for example through interviewing the users, observe users, questionnaires, have focus group discussions and workshops or by studying documentation. Which one to choose depends on what kind of information one want to have and how much time there is. Since the time available in the master thesis project to this phase was limited, it was decided that documentation should be studied (also called literature search) since it is known not to take as long time as the others. This summer the author also made interviews and observations with owners of Volvo XC90 how they used the infotainment and navigation system in the car. This knowledge about how the users use a built-in car phone system (a part of the infotainment system) will also be used in the analysis. It was further decided that documentation in form of focus group discussions and results from questionnaires that the Swedish National Road Administration have made about using a cellular phone while

driving should be studied. Customer analysis and target group analyses that VCC has made was going to help out to show who the user is. To the task analysis VCC already had defined which tasks should be available. In these analyses some requirements for the interface was to be found and together with general guidelines for in-vehicle systems, these will be the basis for the requirement specification. The usability requirements extracted from the user and task analyses should be turned into measurable usability goals in the *requirement specification*. Also the constraints to this interface are to be investigated before the design phase can begin.

The *design* phase can be divided into two parts: conceptual and physical design [Preece 2002]. The conceptual design is the development of a conceptual model that captures what the product will do and how it will behave. The physical design is the details of the design, such as menu structure and screen design with icons and graphics. The basic conceptual model is already done by VCC but an extended conceptual model with more details for the Bluetooth node is also needed, therefore questions like: “what input and output devices do best suit the driving situation?” will be investigated. A brainstorming about different interaction possibilities will be made. These different ways of interaction will be evaluated for the driving situation. Some of them that fit the driving situation best will be further developed and different surfaces for these different interactions will be designed. The extended conceptual model also includes exploration of how the tasks will be divided up between the human and machine (how the interaction will work). Therefore Use Cases will be developed for the wanted functions.

In the physical design step the structure of the information will be designed and different screen designs will be sketched and paper-mock-ups will probably be used. The designs will then hopefully also be implemented in the boxcar.

There are a lot of ways to *evaluate* a design, the evaluations can be user-based, inspection-based or model-based [Jacko 2003]. The user-based evaluations are based on the involvement of individuals, representative of those who will use the system. In the user-based kind of evaluation some of the methods are the same as in the analysis phase, such as interviewing users, questionnaires and observing users. To evaluate is synonym with to test something for many people, and of course is also tests a method for evaluating. Within interaction design this test should of course be a user test that shows how well the user can use and understand the intended interaction. This test can be observed and data recorded and analyzed, or data can be measured or think-aloud protocol can be used. The inspection-based evaluation are based on the judgment of experts rather than input from potential users. Examples of inspection-based evaluations are heuristic evaluation or cognitive walk-through. The model-based evaluation uses a model of how a human would use a proposed system as a base. Examples of model-based evaluations are: GOMS model or task network model [Jacko 2003].

For the master thesis project, a user test is planned for the evaluation phase where the users get to test the interface and are meanwhile observed. To catch the interaction the user test will not only be observed, it will also be recorded for later analysis of the interaction. There will be no measures during the test since the test is only made to get initial responses to the interaction and catch early errors. More exact measures are motivated for a test later on in the development process (i.e. for a test in the second or third iteration cycle) which is outside the scope of this master thesis. Then the users get to answer some questions to catch their attitude towards the interface. The evaluation should help to tell if the interface meets the requirements in the requirement specification.

4 Requirements Gathering & Interactions

To be able to answer the first question statement: “*What do the special context and the task mean for the design of such an interface and which interaction technique is suitable for this task in this context?*” several other questions are identified:

- What is the users’ context (the driving situation in a car environment) like and what extra demands/requirements does that add to the design of the Interface?
- What does the task of using a cellular phone mean and what demands/effects does this task have on the driver?
- What interaction techniques are there and how do they fit the user context?

To answer the two first questions a requirements gathering was made, consisting of a user analysis and a task analysis. Requirements were extracted from these analyses and resulted in the requirement specification. To answer the third question different interaction techniques was thereafter explored. For the constraints for this user interface to be clear a description of the technical environment is added at the end of this chapter.

4.1 User Analysis: Characteristic of the User Group.

In this user analysis we will first look at who the user is. Then we will find out how the user context look and which demands the context place on the user. And finally we will look at the user situations: in which situations might the user use the system?

4.1.1 Target Group - Who is the user?

A lot of different users use a car today; also cellular phones are today spread among a lot of different kind of users. More and more people also use both a car and a cellular phone at the same time. Trying to narrow down the target group a little to be able to say something about them, it was decided to look into what are the Volvo car owners of today like and also what are VCC’s target groups like. These facts are VCC specific and this chapter 4.1.1 "Target Group – Who is the user?" will therefore be found in an extended form in Appendix E (for VCC only).

Another study that was used as a basis for this analysis is a study that the Swedish National Road Administration (SNRA) have made of cellular phone usage while driving. The study consists of 3 subprojects, the first subproject contains a literature review and interpretations on an questionnaire, in the second subproject they had discussions about cellular phone usage while driving with focus groups, one older (between 45 and 60 years old) and one younger group (between 19 and 26 years old) [Gustavsson 2003]. And that discussion was the basis for a questionnaire that they made as a third subproject and that considered the behavior and habits of drivers using cellular phones while driving [Thulin 2003].

Gender

If we look at car owners in general they can be both men and women and therefore should the design fit both genders. According to the study made by the SNRA the usage of cellular phones in the younger groups are as wide spread among men as among women, while in older age groups the men are more likely to have a cellular phone with them while driving [Thulin 2003].

Age and family situation

Persons can take their driving license when they are 18 and then drive until they can not handle it anymore, which mean we have a great age span among the users of a car. In the study made by the SNRA drivers that have access to a cellular phone in their daily travels are between 18 and 84 years old, 90 % of the age group 18-24 years had access to a cellular phone whereas only 30% in the age group 75-84 years [Thulin 2003]. This great age span among the car users mean the users are in very different life stages, some are in the pre-family stage, some have family and some are in the post-family stage.

Culture

A car is to be sold at a lot of different markets; hence the users are spread around the world, which means every specific language for every market is to be considered. That also means the users come from a variety of cultures.

A novice or an expert, i.e. a casual or a frequent user?

Sometimes car users can have access to more than one car and we therefore might have casual users of the car. It is therefore important to think of that the user might be using other brands with other technical solutions in it. The user might then confuse the different user interfaces in the different cars.

In the SNRA study there were some of the users that were less experienced with using a cellular phone and they had a little more restricted way of using their cellular phone while driving, for example not using the telephone when dark or stopped when they got a phone call. In the subproject with focus group discussions, it was more people in the older group that were less experienced [Gustavsson 2003]. In the younger group some of the users were addicted to their cellular phone; we can therefore call them experts.

Motivation

Using a cellular phone while driving is most of the time a voluntary act, except for the users that need to drive a lot in their work and at same time are required to be reachable. For other users it is voluntary to have the cellular phone on while driving, it is also voluntary to use it or not. The users can always choose when to make a call or if they like to answer an incoming call depending on the traffic situation at the moment. The voluntary aspect make the users motivated when using the cellular phone while driving, otherwise they would not use it. Though in the study made by the SNRA the younger group in the focus discussions felt a pressure when they had a cellular phone to always have it turned on, they wanted to be reachable 24 hours a day [Gustavsson 2003]. This pressure might make them feel like it is a little less voluntary to use the cellular phone while driving. But in the end they still always have the choice to use it or not. Some of the less experienced in the older group did not use the cellular phone much when they were driving, that means that they most of the time were not motivated enough; on the other hand when they used it they really were motivated.

4.1.2 User Context

The user context is in a car. If the user is the driver the user context is much more complex than if the user is a passenger, since a driver of a car usually performs much more complex tasks than a passenger. The primary task for the driver is always to operate the vehicle in a safe way both concerning themselves and other road-users in the surrounding. The driving task consist of gathering visual information from the forward scene, processing that information, and performing appropriate manual responses to maintain the vehicle on the road and avoid collisions with other objects. While driving the driver may also do secondary tasks, for example obtaining information about vehicle performance and status, responding to changes in driving conditions, or accommodating comfort and entertainment interests of passengers. In general, secondary tasks place similar demands on the driver as the primary task; for most secondary tasks to be completed the driver have to allocate visual, manual and cognitive resources. Many studies have been made where various aspects of the driving task with regard to attention demands were evaluated. Attention demands when driving a vehicle can be divided into three categories: visual, manual and cognitive demands [Gellatly 1997].

The driver gathers information from the driver environment through the visual channel, at the same time the most in-vehicle devices require visual attention to its interface, either to read visual output or to manually give input. That means the visual demands of the drivers are to use their vision to obtain both information from the forward road scene and the in-vehicle display or control. For these competing tasks drivers only have one visual resource. Given that the eyes do not operate independently of one another the drivers must apply time-sharing between the two tasks. As a result the visual demands of a secondary task can affect the driving performance, behavior and the driver acceptance of the secondary task design [Gellatly 1997].

To control the vehicle and accomplish in-vehicle tasks the driver performs manual output. For example the driver uses the hands to steer the vehicle and to manipulate in-vehicle systems and the feet to control acceleration and deceleration of the vehicle. The driver can do two or more different manual tasks at the same time (hence the driver does not have to do

timesharing all the time as in the visual channel). However not all manual tasks can be performed at the same time in all situations. One example is that when drivers drive they can have one hand on the steering wheel to control the vehicle while the other hand is used to manipulate an in-vehicle system, but then the driver have to do a sharp turn and then both hands are needed on the steering wheel. That means the secondary task will be interrupted. Consequently the driver occasionally has to do timesharing between the manual demands. Steering the vehicle is a primary task that has a high level of manual demand. A secondary task that also has a high level of manual demand is to manually dial on a handheld cellular phone and therefore it may interfere with the primary task to steer the vehicle in a safe manner. For that reason also the manual demands of a secondary task can affect the driving performance, behavior and the driver acceptance of the secondary task design [Gellatly 1997].

Cognitive processes are for example problem solving, information processing and decision making. Examples of tasks where these kinds of cognitive processes are used while driving are route planning and to estimate if the car will fit into a parking space. The cognitive processes are constantly changing, following the changing of the environment. The traffic is part of the environment for the driver and it is dynamic and always changing, and can also be very complex some times. Another part of the environment is in the car, where instruments, controls and talking to passengers can change the cognitive processes. Secondary tasks could, as with the example of speaking in a cellular phone, demand high cognitive attention which can disturb, delay or eliminate the ongoing cognitive processes concerning the driving task. According to studies, experienced drivers (with more than 10 000 driving hours) get less distracted by secondary tasks, since the driving task demands less cognitive capacity from them than from an inexperienced driver [Patten 2003]. The cognitive process of information processing is a selective process, which in the driving situation is important for the driver to be able to sort out unnecessary information to safely drive the car. If the driver does not manage to sort out any information in a complex situation with a lot of information, there might be an information overload, which means there is too much information for the brain to process. Information processing is partly automatic but is sensitive for distractions [Spolander 2001].

A study that examined the driver's visual behavior showed that when the cognitive load increased the drivers made fewer saccades³, spent more time looking centrally and spent less time looking to the right periphery. They also spent less time checking instruments and the rear view mirror. Performing additional tasks which increased the cognitive load while driving, also resulted in more incidents of hard braking. The result of that study indicates that even when in-vehicle devices are hands-free, the cognitive distraction associated with the use of the devices result in a change of the driver behavior [Harbluk 2002]. That is, the cognitive demands affect the visual and manual behaviors which are affecting the driver performance. Also to divide attention between two different tasks seems to implicate that they both get done worse. Therefore the interfaces for these secondary tasks have to be adapted to and subordinated to the driving, hence they should acquire minimal cognitive and physical load.

The user context can differ in light conditions, some times the user might be driving at night and some times in bright daylight. The light conditions may affect the visual and cognitive demands, for example when it is dark it can be harder to see something (the visual demand is higher) and decide what it is (the cognitive demand is higher). For that reason the interface should be designed not to have higher demands in a situation where the driving task has higher demands. Also the audio both inside and outside the car can differ in different driving situations, which if it is loud might disturb the cognitive processes.

4.1.3 User Situations

There are a lot of different driving environments which means the demands on the driver varies depending on the driver situation. Some time it is a complex situation, e.g. in town with a lot of traffic, signs and pedestrians and sometimes there is a simpler situation e.g. driving on an empty motorway. Further, the internal situation varies, e.g. the drivers can be alone in the car or have passengers. This means that the design should consider that drivers could be alone in the car, hence the drivers have to be able to do it themselves, and they cannot always ask a passenger to do it. It should also consider the fact that in some situation

³ A saccade is a rapid irregular movement of the eye as it changes focus moving from one point to another.

the users might be carrying children in the back which might mean a noisier environment. For VCC figures on these different driving situations can be found in Appendix E (not in the public version).

In the study of mobile phones usage while driving made by the SNRA 70% of the drivers of private cars that had cellular phones with them always or almost always have them activated [Thulin 2003]. There is a difference in the age groups, in the age groups 18-24 and 25-34 over 80% had their phones activated always, whereas in the age group 65-74 years the percentage was under 50%. The average for company drivers that had their phone activated always was 80 % (compared to 70% for private drivers). Users that really used their cellular phones during their daily travels (and not only had them activated) were approximately 30%, were men used their cellular phones more than women and the age groups 18-24 and 25-34 used it more than other groups. 26% of all the drivers' conversations occurred in the weekend, which relative to the mileage that is driven on weekends means that more conversations occur on the weekend than on weekdays [Thulin 2003].

The younger group in the study with focus groups used it in country roads, on motorways and while driving in town. They thought it was easier to use it while driving out of town, on motorways and country roads, than in the more complex traffic situation in town [Gustavsson 2003]. In the questionnaire a third of the drivers said that they used their cellular phones most often in urban traffic [Thulin 2003]. 65% of the drivers who made calls while driving said they always, almost always or often choose a time when there was little traffic when they were going to make a call. 55% said they always, almost always or often choose a time when the traffic stood still or was moving slowly. 25% of the drivers avoided answering their cellular phones under night driving and a third from the rest at least reduced their usage when it was dark.

The young group wrote and sent text messages while driving much more than the older ones [Thulin 2003]. Text message were not written when it was heavy traffic, congestions or while driving at night. The younger group stated that they were curious when somebody called or they got a text message, they then wanted to read the text message and answer it immediately [Gustavsson 2003]. They younger users often called from the car simply to say that they soon will arrive.

In the focus group discussions, there were a difference in the older group in experience with cellular phone use depended on if the users used their cellular phone for work or not. For the ones using it for work it was a lot of time a condition to be able to use it while driving, since the time they spent in the car were working time. Some in the older group thought that they did not really needed the cellular phone on their short way to and from work, but the most in this group had their cellular phones on at these times anyway [Gustavsson 2003].

4.2 Task Analysis

4.2.1 Definition of the Task

The task is to use a cellular phone in a car environment. If the user is the driver, the car environment implicate a driving situation, which means the task is a secondary task to the primary task to control and safely maneuver the car. If the user instead is a passenger the task of using a cellular phone is not directly affected by the car environment and that case is therefore not considered further in this analysis.

4.2.2 The Goal of the Task

The goal of the task is to in one way or another communicate with someone elsewhere.

4.2.3 Task and Subtasks

A user can use a cellular phone in many ways. The task to use a cellular phone can be broken down into several tasks depending on what the user want to use it to. The important different subtasks to use a cellular phone in a car environment are the following:

- Make a call
- Receive a call
- Reject a call/ terminate a call

- Use the phone book
- Use Text messages (SMS)
- Make adjustments to the performance

These subtasks are further divided into subtasks as follows. Some of these subtasks can be made in different ways which implicates that these subtasks have different subtask depending on in which ways they are made.

- Making a call
 - Activate the phone
 - Dial the number
 - Dial the number manually
 - Recall the number
 - Give the digits in the recalled number as input
 - Start the call
 - Speed dial
 - Recall the speed number
 - Give the speed number as input
 - Start the call
 - Last number called
 - Find the last number called
 - Start the call
 - Choose a number from the phonebook
 - Find the right entry in the phonebook
 - Start the call
 - End the call (that is tell the system to terminate the ongoing call)
- Receiving a call
 - Answering an incoming call
 - Using buttons
 - Using voice
- Use Phonebook
 - Write to it
 - Read from it
 - Delete entry
- Use SMS
 - Write and send
 - Receive and read
- Make adjustments to the performance
 - Change the call volume

If the cellular phone is also to have a Bluetooth connection with the car the task of pairing and establish a connection between the cellular phone and the car have to be completed.

- Pairing
- Connection

4.2.4 Cognitive Aspects on the different Subtasks

In general to speak in a cellular phone demands cognitive resources and this can effect the cognitive processes used for driving (see chapter 4.1.2) The cognitive aspects of the different subtask follows here:

Making a call (manually)

1. Activate the phone (manually)
 - a. Move hand to phone
 - b. Press Power (or similar)
2. Dial the number
 - a. Dial the number (manually)
 - i. Recall phone number (normally in blocks of numbers)
 - ii. Press digit (repeat until last number)

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- iii. Press last digit (repeat until last block)
 - iv. Choose to send the phone number
 - v. Move hand to wheel (if hands-free)
 - b. Speed dial (manually)
 - i. Recall the speed number
 - ii. Press speed number
 - iii. Choose to send the speed number
 - iv. Move hand to wheel (if hands-free).
 - c. Last number called
 - i. Find last number called
 - ii. Choose to send the number
 - d. Choose a number from the phonebook
 - i. Choose Phonebook in menu
 - ii. Find person either by
 - a. Go through the phonebook step by step (through using forward button) until the right entry is found
 - b. Chose search in phonebook menu, then recall and enter the name or the beginning of the name
 - iii. Press send
 - iv. Move hand to wheel (if hands-free).
3. End the call
 - a. Move hand to phone
 - b. Press Hang-up
 - c. Move hand to wheel

Receiving a call (manually)

1. Hear the ring signal
2. Look at the phone number at the display
3. Decide to answer (or not)
4. Press the yes/enter button

Use Phonebook (manually) (for dialing number from phonebook see above)

For all tasks concerning the phonebook the phonebook entry in the menu first has to be chosen.

1. Write new entry
 - a. Choose add
 - b. Press the digits to give every letter in the name in
 - c. Confirm the name
 - d. Press every digit in the phone number to give it as input
 - e. Confirm the phone number
2. Read from it
 - a. Choose search
 - b. Read the entries name for name in a step by step manner
3. Delete entry
 - a. Find the entry (as described above in Making a call:2:d:ii)
 - b. Choose delete

Use Text messages

Choose Messages in menu first.

1. Write and send text messages
 - a. To answer a received message
 - i. Having the actual text message present, choose to reply
 - ii. Formulate what to say in message
 - iii. Write the message with the digits to entry the letters in the message and check on the display that the right letters where entered.
 1. for those with T9 choose between words
 2. for those without: entry every letter of the message
 - iv. Choose send
 - b. To write a new SMS
 - i. Choose write message in menu
 - ii. Formulate what to say in message

4 Requirements Gathering & Interactions

- iii. Write the message with the digits to entry the letters and check on the display that the right letters where entered.
 1. for those with T9 choose between words
 2. for those without: entry every letter of the message
- iv. Choose to whom the message should be sent, either by
 - a. give the phone number in
 - b. find that person in the phonebook
- v. Choose send

2. Receive and read text messages

When receiving text messages, one only needs cognitive aspects to attend to the signal.

To read text messages:

1. Choose read
2. Look at the display
3. Press forward button to be able to read the entire message.

4.2.5 How is the Task accomplished today?

The SNRA study about cellular phone usage while driving, shows that the subtasks are different accomplished by different people while driving. Among the younger users in the focus group discussions there was a slight difference between male and female users. The women were a bit more restrained in their use of their cellular phones while driving, whereas the men were more self-confident in the traffic and were less restrained with their use. In both the younger and older groups there were some users that were less experienced with using a cellular phone and they had a little more restricted way of using their cellular phone while driving, for example they tried to stop somewhere if they got a call while driving in a complex driving environment in a town. Some of the older ones always stopped when they got a call. Some of the users stop if they have to take a note as well and some of them stop so the cellular phone will not lose its signal strength [Gustavsson 2003]. In the questionnaire 25% said that they did not make calls while driving and 10% never answered a call when driving. More women then men avoided to use the cellular phone while driving, also older ones avoided it compared to younger ones (except for the age group 18-24, where they have not had their driving license for that long). Among the ones who made calls while driving there were 30% who said that they always, almost always or often stopped when they made a call [Thulin 2003]. 55% said that they always, almost always or often slowed down when they were going to make a call, one can speculate that they do it to make up for the fact that their attention is diverted to a secondary task and not only to the primary task.

65% said that they always, almost always or often choose a time when there is little traffic when they are going to make a call. 55% said they always, almost always or often choose a time when the traffic stood still or was moving slowly. 70% said they always or almost always avoided passing other cars when they made a call [Thulin 2003]. In the focus group discussions the users thought it was easier to use the cellular phone when driving out of town. Some of them only made calls themselves when driving out of town. Some of the older users prepared the call by first giving the phone number in and then they waited until a better driving situation occurred before connecting [Gustavsson 2003].

Drivers made or received 7.4 calls per week in average while driving, in most cases they received more calls than they made. The duration of the calls had an average of 2 minutes, where the received calls were longer than the ones that the driver made. 70% of the drivers who received a call when driving said that they tried to minimize the duration of the call. 40% also said they asked a passenger to answer the phone call. Another usual thing for the drivers to do was to ask if they could call back later at a more appropriate time or if the caller could try later [Thulin 2003].

More users among the younger users write and send, receive and read text messages while driving, than among older users. When they write a text message they first write it and thereafter check it. Some of the younger ones did not write/read text message in complex traffic situations [Gustavsson 2003].

In the focus group discussions all the users thought they were worse drivers when speaking on the cellular phone while driving. They believed that they were then less concentrated on the driving task, which made their driving unsteady and jerky. They also said that they

missed exits and changes of traffic lights more frequently when using their cellular phones while driving. They also had problems with holding the right speed; either they drove too slowly or too fast for the traffic conditions. When using cellular phones they also had problems with steering, putting the blinker on and changing gear.

Some of the users used hands-free when driving, some did not. The users thought it were difficult to drive without a hands-free to the cellular phone compared to having one, even though not all of them had one. Especially it was easier to change gear, steer and use the indicator when a hands-free was used. The ones who had hands-free kits to their cellular phones had problems with the cable getting stuck in the stick shift or in the safety belt. They thought that the best thing were the permanently mounted hands-free that are available in cars today, since it is only to press a button to answer a call and then the music is lowered as well [Gustavsson 2003]. Users that have a built-in phone with hands-free system in their cars today and do not want to have a special phone number for the car, have to transfer their SIM card from the cellular to the car or if they have a twin card they have to transfer the calls to the car by giving a number in. In the usability evaluation of this system [Larsson, 2003a] this was one part where problems were identified. The ones which had to take out the SIM card of the cellular phone and put it in the car phone thought it was too much work doing this step therefore a lot of them did not care to do that on an every day basis. Some of the ones with a twin card never remembered what number to call; therefore they thought it was too much work with transferring the calls to the car phone. According to the SNRA questionnaire 75% of the cellular phones used while driving are of handheld type, the rest is hands-free. Among the hands-free the most were of headset type and not permanent car mounted. Company or leased cars were more likely to have hands-free equipment than privately owned cars. The young and older people were more likely to use a handheld phone than the other age groups [Thulin 2003].

As described above using a cellular phone in a car environment can be done either by using a hands-free or handheld cellular phone, what are the advantages and disadvantages with these two?

The driver can be distracted by cellular phones while driving in two ways: either physically or mentally. The physical distraction can be for example when the driver has to move one hand off the steering wheel to make a call or receive a call (through pressing a button) or when the driver has to take the eyes off the road to dial the phone number. The physical distraction interferes directly with the drivers focus on the main task driving. The physical distraction is of course higher with the handheld cellular phone than with a hands-free, the duration of the physical distraction is longer as well. Using a handheld cellular phone means that the user have to hold the phone with one hand all the time and have one hand less for changing gear, steering and using indicators.

A mental or cognitive distraction, is when the driver is concentrating hard on something other than driving the car, for example on a conversation. To divide attention between two different tasks seems to implicate that they both get done worse. Although most people can think of other things when driving, researchers have found that as soon as drivers start to think that the driving conditions are easy or straightforward, their attention to the road lapses and they are actually more likely to have an accident. Drivers that use phones that are mobile while driving are more vulnerable to this form of distraction than other drivers, which have been a concern for researcher since 1969. This since the conversations that the drivers have on their cellular phones while driving are more likely to be business related, urgent and intense than a conversation with passengers [RoSPA 1997].

The users in the study by the SNRA felt safer when using the hands-free, they also seemed to talk longer on the phone while using hands-free compared to using a handheld [Gustavsson 2003]. There are though a lot of studies that says that it is not safer to use a hands-free than a handheld cellular phone, since the greatest safety risk is having a phone conversation due to the high cognitive demands.

Today calls can also be initiated through voice on some cellular phones, but it seems like the technique is not good enough for the sometimes noisy environment in the car (for example when rain are falling against the windscreen). Also, users can only make calls to the ones that they have recorded a voice tag to, hence there is not possible to dial new numbers using the voice.

4.2.6 Advantages with a new system

After these analyses, the following advantages with a Bluetooth connection between the car and the cellular phone can be claimed:

- The new system will have some of the benefits that hands-free have, such as less physical distraction while driving, for example to steer, shift gear and use indicators will be easier.
- The advantage that no cables need to be attached (or get stuck in the stick shift), the phone calls will automatically be transferred to the hands-free in the car.
- Compared to a built in hands-free system today, the user does not have to transfer the SIM card. Or in the case with a twin card the driver do not have to remember what number to call to transfer the calls to the car.
- On today's cellular phones the screen is small, the new system will provide a bigger screen and hopefully then a more legible text.
- Hopefully less cognitive and physical load on the driver with the new interface, this will lead to a safer driving.
- A user interface that is adapted to the car environment and the driving context.

4.3 Requirement Specification

The requirements come from the user analysis and the task analysis. Then there are also many official recommendations and guidelines in this area, e.g. the Europe commission recommendations "on safe and efficient in-vehicle information and communication systems: A European statement of principles on human machine interface" [EU 1999]. The driver focus-telematics working group (in the US) has developed best practice/guidelines [DF-T 2002] and Ford (the owner of VCC) has developed "Trust marks" from these guidelines. Therefore it was decided in the thesis project to look at these guidelines even though many of the guidelines are the same as the recommendations from the EU.

4.3.1 Functional requirements

The functional requirements for the user interface require that the system supply these functions. The functional requirements are ranked in order of priority, where the highest priority is "Need-to-have", then comes "Important" and last comes "Nice-to-have". The functional requirements build on what functionality the system should have according to VCC.

The user interface should support the following functions:

Need-to-have:

- Pair a cellular phone with the Bluetooth node in the car
- Have a connection between the cellular phone and the Bluetooth node in the car
- When a connection is established the interface should give the user the possibility to:
 - Make a call
 - By giving in a telephone number
 - To a phone number in the phonebook
 - To a phone number in a phone list
 - Receive a call
 - Reject a call/terminate a call
 - Use Phonebook
 - Read and search the phonebook
 - Call number from phonebook
 - Make adjustments to performance
 - Adjust the volume of the call
- Handover an ongoing call from the cellular to the car

Important:

- When a connection is established the interface should give the user the possibility to:
 - Make a call
 - To the voice mailbox with a direct button
 - By using voice tags
 - Use Text messages
 - Receive and read
 - Delete

Nice-to-have:

- When a connection is established the interface should give the user the possibility to:
 - Make a call
 - By giving in a telephone number with voice recognition
 - With speed number
 - Use Phonebook
 - Write a new entry ⁴
 - Use Text messages
 - Write and send⁵

The user interface should give the user the following Status information:

Need-to-have:

- If there is a Bluetooth connection and to what device there is a Bluetooth connection
- Signal strength for the cellular phone
- The Operator
- Mode for the cellular phone (such as active and standby)

Nice-to-have:

- The battery load for the cellular phone

The user interface should give the user the following information:

Need-to-have:

- The phone number /speed number /person dialed at the moment
- The phone number (or name if in phonebook) from which a incoming call comes from
- Time duration during the call
- When a call is terminated the interface should give information about what is happening and the time duration of that call
- When the user ask for it, the interface should give the phone number (and name if in phonebook):
 - of received phone calls
 - of missed phone calls
 - of 10 last called

The user should be able to use the interface under the following conditions:

- At nighttime
- In bright daylight
- Under noisy conditions, either noise from the outside(for example roadwork) or inside (for example children in the backseat)

⁴ This have priority "Nice-to-have" because safety reasons make it something that should not be done while driving.

⁵ Here are also safety aspects while driving a reason why it gets this priority, but also the fact that technically there will be no T9 or other simple interface for writing text messages available in the system.

4.3.2 Usability requirements

Usability describes how effectively a user can interact with a product. Usability is a measurable characteristic, which is present to a greater or lesser degree. A very general way of classifying it is to look at: how easy it is to learn and how easy it is to use. There are a lot of different groupings of usability; for this thesis the Bennet and Schackel's grouping [MDI 2002] was chosen based on positive previous working experiences. They divide usability into the following four categories: Learnability, Flexibility, Throughput and Attitude. As the automotive industry regards safety as such an important issue, the category safety was imported. This can be found in other groupings, e.g. Preece [Preece 2002] where the usability goals are: effectiveness, efficiency, safety, utility, learnability and memorability.

Since safety is an important aspect in the driving situation those requirements are first stated in a safety category and then the rest of the requirements are sorted into Bennet & Schackel's categories. All motivations are the author's.

4.3.2.1 Safety

The safety requirements below (except number 13) are taken from the EU-recommendations [EU 1999] and the DF-T guidelines [DF-T 2002].

1. "The user interface should be designed in such a way that the allocation of driver attention to the interface displays or controls remains compatible with the attentional demand of the driving situation."
Motivation: The driving task is the primary task and the Bluetooth device is only a secondary task.
2. "The system should be designed so as not to distract or visually entertain the driver."
Motivation: Distraction can easily lead to a serious traffic situation.
3. "Visually displayed information should be such that the driver can assimilate it with a few glances which are brief enough not to adversely affect driving. A visual or visual-manual task intended for use by a driver while the vehicle is in motion should be designed to the following criteria:
 - a. Single glance durations generally should not exceed 2 seconds; and
 - b. Task completion should require no more than 20 seconds of total glance time to task display(s) and controls."*Motivation:* Visual attention is crucial for the primary task of driving, therefore should not subtasks compete for this resource to much.
4. "The system should not produce uncontrollable sound levels liable to mask warnings from within the vehicle or outside or to cause distraction or irritation."
Motivation: Warnings are important for the safety and should therefore not be masked by sounds from subtasks.
5. "System controls should be designed such that they can be operated without adverse impact on the primary driving task."
Motivation: Since the task is a subtask to the primary task of driving, controlling the subtask should not affect the driving task.
6. "The driver should always be able to keep at least one hand on the steering wheel while interacting with the system. That is; all tasks that require manual hand control inputs (and which can be done with the system while the vehicle is in motion) should be executable by the driver in a way that meets all of the following criteria:
 - a. When some system controls are placed in locations other than on the steering wheel, no more than one hand should be required for manual input to the system at any given time during driving.
 - b. When system controls are located on the steering wheel and both hands are on the steering wheel, no system tasks should require simultaneous manual inputs from both hands, except in the following condition: one of the two hands maintains only a single finger input (e.g., analogous to pressing "shift" on a keyboard).

- c. Reach to the system's controls must allow one hand to remain on the steering wheel at all times.
- d. Reach of the whole hand through the steering wheel openings should not be required for operation of any system controls. "

Motivation: At least one hand is required on the steering wheel to safely drive the car.

- 7. "Speech based communications systems should include provision for hands-free speaking and listening. Starting, ending, or interrupting a dialog, however, may be done manually. A hands-free provision should not require preparation by the driver that violates any other principle while the vehicle is in motion."

Motivation: Speaking and listening are hands-free and that disadvantage disappears for example if the user all the time has to press a button.

- 8. "In general (but with specific exceptions) the driver should be able to control the pace of interaction with the system."

Motivation: When driving all sorts of situations can occur, which means one time the user can interact quickly and another time it may take longer. The interface should also not stress the user to interaction, since that can result in accidents.

- 9. "The system should not require long and uninterruptible sequences of interactions." The users should always have the possibility to interrupt what they are doing. Interrupt here can be in two senses, either interrupt it temporary i.e. the action can later be resumed or interrupt it permanently if they decide not to do the function at all.

Motivation: Some times the driving situation demands users to interrupt secondary tasks, and some times it might be such a complex situation that drivers do not want to continue later and some times the driving situation might only be complex for a moment and then easier again hence users want to resume the task started.

- 10. "The driver should be able to resume an interrupted sequence of interactions with the system at the point of interruption or at another logical point."

Motivation: Some of the users prepare the call by first giving the phone number in and then they wait until a better driving situation occurs before connecting (also see motivation for no 9).

- 11. "The system should not require the driver to make time-critical responses when providing input to the system."

Motivation: The driver might not be able to make a response within a special time, since right then something concerning the primary task can occur that have to have the attention from the driver.

- 12. "Sub-tasks should generally be broken down into discrete "chunks" that are as simple as possible in terms of the momentary workload their performance demands of a driver, and which consistently contribute to task completion. As discussed above, this task atomization approach facilitates interruptibility. "

Motivation: The task and its subtasks should cause as low distraction from the primary task to drive as possible.

- 13. The number of interactions/steps should be as small as possible.

Motivation: To do and remember every step is competing for the mental resources with the primary task of driving.

- 14. "The system's response (e.g. feedback, confirmation) following driver input should be timely and clearly perceptible. The maximum system response time for a system input should not exceed 250 milliseconds. If system response time is expected to exceed 2 seconds, a message should be displayed indicating that the system is responding. (Note: System response time criteria provided here is not intended to apply to systems controlled by voice at this time.)"

Motivation: It is important that the system give feedback and confirmation quickly, hence if there is for example a visual system the driver does not have to glance at the screen all the time to see if anything happens. When nothing happens people

start to wonder after a couple of seconds why nothing happens and start pressing all the buttons, therefore its important for the system to tell the user what is going on.

4.3.2.2 Learnability

Learnability can be defined as how easy it is to get started with the system – as well as how well a system supports competence development and re-learning for systems that are intended to be used infrequently and over a long period of time.

1. The user interface must be simple to use without training or studying the documentation.

Motivation: The driving situation gives no time for studying the manual.

- a. 95% of the first-time-users⁶ should be able to pair the cellular phone with the Bluetooth node at first try.
- b. 98% of the first-time-users should be able to make a call (by manually give the number in) with the device within two tries.
- c. 100% of the first-time-users should be able to receive a call with the device at first try.

2. The user interface should be easy to relearn (intuitive) and remember.

Motivation: The most users drive more than one car (which could have different interfaces or not the function at all), which can mean that there will be some time before the user use it again.

- a. Functions that are often used should be the first to be found.
- b. The second time to use it, after a week gone by, the user have to know how to use the functions within 30 seconds.
- c. 95% of the users should be able to receive and make a call (if the traffic situation allows it) immediately the second time they use it.

3. The user interface should strive for consistency.

Motivation: Learnability can be influenced by the components consistency and generalizability, i.e. if the system have a consistent design within the system and also can make use of general standards and guidelines (for example for icons, symbols and wording) the system should be easier to learn for the user (since it agrees with the users expectations).

- a. The user interface should have a consistent design throughout the whole interface.
- b. International standards for wording, abbreviations, icons and symbols should be used, as far as possible.

Help:

4. Even though the user should be able to use the interface without a manual, there should be a manual describing the functions, to help the user when needed (but not in the driving situation).

Motivation: The users can then prepare themselves before using the system if they want to.

5. 90% of the users should not have to use the manual (more than once) for the functions that they normally use⁷.

Motivation: The system should not differ much from a cellular phone, hence a normal function should not be hard to use for a user for the reason that it requires other interactions than the user is used to.

4.3.2.3 Flexibility

Flexibility can be defined as the extent to which system can accommodate changes

1. The user interface should support further development of more services to the cellular phone.

⁶ They are expected to have a previous knowledge about how to use Bluetooth technology

⁷ Meaning: that if one user never uses text messages, it should not be supposed that this user suddenly know how to use it with this interface.

Motivation: The cellular phone and its functions develops fast today, therefore is it important that the interface is open for new functions that the user might want to use in the car.

2. The user interface should also be extendible for other Bluetooth devices.

Motivation: There are more Bluetooth devices, which the user might want to use in the car in the future. There might also be more devices that will have Bluetooth technology in the future.

4.3.2.4 Throughput

Throughput can be divided into the following subcategories: task accomplished by experienced users, speed of task execution and error rate.

Task accomplished by experienced users

1. The second time to use the user interface 95% of the users should be able to accomplish all the functions that the user interface support (and that they normally uses).
2. The user should be able to identify from what number an incoming call is coming.
3. The user should (through the user interface) be able to tell the status of the cellular phone, such as the signal strength.
4. Novices as well as experts should see no difference in execution speed compared to using the cellular phone directly.

Task completion time

5. For both novices and experts it should not take longer to do the normal cellular phone functions with the user interface than to do it with a handheld device in the driving situation.

Motivation: Otherwise the user will not use the user interface. The user becomes motivated to use the system if their productivity is increased.

Errors

6. Low user error rate

Motivation: A low user error rate is important in the driving situations since errors mean irritation which can be hazardous to the driving.

- a. 95% of the times an user use the functions it should be a success⁸.
- b. When trying to do a subtask with the interface, no more than one error should occur.
- c. There should be no kind of error (depending on the user interface) that a user commonly repeats.
- d. The users should not choose the wrong function for the reason that they do not understand the wording/the language that is used.

7. Error handling

Motivation: If an error occur it is important that it can be handled easy and quick, hence it should not take to much time and attention away from the driving.

- a. For the errors that cause a system error, an error messages should appear and should explain how to recover from the error.
- b. When a complex error is made it should take maximum 5 steps for a novice to recover from that error or undo it.
- c. Undo should be available for most actions.
- d. Actions which cannot be undone should ask for confirmation.

4.3.2.5 Attitude

Attitude is the users' subjective satisfaction with the user interface.

1. The users should grade the user interface at least "6", on a scale from Difficult (1) to Easy (10).
2. The users should grade it at least "6" on a scale from Non-intuitive (1) to Intuitive (10).
3. 80% of the user should answer "no" to the question "Do you find it easy to do the wrong things in the interface?"

⁸ Complex driving situations that prevent the user to succeed is not included.

4. 75% of the user should answer "yes" to the question "Do you find it easy to recover when errors are made?"
5. 80% of the user should think that the user interface makes their driving safer, than driving with a handheld cellular phone.
6. 80% of the users should think that the effort to use the new interface and system is less than for a handheld cellular phone.
7. 90% should answer "no" on the question "Do you think the user interface require too much of your attention?"
8. 80% of the user should think the user interface gives relevant feedback and respond quick enough or when not responding quick enough tells the user what the system is doing.
9. 80% of the users should answer "no" to the question "Do you feel that the user interface stress you for an input?"
10. 80% of the users should answer "no" to the question "Are there a lot of unnecessary functions according to your opinion?"
11. The users should at least grade the user interface as "6" on a scale from Non-appealing (1) to Appealing (10).

4.4 Exploring Interaction Techniques

The human have a fixed amount of senses: sight, hearing, touch, smell and taste. The human uses these senses to interact with the world using *interaction techniques*. When exploring interaction techniques one has to both consider input and output. The different senses support different interaction techniques but an interaction technique often combines one sense for input and another for output, a typical combination being visual output and manual input. Although many interaction techniques do not require computers, the nature of this thesis limits interaction techniques in the following to mean hardware and software elements that together provide a way for the user to accomplish a task.

In research the input to computer systems is usually differentiated from output and will also be differentiated in this chapter (although in the same subsections). There are a lot of different ways of giving input and receive output with the help of the human senses. Smell and taste are though hard to use for human-computer interaction for technical reasons and will therefore not be considered further in this thesis. In the following, the advantages and disadvantages for interaction techniques in the car environment using the other three senses are described.

4.4.1 Visual Interfaces

Visual input is not a commonly used interaction technique. To be able to give visual input to a system a camera is needed to record what the user is doing, for example gestures or how the eyes are moved (eye tracking). What the camera records then has to be interpreted to give instructions to the system.

Visual input is overall not suitable to the car environment. Eye movements can not be used as input in the driving context since the eyes might suddenly have to move to look at the traffic situation. Eye movements are also hard to steer for the user without specific visual targets, and providing such encourage distractions from the primary task of driving, making it inappropriate to give instructions to a system. To do gestures typically the hands have to be moved. As this is the case also when pressing a button and since gesture recognition technology is not as reliable as button pressing, one can raise the question: if we have to move the hand why not press the button directly then, instead of doing a gesture that the system might misinterpret? To be useful, a gesture recognizing system should also have a camera that is always on; otherwise an interaction might be missed. This raises issues concerning surveillance: will the user be comfortable with the system monitoring them the whole time? It seems like visual input does not fit the driving context very well.

Looking at output, the premium way for humans to receive information is through vision, and a lot of interfaces today reflect that by heavily relying on visual communication (output) [Jacko 2003]. The great amount of visual output today makes it a familiar kind of interaction for drivers, meaning that the drivers do not have to learn new ways of interaction.

Visual information is persistent, i.e. it stays on the display until the user performs an action (unless it's programmed with a time out). This is an advantage in driving situations for the reason that the drivers do not have to look at the display immediately; instead they can choose when to look at the display. For example, drivers can wait to look when there is an important situation in the traffic, without missing any information. Drivers can also look back at the display and see the information again, for example if they did not understand the information the first time or they were interrupted when they were looking at the information.

Visual information can consist of both text and pictures. A visual interface easily makes most or all of the functionality of the system visible to a user, using menus and other visual elements. A visual interface is also good when a feedback from the system will take awhile, since it then can show the user what the system is doing, for example "The data is being processed", telling the user what is going on and avoid looking at the display continually to try figure out what is happening. Instead the driver can concentrate on the traffic and look at the road and only throw a few short glances at the display to see if it has changed.

A disadvantage with a visual interface in the driving situation is that it competes with the visual resources required for the driving task. A visual interface therefore interferes with the primary task and as stated in the user analysis this may affect the driving performance. For safety reasons the user's visual attention should therefore remain with the primary task, the driving task, for that reason it is difficult to design a visual interface that can work well under these circumstances.

The legibility of information (both for icons and text) is important in a visual display. The legibility is influenced by the following display parameters: resolution, luminance, contrast color, glare protection and placement [Helander 1997]. To become a good legibility there are a lot of guidelines and standards for these display parameters. This is though a complex subject and beyond the scope of the master thesis project, therefore interested readers are referred to the work by Helander.

4.4.1.1 Traditionally Computer Displays

A traditionally display is usually called a screen. These displays can be varied a lot depending on the display parameters mentioned above. How well such a display fits in to the driving context depends a lot on what values are set for the display parameters and then especially where it is placed. However nearly all cars today already have at least one traditional display, the screen on the car radio, and these have already been designed so they are placed where they do not disturb the driver and at the same time minimize the time it takes to move the eyes between the display and the traffic scene.

4.4.1.2 Head-Up-Displays

A Head-Up-Display (HUD) is a display that projects information onto the windshield. The Head-Up unit is located behind the instrument cluster, where the image is produced and reflected onto the windshield. The image appears to freely float over the hood in front of the driver; this means that drivers do not have to take their eyes off the road. An advantage with the Head-Up-Display is that the information is included in the visual scene which means that the peripheral vision can be used to detect emergencies and hazards at the same time [Peacock 1993]. However, the eyes have to adjust to the distance difference between the road and the displayed information but this is faster than adjusting to the greater distance difference between the road and the instrument cluster. For an average driver to read information from the instrument cluster it takes approximately one second, for drivers with eyes adjusting slower to distance changes the HUD can reduce this time by half. The HUD can be adjusted after the driver's seating [ARC 2001].

A study by Briziarelli and Allen to test the effect of a HUD speedometer on speeding behavior found no significant difference in behavior, but 70% of the test participants found the HUD speedometer easier to use and more comfortable to read from, than a conventional speedometer [Helander 1997]. The participants also said that they thought they were more aware of the speed when using the HUD Speedometer. In a simulator study made by Campbell and Hershberger (also reported by [Helander 1997]) a conventional display and a HUD display was compared under different levels of workload, with focus on steering

variability. The steering variability was less for drivers using the HUD than for the ones using a conventional display, both under low and high workload conditions.

A number of concerns concerning the display parameters (for example luminance and glare) have been raised about the use of HUDs. Another issue that has been questioned is the division of cognitive attention with HUDs, even if the driver look forward it does not mean that the traffic information is processed [Helander 1997]. The fact that the HUD is placed in the visual driving scene might cause a distraction for the driver. The virtual image (displayed by the HUD) might also obscure scene information [Peacock 1993]. Research has to find out if these aspects of the HUDs can be eliminated by improving the HUDs.

Every millisecond less the driver have to look away from the road is time that can be spent on the primary task of driving, therefore the head-up display could be a great progress for the driving situation (if the aspects above is solved). But what kind of information should be displayed on the windshield? Different car manufacturers may have different views on this. Some car manufactures already offers head-up displays today, and in the following picture we see the head-up display in the BMW 5 series.



Figure 8 The BMW head-up display [Siemens].

With visual displays there is the risk that it will be too cluttered when presenting a lot of information. Too much information easily causes a sensory or cognitive overload and the user will have problem understand any of the information. For these reasons only the most important information in the car should be displayed using HUDs. This leads to the question: what is the most important information in the car environment? Is the Bluetooth information included in the most important information? The importance of safety in the driving context dictates that information concerning the entertainment section in the car is not as important as that related to the driving task, e.g. speed, breaking distance and oil warnings.

Further, since an image from a HUD is displayed in front of the driver one can also answer the question of how good passengers can see the information (since the Bluetooth interface should also be available for the passenger). It also means if the passenger wants to use the interface and it is displayed in front of the driver, then the driver will be unnecessarily disturbed while driving.

4.4.1.3 Touch Displays

A touch display is a direct display, which means that the display is also the input surface. A touch-screen enables an intuitive interface, the user can choose something by directly touch it and do not have to handle a navigation tool. This could be a good form for controls in the car for pre-drive or zero speed cases, but research has shown that it is not good in the driving situation. A study (by Zwahlen et al) found an unacceptable increase of lateral lane deviation

(meaning swerving or changing lanes) with the use of touch panel controls, which demonstrated the high visual demands for the touch screen panels [Helander 1997].

Another disadvantage with touch screens are that depending on the angle of the touch screen the user's hand might cover some part of the screen and therefore hide some information. Also depending on the mounting angle, touch screens may result in arm fatigue [Jacko 2003].

An advantage with touch screens are that they support virtual buttons which can easily be changed and do not take more space after the initial investment in the screen, the latter good in the car environment where there is a limited space. But the touch screen lacks haptic feedback, which means that the user can see the buttons but cannot feel them, which means that they might not know if they pressed the button or not. The lack of haptic feedback leaves the user with the visual feedback, which might result in the fact that drivers have to look away from the road a longer time. First the drivers have to find the right button by looking at the display, then they have to look as they hit the button and then look for feedback (hence they can be sure they really hit the button). The greater visual glance time for the use of touch screen buttons while driving was shown in a study by Monty 1984. In this study it was also shown that the touch screen buttons resulted in greater driving and system task errors than conventional buttons [Helander 1997].

4.4.2 Auditory Interfaces

Vision and hearing is independent, therefore will auditory information not compete with the visual attention for the road. Investigations show that the user makes a better result if visual tasks are combined with auditory tasks and since the driving task have a high visual load, it should therefore be a good idea to have an auditory interface in the driving situation [de Waard 1996]. Our eyes have a small area of focus from which they can give us detailed information, whereas our ears provide us with information from all around. That means if we hear a interesting sound from outside our visual field we turn to look in that direction to get more detailed information. With other words our ears are telling our eyes where to look. This makes the combination of visual and auditory information a powerful interface [Jacko 2003]. The combination of auditory and visual information is good in the driving situation; an example comes from the observing of users using a navigation system that the author did this summer [Larsson, 2003b]. The users first listened to the speech directions and looked around to try to apply the information in the real world. Some times when they thought they could not apply the auditory information on the real world, they looked at the provided map (visual information) to understand what action to take.

Sound is attention grabbing. With visual information the user can chose not to look at it, but it is more difficult to avoid hearing auditory information [Jacko 2003]. Hence for information that demands immediately reaction or for delivering other important information sound is very useful. But on the other hand it also means that the sound also grabs the user attention when it is communicating not important information.

The facts that it is hard to shut out sounds and sounds are attention grabbing also leads to that people find auditory interfaces annoying. Example of users that found speech output annoying can also be found in the evaluation made by the author this summer [Larsson 2003b]. The fact that sounds can be annoying is one of the most common arguments for not using sounds in interfaces. There are two different actors that can be annoyed by the sound, on one hand the user and on the other hand the people in the environment around the user. There is a challenge in designing sounds that are informative and not considered as noise. If the user interface has a noisy environment it is also not a good idea to have an auditory interface, since information easily can be missed.

Sound is *transient*, which means that it disappears after it has been presented [Jacko 2003]. This means that users must remember the information that the sound gave and that can cause problems. Users' short-term memory is used when listening to speech, this in combination with the fact that speech is transient means that users can remember only a limited number of items in a list and important information that is provided in the beginning of a long sentence may also not be remembered. Therefore speech should preferably not be used as an interface when a large amount of information must be presented. In all cases the user must have a way to replay the information that was missed or forgotten.

A great advantage with an auditory interface is that it is both hands-free and eyes free, which is really appreciated in the driving situation where the hands and eyes are busy with the driving task. There are two kinds of auditory interfaces, speech and non-speech sounds.

4.4.2.1 Speech

Speech can be used both by the system for giving output and be a way for the user to provide input. Speech synthesis is used to simulate human speech as output. There are two kinds of speech synthesis; concatenated and formant synthesis. Concatenated synthesis uses the computer to assemble recorded voice sounds into meaningful speech. The recorded voice sounds make the concatenated synthesis to sound more natural than the formant synthesis, which creates machine generated speech based on a rule-based process. The formant synthesis however produces highly understandable speech and has the advantage that it can produce nearly unlimited speech. According to Weinschenk [Weinschenk 2000] it requires more processing capacity to listen to synthesized speech than to listen to natural speech since synthesized speech is harder to encode for humans. The encoding difficulty disrupts working memory and the transfer of the information to the long-term memory; therefore the humans also have more trouble to remember synthesized speech messages than natural speech messages.

When speech is used as an input technology, a speech recognition unit is used. Speech recognition refer to technologies that enable computer systems to recognize the sound of a human voice and separate it from other sounds in the environment (noise) and use the information provided by the voice for controlling the system. There are two kinds of speech recognition, continuous and discrete recognition. Continuous recognition is related to natural language and therefore can the user speak to the system in an everyday language and the user does not have to use fixed commands. To recognize everyday language is a difficult task and therefore the existing continuous recognition systems today are error prone and expensive to develop. Hence there are not many of these systems on the market today [Weinschenk 2000]. In contrast to continuous recognition systems discrete recognition systems only recognizes a limited amount of predetermined commands that are spoken with a pause between every word. Hence the user speaks a specific command and the system does the action that is coupled to this command and therefore are these applications called command-and-control application. The discrete commands might not be natural but they are easy to learn and give a higher rate of accuracy.

The speech recognition can be either speaker dependent or speaker independent. The speaker dependent recognition requires that the user do an enrollment, where the user reads a fixed text which the recognition optimizes for that person. With current speech recognition this enrollment takes between 20 and 30 minutes. The speaker dependent recognition has a higher accuracy than the speaker independent but is also less flexible since it cannot be shared. The car might have different drivers therefore there is not a good idea to have a speaker dependent recognition system in the car. It is also doubtful if the driver would take the time to do the enrollment process of 20-30 minutes. The speaker independent is in contrast designed to work for multiple users. Since there are no enrollment process, the accuracy is lower and therefore the system are not reliable for tasks that need a large lexicon, it is instead used for specialized and single tasks. The realistic size of the lexicon to the speaker independent recognition is at the present 40 command words or less, plus the digits zero through nine [Weinschenk 2000].

Native speakers of a language are more successful in using speech recognition systems than nonnative speakers, since the nonnative speakers may create sentences that do not obey the rules of the languages. Hence when the users have different native languages then the system should be developed so the users can chose in what language they want to communicate with the system, from a specific set of languages available [Jacko 2003].

One important issue with speech recognition is to sort out the noise since the noise and interfering sounds leads to higher error rates for the speech recognition. The car environment is a pretty closed environment which gives the user a chance to control background conversations (as long as the driver can control screaming kids in the backseat). The audio system in the car is another source for noise, but this source is known and therefore can the interfering signal be measured and strongly suppressed by the system. Transient noise such as for example a truck passing by a car with the windows down is though still a difficult challenge for the voice recognition systems today [Jacko 2003].

Speech is natural for humans, which is a major benefit for using speech as an interface. Since speech is a natural everyday activity it may be more easily learnt and accepted by the users [Graham 1999]. The fact that speech is natural for humans also means that the expectations of the users on the speech application tend to be extremely high. Unfortunately speech is not natural for computers which mean it is hard to get a speech interface with 100% accuracy. When humans interact with a machine, they can be expected to speak slower and clearer and this would then enhance the recognition performance. But we humans tend to react to new media with our "old brains", therefore we respond automatically to speaking computers as if they were other humans [Jacko 2003].

User motivation is important when using speech interfaces, if users are motivated they do not mind a 20 minute enrollment process to train the system with their voice and they make an effort to speak clear. One way to motivate users is always to increase their productivity. System functions that are embedded in a deep structure might be more easily accessed with speech control than in a menu structure in a visual-manual interface. But that requires that the user already know that this function is available. And that is a challenge for speech, to make it visible for the user what functions the system provides; to show the users what actions they can perform and what to say to perform these actions.

Feedback is important for users and when there are systems delays in speech only systems, the systems do not have a way to tell the users what state it is in. Users might therefore see performance delays as pauses, and pauses in a human-human conversation often means they were not heard or not understood and if the users interprets the pauses in that way they will be confused by the system [Jacko 2003].

If we look at the competitors in the automotive industry most of them have some kind of voice recognition to their Bluetooth Solutions (at least DaimlerChrysler, Ford and BMW). When an evaluation of the infotainment system was made in the year 2000 the question about what the user wanted in the future was asked and then all of the respondents wanted to have voice activation controls in the car [US-study1 2000]. In the evaluations the author did this summer [Larsson, 2003a&b] there were also 10 users of 15 that wanted to be able to control the navigation system with voice control in the future, and 5 users who wanted to control the infotainment system with voice control, although some of them required better speech technology than is available today. And as said before, the fact that speech is a natural way for humans to communicate easily make their expectations of speech interfaces high, and the speech technology of today do not meet these expectations. Hence if one wants to use speech technology today it is important to find good ways of dealing with the misrecognition and misunderstanding in speech recognition of today. Speech is right now a developing field, where a lot of research is done, which means one can expect improvements in the performance for the speech interfaces. For the driving situation that would be great, since a speech interface have the great benefit of being hands-free and eyes free, which is important for the manually and visually demanding primary driving task.

4.4.2.2 Non-Speech Sounds

In the area of non-speech sound in human-computer interface there have emerged two types of information presentation techniques: auditory icons and earcons.

Auditory icons are sounds of natural everyday events, for example tapping or smashing sounds that are used to represent actions or objects in the interface. Since auditory icons use natural sounds the listeners can easily learn and remember the meanings of the sounds, which is a great advantage with auditory icons [Jacko 2003]. In contrast, earcons use abstract and synthetic tones to combine an auditory message. Since earcons and what they represent have no intuitive connection, it is harder for the user to learn the meaning of an earcon than for the auditory icon.

If sound is to be used in a user interface it has to be sounds that can not be misinterpreted. In those cases where there are no naturally sounds it means the user have to learn which sounds mean what. Recommendations on how to design sounds "for use in cars to convey non-urgent or non-critical information" can be found in the master thesis "An Investigation of the Functionality and Acceptance Factors of Earcons for Car Use" [Berg, 2002]

If we compare speech and non-speech sounds for interface design, it is like comparing text (speech) and icons (non-speech) to use a visual analogy. Speech has a serial nature; the user has to hear the speech from the beginning to the end which makes it a slow way to present information. Non-speech sounds are instead short and therefore more rapidly heard. In speech the meaning is contained while the user has to learn the meaning of the non-speech sound (as in the visual case). These characteristics of the different sounds makes the speech more suitable for giving instructions and the non-speech sound more suitable for rapid feedbacks on actions [Jacko 2003]. Non-speech sounds alone as interface is therefore not to recommend in this case. Although in a speech interface or a visual interface the non-speech sound can be a great help.

4.4.3 Haptic interfaces

The sense of touch is important when understanding the world, but an output that uses the sense of touch, a haptic output, is not common in the human-computer interaction field. Looking at feedback from a technical perspective, different forms of feedback can be passive or active. Applied to haptic feedback, passive haptic feedback is given by physical properties, such as the feel of a button (shape and surface) and active haptic feedback is controlled by a computer, for example vibrations.

In an active haptic output the computers produces synthesized physical sensations to the skin and muscles of the user, using the users' sense of touch, weight and rigidity. Haptic sensations are though hard to synthesis if compared with visual and auditory sensations. One reason for that is the fact that haptic sensations can occur at any part of the body (in comparison with the visual sensation that is gathered at one place, in the eyes, and the auditory in the ears). This makes it hard to separate from actual physical contact.

Force feedback and tactile feedback is included in active haptic feedback. Force feedback is an active representation of forces to the user, for example different degrees of resistance can be used. Tactile feedback is an active presentation of vibrotactile stimuli to the user, for example vibrations. Even though there are difficulties in synthesizing haptic sensations there are several commercially available active haptic interfaces, but then they also are limited in their functionality and are expensive [Jacko 2003].

A disadvantage with haptic feedback (provided by a computer) is that it is hard to convey a message to the user and that it is a very unfamiliar interaction for the user. Since haptic feedback means physical contact it will also be hard to make a suitable haptic interface that both the driver and passenger can use. The tactile sensitivity is degraded by low temperatures, which makes it less good solution for users in colder climates [Helander 1997]. More studies also have to be made about how humans react to haptic feedback, since there would be no good idea if the user (naturally) reacted on the sensation on the skin with moving that part of the body, for example the arm and then at the same time accidentally moved the steering wheel.

If we are not looking particularly at the human-computer interaction field, there are kinds of haptic feedback that are used in the car environment and that is in the design of manual controls. For example the resistance in the pedals or turning knobs that have different states or that the buttons feel different (passive feedback) hence they can be differentiated without looking at them. Sometimes when the users use manual controls to give input they both use their vision and their touch, for example to press the right button and become feedback that they really have pressed the button. If the buttons feel different the users can learn which button is feeling like what and what position it has and then press the right button by only feeling and can keep their eyes on the road. Therefore it is important to consider haptic feedback when designing manual controls used for interactions in the car environment.

4.5 Technical environment

The Bluetooth node should be part of the infotainment system in the Volvo cars, which gives some constraints. The same interface, in form of display and buttons, as to the rest of the Infotainment system should be used, meaning it is good if not many special buttons and interactions are needed for the Bluetooth node interface. Therefore it will be good if the same buttons can be used as in the CD and Radio functions. The infotainment system though has different interfaces in different car models. The available buttons (in the different car models) are:

- Number 0-9 , # and *
- Enter and Exit (which are placed both on the center console and the steering wheel)
- Menu Up & Down (one model have a menu button and then a “up, down, left and right button”)
- “<<” & “>>”
- Eject
- AM/FM & CD/(One model CD/MD)
- Source (selector knob in one model, and one model do not have this choice)
- Phone (for the ones that do not have phone it is in some models “my key” instead)
- Volume knob/Power (also Volume up and down buttons on the steering wheel)
- Tuning knob/sound

All these buttons means that there is not much space for new buttons. Adding more buttons for the Bluetooth node interface will also mean more buttons for the users, a more cluttered interface that is harder to use, hence if more buttons will be added it has to be a good reason for that. Renaming some of the buttons could be possible, although it has to be good reasons for that, since the users that have been driving a Volvo car for many years is already used to the names that Volvo Car Corporation uses.

The available interfaces also contain a display, the size differ between the models, in XC90 it is 64 pixel high and 128 pixels wide, the newer models have the same height but the display is a little bit wider and also have higher resolution, the width for them is 256 pixels. The pixels in the display are either on or off, meaning only two colors is available. The XC90 uses green text on black background while the newer models use black text on green background in the daytime and invert the colors when it is dark. The Bluetooth node interface should be designed to fit these displays.

5 Answering the first Question Statement

To be able to answer the first question statement “*What does the special context and task mean for the design of such an interface and which interaction technique is suitable for this task in this context?*” several other questions were identified. These questions are first answered in this chapter and thereafter follow the answer to the first question statement to the main question.

5.1 The Context, the Task and Interaction Techniques

What is the users’ context (the driving situation in a car environment) like and what extra demands/requirements does the user context add to the design of the Interface?

The user context is the driving situation in a car environment. The driving situation means that the primary task is driving and using the Bluetooth function is a secondary task. The primary task (driving) demands that drivers allocate visual, manual and cognitive resources.

Visual attention can not be directed two ways at the same time, which means if the secondary task also demands visual attention, the visual resource has to be shared between the primary and secondary task. This can affect the driving performance in a negative way. Meaning the interface for the secondary task should preferably not require visual attention. If it does require visual attention, this attention should not be required at a special moment in the interaction or for a certain amount of time (meaning no timers in the interface).

To control the vehicle drivers need to perform manual output, the feet are used to control the acceleration and the hands are used to steer and change gear. The manual resources can do two or more things at the same time, in contrast to the visual resource, which means a manual secondary task might be performed while driving. This does not concern all manual tasks in all situations though. Sometimes one hand is okay for steering the car, but sometimes two hands are needed (example by a sharp turn) which means the secondary task can suddenly be interrupted. For that reason the interface should not require a manual input within a special time or for a certain amount of time (once more: no timers in the interface). Steering the vehicle has high manual demands which mean that the secondary task can not have complicated manual demands. Therefore it has to be an easy manual task that is required from the user, if the interface requires manual input. Of course the secondary task should not require more than one hand when doing the manual task and the manual task has to be in reach for the driver.

Problem solving, information processing and decision making are processes that require cognitive resources while driving. Secondary tasks that require high cognitive attention can disturb, delay or eliminate the ongoing cognitive processes concerning the driving task. The cognitive demands are affecting the visual and manual behaviors of the driver that are affecting the driver performance. For that reason the interface should require as little as possible of the cognitive resources. This is especially important for inexperienced drivers since the driving task has greater cognitive demands on them than on experienced drivers. The interface should also not give an excessively amount of information, since then there might be an information overload.

The user context can differ in light and sound conditions which might affect the visual and cognitive demands for the driver. Also the sounds both inside and outside the car can differ in different driving situations, which if loud might disturb the cognitive processes. The interfaces for these secondary tasks have to be adapted and subordinated to the driving, hence they should acquire minimal cognitive and physical load. The car as a user context requires high safety demands and a consciousness about the actual surrounding and situation.

This answer is based on the information in the user context part of the user analysis (chapter 4.1).

What does the task of using a cellular phone mean and what demands/effects does this task have on the driver?

The task is to use a cellular phone in a car environment. If the task is performed by a driver it means that the task is a secondary task to the primary task of driving. That the task of using a cellular phone is affecting the driver is definitely true for the not-so-experienced users of a cellular phone, in a focus group discussion users said they often tried to stop since it became too much for them to handle a call while driving [Gustavsson 2003]. All the users in the focus group discussion also thought they were worse drivers when using the cellular phone while driving, they believed that they were then less concentrated on the driving task which made their driving unsteady and jerky.

What demands does the task put on the driver that affects the driving performance of the driver? Only speaking in a cellular phone has cognitive demands since the driver has to concentrate on the conversation. Other situations when the task of using a cellular phone need cognitive resources are for example to recall phone numbers (to dial) and make a decision if an incoming call should be answered or not. To allocate buttons and look at information on the cellular phone screen are subtasks (to the task of using a cellular phone) that put visual demands on the driver. In the focus group discussion the participants also said that using the cellular phone while driving made them miss exits and changes of traffic lights more often. This can be seen as an effect of the fact that the visual resource has to be timeshared between the primary and secondary task. To move one hand off the steering wheel to the cellular phone and to press a button are subtasks that put manual demands on the driver. If the cellular phone is handheld it means greater manual demands since one hand has to hold the cellular phone the whole time (while being used). That means that the user have one hand less for changing gear, steering and using indicators. Therefore it is not surprising that the participants in the focus group discussion said that they had problems with these driving subtasks when using the cellular phone while driving.

This answer is based on the information in the Task Analysis (chapter 4.2).

What interaction techniques are there and how do they fit the user context?

The interaction techniques are divided into input and output in the following discussion. They are also sorted into different interfaces depending on what sense they use.

Visual interfaces

Visual input does not fit the driving context very well (with the technology available today). Visual output means that the driver's visual attention is needed to see the visual information. On the same time the visual demands from the driving task is high and since the visual resource have to be timeshared between the primary and secondary tasks the best thing would be if the secondary task required no or as little as possible of the visual attention. Visual information is though persistent which makes it easier to share the visual attention between the primary task and secondary task.

How well a traditionally display fit in to the driving context depends a lot on what values are set for the display parameters and then especially where it is placed

Head-Up-Displays (HUD) have both advantages and disadvantage in the driver context. The advantage is that the information is placed on the windshield in front of the driver which gives shorter accommodation times (which saves time in the visual timesharing). That it is placed in the driver's visual scene also means that the peripheral vision can be used to detect emergencies. One objection to using a HUD is that it is not clear that traffic information is being processed from the fact that the driver is looking forward. There is also concerns about that the virtual image might obscure a part of the traffic scene. Also not all information should be displayed by a HUD since then it will be too cluttered and there is a risk for an information overload. Therefore only the most important information should be displayed by a HUD and it is doubtful if the Bluetooth node information is included in this category.

A touch screen is a direct display which means that the display is also the input surface. This makes a touch screen an intuitive interface; hence the user can choose something by directly touching it. For the interface designer it also has the advantages that the interface buttons can easily be changed. Driver context studies though have shown that the touch screen is too visually demanding for using it when the vehicle is in motion. This means that touch screens do not fit the driving context very well.

Auditory interfaces

The advantage with using audio in an interface in the driving context is that it is hands-free. The fact that it also does not require any visual attention is a plus in this context. In this context there could be noisy kids in the backseat or a big truck passing by, which might mean that the auditory input or output is drowned in noise. Hence it is important in this context that the audio should be possible to repeat.

Auditory output is also transient, which means that once the audio is presented it disappears. That means that users have to be able to give the auditory output attention at a special time for a certain amount of time and that is not good in the driving environment. For that reason it is also important that drivers can repeat the auditory output, it could also be the case that they did not comprehend what was said. Auditory output is attention grabbing, which is good if the information demands immediate reaction, it also means that it is distracting when the information is not that important. This leads to the fact that users can find auditory output annoying and annoyance is not good in the driving context. However, non-speech sounds are good for rapid simple feedbacks although not suitable alone as an interface. Speech is more suitable to give instructions.

For the user to be able to provide *auditory input* the system needs to have a speech recognition unit. How this speech recognition unit is designed is what differs between the different auditory input interfaces today. There is the continuous speech recognition where the user can speak natural everyday language, but since it is a difficult task to understand natural language (for a computer) the continuous systems of today are error prone. The discrete speech recognition only recognizes a limited amount of predefined commands (spoken word by word) which makes it less error prone than the continuous speech recognition but also less natural for the user. To remember what command one can say is something that uses the cognitive resources which is not appreciated in the driving context, but that a system is error prone is worse in the driving context, hence out of these two speech recognitions a discrete is the best choice in the driving context (at least until better speech recognition technology is developed).

The speech recognition can also be speaker dependent or speaker independent. If it is speaker dependent it requires the user to do an enrollment process, this gives a higher accuracy but also means that it is less flexible since it can not be shared. Since there might be many different drivers in a car the speaker independent is better for the driving context.

Haptic Interfaces

Haptic sensations are hard to synthesize, which is a reason for that there are not many active haptic feedbacks in the human-computer-interaction field today. More research has to be done before this kind of haptic output can be used in the driving context. The passive haptic feedback is though already used in the car environment today, in form of the surface and shapes of different buttons, this means they can be differentiated with only touch and drivers do not have to look at them. Therefore we can say that the passive haptic feedback fits well into the driving context.

This answer is based on the information in the Interaction Techniques chapter (chapter 4.4).

5.2 The Answer to the first Question Statement

With the answers from the subchapter above available we can now answer the first question statement: “*What does the special context and task mean for the design of such an interface and which interaction technique is suitable for this task in this context?*”

The user context is really important for a design in a car. The first answer above shows that the driving context puts visual, manual and cognitive demands on the driver and it is therefore important that the interface demands do not interfere with these demands in such a way that the driving task can not be done in a safe way. The second answer shows that the task of using a cellular phone also puts mainly visual, manual and cognitive demands on the driver and that affects the driver when performing the driving task. Therefore these demands have to be reduced in a new user interface. The context and the task also implicate many more detailed requirements for the user interface; these are found in the requirement specification in chapter 4.3.

5 Answering the first Question Statement

What kind of interaction is best suited for the driving situation i.e. which one should be used for the design of the user interface? It is hard to say, they all have their advantages and disadvantages as has been previously described. Haptic feedback is important when designing manual controls for interaction in the car but since a set of buttons that already is designed (for the infotainment system) have to be used and there is little research made on haptic output, there will be no haptic interface⁹ design proposal. The visual output is a familiar kind of output for the driver and has the advantage of being persistent, but on the other hand it will compete with the primary task of driving for the visual attention/resource. The auditory interfaces have the great benefit of being hands-free and eyes free which is important for subtasks to the manual and visual demanding primary driving task. Although auditory output has the disadvantage of being transient (that is the sound disappears once it has been presented) and auditory input interfaces have problems with the speech recognition (there is no good technology for that yet).

This means that there is no superior interaction technique for this task in this context; hence there is no clear answer to this part of the question. Since there is no superior interaction technique three different design proposals should be designed, one visual proposal, one audio proposal and one combined proposal and they should then be compared with each other.

⁹ The haptic feedback already provided by the buttons in the infotainment interface will though be used.

6 Design Development

The Design phase can be divided up into two parts, the conceptual and the physical design (see chapter 3). VCC already had done the conceptual level but the conceptual model can be extended by exploring how the task can be divided up between the human and the machine, this is in this case done by developing general use cases. The functions for which the use cases describe the performance of, were given a priority in the requirement specification, this priority is also given to the corresponding use case. The use cases for all the functions in the requirement specification are found in Appendix C. Another way to extend the conceptual model is to explore the interaction possibilities, that was done relating to their advantages and disadvantages in the user context, as described in chapter 4.4. That chapter served as a basis for answering the question statement in chapter 5, which was asked to get advice on which interaction technique(s) to use in the design proposal. There were no clear answer to this question though and therefore it was decided to design one visual proposal, one audio proposal and one combined proposal and compare them with each other. The wish of the supervisor at VCC was however to do only a visual proposal since the technology to show an audio proposal (and thus a combined) was not available. Because of this, only a visual proposal has been developed, although the audio alternative should be considered in future work as most competitors in the automotive industry have an audio solution or a partly audio solution. An interface has to provide a way to give input and one way to give output, since visual input is no good idea in the driving context the visual design proposal will use manual input instead. The intention is to reduce the manual and visual demands from the task on the driver.

There were too many general use cases developed to fit within the time of a master thesis, therefore the design proposal is limited to cover only some of them. The design proposal covers the specific Bluetooth use cases (No 1, 2, 9 and 10) since they are more interesting for this question of the thesis. Also the use cases for the functions with priority (1) need-to-have are included in the design proposal, since they were need-to-have. Even if not all the functions are included in the design proposal a general menu structure was designed (to support extension of the design proposal). The information that was need-to-have is also included in the design proposal, for example the status information with highest priority.

The Bluetooth node should be a part of the Infotainment system in the Volvo cars and therefore have to be adapted to the technical environment described in chapter 4.5. This of course gives a lot of restrictions for this design proposal. The user interface should according to learnability requirement 3 (chapter 4.3.2.2) have a consistent design through the whole interface, which also means that the same font and font size as in the rest of the infotainment system should be used. The infotainment system looks a little bit different in the different car models, for example the XC90 has a much smaller display than the newer interfaces which give different conditions for the design, and hence the same design solutions cannot be used in all cases. The newer interfaces are more important for the development than the XC90 interface, but the boxcar that this might be implemented on has the XC90 interface, therefore will the design proposal be developed in two sets. The newer interfaces are the focus for this chapter were the development for the design proposal can be followed. To see how the XC90 differs in design see Appendix D.

6.1 Status Information

The following status information should be presented to the user according to the requirement specification:

- Mode for the phone (for example standby or active)
- When there is a Bluetooth connection and to what device
- The signal strength and the operator for the cellular phone

All this information should be available to the user in a standby mode if possible. It is not much space left in the displays today and then to get all these things in as well means little space for every separate thing.

6.1.1 Modes - Active or Standby

How many modes can the Bluetooth node be in? How many is really necessary? Normal modes for things are off and on. Following this argument, when the Bluetooth device is a cellular phone it also make sense to have a standby mode, i.e. it is active in the background of the Infotainment system. The system also has to know when the button presses is meant for the Bluetooth node part of the infotainment system and not for the audio part, which means the user have to tell the system that by activating the Bluetooth node somehow. Consequently there are two different on-modes, standby and active mode.

In the evaluation the author did this summer [Larsson 2003 a] the users had problems with the built-in-phone and its three modes: on, off and standby. In the Infotainment system in XC90 the user change mode by giving the phone button a short press (to switch between standby and active) or a long press to turn it off. The users did not understand that there was three modes and did not know how they should switch mode. One of the results in the evaluation thus advocates that it would be good to have fewer modes than three; hence the different modes and the interaction of switching modes will be easier to understand for the users. Since the connection with the Bluetooth device should be automatic the Bluetooth node should actually never be off. If there is an off mode the user might has to turn it on when entering the car if somebody turned it off earlier. In the situation where the users are used to an automatic handover between the cellular and the car, they will be confused when suddenly nothing happens when they enters the car. The big advantage with Bluetooth is the fact that when the devices once have been paired the connections will be established automatic and this benefit is lost if the Bluetooth is turned off. Therefore, this master thesis assumed that the off mode is not needed, even if it can be discussed since people might want to turn it off since they are afraid of a possible radiation. This leaves us with the two modes Standby and Active.

How should users switch between these modes? This is an interaction that should be easy to access, which in a visual interface means that the user should have direct access to it, in the VCC infotainment interface that means having a special button for that. Since it is hard to add new buttons to the VCC Infotainment interface of today (see chapter 4.5), it would be good to use one of the buttons already in the interface if possible. If the car will have a Bluetooth node for connection with the personal cellular, the built-in phone will no longer be an alternative which means the phone button is unnecessary and its place in the present interface will be free. This button should be marked with the Bluetooth symbol, partly since the name Bluetooth is a bit too long to put on a button and partly since the symbol probably will be something users in a few years will recognize from other Bluetooth things.

How should users interact with the button to switch between the standby and the active mode? The most simply interaction is that a button press means switching mode and if pressed once more it is switches back to the former mode. Sometimes the switch will be done automatically by the system, for example when there is an incoming call then the system switch from the standby mode to the active mode automatically.

For the user to be able to distinguish between the two modes they have to look different, hence it's clear that it is two different modes. The standby mode is pretty much already set, it will be the screen of the other function that is used in the infotainment system at the moment, for example the CD screen or the Radio screen, and then some status information about the Bluetooth node has to be added to those screens. To see how the rest of the status information is designed to fit into these screens see chapters 6.1.2 and 6.1.3 below.



Figure 9 The standby screen

What does the active mode means? Here it is that the user should interact with the Bluetooth node, which means the functions should be presented to the user and this should of course be done to the user in a structured way (to see how this will be structured see chapter 6.2 below). Assume that the functions are structured in a menu. When the Bluetooth node is activated, should the function menu appear immediately or should there be some other screen before, from where the menu can be activated? If the menu occurs directly it will be one less

step to get to the menu and is a reduction in the interaction for the user, which is really appreciated in the driving situation. There might though be a problem with the Use Case 7 Last number called, on some cellular phone this is made by pressing the enter button, if users will use this knowledge in this case they will then accidentally chose the first menu alternative by doing that. If we look at the rest of the infotainment system to seek consistency (one of the design guidelines by Donald Norman [Preece 2002] and learnability requirement 3) we see that both in the CD-part and the Radio-part the menu is shown first after it has been activated by the user pressing the Menu button in the interface. This would mean an extra step to access the Bluetooth menu. The consistency with the rest of the system is though important for the user friendliness and in this case it will also mean that we can have consistency with use case 7 last number called, therefore the design will have an active screen first and then will the menu be activated by a press on the menu button.



Figure 10 The active screen

The system is also active when there is an ongoing call and then the system should show the user information about the call. This means we have three different parts of the active mode, we have: "Active", "Active + Menu" and "Active + Call". Pressing the Bluetooth button thus means switching between the Standby and the Active screen.

The "Active + Menu" screen is then accessed by pressing the Menu button when in the Active screen, and when the Exit button is pressed it returns to the Active screen.

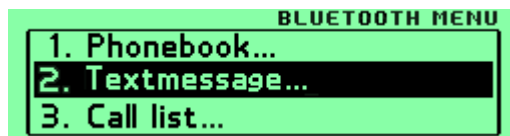


Figure 11 The "Active + Menu" screen

The "Active + Call" screen is accessed by calling somebody (which is made from the Active screen or "Active + Menu" screen) or is automatically made by the system when the user chose to answer an incoming call.



Figure 12 The "Active + Call" screen

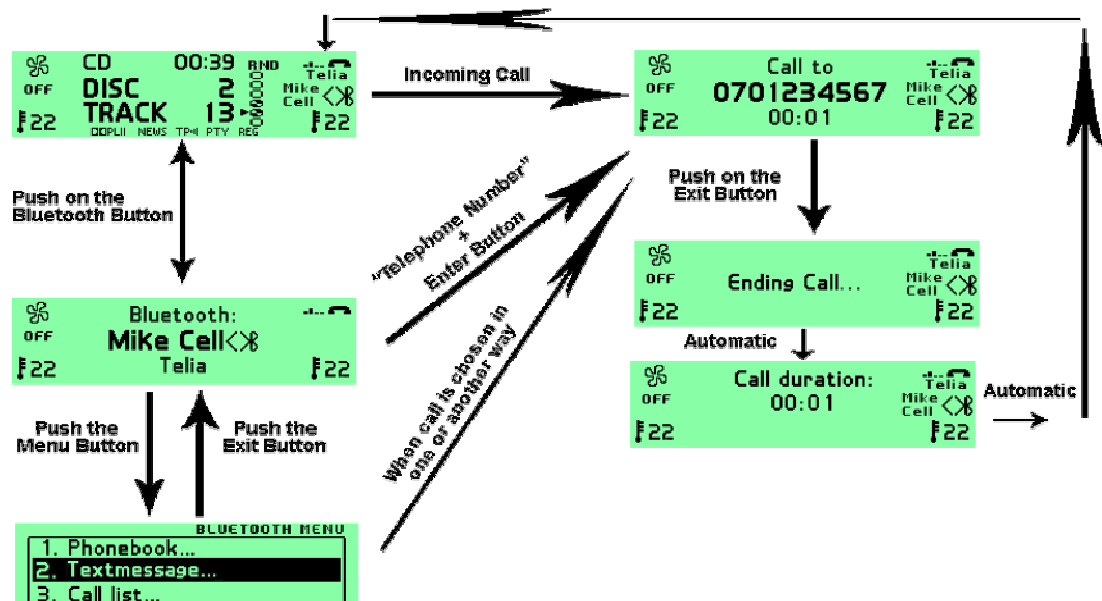


Figure 13 The structure of the different modes and the interactions that switch modes.

6.1.2 Bluetooth connection

When there is a Bluetooth connection this has to show for the user and also show what device is connected. This information is interesting, especially in the standby mode, for the reason that users should know there is a connection even if the Bluetooth node is not active. In the standby mode there is not much space for the information, therefore it is a good idea to design an icon that shows if there is a connection or not.

To start with there is a Bluetooth symbol designed by the Bluetooth Interest Group. It looks like this:



Assuming that people get used to Bluetooth devices they will probably also start to recognize the Bluetooth symbol. Therefore this symbol will be used as a basis in the design of the Bluetooth icon; unfortunately the correct colors can not be used since the display only has green and black colors.

Should the icon be used only when there is a connection or also otherwise? The Bluetooth node in the car is always on (as assumed earlier) and this should be communicated to the users for the reason that they should know that it is always ready to pair or connect. Since the space is small it would be great to use the features of the Bluetooth symbol. To the left in the symbol it looks as an opening that could symbolize an opening towards other Bluetooth devices.



How should then the connection look like? It could be shown by doing the same sort of opening but reversed, that is:



Then it should also show the other Bluetooth device, maybe:



But this symbol only shows that there are two Bluetooth devices that have a connection, not what kind of Bluetooth device is at the other end. If many devices are paired with the Bluetooth node and have a priority order (see design of use case "1.2 Establish connection" for more information on that) their priority number can be used to represent them. Hence if the connected device has priority number 2 we will have:



This requires little space, although it can really be confusing; the user might think that it means that there are two Bluetooth devices that are connected to the Bluetooth node. A number is not representative for the device. Especially since the priority number may change. Maybe it is better if the Bluetooth device can be represented by an icon telling what it is, that means for the cellular phone there will be a phone icon (receiver):



This icon can also in the case of the cellular phone, be combined with showing the signal strength as following:



We then have a problem if more than one of the same kind of devices is paired with the Bluetooth node then we do not know which one is right now connected. For example if there are three cellular phones in the car at the same time that all are paired with the Bluetooth node, then the user can not tell which one is connected by only seeing a phone icon. Each

Bluetooth device have a user-friendly name, that the users set themselves, and this name is probably the best way to represent the device. Then we get:



Since the icon grows to the left (because of the form of the Bluetooth symbol) this icon is best placed on the right side of the display, if placed on the left side it would look funny before a connection existed with an empty space and then the symbol. On the other hand this empty space might tell the user that something is missing. Although one might argue that to get more "air" into the crowded screen, the other advantages indicate that it is better to have this placed next to the right edge of the screen. Or maybe the connection should not be showed in that way, maybe the device does not need to have an opening towards the Bluetooth symbol, maybe this is clear enough:



Or do users not need this symbolic meaning of an opening? In that case the Bluetooth icon could come first and then the user-friendly name could appear on the other side like this:



(This symbol would then be better placed on the left side of the screen).

Further reasoning is unlikely to give concrete arguments, which symbol works best for the users, has to be tried out. However one can conclude that, if we want to place the icon at the right edge of the screen there is little space left for it. One can also draw the conclusion that the Bluetooth Connection icon and the signal strength should be placed close to each other, since it should be understood that they both concern the same part of the infotainment system.

6.1.3 Signal strength and operator

When the Bluetooth device is a cellular phone it means we get some extra information that should be available in standby mode also, such as signal strength and operator. For the signal strength there is already a place where such an icon has a place in the infotainment displays, used for built-in-phones which can be reused. The symbol for signal strength is clear hence that is also reused in this design.



The operator name is strongly coupled to the phone; therefore it should be placed close to the signal strength icon. For the users to be able to understand that it is the phone operator, the operator name is placed directly under the phone icon in the newer displays. The display in the XC90 is small, therefore is not the operator shown in standby mode, it is only shown in active mode.



6.2 Menu Structure

The functions available for users have to be structured and shown for them somehow. There should also be a way for users to navigate in the structure. A usual structure for functions in visual systems is menus. There are different kinds of menus, for example pie menu, pop-up menu, roll-down menu, tabs, vertical and horizontal menu. In the beginning some quick sketches was done on how it could look with different kind of menus.

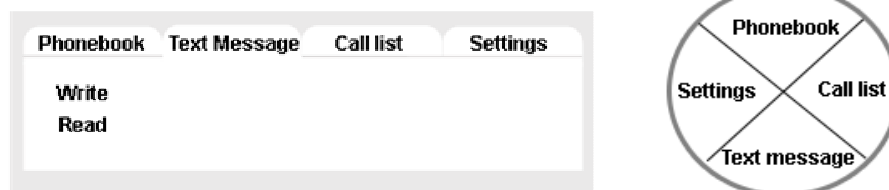


Figure 14 Sketches of how a tab menu and a pie menu could look for this user interface

The limited screen space means that the tabs would be too cluttered in this design, since then all the headings are visible at the same time as the submenu. There also might have to be more submenus (deeper menu structure) than only one to every menu alternative. Pie menus take up more space than a linear menu [Helander 1997] and there is limited space in the screen therefore a pie menu is not a good idea in this case. A turning knob would be appropriate for navigating in a pie menu, but there is no turning knob available and it is hard to add a new. This means that the up and down buttons have to be used for navigation in the menu and then it is not easy to present an understandable navigation model for the user in the pie menu. If we think of the fact that we want to navigate in the menu with the up and down buttons the traditional menu (vertical menu) offers a logical way to navigate with these buttons. The traditional menus also give the advantage of the users already knowing (from previous experience of menus) how to navigate within them.

The items in a traditional menu can be ordered in different ways, for example in alphabetical, categorical, conventional or frequency order. Conventional menus are such menus where the items have a conventional order, for example the weekdays or the months of the year, which can not be applied in this design. Frequency menus order the items according to the frequency every menu item is used. This kind of order could be applied in the menus used in this design, although they are not really suitable since there might be more than one driver in the car and then to have a menu that change the order could be really confusing for the different drivers. To use an alphabetical order is no good option since the users might have another wording for a function on their personal cellular phone which means they have to scan the whole menu to find what they want anyway. The most suitable way to order this menu seems to be in a categorical way. And if we look at cellular phones today, that is the way it is done for most models.

The best thing would be if the cellular phone menus could be transferred to the Bluetooth node since then the user would already know where to find the different functions. Then a Bluetooth menu alternative could be added in the end of that menu, where the Bluetooth specific settings could be made. Unfortunately it is not technically possible to transfer the cellular phone menus to the Bluetooth node today. Therefore the users will have to learn how to find their way in a new menu system. This learning should be as easy as possible, meaning that the menus should be as much alike the cellular phones menus as possible. There are however many different brands of cellular phones which have their own kind of menu.

When making a menu structure there is always the question if there should be a deep or wide structure. A wide structure means that there are many choices at the same level and that it does not take many steps to get to the deepest level and a deep structure means that there are only a few choices on every level and it takes more steps to get to the deepest level.

The driving situation dictates that the driver should not have to do too many steps, meaning we want a pretty shallow menu tree. The problem with the infotainment displays is though that they can only show three menu alternatives at the same time and if the users want to see the others they have to press the up or down buttons, which is also a step for the user. However, the step of choosing a menu alternative demands more cognitive resources than pressing the up or down button [Helander 1997]. The best thing would be if the amount of menu alternatives were small, since then the menu structure did not need to be neither deep nor wide. We then have the question do we need to have the possibility to do everything we can do on a cellular phone today, in the car while driving as well? Here we also have a safety aspect, should the functionality be limited while driving? This is an area where more research is needed and nothing that can be decided now. Therefore only the functionality that is required in the requirement specification will be included in this design, although it might be a point in not expanding the functionality much beyond this.

The different alternatives in a menu can be represented by text or icons. If we compare text and icons, the text has to be read from the beginning to the end which makes it a slower way to present information while icons instead can be rapidly understood. However, in text the meaning is included while in icons the user has to learn their meaning. The screen that should be used do not have the best resolution and only have two colors (black and green) which speak against using icons and therefore text will be used to represent the menu alternatives in this design proposal.

The special Bluetooth functions and settings should be gathered under the same menu alternative to be easy to find. A proper name for that menu alternative would be something with Bluetooth in it. If we look at the rest of the infotainment system for consistency again, we can see that the first menu in the CD part is called "CD menu" and in the radio part "AM/FM Menu", which means that the main menu in the Bluetooth node should also have such an explaining and comprehensive title. This means that the word Bluetooth should also be included in this title, the Bluetooth menu is a good name. Although then the menu alternative for the Bluetooth specific functions and settings has to have a name that is separate from that. One could add another word to Bluetooth, for example Bluetooth settings, then we although get a very long name and the question is if it will fit. It is also questionable if the difference between "Bluetooth menu" and "Bluetooth settings" is clear enough? And if there is one "Bluetooth settings" and one "Settings", will it be clear for the user what is set under each menu alternative? The best thing is if all the settings are set under the same menu alternative, therefore it will all be done under the menu alternative "Settings". The risk with that is if more functions from the cellular phone should be available in the car, since then it might be a lot of settings that have to fit under that menu alternative. The "Settings" menu alternative has its place last in the menu since that is something that is supposed not to be done often. Since the first menu alternative is marked when the menu occur it is also only one step up to come to the last item in the list, hence it can be fast accessed.

For all the Bluetooth devices (that might be able to add to the Bluetooth node in the car in the future) the general menu structure is needed and then specific menu alternatives will be added depending on what device is connected.

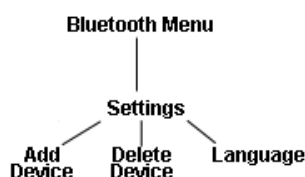


Figure 15 General menu structure for all Bluetooth devices.

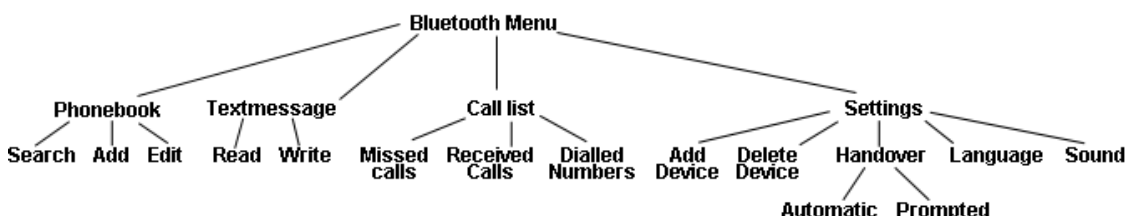


Figure 16 The menu structure for the user interface when having a connection to a cellular phone

6.3 Design for the Use Cases

The design use cases are based on the use cases, hence for the preconditions and the post conditions see Appendix C. Recall from the technical environment (chapter 4.5) that the buttons Exit and Enter are placed both on the center console and the steering wheel which gives easy access for the driver without shutting the passenger out from interacting with those buttons.

6.3.1 Use Case 1: Pairing

The inquiry in the pairing should be done from the car, since otherwise the car has to be discoverable all the time and for safety reasons that is not recommended. Looking at related work we see that when a PDA or a laptop is paired with a cellular phone, this is initiated from the PDA or laptop.

How should users tell the system that they want to pair the cellular phone with the Bluetooth node? Since this is something that is not used that often, users do not have to have direct access to it, i.e. it is something that can be placed in the menu. It is suitable if this menu alternative is placed under the menu alternative with the Bluetooth specific functions. The question is what this menu alternative should be named. Pairing is one alternative although the question is if users really know what pairing is, it is a vague term for this function. Hence something more describing of the action such as "Add device" is better. On the same level should also the function "Delete device" then be able, since users need a way to delete a device if they do not want them to connect anymore. Also in the case when the system is able to pair for example 5 phones (as some other car manufacturers have) and these places already are busy, the system have to tell the user that and it has to be such a function to delete the current phones to be able to add new ones. The system could tell the users in form of: "No free space. Please delete a device".

When the pairing is initiated, by the user choosing "Add device" in the menu, the system will do the inquiry and then give a list of nearby devices as feedback to the users. If it takes awhile to find the devices the system will tell the users that by:

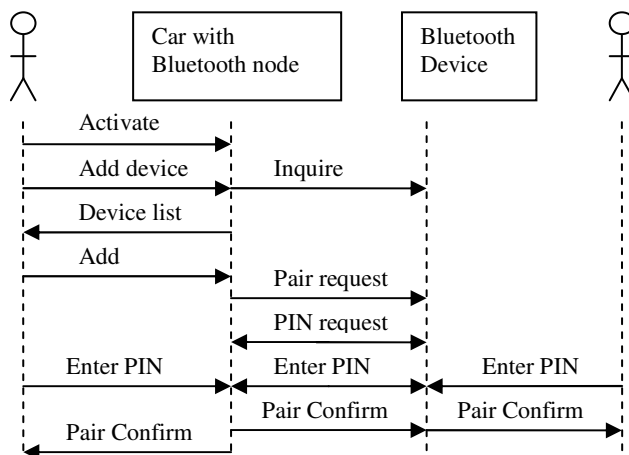
**Searching
for
Device**

If no devices are found, the system will tell the users: "No device found". No by the way it should be "No discoverable device" instead since then the user gets a tip about that the device has to be discoverable as well.

**No Discoverable
Device
Found**

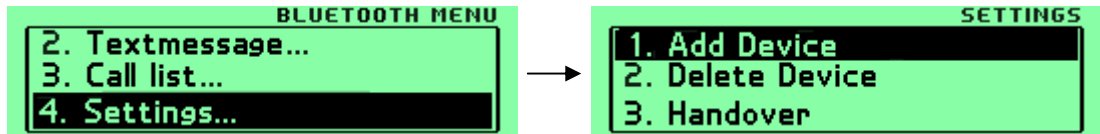
When the list of nearby devices is given users can use the up and down functions to make one of the devices marked and then press the enter button to tell the system that it is that one they want to pair with the Bluetooth node. If the users do not want to pair any of the devices they press Exit and the pairing quits. If a device is chosen for pairing both the Bluetooth device and the Bluetooth node will ask for the PIN, for security reasons. The users will have three tries to give in the right PIN then they have to start all over with the pairing.

Design Use Case 1: Pairing



Main success scenario

1. Users activate the Bluetooth node by pressing the Bluetooth-button.
2. The users go into the menu (by pressing Menu) and chose "Settings" by pressing Enter when settings are marked. In the settings menu the user chose "Add device".



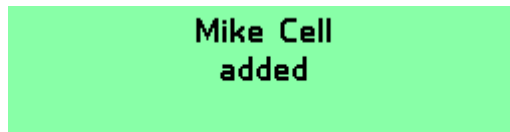
3. The system does an inquiry and then shows "Add:" and then a list of devices.



4. The users request to pair the Bluetooth node with the wanted Bluetooth device by making sure that the device is marked in the list and then press Enter.
5. The Bluetooth node and the Bluetooth device ask for the PIN number.



6. The users supply the PIN number and then press the Enter button.
7. The Bluetooth node confirms the pairing by showing "<Device Name> added".



8. Use Case ends.

Alternative scenario

6. The users supply the wrong PIN number to the Bluetooth node.
7. The Bluetooth node rejects the pairing and tells the users that it is the wrong PIN number in form of "Invalid PIN".



8. The users have to enter the PIN number again.
9. The users get three tries to enter the PIN number, when the users fail to enter the right PIN number the users have to start all over.

6.3.2 Use Case 2: Establish connection

This use case does not contain much interaction, since it should be automatic. Although the system still has to tell the user what is happening. It is not critical that users see when it happens they only need to know that a connection was established. Hence if the user looks at the display when the connection is established the user should see what happens, otherwise the user will also see it thereafter on the Bluetooth icon that has changed.

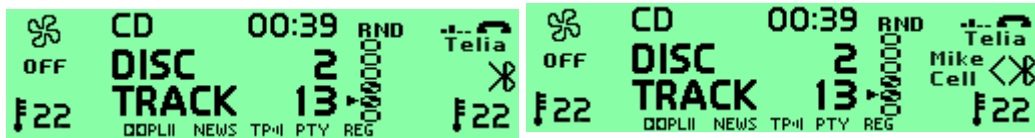
The establishment of the connection should be automated, but what if more phones are paired and get into the car at the same time, which one will connect? One could solve this by giving the devices priority order, meaning the one with highest priority in the car will connect (this was how Daimler Chrysler solved allowing 5 phones to be paired). That will

probably work fine as long as it most of the time is the same person who drives (and therefore mostly need the Bluetooth connection) when there are multiple devices in the car, hence the priority order does not have to change. This means that it has to be pretty easy for users to change priority order. However this does not have to be considered in this design since only one cellular phone has to be supported.

Design Use Case 2: Establish a connection

Main success scenario

1. The Bluetooth node discovers the Bluetooth device.
2. The Bluetooth node sends a connection request to the Bluetooth device.
3. The Bluetooth device accepts the connection.
4. The system short shows "Connected to <Device name>" and then "<Device name>" is added to the Bluetooth-icon on the screen.



Before

After

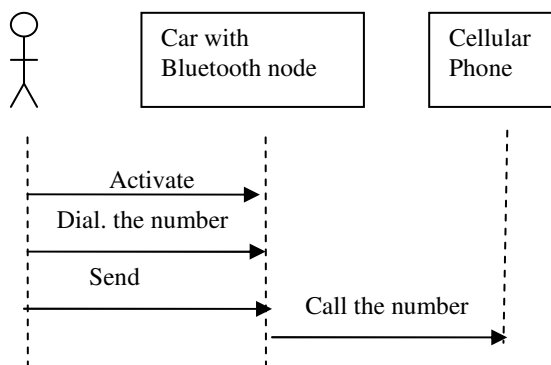
The difference is shown in the Bluetooth connection symbol at the right edge of the screen.

5. Use Case ends.

6.3.3 Use Case 3: Making a call (with buttons)

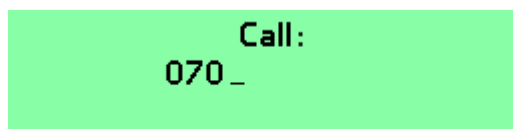
This can be solved rather as making a call with any cellular phone is done today.

Design Use Case 3: Making a call (with Buttons)

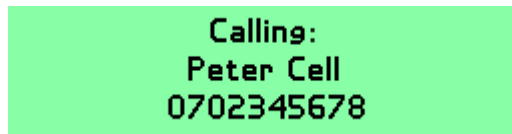


Main success scenario

1. Users activate the Bluetooth node by pressing the Bluetooth-button.
2. The users enter the desired phone number by using the digit buttons (hence if Bluetooth is active and users enters a number it means they want to call a phone number) and every digit is shown on the display.



3. The users send the phone number by pressing the Enter button.
4. The system gives the users feedback in form of "Calling <Telephone Number >". If in the phonebook also the name will be added:



5. The system uses the cellular phone to call the desired number.
6. Use Case ends.

Alternative scenario 1

2. Users enter the digits and then suddenly the users enter another digit than intended.
3. The users press the Exit button quick to erase the last digit. (Every press on Exit erases one digit). The users continue to give numbers in. And then they proceed on number 3 in the main success scenario.

Alternative scenario 2

3. The users changes their mind and want to cancel the call, the users then give the Exit button a long press (or they could also erase every digit by pressing Exit for every digit if they want to). It then goes back to the active screen.

Alternative scenario 3¹⁰

4. The signal strength is to low for the cellular phone to call the number. The system tells the users "Signal strength too low to place call"

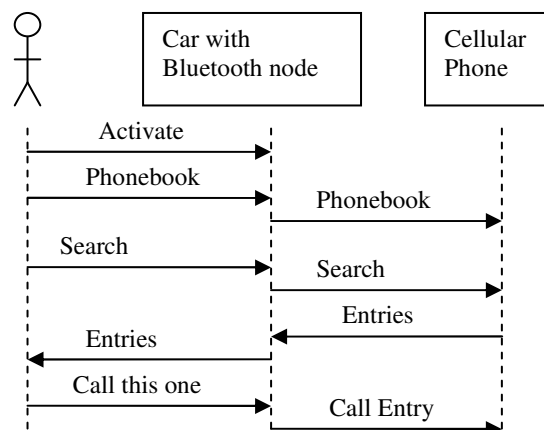
Alternative scenario 4¹¹

4. The number given in is an invalid number, the display give the feedback "Invalid number"

6.3.4 Use Case 4: Read and call entry in the phonebook

In cellular phones there are two ways of finding an entry in the phonebook: Step-by-step or Search by typing letters. And both these possibilities should also be available in the car interface.

Design Use Case 4: Read and call entry in the phonebook (with buttons)

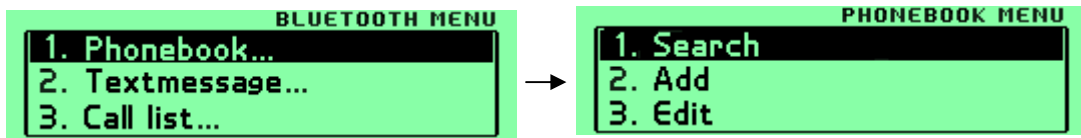


¹⁰ Can not be implemented because the technology for that is not available

¹¹ Also technology for this is not available

Main success scenario

1. Users activate the Bluetooth node by pressing the Bluetooth-button.
2. The user goes into the menu and chooses "Phonebook".



3. The users choose "Search" and then:
 - a. Goes through the entries in the phone book in a step-by-step manner by choosing search and then using the Up and Down buttons.
 - b. Search for the wanted entry
 - i. The users write the name or the beginning of the name they are searching for with the digits and then get a list with entries that starts in that way or the entry that correspond to that name.

The screenshot shows the search results for the name 'MA_'. The text 'Search: MA_' is at the top, followed by 'Maria Cell' and 'Mark Cell' listed below it.

 - ii. And can then use up or down function to go to the right entry in the list that fit the letters given in.
4. The entries in the phonebook of the cellular phone are communicated to the users.
5. When the users found the right entry the users tells the system they want to call this number. That is when the person is marked they press Enter.
6. The system uses the cellular phone to call the desired entry and the display shows "Calling <Name/Number>".



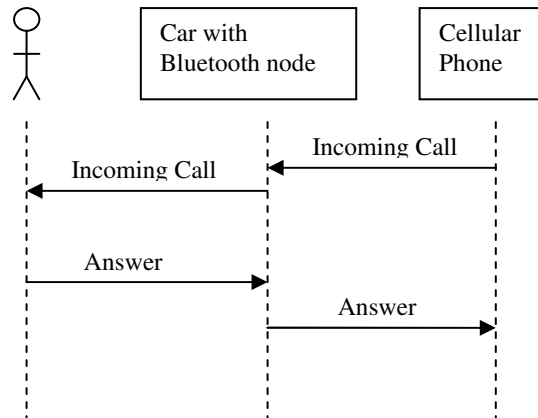
7. Use Case ends.

Alternative scenario

5. Users only wanted to know the number and not call it, hence after the users read it they exits by pressing the Exit button.

6.3.5 Use Case 5: Receiving and rejecting call (using buttons)

If users do not have time to answer the call because of a hectic traffic situation the ringing should stop after some signals, hence the signals should not disturb the user. Users should although also have the possibility to reject an incoming call immediately. A good interaction for that is pressing the Exit button. This use case is a use case that is initiated from the caller on the other end which means it might not be a good time for the driver to speak on the phone. Therefore should it be a really easy interaction for the driver to either reject or receive the call, therefore should only the Exit and Enter buttons be used, which are also placed on the steering wheel for easy access.

Design Use Case 5: Receiving and rejecting call (using buttons)**Main success scenario**

1. The system tells the users there is an incoming call: Ring signal and the display shows "Incoming call from <Telephone number>"



2. The users tell the system they want to answer the call by pressing the Enter button.
3. The system uses the cellular phone to receive the call. And while the call is going on the display shows "Call from <Telephone number>" and a timer for the call duration.



4. Use Case ends.

Alternative scenario 1

2. The users reject the call by either:
 - a. The users tell the system they do not want to answer the call by pressing the Exit button.
 - b. The users do nothing (the phone will ring for 5 signals)
3. The system uses the cellular phone to reject the call and then goes back to standby mode.
4. Use Case ends.

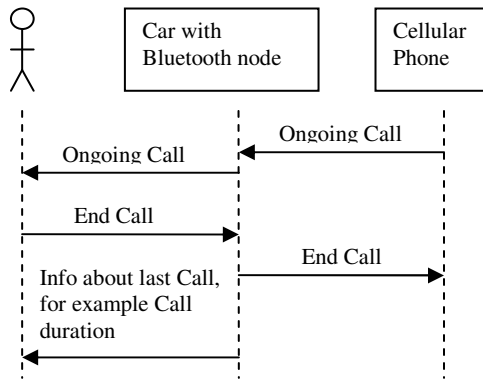
Alternative scenario 2

2. Automatic answer is set in the settings, meaning that the incoming call is automatic answered after one signal and not rejected.

6.3.6 Use Case 6: Ending call

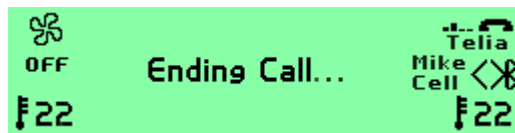
Users should tell the system when they want to end the call or the other part of the call might end it. For users to know what is happening the display should then give feedback, i.e. tell the user that the call is ending. When the call is ended the system should also show the call duration for the user (according to the functional requirements).

Design Use Case 6: Ending a call

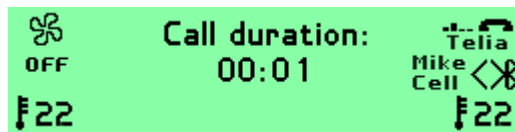


Main success scenario

1. Users tell the system they want to terminate the call by pressing the Exit button.
2. The system uses the cellular phone to terminate the call and show "Ending call".



3. The Bluetooth node gives information about last call, e.g. call duration. The display shows "Call duration: XX:XX" and then goes back to standby mode.

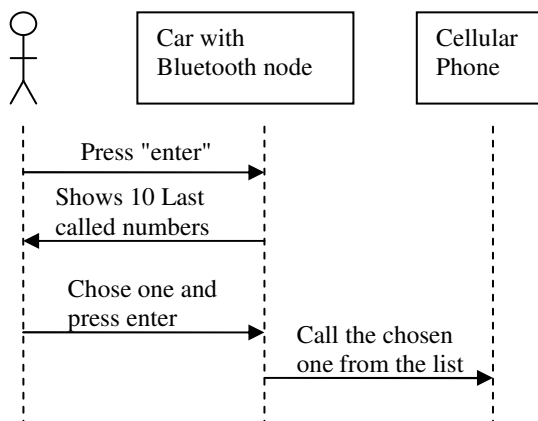


4. Use Case ends.

6.3.7 Use Case 7: Last number called (with buttons)

On cellular phones it is usual that when one presses enter one get the last numbers called. To seek consistency this should apply in the car context as well. Though it all depended on how the structure of the Bluetooth interface should be designed (See chapter 6.2).

Design Use Case 7: Last number called (with buttons)

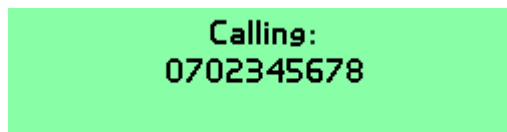


Main success scenario

1. Users activate the Bluetooth node by pressing the Bluetooth button.
2. The users press the Enter button on the Bluetooth node interface.
3. The Bluetooth node-interface shows the (10) last numbers dialed.



4. The users can browse through the lists by using the Up and Down buttons.
5. When right number is found the users press the Enter button.
6. The system uses the cellular phone to re-dial the requested number.



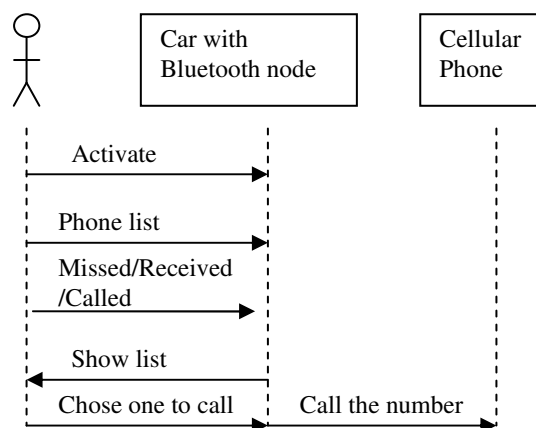
7. Use Case ends.

Alternative scenario

5. The users change their mind and do not want to call any number, and they press the Exit button to exit the list and come back to the Bluetooth active screen.

6.3.8 Use Case 8: Phone lists

When looking at the phone lists on the different cellular brands there are two different solutions either there is separate lists or all the different calls (such as received called and missed) are mixed in the same list and icons show what kind of call it was. The question is what should be used in the car? Having three different lists means an extra step to get to an entry, and as said before extra steps are not good for the driving situation. On the other hand small icons can be hard to see when driving. To look for consistency it seems that the most cellular brands have separate lists, for example Nokia, Siemens and Motorola, which means that these users would benefit for separate lists. The Sony-Ericsson users on the other hand is used to have only one list and then have to learn that it in the car user interface is three different lists.

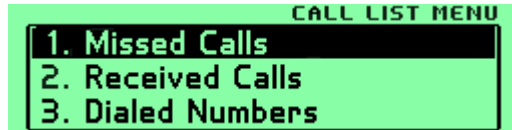
Design Use Case 8: Phone lists

Main success scenario

1. Users activate the Bluetooth node by pressing the Bluetooth-button.
2. The users press the Menu button to get the menu.
3. The users choose "Call list" in the Bluetooth menu.



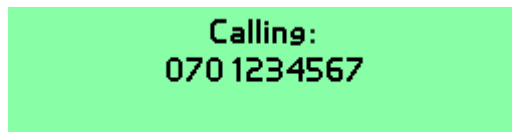
4. The users choose received calls, missed calls or dialed numbers.



5. The system shows the chosen list.



6. The users can browse through the lists by using the Up and Down buttons.
7. If the users want to call a list entry they go to the wanted entry, hence it's marked, and then they press the Enter button.
8. The system uses the cellular phone to call the chosen entry.



9. Use Case ends.

Alternative scenario 1

4. The users do not find the wanted number.
5. The users exit the phone list by pressing the Exit button.

Alternative scenario 2

5. The users change their mind and do not want to call the number and therefore they press the Exit button.

6.3.9 Use Case 9: Handover (From cellular to the car)

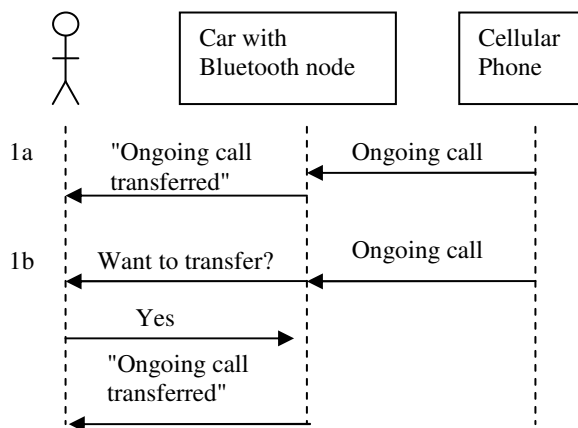
Handover here means that an ongoing call is transferred from the cellular to the car when the user gets into the car. Handover is something that is smooth if it is automatic, since then the users do not have to remember what to do. It is also a way to force the user to use the hands-free Bluetooth interface, otherwise the user could get into the car and start driving still speaking in the handheld cellular phone, and therefore this enforcement is good for safety reasons. Enforcement is however risky; users usually do not like to be forced to do things. Maybe there could be a setting if the handover should be automatic or not. Automatic may be better if it is normally only one person who drives the car. Although if there are several paired devices in the car and for example the daughter in the family gets into the backseat, she might not want her call to be automatically heard in the speakers. Maybe one can have different settings for the different devices? That one can choose for every device if one want the handover to be done automatic or if one wants to be prompted. If prompted is chosen the user will be prompted with a question in the display every time when a handover might be

made, and then have to press Enter (to agree with the handover) or Exit (to keep the call on the cellular phone). This means there will be an extra interaction step.

The situation could also be that the person normally is alone in the car and therefore have automatic handover, then one day somebody else is going to ride along and the user then does not want the call to be heard in the speakers. Therefore it is important that it is easy and quick to transfer the call back to the cellular phone (privacy mode).

If automatic is chosen, then it is the question when should the call be transferred? The trigger for the handover should not be when the user unlocks the car, since then the user will miss part of the call. It has to be when users are already seated in the car but before they drive away, hence there have to be time to put the handheld unit away. Maybe it could be when the key is put into the ignition? What is technical possible? Since this problem have more of a technical character it will not be thought of more in this master thesis, the only design conclusion is that if the handover should be automatic it should be truly automatic and not require any extra interaction from the user.

Design Use Case 9: Handover (From Cellular to the Car)



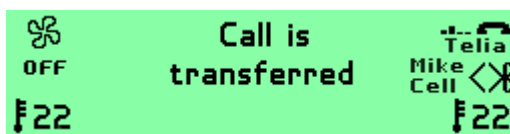
Main success scenario

1. Depending what is set in the settings (under the header "Handover"):
 - a. If "automatic" is chosen, then the call is automatic transferred to the car when it is triggered.
 - b. If "prompted" is chosen then
 - i. The system asks the users if they want to transfer the call.



- ii. The users answer yes by pressing the Enter button and the call is transferred.

2. The system tells the users that the call is transferred.



3. Use Case ends.

Alternative scenario

1.
 - b.
 - ii. The users answer no by pressing the Exit button and the call is not transferred.

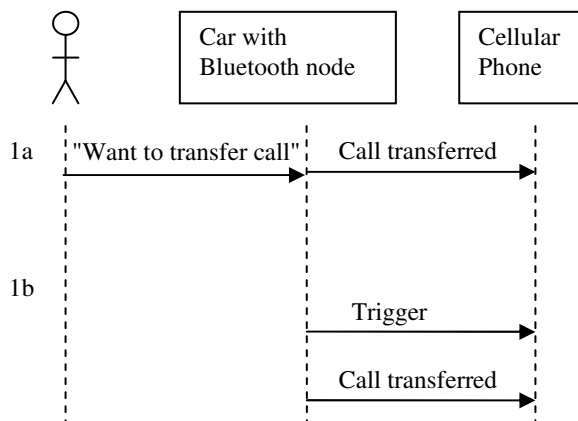
6.3.10 Use Case 10: Privacy mode (Transfer call from the Car to the Cellular)

Privacy mode here means that an ongoing call is transferred from the Bluetooth node in the car to the cellular phone. There are two situations when this kind of handover is wanted, one is when there is an ongoing call and the user want to leave the car (1) and the other is when the user wants to have a private conversation that is not heard in the speakers (2).

With situation 1 we have the same question as with automatic handover when getting into the car, what should this be triggered by? What about when the person locks the car? Well that will be too late since then the person is already out of the car. Maybe when turning off the ignition? Maybe not, since the user might only have stopped to be able to concentrate on the call and then suddenly have to find and pick up the handheld cellular phone. This situation can though be solved if one uses the different positions of the ignition hence if the user only stops to be able to concentrate on the call the key can still be in position I or II and when the ignition is totally turned off (position 0) then the call will be transferred to the cellular phone. We may however have the situation when the driver leaves the car and wants to bring the call along but somebody is waiting in the car and wants to listen to the radio, hence the keys are still in (in position I or II) and the car is not locked. That situation is though maybe more like situation 2. It is hard to find something to trigger on when the user gets out of the car in this situation, therefore an interaction from the user might be needed. This situation is different from that when the user gets into the car in that way that the user will really remember to transfer the call to the cellular phone, since the Bluetooth node interface can not really be heard outside. (When getting in, the user can always continue to talk in the cellular phone, but getting out of the car the user can not keep talking in the microphone and listen to the speakers). Therefore is an interaction here more okay, since it is not hazardous to the safety either (if it is done after stop driving at least).

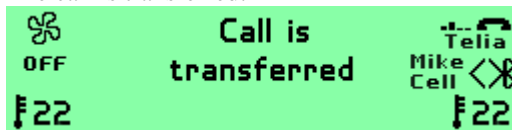
Situation 2 is such a situation where it is wanted that the function will be quick, that is after one has decided that one want to transfer the call it should not take long before the call is transferred. The best thing would therefore be if the user could have direct access to this function, that there was a special button for that. It is also a reasonable interaction for users to press a button to tell the system that they want to transfer the call. Thus, when there is a connection between the Bluetooth node and the cellular phone and the button is pressed the call is transferred to the handheld cellular phone and can be transferred back by pressing the button again. Since it is not safe to drive with a handheld the best thing for the safety would be if the call was transferred to a wireless headset instead of the handheld cellular phone, although it can not be required of the users that they also have a headset available for these situations and that they also know where it is right then when needed. A special button is therefore the best thing for this interaction. In the XC90 there is a button that can be used for this called "My key", in the others a new button has to be added or the buttons have to be rearranged. This solution has the problem that it is difficult to introduce new buttons in the interface but this might be solved by giving an existing button a double function. We could for example use the Bluetooth button that normally is used to switch between active and standby mode. If we have an ongoing call and want to transfer it to the cellular phone, one can look at it as putting the Bluetooth node in standby mode and then the interaction of pressing the Bluetooth button to do that seem naturally. The question is although if the user will understand this step or if it will only confuse the user how to use the Bluetooth button (that before was a simple interaction). If the possibility to change into privacy mode before answering a call should be available the button has to be programmed in the way that it transfers the call when there is an incoming call or an ongoing call and otherwise it change between active and standby mode. This means there will be no possibility to change into privacy mode before making a call, then the button will only change mode (a step backwards in that situation). There could also be a problem if the user tries to use the Bluetooth button to terminate the call and think he has succeeded since the call can not be heard in the speakers and not be seen in the display anymore. For that reason the best thing would be a special button, as said before.

Design Use Case 10: Privacy Mode (Transfer call from the Car to the Cellular)



Main success scenario

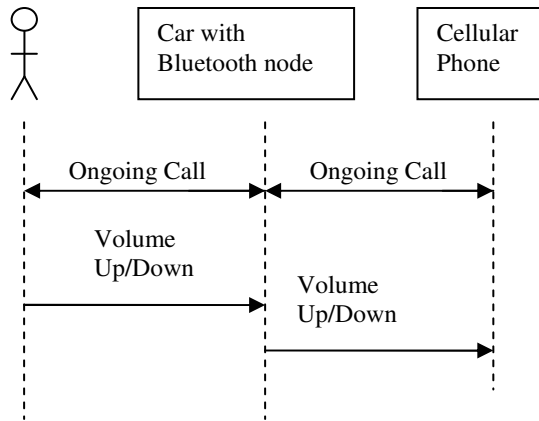
1. Users want to transfer the ongoing call to the handheld cellular phone either because:
 - a. the users want a private conversation
 - b. or the users are leaving the car
2.
 - a. The users tell the system they want to transfer the call by pressing the "Privacy" button.
 - b. The transfer of the call is triggered (or if the trigger do not work in a special situation then the user can do a).
3. The call is transferred.



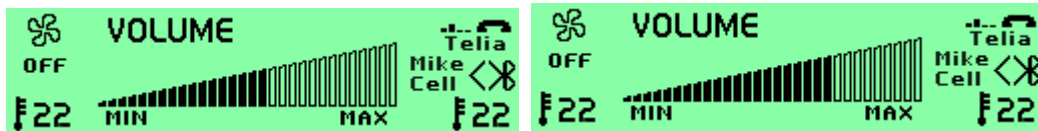
4. Use Case ends.

6.3.11 Use Case 11: Call volume

The easiest way for the user to change the volume on the call during the call would be to turn the volume knob. This however means that if the radio still plays in the background and the users think the radio has too high volume then the user does not have any way to lower the radio volume more during the call. The solution for that in the Volvo cars today with built-in phones is that the phone volume can only be changed on the volume buttons on the steering wheel. This is a solution that shut the passenger out, meaning the driver has to do the interaction. If for example the whole family is riding along and there is an incoming call from Grandma that everybody want to hear. The little son in the backseat though thinks he can not hear clear enough and therefore asks the driver to raise the volume. This make the situation for the driver more complex, it might also disturb the balance the driver has managed to find between the driving situation and the ongoing call. The driver then has to, besides driving and talking /listening to the ongoing call, listen to the son, interpret what he is saying and do the wanted action. In this situation it would be really good if the passengers could do this instead, therefore there should also be possible for the passenger to change the volume. The raise of the volume by the passenger should although not be a surprise to the driver, since then the driver might get chocked by the high sound and temporary loose the control, potentially dangerous. Therefore the raise of the volume by a passenger should also not be possible to be accidental. If it is done in the menu it requires a conscious action from the passenger and the driver will know that the passenger is changing the volume. This menu option can then also be available also when there is no ongoing call; hence there is a possibility to change anyway, for example if the different drivers know they have different preferences. There might also be a child seat in the front passenger seat meaning that a remote control to the infotainment system should be available with the same functions, hence it can be done from the backseat as well.

Design Use Case 11: Call volume (Steering wheel)**Main success scenario**

1. Users want to change the volume
 - a. If there is an ongoing call the user turns down/up the volume on the volume buttons on the steering wheel (or the passenger do it in the menu).
 - b. If there is no ongoing call the user can change the volume in the setting menu.
2. Volume indicator shows the volume.



3. The system adjusts the volume.
4. The system saves the volume¹².
5. Use Case ends.

¹² Except if the users turn down the volume to 0, then the system next time will start on 10% of the maximum volume.

7 Evaluation

A small evaluation was made to get some feedback about the interaction. The evaluation was planned to be more extensive from the beginning but as the design phase took longer time than planned there was not much time left for the evaluation. The limited time meant that the evaluation took more of a "quick and dirty" character than it was meant from the beginning. For example, the initial planning was that the test should be recorded for later analysis but with the limited time there were no time for a thoroughly analysis, and therefore the test was not recorded, only observed.

From the beginning it was meant that the evaluation should be made on the boxcar, but since there were technical problems with the boxcar an interactive model to test on a computer was developed by the author instead.

7.1 Limitations

Since the test was performed on an interactive model the results do not show how the interaction affects the driving. It also does not give the test participants the right feeling since a real screen and real buttons was not used (which was the point with implementing it on the boxcar). The interactive model is implemented after the design proposal and is developed in English and the test participants are all Swedish, which means the interface is presented in a language that is not the test participants' mother tongue.

The test was not recorded since there would not be enough time to analyze the material. That meant that the test was only observed by one observer (the author), who was making notes at the same time which might have meant that some information might have been missed.

7.2 Test Participants

The limited time made it suitable to test the interface on ten persons. To see if there were any differences in how a participant interacted with the system depending on if the participant was a user or non-user of Bluetooth today, it was decided that five users and five non-users would be tested. This might also reveal if the different groups have different problems with the interface. Hence among the test participants there were one group that have used Bluetooth devices before and one group with persons that never have used Bluetooth devices before. Since there was little time not many test participants that used Bluetooth were found, and the proportions became four Bluetooth users and six non-users instead. The participants were between 25 and 43 years old. Three participants were women and seven were men. They were all users of cellular phones.

7.3 The Test

First the test participants were told that it was the interface that would be tested and not them and their knowledge. They were told how to interact with the interactive model (to use the mouse to press the buttons). The limitations with the model were also discussed hence there were no questions about the model before the test began. The participants were told to "think-aloud", i.e. they should tell how they were reasoning while they performed the task. If the participants did not have former knowledge of Bluetooth they were given a short introduction about Bluetooth before the test began.

The users were given the following tasks:

- Pair the Phone with the Bluetooth node (without the interaction on the phone, since no real connection could be established on the interactive model).
- Make a call (with buttons).
- End the call.
- Reject an incoming call.
- Receive a call.
- Check if Marks cellular phone number is in the phonebook.
- Call the last number called.
- Check from who the rejected call was.

For the instructions the user was given (in Swedish) see Appendix B.

7.4 Questions and Questionnaire

To get some advice about the design some questions about different proposals were asked after the test. Some questions were also asked to get to know the users view of the interface and then they got to fill out a one page questionnaire with personal information and grade some things. The interview questions and the questionnaire, both in Swedish, are found in Appendix B.

7.5 Results from the Evaluation

7.5.1 Test Results

The results from the test are sorted into the different tasks that were given to the test participants and then at the end there are some overall results. The tasks are here translated to English, for the original tasks that were given to the test participants in Swedish see appendix B. The tasks are written in italics. In this chapter the pronoun "he" will be used throughout this text even if it is a she who did or said something to make it more objective.

1. *Pair the Cellular phone with this system. The Cellular phone has the name Mike Cell and the PIN code is 1234.*

First to be able to pair the cellular phone with the Bluetooth node interface, the user has to activate the Bluetooth function, since the interface first shows an active CD screen. The **activation** is made by pressing the button with the Bluetooth symbol on it. It varied how successful the participants were with achieving this goal.

One participant wanted to press the enter button since there is a receiver symbol on the button. Another participant (that pressed the Bluetooth button directly) commented that it perhaps would be better if the button is named phone. This, however, is not a good idea if other devices will be added to the Bluetooth node in the future. Three participants commented that they did not know what the Bluetooth symbol meant, but they all guessed it was this button they should press. One of them commented that the Bluetooth symbol looked like a bow. One of these persons said he has never thought about the symbol, he had always thought of the Bluetooth symbol as a blue circle with something white in it, but what the white was he has never reflected on. Another participant that was used to Bluetooth (and therefore recognizes the symbol) observed that people that not are used to Bluetooth can have problems with understanding the symbol and therefore he suggested that it instead should be written Bluetooth with text on the button. Although after been thinking more he realized that it will not fit on the button and he said that it only matters the first time, after this the user would know that the symbol means Bluetooth and thereafter it is unnecessary that it is written in text.

To activate the Bluetooth node one participant wanted to press the Menu button directly and here the interactive model showed it limitations, since this action would have made the CD-menu appear (since the interface from the beginning was in CD-mode) but now nothing happened. This was explained to the user and then the user pressed the Bluetooth button instead. Seven of the participants pressed the Bluetooth symbol first, although four of them first looked around on the other buttons. One participant needed a clue about that the Bluetooth needed to be active before he knew what to do.

Now the users were presented with a screen saying "Bluetooth: No device Connected" and had to figure out how to **pair** the cellular phone with the Bluetooth node interface. To pair they first had to press the Menu button to be presented with the menu and then they had to choose Settings in this menu and then in the settings menu they needed to choose the "Add Device" alternative.

Six of the participants had no problems with pressing the **Menu button** (three of these though had used newer Volvo car interfaces, i.e. they had a previous knowledge of the interface). One of these participants said that he could imagine that one can press enter if one has not read the manual. Three participants tried to press other buttons (Enter, Scan, Up, Down, Left or Right) first and then the Menu button. One of the participants pressed a lot of buttons

including Menu, but he did not think any of the first menu alternatives that was shown (Phonebook, Text Message, Call list) was of use, therefore he exited again. After pressing a lot of buttons he said that he would now have taken out the manual and started to read it. When he was given the clue that he already has pressed the right button, he pressed the Menu button once more.

Nine participants chose *Settings* in the menu without problem, six of these however went through the whole list one time to be sure there was no better choice. Only one participant chose Phonebook in the menu first, then realized it had to be Settings instead.

When looking at the *"Add Device"* alternative in the setting menu one of the participants said: "does this mean I want to add?" This was probably a cause of the fact that the interface was in English and not in the participants' mother tongue. One of the participants had no problem understanding "Add Device" but questioned this wording anyway; he would have preferred something with "phone" in it instead of "device". This meant that nine participants had no problem to understand the menu alternative "Add Device" and the one that had a slight problem with that can be referred to the fact that the language used was not the mother tongue of the participants.

When "Add device" was chosen a static screen that said "Searching for Device" was shown and one of the participants commented this screen. He said he would have found it irritating if it was only showing the same thing for example 30 seconds, he would like this screen to be non-static, that it would show that it is working with little time symbols or something. The best thing, he thought, would be if the different devices would appear one after one, when they were found, since then the search could be interrupted before it's done if the wanted device were already found.

When the wanted device is chosen a screen appeared that said "Enter PIN:" one participant (that was a Bluetooth user) commented this screen. He said that users that are unused to Bluetooth might be unsure of which PIN code they should enter; he therefore suggested a wording in style with "Enter PIN code for Mike Cell" instead.

2. *Call 0702345678 and hang up when the call starts.*

To make a call (to a telephone number that will be given in digit for digit) the user only has to start by pressing the first digit in the telephone number. And at the end press Enter.

One participant first entered the menu, and then exited again, and tried to use the Up and Down button, then started to dial the number. The other nine participants had no problems with this task. One of these participants commented that it might not be easy to dial the number if more phones would be connected since then one first have to choose which phone to call with.

3. *Incoming call but there is a demanding traffic situation at the moment; hence you do not want to answer the call.*

To reject an incoming call the user can either press Exit or wait until the signals stops. No one had problem with this task. One of the participants (a Volvo car owner) said "it is exactly like in my car". Another participant commented that in a real car he would have done it on the steering wheel and not on this interface.

4. *Incoming call, but this time you like to answer. Then end the call.*

To be able to answer the call the user has to press the Enter button and to end the call the user has to press the Exit button. There were no problems with this task for the test participants.

5. *Check that you have Marks Cellular phone number in the phonebook.*

To be able to do this the user has to go into the menu (from the Bluetooth active mode) and chose "Phonebook" and then search for Mark.

A mistake in the interactive model was discovered in this part of the test, at the first search screen the first entries in the phonebook should show. The fact that this was not the case in the interactive model might have influenced the way the test participants acted.

In the Bluetooth active screen three participants wanted to press the "M" to get to the M-section in the phonebook. That is they wanted to press the button for a little bit longer otherwise it would have become the digit 6 instead, a 6 in this case would have led to that the system would be thinking that the user would like to call a number that starts with the digit 6, but since there were no function behind the model nothing happened. Three participants wanted to press the down (or up) arrow in the Bluetooth active screen, since that was a known shortcut to the phonebook for them on for example an Ericsson cellular phone or the built-in Volvo car phone. They all managed to go "the long way" to the phonebook and find Mark, but some of them obviously wanted a shortcut.

In the phonebook five participants complained that the number was not shown. They wanted to control the number and therefore pressed the Enter button and suddenly they were calling this phonebook entry. They wanted the number to show immediately or some of them said it would be okay if they had to press the right arrow to see the number (these were technicians that saw the menu as a menu tree were right means going to a sublevel).

6. *Call the last dialed number.*

To call the last called number users can act in two ways, either they take a shortcut by pressing the Enter button in the Bluetooth active screen or they go the long way i.e. they go into the menu and choose the "Call list" alternative and then choose the "Dialed Numbers" alternative.

Seven participants immediately pressed the Enter button to take the shortcut to the list with the last called numbers. One participant first went the long way but then he remembered that he usually uses a shortcut and he did that as well. Only two participants went the long way.

The participants were also asked what they did prefer all the calls in the same list or separate lists for missed calls, received calls and dialed numbers. Two participants wanted separate lists since that is how they have sorted the calls in their brain, even if this meant that the shortcut would only be a shortcut to one of these lists. The other eight participants wanted all calls in the same list at least when the shortcut button Enter was chosen. (Interesting to note here is that they all were using one SonyEricsson either as private or work cellular phone). They were then asked the resulting question how they would like to differentiate the different kind of calls. Some of them first answered with icons, but when it was questioned how easy it would be to see the icons in the car they started to think about alternatives. Some of them was discussing around this and realized that it was only when the call was from somebody who was not in the phonebook that it mattered if it was an incoming or outgoing call. One participant said it depended on where the information was placed, the icons might be easier seen if the information is placed somewhere else, but with the current placement of the screen maybe icons would not be such a good idea. Another participant thought it would be okay with small icons if the calls had a chronological order since then the call could be identified with the help of time and date. One participant suggested that only one possibility (incoming or outgoing) should be marked with a dot or something, then it would be easier (and faster) to differentiate a call with an icon from a call with no icon. Some of these participants decided icons would be the best anyway. One of these wanted though to complement the icons with different colors on the phone number/name. And one participant only wanted to code the different calls with different colors. This can unfortunately not be done with a display with only two colors.

7. *Check who called before when you could not answer because of the demanding traffic situation. Which number was it?*

To do this task the user has to go into the menu and choose "Call list" and then choose "Missed calls". All the participants handled this task satisfactory. Two of the participants were a little bit unsure if they would find the call under the received or missed calls. Since they had actively chosen not to receive it, they asked themselves if the system thought it was a received or missed call.

Something shown to be different for different participants was the way they wanted to choose something in a menu. To choose an alternative in a menu the Enter button has to be pressed when the right alternative is marked. Five participants were trying to give the number for the wanted menu alternative instead. Three participants tried to use the right arrow to see the sub menu (chose the alternative). This was also a suggestion from two of these participants that the "Up Down Right Left" button would work in the following way in the menu structure: Up and down means going up and down in the menu, right arrow means going to the sub tree and the left arrow means going to the mother node (exit the menu to the previous menu). For them this would be a natural way to navigate in a menu structure. They are though both technicians that see the menu as a menu structure; it can be questioned if users that are not into menu structures could understand this kind of menu navigation.

A short summary of the test: The first task to pair the cellular phone with the Bluetooth node (in form of the interactive model) was the most difficult task for the test participants. Probably since it was a Bluetooth specific task, in the other tasks they could use their knowledge about using a cellular phone (even if it not all the time was exactly the same thing).

7.5.2 Interview Results

The questions are here translated to English, for the original questions in Swedish see appendix B. The questions are written in italics. As in the previous chapter the pronoun "he" will be used throughout this text even if it is a she who have said anything.

1. *An advantage with having Bluetooth could be when you have an ongoing call on your handheld cellular phone and get into the car, then the call could be automatic transferred to the Bluetooth node interface in the car. Would you like this transfer to be automatic or would you like to be asked every time if you wanted to transfer the call?*

Eight of the participants wanted to be asked if the ongoing call should be transferred from the cellular phone to the Bluetooth node interface. Seven of these mentioned the privacy aspect as a reason for that; there could be persons in the car that should not hear the whole conversation. Four of the eight suggested that there could be a choice somewhere to choose if this handover should be automatic or prompted, since in some usage situation it could have advantages with automatic handover. The remaining two participants wanted to have total control over the handover, they wanted to decide themselves if it should be handed over, with an interaction in some form. That is, they would like to tell the Bluetooth node when they want a handover, they find that a question can be annoying.

2. *If we take the opposite situation, you have an ongoing call on this interface and want to leave the car and therefore want to transfer the call to your handheld cellular phone, do you want this to happen by automatic or is it okay to press a button for the transfer to happen?
If you would like it to be automatic, when would you like the transfer to be done? (If they do not know, give proposals: When the ignition is turned off? when the seatbelt is taken off? when the door is opened?)*

Two of the participants wanted that this reversed handover (from the car to the cell) should be automatic, one of them wanted it to be transferred when the door was opened. The other person wanted to safeguard himself for handovers that he did not want to do, therefore he wanted the call to be transferred when both of the following conditions were fulfilled: the ignition is turned off and the door opened.

Five participants thought that they would like to do an interaction in this case; one reason that came up once more was that the user wanted to have the control. Two of them suggested that it also in this situation could be a choice somewhere that the user could set to automatic or interaction. Two of the participants wanted to do an interaction on the handheld cellular phone to tell they wanted to transfer the call. This is dependent on that the cellular phone will be able to communicate this to the Bluetooth node, if the cellular phone developers do not want to provide this option the automotive industry have to solve it any way, therefore they participants were asked how they would like to have it if this was not possible. One of them then preferred it to be automatic and the other preferred to do an interaction on the Bluetooth

node interface instead. One of the participants said it did not matter if this was done automatically or if an interaction was required.

3. *What do you think about the system in general?*

Three participants commented that they thought the most difficult part was when the Bluetooth active screen appeared the first time and the screen showed "Bluetooth: No Device connected". In this situation they would like to be asked if they would like to add a device or something similar to make the situation easier. One participant also suggested that smart menus could be used meaning when no device is connected the "Setting" alternative comes first in the menu instead of last.

Two participants said that they would like to move the section with the buttons Bluetooth, Menu, Exit and Enter for an easier interaction. One of them would like to have access to them all on the steering wheel and the other one want to have them higher up in the interface (but not on the steering wheel). One of the participants said that he likes turning knobs and therefore would like to scroll up and down in the lists with a turning knob instead. One participant commented the design of the buttons with that it looked like a BangOlufsens remote control.

Otherwise the participants said positive things like for example: "Good"; "Nice Integrated"; "Easy, when pressing a button what one expect happens"; "No difficulties"; "Straightforward".

4. *Do you think the interface is consistent (within itself)? Does it differ a lot from a cellular phone do you think (for example the wording)?*

Every participant thought that the interface was consistent within itself. They also thought it pretty much agreed with their experience of how a cellular phone works. One participant commented that it was very few menus compared with a cellular phone but then said it is though okay since one are driving and then one might not have to have access to everything in the cellular phone. One participant saw the interface as a mean of many cellular phones; he thought that both Siemens-, SonyEricsson- and Nokia-users would recognize some things in the interface.

5. *I do not know how much you were thinking of the small symbol that showed that it was "Mike Cell" that was connected to the Bluetooth node. I have some different proposals for that symbol and wonder which one you like best?*

Four participants thought proposal A was the best. Three of them said it was evident that it had to be A. Two of them explained it with the fact that they directly thought that the <> meant a connection. Another participant said he got a strange icon feeling in A, since the Bluetooth symbol disappeared in the proposal, he thought it did not matter which one of proposal B and C was used. (He also questioned if the Bluetooth symbol should show in the standby screen if there is no device connected to the Bluetooth node).

Two participants thought that proposal B was the best one. One of them motivated it with that he in proposal A saw <> as one sign and then a single letter B and that gives the wrong signal. Then B was a better proposal with an opening towards Mike Cell. The other one said that in proposal B it looked like an opening against Mike Cell, but thought that proposal A was ugly. This participant also commented that he thought that the standby screen was too cluttered and he wanted to differentiate this symbol with another color.

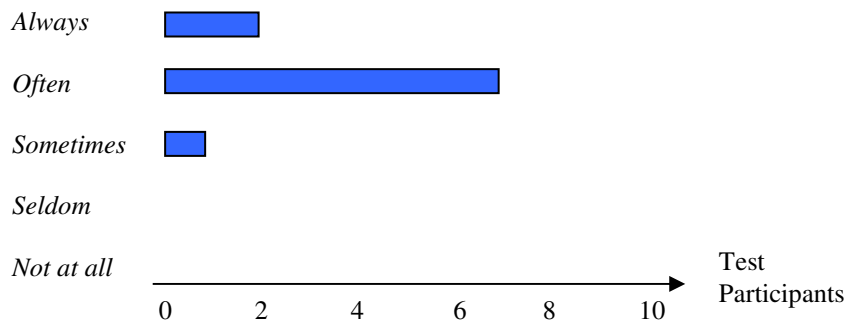
One participant thought that proposal C was the best, since then the Bluetooth symbol seemed more important (since it came first), in the other alternatives he found "Mike Cell" to be more important and he did not agree with that. One participant meant that it did not matter at all; any of the three proposals could be used. Another participant thought that the phone icon in form of a receiver (that was used as a part of the signal strength symbol) was enough to show there was a connection to a phone. The user was asked what happens in the future if there would be other devices that would have a connection to the Bluetooth node. There would be other symbols for these devices then, he answered. When asked which one he would choose if he had to choose he said that he would chose proposal A or B. He would not chose proposal C since he thought that "Mike Cell" was more important than this "ancient

monument sign" (he thought that the Bluetooth symbol looked as the Swedish sign for an ancient monument). He also thought it was enough with "Mike Cell" and that the Bluetooth symbol was not necessary at all.

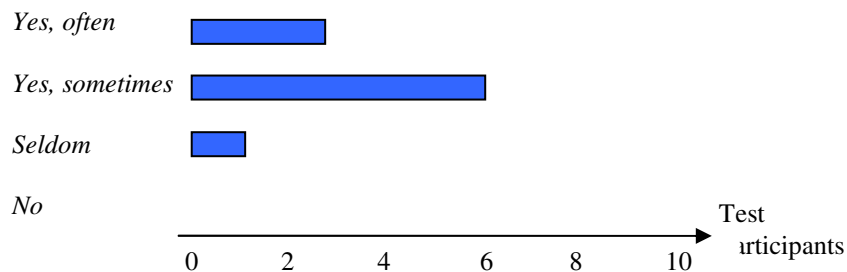
7.5.3 Questionnaire Results

The questions in the questionnaire are here translated to English for the original questionnaire that were given to the test participants in Swedish see appendix B. The questions are written in italics. The first questions about personal information are excluded here and only the answers to the questions about the use of a cellular phone and the interface are presented.

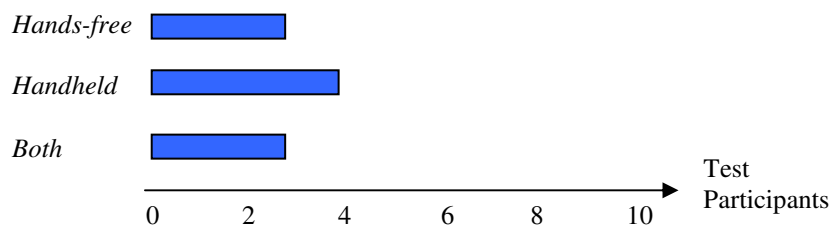
How often do you use your cellular phone?



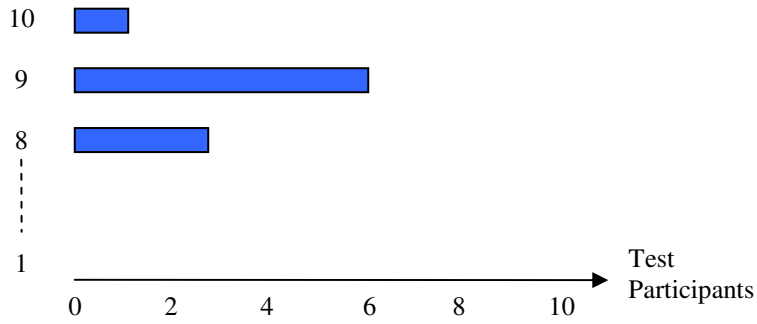
Do you use your cellular phone while driving?



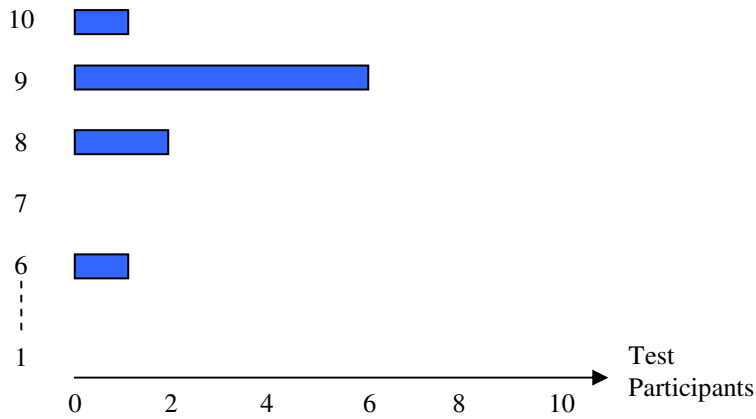
Do you then hold the cellular phone or do you use hands-free equipment?



How easy do you find it was to use the interface on a scale from 1(difficult) to 10(Easy)?



How intuitive do you find it on a scale from 1 (Not at all) to 10 (very much)?



The ratings in these two last questions accompany each other, i.e. if a participant rated the ease as 9 he also rated the intuitiveness as 9.

The two remaining questions result is only provided for VCC. See Appendix E.

8 Analysis of the Evaluation

8.1 The Design Proposal

How good is the design proposal? What did the evaluation of the design proposal give? Why did the evaluation give those results? What in the design proposal should be made different according to the evaluation results? These are things one can ask after an evaluation is made, and in this chapter these things will be discussed. The different design steps will be addressed in the same order as in the “Design Development” chapter, starting with the more general design parts and then comes the design use cases. If a design use case is not mentioned, there is nothing to discuss about that design use case. As before when writing about the test results, the pronoun “he” will be used even if it was a she who did or said something, this to have a short and uniform style.

8.1.1 Modes – Active or Standby

Three people did not understand at first that the Bluetooth had to be activated and that it was not that when the test began. Two of them tried to press other buttons first but when that did not work they saw the Bluetooth button and realized they had to press that one. One reason why they did not understand that the Bluetooth was not active (and therefore have to be activated) might have been that it was not clear for them that the interface was in CD mode when the test began (since there was no music playing). This limitation of the interactive model might have influenced their way of thinking. If music would have started playing when the test began, maybe they would have understood that the interface was in CD mode and then they might have thought that they have to activate the Bluetooth somehow. Something that might also have affected this result is that the Bluetooth button was placed where it was and how it looked. For example if it would have been the same size as the CD and AM/FM buttons and placed close to them it might would have been more obvious that the Bluetooth has to be activated.

Two of the participants that at first did not understand that the Bluetooth had to be activated were two of the persons (out of three) that did not recognize the Bluetooth symbol, which might have made them more uncertain what to do next. If they had known that this was the symbol for Bluetooth they might have tried to press that button and then activated Bluetooth (even if they might not think of it in terms of activating Bluetooth they would have succeeded). One of the other participants (a Bluetooth user that had no problem with this) also said that he could understand if non-users had problems to understand that this symbol were standing for Bluetooth. He therefore suggested that it instead should be written “Bluetooth” with text on the Bluetooth button. He then realized that this would not fit on the button and he thought it through once more. He then concluded that it only mattered what was on the button the first time, for example if the Bluetooth symbol was on the button and the user tried this button he would then know that this button meant Bluetooth (that is after the first time the user will have no benefit of having Bluetooth in written text). Hence having the Bluetooth symbol on the button might be critical for first time users, with no previous knowledge of Bluetooth. Though there was also one participant that had seen the Bluetooth symbol before but did not recognize it anyway since he has always thought of it as blue circle with some white in it and not reflected what the white symbol looked like. This Bluetooth button could therefore be improved by having the original symbol with the right colors on the button. It also have to be said that even if there were problems with understanding the Bluetooth symbol everyone figured out that it have to be that button.


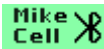
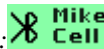
Another comment is if this Bluetooth button really need to function as a switch between the two modes standby and active, since will not the user press the CD button (or radio button, depending on which one he was listening to before) when he no longer wants to have the Bluetooth activated? That depends on what happens with the audio part while the Bluetooth node is active. If the music/radio stop when Bluetooth is active then the user will probably press the CD/radio button to start it again when he is done with using Bluetooth for the moment. If the music/radio goes on while the Bluetooth is active (and is lowered during telephone calls) then the user might be more prone to think in the terms of that he would like to turn the Bluetooth off¹³ and not in terms of that he wants to listen to CD /radio again. If he

¹³ Or in terms of want Bluetooth to disappear

thinks in terms of turning the Bluetooth off it is more obvious to press the Bluetooth button than the CD or radio button. This though has to be tried out on users to be verified.

8.1.2 Bluetooth Connection symbol

How the users were seeing the Bluetooth connection symbol was interesting, if they saw it as the Bluetooth symbol was providing an opening or if they did not interpret any meaning to the symbol at all, that it was "just another symbol". For that reason the participants were asked after the test which proposal out of three they thought were the best for representing the Bluetooth connection.

Proposal A:  Proposal B:  Proposal C: 

Three of the participant said that it was evident that it had to be proposal A, two of them since they saw the <> as a symbol for a connection. They had also immediately been thinking that in the beginning of the test. One more participant chose proposal A, but did not see this openings, instead this choice was based on a feeling. Two participants compared proposal A and B and chose proposal B, one of them since proposal A was seen as ugly. The other one since when the device was added he saw <> as one symbol and then there was a leftover B that did not really fit in. He also thought proposal B was better then C since it had an opening towards "Mike Cell". Another participant also said he got a strange icon feeling in proposal A since he thought that when a device was added the Bluetooth symbol disappeared. He therefore thought proposal B or C were better, since then the Bluetooth icon was more distinct.

Only one participant chose proposal C and he motivated it with that in this proposal the Bluetooth symbol seemed more important (since it came first) and in the other proposals "Mike Cell" seemed to be more important and he did not agree with that that was the case. Another participant said the opposite, if he had to choose a proposal he would choose proposal A or B, since he thinks "Mike Cell" is more important than the Bluetooth symbol. This participant though preferred to have no Bluetooth connection symbol at all; he thought it was enough with the phone icon in the signal strength symbol (as it is implemented in the XC90 boxcar, see appendix D). The phone icon would maybe be enough if it was only one cellular phone that could be paired and no other devices. This interface should though be extendible to include other Bluetooth devices according to flexibility requirement 2 (see 4.3.2.3) which mean we have to take this into consideration when designing. The user then suggested that there could be other symbols for the other kind of devices. That would work as long as only one device can be paired with the interface, but since the competitors' Bluetooth systems can pair more then one cellular phone there is a great possibility that this function would be added to this interface as well in the future. This problem can however be solved if also the device name is shown, i.e. that the connection is shown by showing a device icon and name. If the device name is a good chosen one, one can ask if the device icon then is necessary. Then we have the question if this is enough for the user to understand that there is a Bluetooth connection to this device, or if they wonder why this "Mike Cell" suddenly appeared on the screen. This case has to be tested on users to see the reaction on that design (with and without device icon).

One participant said it did not matter at all for him which proposal was used, for him it was "just another symbol". To conclude the opening to the left in the Bluetooth symbol was seen by half of the participants, then some of them thought that when a device was added it was evident that the <> meant a connection but the other ones thought that the opening from "Mike Cell" was only cluttering the symbol. This means that more time have to be spent on the design of the Bluetooth connection symbol, either more evaluation has to be done to decide on which of the proposals to use or more time have to be spent on developing new proposals (like the new proposal above) and evaluating them.

Some of the participants thought that the standby screen was too cluttered when the Bluetooth node information was added, but if all the status information that is required in the function requirements should be available in that screen it is hard to make it less cluttered. Let's look away from these functional requirements for a moment and start to think about if

we can take away any of the status information from the standby screen. For the user to know there is a Bluetooth connection the Bluetooth connection has to be shown in some way (this Bluetooth connection symbol though might be different and maybe smaller in a future design, see discussion above). In the case of a cellular phone, one wants to know if a phone call can be placed at the moment therefore is the signal strength also important. If other devices might be paired in the future this symbol is though taken away and gives some more air into the screen. The operator is the least important status information in the standby screen today. It is not often that one wonders which operator there is, and if one wonders it can be answered by pressing the Bluetooth button, since then the Bluetooth active screen will show the operator. If the operator is taken away in the standby screen of today that will make the screen less cluttered. In a further development of the design a new Bluetooth connection symbol or the fact that the operator is taken away in the standby screen might make the screen less cluttered.

8.1.3 Menu Structure

What the test participants thought of the depth or wideness of the menu was never tested or asked about, but sometimes the participants indirectly showed that it was too many steps to do some things (i.e. the menu had a too deep structure). One example was when they wanted to go into the phonebook and search for Mark then they were looking for a shortcut to come to the phonebook. If this depended on the fact that they were used to have a shortcut on their cellular phones or if they anyway would have thought it were too many steps is hard to say. Also when the participants should dial the last number called, seven of the participants used the shortcut (to press Enter) that was provided in this case. Also in this case it is questionable if they did it since they were used to it or why they did it. These two examples show that this interface should provide these shortcuts to meet the user expectations. If users are used to a shortcut on their cellular phones and that shortcut is not provided at this interface they will definitely find that there are too many steps to do this in the interface. Not all of the functions can have shortcuts though, since if every function would be one button away we would need a lot of buttons, and that is not possible. Although in other situations, e.g. when the user would like to edit someone in the phonebook, it would probably be more okay to go all the steps through the menu structure (since that was not tested it can not be said for sure though). A thought is though, that users do not edit an entry in the phonebook when driving in tough traffic. The importance of the different functions and how important it is to have an easy access to them is reflected in the priority order made in the functional requirements. All the functions with priority need-to-have are “one button away”¹⁴, except the pairing but that is not done as often as the others therefore it is okay. (If assumed that the above discussed shortcut to the phonebook is provided).

It was a problem with the wideness of the menu one time; one participant did not think there were more alternatives in the menu than he saw; therefore he exited even if the right alternative were just below the ones showing. This problem can be solved with adding a small arrow to show that the menu alternatives go on below the ones shown at the moment. The other participants went down in the menus to see if there were more alternatives and one of them commented that it should somehow show if there were more alternatives or not, one should not need to check that by going down in the menu step by step. This therefore has to be illustrated somehow, probably with some form of arrow. One participant also commented that he thought it was too few submenus when comparing with a cellular phone. Then he thought it through and said that maybe it was not necessary to have all those functions while driving.

The Enter button had to be pressed to choose a menu alternative and most of the participants had no problems with that. Some of them however first tried to press the number for the right menu alternative and then they realized the alternative had to be marked and Enter had to be pressed. It was also some that wanted to navigate in the menus in another way; they wanted to choose something by using the right arrow button. There were technicians and saw the menu as a menu tree and therefore they thought it would be naturally if the left arrow meant going back to the previous menu and the right arrow to see the submenu/choose that

¹⁴ One button away should not be taken literally, there is not many tasks that can be done with just one button press, in this case it means that with one button press the user should have started the task, for example to dial a number requires a lot of button presses but as soon as the first digit is pressed the task is started.

alternative. The up and down arrow buttons would mean going up and down in the menu. The question is how would users that do not see the menu as a menu tree, like this kind of interactions? It is doubtful that they would find it a natural interaction; they would probably have problems understanding it. To choose something by pressing Enter is a more known way to choose for many more users than this alternative solution, therefore that will not be changed in this design.

8.1.4 Use Case 1: Pairing

When no device is paired with the Bluetooth node, the active Bluetooth screen shows "Bluetooth: No Device connected". This situation many test participants found as the hardest in the test, they did not know what to do next. If this was influenced by the fact that this was the first task they should do in the interface (which meant they had no previous knowledge at all in this stage of the test) or if this only was a result of a bad design can be questioned. Anyway the interface should be easy to use for the user even if it is the first time the user uses it, which means that this situation have to be redesigned, it should give the user a hint what to do. Some of the participants said they would have liked to be asked if they would like to pair in this situation, and that is a possible solution to the problem that the test participant faced in this situation. One question to this proposal is though if it in the future might be possible to pair more than one phone then there will be no question when the second phone should be paired will then the user find the way? One can argue that by that time the user might be more used to the system and have looked through the menus and found the Add Device alternative.

The design of this use case is really important and therefore more time is needed to decide how this screen can be better designed to help the users, for that reason that will be left for future work.

There was no bigger problem with that this Bluetooth function (pairing) could be found under the setting alternative in the Bluetooth menu. The participants also understood that the alternative "Add Device" were the right alternative for doing the pairing (maybe the fact that "Add device" was the first menu alternative helped the participants). After "Add Device" had been chosen the Bluetooth node searched for nearby devices and a search screen was presented, one of the participants wanted to change this search screen. He wanted to see that it was working and therefore add something that moved to show that. He said he would have gone mad if this static screen would have shown for 30 seconds. He thought that the best thing would be if the devices would appear one after one when they were found, since then the search could be interrupted before it was done if the wanted device were already found. This is a really good suggestion since it gives the user more feedback of what is happening, therefore should the search and add screens be redesigned in this way.

Another participant commented that the "Enter PIN" screen might be too vague for those who are unused to Bluetooth, they might not know which PIN code should be entered. He suggested that the screen instead would have a wording like "Enter PIN code for Mike Cell". The fact that none of the non-users complained about that could depend on how the task was given to the users, hence this might be a problem for users that is not given a task like these participants. Therefore this screen should also be redesigned according to a suggestion from a participant.

8.1.5 Use Case 2: Establish connection.

The establish connection functionality was not tested in the test but one participant mentioned anyway that he would like to have control over this; that it should only be done after an interaction and not be automatically done. He suggested that also in this case there could be a choice between automatic or not, as with handover. Another participant said that he in some situations might not want the connection to be established and therefore wanted to have a choice between automatic or not. After some seconds he changed his mind when he realized that if he did not want a connection to be established he could turn of the Bluetooth on his cellular phone. When looking at the clear majority that did not want the handover to be automatic, it would have been interesting to have asked the participants if it would be all right that this connection was established automatic or not.

8.1.6 Use Case 3: Make a call

There were no problems with this task. One of the participants however thought about the future, what if more phones are connected, does one have to choose which phone to call from first then? This is an interesting question to think about for future designs.

8.1.7 Use Case 4: Read and call entry in phonebook

More than half of the participants looked for a shortcut to the phonebook when performing the test task to find Mark in the phonebook. And as said above, when discussing the structure, a shortcut should be provided by this system if the users are used to a shortcut on their cellular phones (if possible). The participants tried with two different kinds of shortcuts to reach the phonebook, some tried to press “M” (digit 6) and some the down arrow. The “M” shortcut would take the user directly to the M-section in the phonebook which saves the user from having to go through the whole phonebook from the letter A and on. It is though harder for the user to see the letters on the digit buttons; i.e. to know which button to press for M. The down arrow button is easier to recognize and press, although this shortcut starts in the beginning of the phonebook and then the phonebook have to be gone through in a step by step manner. The best thing would be if both shortcuts could be provided as then the expectations of the users would be met independent on which shortcut they have on their cellular phone.

The test also showed that the entries in the phonebook should show both name and number, hence the number can be controlled. This was something that was not really thought through in the design proposal; of course should also the number show.

8.1.8 Use Case 7: Last number called & Use Case 8: Phone lists

The majority of the users would like to have only one call list with all the calls in, which would change the design of these use cases. The fact that this majority were all using a SonyEricsson cellular phone (that has only one call list today) might have influenced them. To make sure that this is the opinion of a greater group of people, this question has to be asked a greater amount of people than these 10 test participants, and then especially users of other cellular phone brands. If this is the opinion of the greater amount of people then the three call list should be converted in to one list. That would mean that the Enter shortcut would lead to a list where missed calls, received calls and dialed numbers would be mixed. This would change the Use Case 7, since then the user has to be able to differentiate the dialed numbers from the missed and received calls in the call list. How this could be done was discussed with the participants, most of them thought that icons, like in the cellular phones of today, should be used. There might though be problems with seeing small icons while driving therefore should alternative ways of differentiating the calls be considered. How the calls could best be differentiated is a complex discussion that needs more research and time, therefore it will not be further considered in this master thesis.

If one call list is used instead of three also use case 8 will look a bit different, maybe it is not needed at all, since the call list can be reached with the shortcut button Enter. In that case this would also mean one less alternative in the menu. If use case 8 is needed in case of only one call list though have to be investigate further before it is taken away.

8.1.9 Use Case 9: Handover

Users do not like to be forced to things, is it therefore that people seem to be skeptical to automatic functionality? The result of the interview showed that none of the participants wanted to have the handover automatic (all the time). It also showed that the participants wanted to have the control on what was happening with their ongoing call. Eight of the participants thought it was okay to be asked if they wanted to transfer the call. The remaining two participants wanted to do an interaction themselves to handover the call; even to be questioned were too much for them. They wanted to have total control. The thought with having automatic or prompted from the beginning, was that it should be as easy as possible for the users when they wanted a handover, hence they would really do that and not drive off speaking in the handheld cellular phone and be a greater safety risk. If interaction should be a

possibility then an easy interaction has to be chosen to not lose the base thought. The most basic interaction in this situation would be to press one special button for the handover, but then again we have the problem with adding new buttons to the interface. If privacy will have an own button (as discussed in chapter 6.3.10) maybe this button could work for handovers both ways. If there is an ongoing call on the Bluetooth node interface and the button is pressed then the call will mean a handover to the cellular phone (privacy) and if there is an ongoing call on the cellular phone but not on the Bluetooth node then it will mean a handover to the Bluetooth node. To make those participants that wanted to have total control satisfied the alternative interaction can be added to the handover choices automatic and prompted. The interaction choice should though not be the default choice since then the users might think it is too much hassle to transfer the call and will therefore not do it.

That there should be a choice in which way the user would like the handovers to be done is clear, since some of them also saw the advantages with automatic handover and they spontaneously suggested that there should be a choice somewhere.

8.1.10 Use Case 10: Privacy

Once more the issue of control was raised, the users wanted to control when the handover is done. Seven participants said they wanted to do an interaction for the handover from the Bluetooth node to the cellular phone to be done. Two of them would like to do the interaction on the cellular phone and the rest is okay with doing it on the Bluetooth node interface. This opinion, that an interaction is wanted, means that situation 1 and 2 in this design use case (see chapter 6.3.10) can be merged into to the same situation and that either a new button have to be designed or another button have to have a double function.

There was however two participants that wanted this to be automatic. Therefore we have the question: should we also in this case have a choice between automatic and interaction? If automatic should be a possibility then a good technical solution to what it should trigger on has to be found. To find out if the automatic choice should be considered, a greater group of people should be asked to verify that time and money should be spent on finding a technical solution to the trigger problem.

8.2 *Fulfilling the Requirements*

How well does this design proposal fulfill the requirements in the requirement specification? (For the requirements see chapter 4.3). Since the evaluation was done on an interactive model on the computer some of the requirements could not be checked because of the limitations of the model. That was the case for Safety requirements number 1, 2 and 14; Learnability requirements number 4 and 5; Throughput requirement number 6b and 7; Attitude requirement numbers 3-11. Then the art of test also excluded some requirements to be tested. Since no measurements were made the following requirement could not be tested: Safety requirement number 3 and 12; Throughput requirement number 5. That the test were only performed once with the test persons also excluded the requirements were experienced users were needed and were a second test was needed for verifying relearning, that was the following requirements: Learnability requirement number 2; Throughput requirement numbers 1-4, 6a and 6c. Safety requirement number 7 concerns speech systems therefore it can not be applied on this design proposal. How the rest of the requirements were fulfilled follows here (where the requirements are in italics).

8.2.1 Safety

4. *"The system should not produce uncontrollable sound levels liable to mask warnings from within the vehicle or outside or to cause distraction or irritation."*

There are not many sounds in the interface proposal; it's the ring signal and the call volume that both can be adjusted, therefore this requirement is fulfilled.

5. *"System controls should be designed such that they can be operated without adverse impact on the primary driving task."*

Since the interface uses the same controls as the rest of the infotainment system which has gone through VCC testing this requirement is seen as fulfilled.

6. *"The driver should always be able to keep at least one hand on the steering wheel while interacting with the system. That is; all tasks that require manual hand control inputs (and which can be done with the system while the vehicle is in motion) should be executable by the driver in a way that meets all of the following criteria:*

- a. *When some system controls are placed in locations other than on the steering wheel, no more than one hand should be required for manual input to the system at any given time during driving.*
- b. *When system controls are located on the steering wheel and both hands are on the steering wheel, no system tasks should require simultaneous manual inputs from both hands, except in the following condition: one of the two hands maintains only a single finger input (e.g., analogous to pressing "shift" on a keyboard).*
- c. *Reach to the system's controls must allow one hand to remain on the steering wheel at all times.*
- d. *Reach of the whole hand through the steering wheel openings should not be required for operation of any system controls. "*

Since the interface never requires more than one hand these requirements are fulfilled.

8. *"In general (but with specific exceptions) the driver should be able to control the pace of interaction with the system."*

9. *"The system should not require long and uninterruptible sequences of interactions." The users should always have the possibility to interrupt what they are doing. Interrupt here can be in two senses, either interrupt it temporary that is so they later can resume the action or interrupt it permanently if they decide not to do the function at all.*

10. *"The driver should be able to resume an interrupted sequence of interactions with the system at the point of interruption or at another logical point."*

11. *"The system should not require the driver to make time-critical responses when providing input to the system."*

These requirements (8-11) are fulfilled since there are no time restrictions on the interactions with the system.

13. *The number of interactions/steps should be as small as possible.*

This requirement can not be decided if it is fulfilled or not, since how can one decide when the number is as small as possible? This requirement is not measurable, i.e. it should not have been in the requirement specification. It is more of a guideline for the designer in the design phase.

8.2.2 Learnability

1. *The user interface must be simple to use without training or studying the documentation.*
 - a. *95% of the first-time-users¹⁵ should be able to pair the cellular phone with the Bluetooth node at first try*
 - b. *98% of the first-time-users should be able to make a call (by manually give the number in) with the device within two tries*
 - c. *100% of the first-time-users should be able to receive a call with the device at first try*

a) To judge if this requirement is fulfilled one has to know how "at first try" is defined. This was unfortunately not defined when the requirement was written and therefore we now have the question: what does first try mean? When does a try ends? If a user try different possibilities are they all different tries or does a try first ends when the user gives up (do not know what to try next)? Or does it ends when the user gets the manual out to read it? The first try will here go on until the user do not know what to do. This requirement is then not fulfilled since one of the test participants needed a clue to get further when doing the pairing task. Also another one participant said he would by one time have taken out the manual to read how to do this. This means that with this definition of first try only 80% of the first-time-users managed to pair it at first try. It can though be questioned if these first-time-users had enough previous knowledge of using Bluetooth to be included in this group, some of them only had the previous knowledge about Bluetooth that was given before the test. The 2 participants that did not manage at first try were non-users of Bluetooth.

b) In this requirement a definition for what a try is also should have been written when the requirement was written. This requirement is fulfilled by both users and non-users of Bluetooth.

c) This requirement was fulfilled during the test.

3. *The user interface should strive for consistency.*
 - a. *The user interface should have a consistent design throughout the whole interface.*
 - b. *International standards for wording, abbreviations, icons and symbols should be used, as far as possible.*

a) This requirement is not really measurable, although the test participants were asked about the consistency within the interface and all participants thought the interface was consistent within itself; hence the requirement could be seen as fulfilled.

b) If this requirement is fulfilled or not have to be left open since there might be standards that the author is unaware of. Although at least the test participants did not complain about that the interface was breaking any standards.

8.2.3 Flexibility

Extent to which system can accommodate changes

1. *The user interface should support further development of more services to the cellular phone.*
2. *The user interface should also be extendible for other Bluetooth devices.*

This has been the underlying thought, although it is hard to test before one really tries to build out the interface.

¹⁵ They are expected to have a previous knowledge about how to use Bluetooth technology.

8.2.4 Throughput

6. Low user error rate

- d) *The user should not choose the wrong function for the reason that they do not understand the wording/the language that is used.*

There was one user that did not really know if "Add Device" was the wording for what he was looking for, although the test participant did not choose the wrong function, meaning this did not occur during the test and the requirement was fulfilled.

8.2.5 Attitude

1. *The users should grade the user interface at least "6", on a scale from Difficult (1) to Easy (10).*

No one of the participants rated the ease of the interface lower than 8, which means that requirement 1 is definitely fulfilled.

2. *The users should grade it at least "6" on a scale from Non-intuitive (1) to Intuitive (10).*

When the test participants were asked to rate how intuitive the interface was, one participant rated it 6 and the rest rated it 8, 9 or 10, which means that also requirement 2 is fulfilled.

8.3 The Analysis Result

The Analysis of the test results shows that it is important that the design follows the way things are performed¹⁶ on the Bluetooth device. In this evaluation this was shown by the participant having no greater problems with the tasks that was performed in the same way in the user interface as on their cellular phones. The participants had problems (smaller or greater) with the tasks where the interaction, which they normally would do with their cellular phone, was not supported. An example of that are the shortcuts that the participants wanted to use but the user interface did not support. There are however cases where different interactions are required for doing a task depending on which brand of cellular phone the user have, i.e. there is not only one design to follow. In these cases it is important to look closer to the disadvantages and advantages with the different designs before deciding if one of these should be followed or if a new design should be developed.

In this design proposal there were also use cases where there are no other designs that have to be followed, i.e. the specific Bluetooth use cases (No 1, 2, 9, 10). Only the pairing use case (No 1) was tested in the evaluation and the participants had problems with this new function and how to interact with it. The evaluation shows that the user needs more support what to do first when pairing a device with the Bluetooth node. This is probably an effect of the fact that this use case is new for them and they have none or only little experience of pairing and therefore have nothing to refer to. The use cases Handover (No 9) and Privacy (No 10) were also discussed with the participants; how they would like these functions to be carried out. The fact that humans do not like to be forced to things showed in this case since the participants were skeptical to automatic handovers, they would like to decide on their own if something should be done or not. Some of the participants wanted to have total control i.e. a question from the interface was too much, they wanted to perform an interaction before the system did anything.

The standby screen was also too cluttered according to some test participants, and this have to be solved with either take away some Bluetooth information or redesign it. In that way the legibility of the information can be higher and thereby reduce the visual load for the user.

¹⁶ I.e. the overall thought should be followed and not the design details.

8 Analysis of the Evaluation

Answering the first question statement (see chapter 5.2) the importance of the user interface fulfilling the requirements in the requirement specification was pointed out. Many of the requirements could though not be tested during the evaluation because of the type of test. Among the requirements that could be tested, the most were fulfilled. The requirement concerning pairing could though be discussed if it was fulfilled or not. Hence once more we can establish the fact that the user needs more support when pairing.

The test results and the analysis of them shows that it is mainly in the Bluetooth specific use cases and information where more time have to be spent on developing this design proposal. This design proposal would need another iteration on the intertwined interaction/surface level; that is be redesigned and then tested once more.

9 Discussion

9.1 The Work Process and the Methods

The development process can be made in a lot of ways; it was chosen to work according to the user-centered system development model since the user and the user context are important in this design. This model has also been used by the author in previous projects and was then found to give the right kind of support during the development process. In the beginning of this project the plan was to do two iterations on the intertwined interaction /surface level, but it was pretty soon realized that there would not be time for that, hence the plan was changed to only one and a quarter cycle. How the different steps worked out follows here:

The analysis phase: To do a user analysis gave a good understanding for the user and the user context. Of course this understanding could have been deeper if other methods than study of documentation were used, for example if the user would have been observed or interviewed. Since this project should include more steps the time though was not enough for doing such a deep user analysis. There were a lot of studies made about the driver situation and using cellular phones in the car that could be studied, a lot of them had a more quantitative approach which gives some information about the situation, although to become a deeper understanding more detailed studies needed to be studied. Fortunately the National Road Administration in Sweden had made a project where focus group discussions about using the cellular phone while driving, was included. The documentation of these focus group discussions gave a deeper understanding, not only for the user but also for the task (using a cellular phone). The user and task analyses were a good base for doing the requirement specification and helped answering the first question statement.

To prevent the wheel from being invented again and to get some inspiration related work was studied. Studying related work in the automotive industry gave some inspiration for how things could be designed but also what difficulties to think about when designing. A deeper understanding for how other solutions worked out or not could have been obtained if the other systems could have been tried out. Unfortunately the other systems were not available at that time, which meant that the other systems could only be read about and not tested in reality.

The specify phase: To write the requirement specification the analyses (from the former step) were used as a base together with some guidelines and recommendations from EU and the American Automotive industry. The good base material made it easier to decide upon what requirements there should be. Although to make all the wanted requirements measurable were not that easy. Otherwise there were no problems in this step.

The design phase: To develop general Use Cases was a good way to divide the task between the user and the Bluetooth node, since then every step in the required functions was thought of. An Exploration of what interaction techniques there are and their advantages and disadvantages in the driving environment, were made to be able to answer the first question statement. It was supposed to be a base for the decision what interaction technique to use in the design proposal; that is the interaction technique that was best suited for the driving situation and the car environment. Since there was no superior interaction technique, this did not lead to an obvious interaction technique to use in the design proposal. Therefore it was decided to do three different proposals, one visual, one auditory and one were the two were combined, and then to evaluate them against each other. This decision was then further limited by available technology, which meant that only one design proposal, a visual design proposal, was developed.

The design proposal was only developed for the functions with the (highest) priority “need-to-have”, since the time was too short to do it for all the functions. The physical design for these “need-to-have” functions were developed in two sets, since the XC90 interface has a much smaller display then the newer interface (which made that some things had to be made different on the XC90 interface). The physical designing was shadowed by all the limitations on the system; since the Bluetooth node should be a part of an already existing system, the infotainment system, it had to be consistent with that in the design and also use the same interface (buttons and display). A more new-thinking design could have been made without these restrictions.

In the design part the difficulties of being an alone interaction designer became obvious; when one do not really have another person to discuss ideas with. To be more persons in a design team is important since then the others can see the disadvantages with the thinking /design, that oneself is blind for.

Too little time was planned for the whole design step. There were too many things to do in this limited amount of time available, they were however necessary to do, which meant that this step was not ended in time and that had negative consequences for the next steps in the iteration cycle.

The evaluation phase: The delay in the step before meant that it was short of time to do the evaluation and the question if the evaluation should fall outside the scope of this master thesis was raised by the supervisor at the university. It was though important to test the design proposal on users to see how it worked out in reality. As this design proposal was developed by a single designer the feedback from users were needed.

The design proposal was supposed to be implemented by another person in a boxcar to be tested with users; meanwhile the preparation of the test was planned. Since there were technical problems with the boxcar the design proposal had to be tried out on users in another form. The interaction was the most important thing to try out; therefore it was decided that an interactive model on the computer should be built instead, to see how the interaction worked out. Meaning that the author had to spend extra time on building the interactive model, which was not in the time plan from the beginning. The test was not recorded since there was not time to analyze the material. This might have meant that some information might have been missed, since it was hard to be the only observer and taking notes at the same time. The test although resulted in valuable feedback from the test participants.

The second analysis phase: A more detailed analysis of the evaluation was planned from the beginning now this analysis of the evaluation had to be done quickly, which might mean that not all important things were discovered or analyzed.

To summarize the time planning was to optimistic, especially for the design part. Consequently the time plan could not be held in the design step, as a result of that the last steps had to be reduced, or done in a hurry, even though those steps were not less important than the previous ones.

9.2 The Question Statements

9.2.1 The first Question Statement

The first question statement was: *“What do the special context and the task mean for the design of such an interface and which interaction technique is suitable for this task in this context?”* How can the answer to this question help us answer the main question?

The driving context put mainly visual, manual and cognitive demands on the driver which also the task of using a cellular phone does. Therefore it is important in the design that the tasks demands are reduced and designed not to interfere with the driving demands in such a way that the driving task can not be performed in a safe way. The context and the task also implicate more detailed requirements for the user interface that is specified in the requirement specification. A suitable user interface should therefore fulfill the requirement specification and try to reduce the visual, manual and cognitive demands for the user when performing the task.

To see what interaction possibilities for the interface was suitable in the user context the following question was asked: *What interaction techniques are there and how do they fit the user context?* The interaction techniques that were found were based on the senses sight, hearing and touch. All the different interaction techniques have their advantages and disadvantages in the driving context. The disadvantage with the visual output is the fact it requires visual attention and therefore has to timeshare the visual resource with the visual demanding primary task of driving. The visual output is although persistent which makes it easier to do timesharing. Visual output is also an interaction to which the user is used to. The

auditory input and output have the great advantage of being hands-free and eyes free. The auditory output is though transient, which means that once the audio is presented it disappear. For that reason the user have to be able to give the auditory output attention at a special time for a certain amount of time and that is not good in the driving environment, therefore the user have to be able to repeat auditory output. It is also attention grabbing which is good when it communicates important information but can be annoying when it communicates not important information. The auditory input is still an area where better technology has to be developed before it will work satisfying for the driver context. Active (controlled by computers) haptic feedback is also an area were more research has to be done before it is should be brought into to the driving context. Passive haptic feedback is though already used in cars today for example in form of different surfaces and shapes of buttons.

If we look at the different demands on the driver the best thing would be if the user interface were auditory since then it would not have the same main demands on the driver as the driving task. The auditory output is though attention grabbing which can disturb ongoing cognitive process and also be found as annoying by the driver. Auditory input would though be a great idea if it worked satisfying, but we are not there yet. It seems like it is hard to find interaction techniques that do not disturb the demands that the driving task have on the user, but then we could at least try to reduce the demands that the interface puts on the driver. For example would the manual demand get less with a hands-free system and if the buttons had different surfaces and shapes they could be differentiated without looking, hence there would also be less visual demand. Studying literature and research it seems like there are no mature interaction technique alternatives (to the traditionally visual-manual) that fit the driving context and car environment.

9.2.2 The second Question Statement

The second question statement was: *“How can a user interface that takes the context, the task and the suitable interaction technique in consideration be designed?”* To be able to answer this question a design proposal for such a user interface was developed.

This design proposal should include three different kinds of user interfaces according to the Bluetooth Project at VCC; these interfaces were also given a priority order as follows:

1. General user interface for all Bluetooth devices (i.e. pairing and connecting the Bluetooth device with the car).
2. User interface for a cellular phone device.
3. User interface for another device (first part of the project gives device suggestion)

A design proposal for a user interface that could function as a general user interfaces for all Bluetooth devices and as user interface for a cellular phone was developed. The cellular phone part of the user interface can however be extended to include more functions. The last user interface was not developed since the first part of the project changed and therefore no device suggestion was made.

Since there were no obvious interaction technique to use for the user interface the thought from the beginning was to develop more proposals and test them against each other, but then there were some technology constraints. For that reason was only a traditionally visual-manual design proposal developed, where the intention was to decrease the task's visual and manual demands on the driver.

The fact that the Bluetooth node should be a part of an already existing system meant that there were a lot of restrictions that had to be followed for the user interface in the design proposal; therefore also no revolutionary design proposal was developed. The evaluation of the design proposal gave useful feedback for future designs. The evaluation showed that some things have to be redesigned; hence the design proposal is not a final design proposal.

The fact that several design proposals were not developed and evaluated meant that this did not result in any additional information regarding the suitability of different interaction techniques to use for a Bluetooth node user interface in the car environment. The development of the design proposal and the evaluation though gave indications on how to make a suitable visual-manual user interface for the Bluetooth node (with special regard to the connection to a cellular phone).

The design proposal was supposed to be an example for how a user interface that takes the context, the task and the suitable interaction technique in consideration can be designed. It is also an example of that, but the evaluation of it shows that some things need to be redesigned before it can serve as an answer to the main question.

9.3 Future work

This is only a beginning and much more work can be done. The test results shows that it is mainly in the Bluetooth specific use cases and information where more time have to be spent on developing this design proposal. This design proposal would need another iteration on the intertwined interaction/surface level; that is be redesigned and then tested once more. Then the test has to be more thoroughly and should be performed on a boxcar or a real car. Safety measures should also be done during the test, hence the affects on the driving can be revealed. The test should also be preformed in such a way that one can see if the rest of the requirements are fulfilled or not. This design proposal should also be widened to include all the use cases in Appendix C, since people do want to write text messages in their car for example.

To develop alternative design proposals based on other interaction techniques would be interesting, since they then could be tested against each other. Future work is also to widen the design proposal to include that more cellular phones can be paired and connected at the same time. Then the use cases have to be extended to handle more than one possible source in a smooth way. Also design proposals for specific user interfaces for other Bluetooth devices, for example PDA, are included in future work on this Bluetooth node.

10 Conclusion

The main question for this master thesis has been “*How can the car provide a suitable user interface for a cellular phone with a Bluetooth connection to the car?*” To be able to answer the research question, two other question statements were identified.

1. What does the special context and task mean for the design of such an interface and which interaction technique is suitable for this task in this context?
2. How can a user interface that takes the context, the task and the suitable interaction technique in consideration be designed?

The thought was that the answer from the first question was going to be used as a base for developing design proposals for a Bluetooth node user interface with focus on the connection to a cellular phone. The design proposals were to be evaluated with users and these results and the development process would answer the second question and give additional information to answer the main question.

However, there were no clear answers to which interaction technique was suitable for this task in this context. Therefore this was to be tested out by developing design proposals based on different interaction techniques, although only one design proposal were developed due to technology constraints. The fact that not several design proposals were developed and evaluated meant that these processes did not result in any additional information regarding the suitability of different interaction techniques to use for a Bluetooth node user interface in the car environment.

The design proposal is a part of the answer, since it is a suggestion for such a Bluetooth node user interface, although some parts of it has to be redesigned before it can serve as a complete answer to the main question. The development of the design proposal and the evaluation though gave indications on how to make a suitable visual-manual user interface for the Bluetooth node (with special regard to the connection to a cellular phone). The user interface have to give the user extra support during the Bluetooth specific use cases and in the phone specific use cases it should provide the same shortcuts as cellular phones.

It seems like more research has to be done in this area before a new answer can be given to the main question “*How can the car provide a suitable user interface for a cellular phone with a Bluetooth connection to the car?*” Since today there are no mature interaction technique alternatives (to the traditionally visual-manual) that fit the driving context and car environment. Therefore a part of the answer to the main question has to be that with the technology and research available today a suitable user interface will have visual output (that though require as little visual attention as possible and have no timers) and manual input (also with no timers in it). A suitable user interface should also try to reduce the visual, manual and cognitive demands for the user when performing the task and fulfill the requirement specification (chapter 4.3).

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Abbreviations & Descriptions

Abbreviation	Stands for	Description
	Boxcar	The involving technologies are mounted on a board to function as in a real car, for picture see Appendix D.
CD	Compact Disc	
DF-T	Driver Focus-Telematics Working group	
EU	European Union	
HUD	Head-Up-Display	A display that projects information on the windscreen.
ISM	Industrial, Scientific and Medical	Name for the frequency band Bluetooth uses.
IT	Information Technology	
	Infotainment system	A system in the car that provides information and entertainment to the users, for example in form of audio and phone functions.
	Interaction techniques	Interaction techniques here means the hardware and software elements that together provide a way for the user to accomplish a task.
LAN	Local Area Network	A local area network is a group of computers and associated devices that share a common communications line and share the resources of a single processor or server within a small geographic area.
MOST	Media Oriented Systems Transport	The optical network for infotainment in cars.
PC	Personal Computer	
PDA	Personal Digital Assistant	A small handheld computing device
PIN	Personal Identification Number	A PIN is a personal identification number. PINs are commonly assigned to bank customers for use with automatic cash dispensers.
SIG	Bluetooth Special Interest Group	Group of all companies who have registered interest in Bluetooth via the SIG website.
SIM card	Subscriber Identity Module card	A plastic card in a cellular phone that contains ones personal information and that allows one to use the phone
SMS	Short Message Service	
SNRA	The Swedish National Road Administration	
SUV	Sport Utility Vehicle	
	Twin Card	Twin card is here directly translated from Swedish and is when one user has two SIM cards to the same phone number.
VCC	Volvo Car Corporation	

Appendix A:

**Project plan for
General User Interfaces for Bluetooth
Devices in a Car Environment**

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1 Introduction

1.1 Purpose of this document

This document defines goals and the time plans for this master thesis, which should try to answer the question "How can the car provide a suitable user interface for a cellular phone with a Bluetooth connection to the car?"

1.2 Who should read this document

The document is designed for Volvo Car Cooperation, my supervisor at Chalmers as well as other interested parties.

1.3 How to receive more information

Contact Maria Larsson, mlarss87@volvocars.com

2 Basic Information

2.1 Purpose

The purpose of this project is to investigate the possibilities and constraints on using Bluetooth in the car for a wireless connection between different infotainment devices and the network MOST in the car. This master thesis purpose within this project is to suggest a suitable general user interface in the car for these Bluetooth devices and especially suggest a suitable user interface for a Bluetooth cellular phone.

2.2 Background

The automotive industry is increasing its effort in providing customer functions with entertainment and information giving character. One possible way to make it easier for the customer to use different entertainment devices in the car is to have a wireless connection between the car and the devices, for example a Bluetooth connection. The Bluetooth device then requires a user interface in the car. It is important that the user interface fit in to the special driver situation.

2.3 Prerequisites

- MOST boxcar with Bluetooth
- Bluetooth devices, including a Bluetooth cellular phone
- A car to implement it in, for demonstration.

3 Project overview

3.1 Scope of work

Two parts, part one is to suggest and construct an interface between a hands-free telephone and other interesting devices and the car, the other part is to suggest and construct a general user interface for these Bluetooth devices. The second part is the scope for this master thesis.

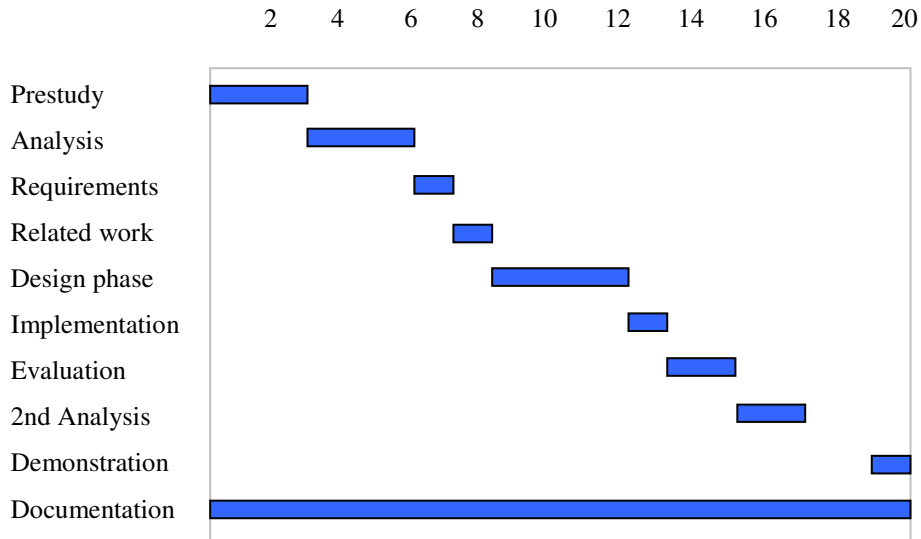
The user interface part consists of different steps. The Interfaces that are to be developed or modified are in priority order as follows:

1. General user interface for all Bluetooth devices (pairing and connecting the device with the car)
2. User interface for a cellular phone device
3. User interface for another device (device suggestion will come from the first part of the project).

3.2 Overview of required work

- Analysis
- Design
- Implementation
- Evaluation
- Documentation
- Demonstration.

3.3 Time plan



- Project start 2003-09-01
- Project end 2004-02-15

4 Project Process

Project week	Date	Phase
1-3	w.36-38	Prestudies
4-6	w.39-41	User analysis & Task analysis
7	w.42	Requirements and technical constraints
8	w.43	Related work
9-12	w.44, 46-48	Design phase
13	w.49	Implementation
14-15	w.50-51	Evaluation
16-17	w.3-4	Analysis of the Evaluation and a final design proposal
18-20	w.5-7	Final documentation and preparation of presentation
20	w.7	Demonstration

5 Work Phases

The project is developed with an iterative process consisting of Analysis and Requirement, Design, Implementation and Evaluation phases. One whole cycle is made and the beginning of a second cycle, that is, the Analysis part is repeated twice.

5.1 *Prestudy*

5.1.1 Background

The automotive industry is increasing its effort in providing customer functions with entertainment and information giving character. One possible way to make it easier for the customer to use different entertainment devices in the car is to have a wireless connection between the car and the devices, for example a Bluetooth connection. The Bluetooth device then requires a user interface in the car. It is important that the user interface fit in to the special driver situation.

5.1.2 Goal

The Goal of the prestudy is to understand:

- Roughly how the Bluetooth standard work
- The driver situation from a cognitive aspect

5.2 *Analysis*

In the first cycle the Analysis will consist of one user and one task analysis and in this phase it is important to find out whom are the user and in which situation is the interactions to take place? And which tasks does the interface have to support? These Analyses should also result in a requirement specification for the interface.

In the second cycle the evaluation will be analyzed to find out additional requirements and to find out what would improve the design.

5.3 *Design*

Some design proposal for a good user interface is to be generated. These proposals should concern usability, cognitive possibilities in the driving situation and safety. The designs should meet the requirements in the requirement specification. A couple of the design proposals are to be chosen to be implemented and evaluated with users.

5.4 *Implementation*

The chosen design proposals are to be implemented in a MOST boxcar with the XC90 infotainment system display and buttons to interact with.

5.5 *Evaluation*

In this phase the design proposals are to be evaluated; do they fulfill the requirement specification? The interfaces are evaluated with users on the boxcar.

5.6 *Demonstration*

The project will hopefully be demonstrated within a XC90.

5.7 *Final Documentation and preparation of presentation*

The last weeks are reserved for preparing the demonstration (implement it in a car) and the presentation and also finishing the documentation of the master thesis.

6 Methods and Tools

For theoretical methods see separate chapter in the final report.

6.1 User analysis

In the user analysis market reports and reports about the driver situation will be studied. Also personal knowledge from what user thought about interacting with the infotainment system in XC90 (from the evaluation of that system made by the author summer 2003) will be used to get a picture of the user.

6.2 Implementation

The tool to be used for implementation is a MOST boxcar. And hopefully a XC90 for the demonstration.

6.3 Evaluation

The methods to be used in this phase are a user test under observation and interviewing the users about how the interaction feels. During the evaluation a MOST boxcar is used as a tool.

7 Document Plan

- Project plan
- Time plan
- Requirement specification
- Final report

Appendix B:

Test Instructions, Questions and Questionnaire (In Swedish)

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The Interactive Model:





Testuppgifter:

1. Para telefonen med systemet. Telefonen har namnet Mikes Cell och pinkoden är 1234.
2. Ring 0702345678 och lägg på när samtalet börjat.
3. Inkommande samtal men tuff trafiksituation, du vill inte svara.
4. Inkommande samtal men nu vill du svara. Avsluta sedan samtalet.
5. Kolla att du har Marks mobilnummer i telefonboken.
6. Ring det senast slagna numret.
7. Kolla vem det var som ringde innan när du inte kunde svara p.g.a. tuff trafiksituation. Vilket nummer var det?

Frågor:

1. Handover: En fördel med att ha Bluetooth skulle vara när man har ett pågående samtal i sin mobiltelefon och kommer in i bilen så flyttas samtalet automatiskt över till detta system istället. Skulle du vilja ha det så eller skulle du vilja få upp en fråga varje gång om du ville flytta över samtalet?
2. Privacy: Om vi tar det omvända att du har ett pågående samtal på detta system och vill gå ur bilen och därför vill flytta över samtalet till din mobiltelefon, vill du att detta ska gå automatiskt eller är det okej om du måste trycka på en knapp för att detta ska hända?
Om du vill att det ska ske automatiskt när vill du att samtalet flyttas över?
3. Vad tycker du om gränssnittet allmänt?
4. Tycker du att gränssnittet är konsistent? Avviker det från hur en mobiltelefon fungerar tycker du? Iså fall på vilket sätt?
5. Vet inte hur mycket du tänkte på den lilla symbolen som visade att det var Mike Cell som var kopplad till Bluetooth enheten, men jag har lite olika förslag på den här och undrar vilken du tycker bäst om?



Standby:



- a.
- b.
- c.

Aktiv:

- d.
- e.
- f.

Testformulär

1. Namn:
2. Kön:
3. Ålder:
4. Yrke:
5. Mobiltelefon märke/modell:
6. Hur ofta använder du din mobiltelefon? (Ringa in rätt alternativ)

Alltid Ofta Ibland Sällan Inte alls

7. Använder du mobiltelefon när du kör? (Ringa in rätt alternativ)

Ja ofta Ja ibland Sällan Nej

Gränssnittet

8. Hur lätt tycker du gränssnittet var att använda på en skala från 1 (svårt) till 10 (lätt)? (Ringa in rätt alternativ)

Svårt Lätt
1 2 3 4 5 6 7 8 9 10

9. Hur intuitivt tycker du att det är? (Ringa in rätt alternativ)

Inte alls Mycket
1 2 3 4 5 6 7 8 9 10

10. Finns det några andra saker än mobiltelefonen som du skulle vilja kunna koppla ihop med en Bluetooth nod i bilen?

11. Hur mycket skulle du vara beredd att betala för ett sådant här system?

Appendix C:

Use Cases for a Bluetooth node

- Especially for a Bluetooth Connection to a Cellular Phone

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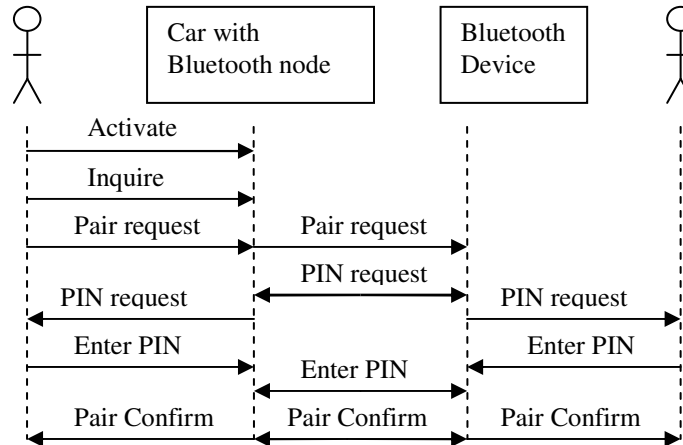
* First Priority: "Need-to-have"

** Second Priority: "Important"

*** Third Priority: "Nice-to-have"

1 General Use Cases

1.1 * Use Case 1: Pairing



1.1.1 Preconditions

1. The Bluetooth device must be in range for Bluetooth communication.
2. The Bluetooth device and the Bluetooth node have to have at least one Bluetooth Profile in common.
3. The Bluetooth device has to be in discoverable mode.

1.1.2 Post conditions

1. The Bluetooth device is paired with the Bluetooth node.

1.1.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users use the Bluetooth node to inquire for nearby Bluetooth devices.
3. The users request to pair the Bluetooth node with the Bluetooth device.
4. The Bluetooth node (and sometimes also the Bluetooth device) asks for the PIN number.
5. The users supply the PIN number.
6. The Bluetooth node and the Bluetooth device confirm the pairing.
7. Use Case ends.

1.1.4 Alternative scenario

4. The users supply the wrong PIN number.
5. The Bluetooth node (or the Bluetooth device) rejects the pairing and tells the users that it is the wrong PIN number.
6. The users have to enter the PIN number again.
7. The users get three tries to enter the PIN number, when the users fail to enter the right PIN number in three tries the users have to start all over.

1.2 * Use Case 2: Establish a connection

1.2.1 Preconditions

1. The Bluetooth device is paired with the Bluetooth node (Use Case 1).
2. The Bluetooth device must be in range for Bluetooth communication.
3. The Bluetooth device and the Bluetooth node have to have at least one Bluetooth Profile in common.

1.2.2 Post conditions

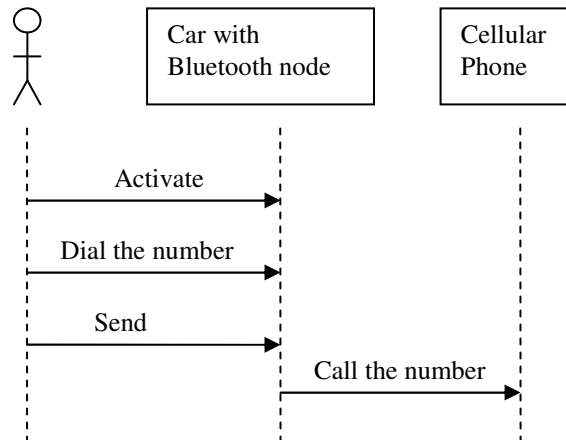
1. The Bluetooth device and the Bluetooth node have established a Bluetooth connection.

1.2.3 Main success scenario

1. The Bluetooth node discovers the Bluetooth device.
2. The Bluetooth node sends a connection request to the Bluetooth device.
3. The Bluetooth device accepts the connection.
4. Use Case ends.

2 Cellular Phone Use Cases

2.1 * Use Case 3: Making a call (with buttons)



2.1.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).

2.1.2 Post conditions

1. The system uses the cellular phone to call the supplied number.

2.1.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users enter the desired phone number by using the digits/buttons on the Bluetooth node-interface.
3. The users send the phone number by pressing a button on the Bluetooth node-interface.
4. The system gives the users feedback in form of "Calling <Telephone Number >".
5. The system uses the cellular phone to call the desired number.
6. Use Case ends.

2.1.4 Alternative scenario 1

2. The users enter the digits and then suddenly the users enter another digit than intended.
3. The users erase the digit. The users continue to give numbers in. And then they proceeds on number 3 in the main success scenario.

2.1.5 Alternative scenario 2

3. The users change their mind and want to cancel the call; the users tell the system they want to cancel the call.

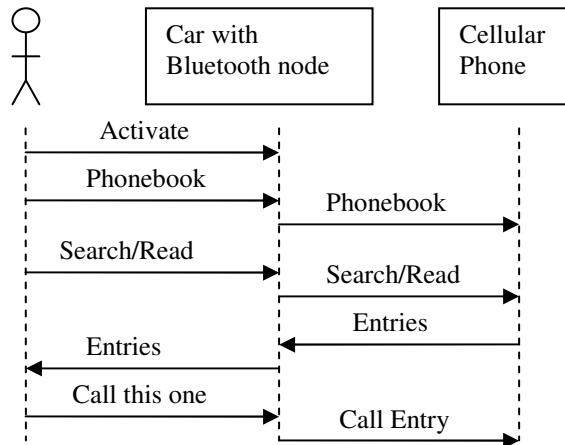
2.1.6 Alternative scenario 3

4. The signal strength is too low hence the cellular phone cannot call the number. The system tells the user "Signal strength too low to place call".

2.1.7 Alternative scenario 4

4. The number given in is an invalid number, the display gives the feedback "Invalid number".

2.2 * Use Case 4: Read and call entry in the phonebook (with buttons)



2.2.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. The cellular phone has a phonebook with entries in.

2.2.2 Post conditions

1. The system uses the cellular phone to read and call the number in the phonebook.

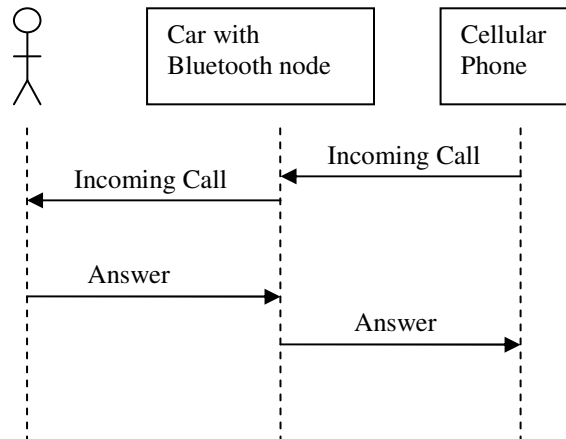
2.2.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users choose "Phonebook".
3. The users choose to:
 - a. Go through the entries in the phone book in a step-by-step manner by using up and down functions.
 - b. Search for the wanted entry
 - i. The users write the name or the beginning of the name they are searching for and then get a list with entries that starts in that way or the entry that correspond to that name.
 - ii. And can then use forward or back function to go to the right entry in the list that fit the letters given in.
4. The entries in the phonebook of the cellular phone are communicated to the users.
5. When the users found the right entry the users tell the system they want to call this number.
6. The system uses the cellular phone to call the desired entry.
7. Use Case ends.

2.2.4 Alternative scenario

5. The users only wanted to know the number and not call it, therefore they exit after they have read it.

2.3 * Use Case 5: Receiving and rejecting call (using buttons)



2.3.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. An incoming phone call.

2.3.2 Post conditions

1. The incoming call is received.

2.3.3 Main success scenario

1. The system tells the users there is an incoming call (with preferred interaction method).
2. The users tell the system they want to answer the call.
3. The system uses the cellular phone to receive the call.
4. Use Case ends.

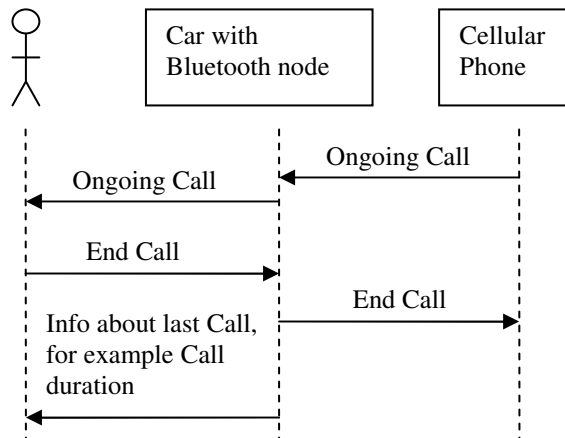
2.3.4 Alternative scenario

2. The users reject the call by either:
 - c. The users tell the system they do not want to answer the call.
 - d. The users do nothing (the phone will ring for ? signals).
3. The system uses the cellular phone to reject the call.
4. Use Case ends.

2.3.5 Alternative scenario

2. Automatic answer is set in the settings, that is, the incoming call is automatic answered after one signal and not rejected.

2.4 * Use Case 6: Ending a call



2.4.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. An ongoing call.

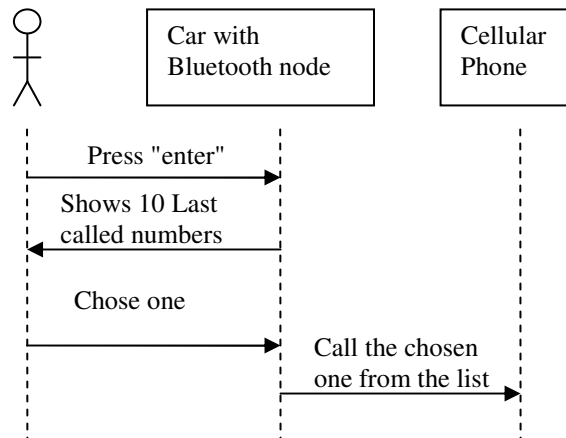
2.4.2 Post conditions

1. The call is terminated.

2.4.3 Main success scenario

1. The users tell the system they want to terminate the call.
2. The system uses the cellular phone to terminate the call.
3. The Bluetooth node gives information about last call, e.g. call duration.
4. Use Case ends.

2.5 * Use Case 7: Last number called (with buttons)



2.5.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).

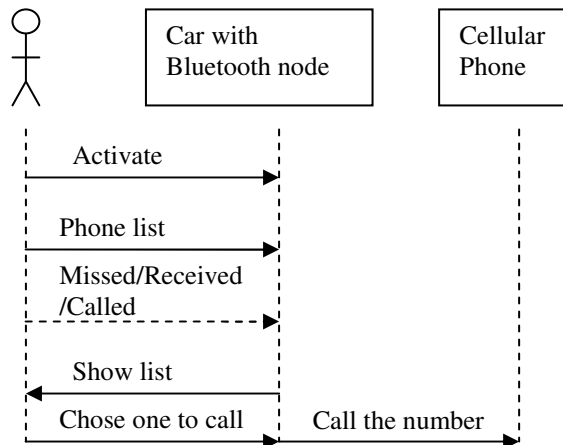
2.5.2 Post conditions

1. The system uses the cellular phone to re-dial the last number.

2.5.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users press the Enter button on the Bluetooth node-interface.
3. The Bluetooth node-interface shows the 10 last numbers dialed.
4. The users can browse through the list by using up and down functions
5. When right number found the users choose that one.
6. The system uses the cellular phone to re-dial the requested number.
7. Use Case ends.

2.6 * Use Case 8: Phone lists



2.6.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).

2.6.2 Post conditions

1. The system uses the cellular phone to call the desired person/number.

2.6.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users choose "Phone list".
 - a. The users choose kind of phone list (missed, received or called).
 - b. Or all calls in the same list.
3. The users can browse through the list(s) by using up and down functions.
4. The users can choose a list element and chose to call it.
5. The system uses the cellular phone to call the chosen entry.
6. Use Case ends.

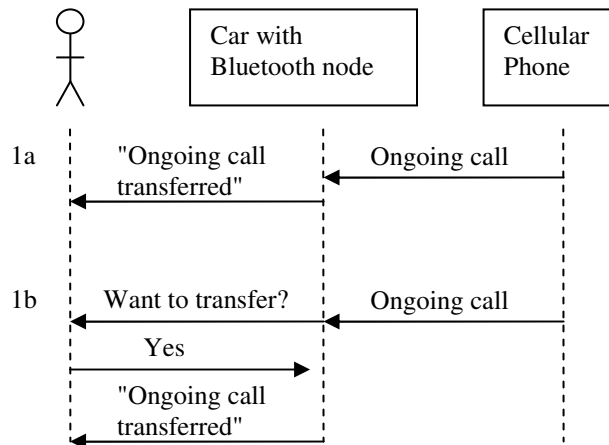
2.6.4 Alternative scenario 1

4. The users do not find the wanted number.
5. The users exit the phone list.

2.6.5 Alternative scenario 2

5. The users change their mind and do not want to call the number and therefore exit.

2.7 * Use Case 9: Handover (From Cellular to the Car)



2.7.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. An ongoing call on the cellular phone.

2.7.2 Post conditions

1. The ongoing call is transferred from the cellular phone to the car.

2.7.3 Main success scenario

1. Depending what is set in the settings (under the header "Handover"):
 - a. If "automatic"¹⁷ is chosen, then the call is automatic transferred to the car when the infotainment system starts.
 - b. If "prompted"¹⁸ is chosen then
 - i. the system asks the users if they want to transfer the call.
 - ii. The users answer yes and the call is transferred.
2. The system tells the users that the call is transferred.
3. Use Case ends.

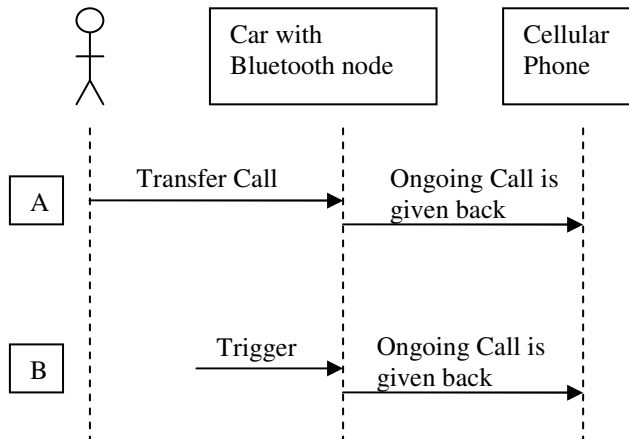
2.7.4 Alternative scenario

1.
 - b.
 - ii. The users answer no and the call is not transferred.

¹⁷ This possibility is available because it should be as little work as possible for the users.

¹⁸ The users might be passenger sometimes and therefore not want the call to be transferred automatic every time when they enter the car.

2.8 * Use Case 10: Privacy Mode (Transfer Call from the Car to the Cellular)



2.8.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. An ongoing call on the Bluetooth Interface.

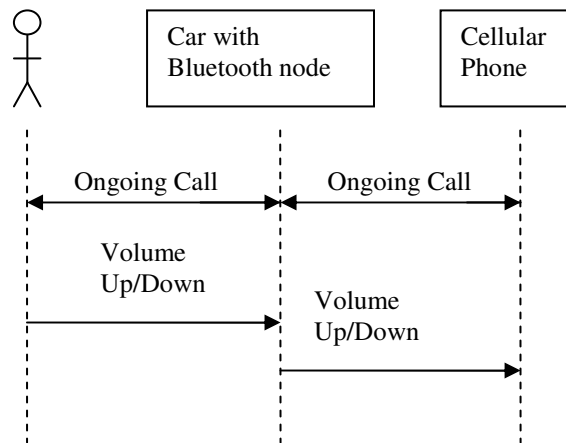
2.8.2 Post conditions

1. The ongoing call is transferred from the car to the cellular phone.

2.8.3 Main success scenario

1. The users want to transfer the ongoing call to the handheld cellular phone either because:
 - a. the users want a private conversation.
 - b. or the users are leaving the car.
2.
 - a. The users tell the system they want to transfer the call.
 - b. The transfer of the call is triggered by something.
3. The call is transferred.
4. Use Case ends.

2.9 * Use Case 11: Call volume (steering wheel)



2.9.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. An ongoing call.

2.9.2 Post conditions

1. The volume is changed.

2.9.3 Main success scenario

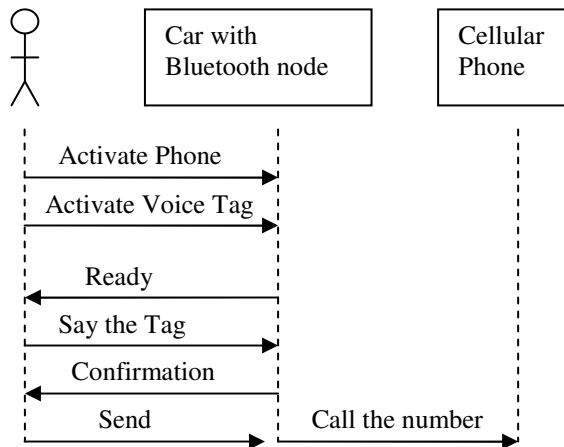
1. The users want to change the volume.
2. The users turn down/up the volume on the Bluetooth node interface.
3. Volume indicator shows the volume.
4. The system adjusts the volume.
5. The system saves the volume¹⁹.
6. Use Case ends.

2.9.4 Alternative scenario

1. The users want to change the volume but there is no ongoing call.
2. The users activate the Bluetooth node.
3. The users choose settings.
4. The users choose change call volume.
Continue on 3 in main success scenario.

¹⁹ Except if the user turns down the volume to 0, then the system next time will start on 10% of the maximum volume.

2.10** Use Case 12: Making a call (using voice tags)



2.10.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. The cellular phone supports the voice dialing function.
4. The desired phone number is connected to the correct voice tag in the cellular phone.

2.10.2 Post conditions

1. The system uses the cellular phone to call the desired number.

2.10.3 Main success scenario

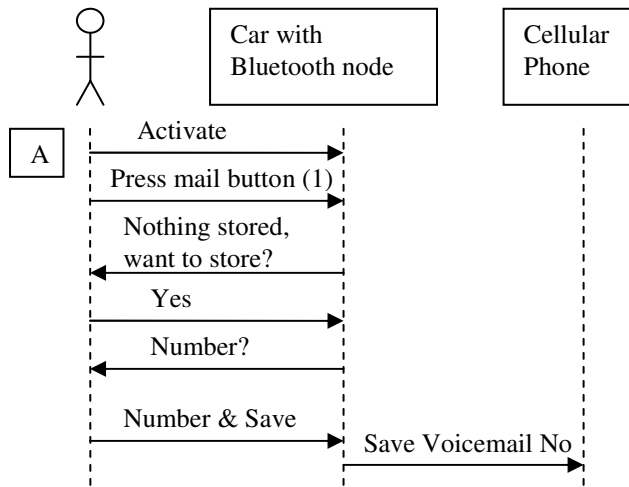
1. Users activate the Bluetooth node.
2. The users activate voice tag.
3. The system tells it's ready to listen to the users.
4. The users speak the name of the person they want to call with a loud and clear voice into the microphone.
5. The system repeats the voice tag.
6. The users agree and send it.
7. The system uses the cellular phone to call the desired number.
8. Use Case ends.

2.10.4 Alternative scenario

5. The system misinterprets the voice tag and says another voice tag.
6. The users choose to cancel.

2.11 ** Use Case 13: Make a call with a mail button

A: When no number is stored



2.11.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. The cellular phone has a mail-button.

2.11.2 Post conditions

1. The system uses the cellular phone to call the voicemail.

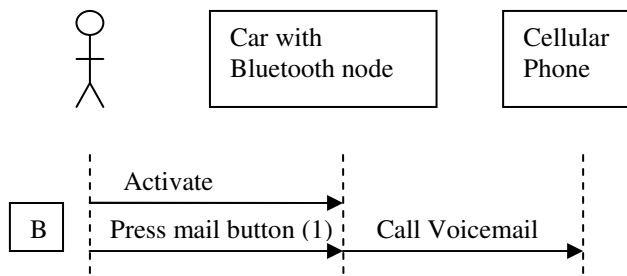
2.11.3 Main success scenario A: When no number stored

1. Users activate the Bluetooth node.
2. The users press the voicemail button (the "1").
3. Since no number is stored on this button the system ask if the users want to store a number on it.
4. The users answer yes.
5. The system asks what number.
6. The users give the number in and choose to save it.
7. The system saves the number.
8. Use Case ends.

2.11.4 Alternative scenario

4. The users answer no.
5. No numbered is stored on the voicemail button and therefore no number is called.

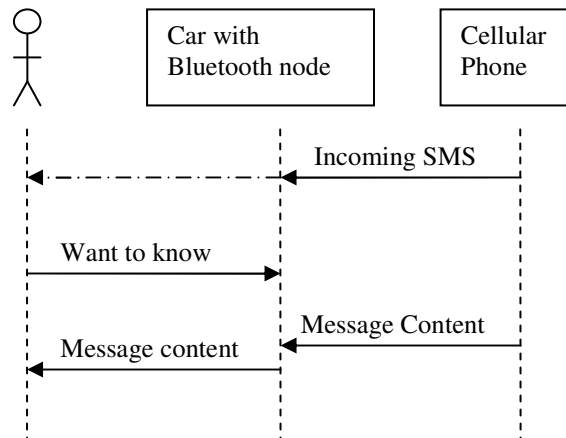
B: When a number is stored



2.11.5 Main success scenario B:

1. Users activate the Bluetooth node.
2. The users press the voicemail button (the "1").
3. The system uses the cellular phone to call the voicemail.
4. Use Case ends.

2.12** Use Case 14: Read incoming SMS/Text message



2.12.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. Incoming text message.

2.12.2 Post conditions

1. The users get to know the content of an incoming text message.

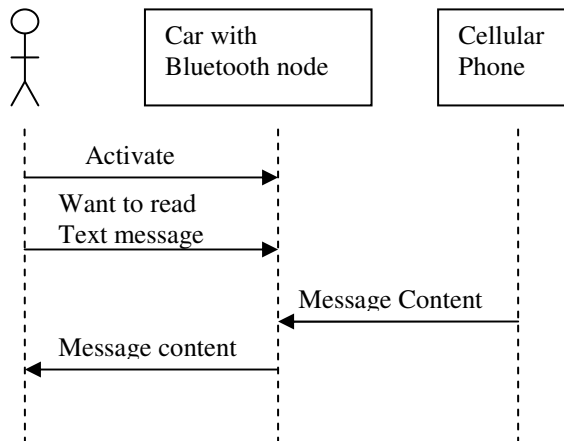
2.12.3 Main success scenario

1. The system tells the users there is an incoming text message.
2. The users tell the system they want to know the contents of the text message.
3. The system communicates the content of the text message to the users.
4. Use Case ends.

2.12.4 Alternative scenario

2. The users do not do anything.
3. The content of the text message is not communicated to the users.

2.13** Use Case 15: Read old SMS/Text message



2.13.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. Old text messages stored in the cellular phone.

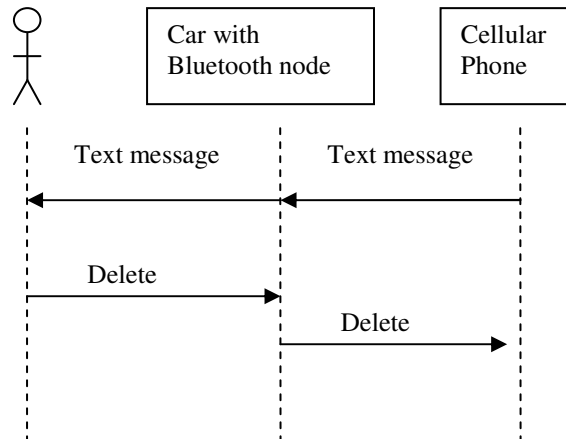
2.13.2 Post conditions

1. The users get to know the content of an old text message.

2.13.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users tell the system they want to read text messages.
3. The system communicates the content of the text message to the users.
4. Use Case ends.

2.14** Use Case 16: Delete SMS/Text message



2.14.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. A text message is active.

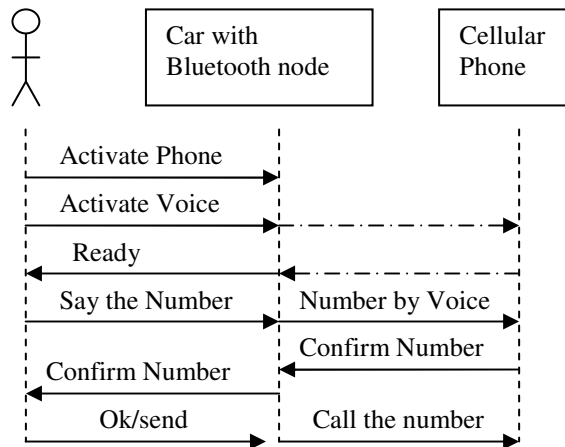
2.14.2 Post conditions

1. The wanted text message is deleted.

2.14.3 Main success scenario

1. The users tell the system they want to delete the (active) text message.
2. The system deletes the text message on the cellular phone.
3. Use Case ends.

2.15*** Use Case 17: Making a call (with voice)



2.15.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. The cellular phone supports the voice dialing function.

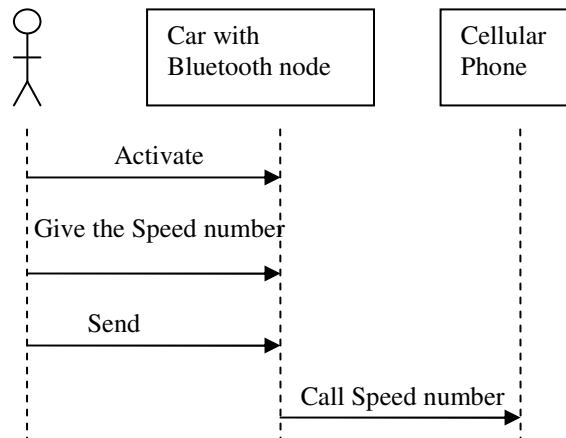
2.15.2 Post conditions

1. The system uses the cellular phone to call the supplied number.

2.15.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users activate voice recognition.
3. The system tells it's ready to listen to the users. (For example it presents a tone and the display shows "Please speak now").
4. The users say the desired phone number.
5. The system confirms the number.
6. If it is the right number the users request it to be dialed.
7. The system uses the cellular phone to call the desired number.
8. Use Case ends.

2.16*** Use Case 18: Speed dial (using button 1-9)



2.16.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. The cellular phone supports speed dial.

2.16.2 Post conditions

1. The system uses the cellular phone to call the requested number.

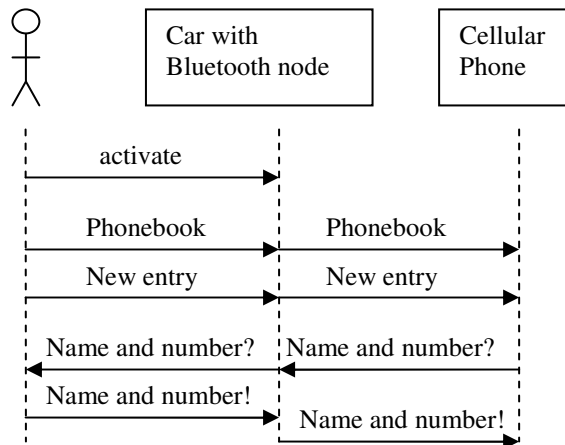
2.16.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users enter the desired memory position 0-9 on the Bluetooth node interface.
3. The users press the Enter button.
4. The system uses the cellular phone to call the desired number situated in the corresponding memory location on the cellular phone and give feedback to the users in form of "Calling <Telephone number>".
5. Use Case ends.

2.16.4 Alternative scenario

2. The users enter a speed number where no number is stored.
3. The system tells the users that there is no number stored on this position.
4. The system asks the users if they want to store a number on this position.
5. The users answer yes.
6. The system asks what number to store on this position.
7. The users give the number in and save it.
8. The system saves the number on this position.

2.17*** Use Case 19: Write entry in Phone book



2.17.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).

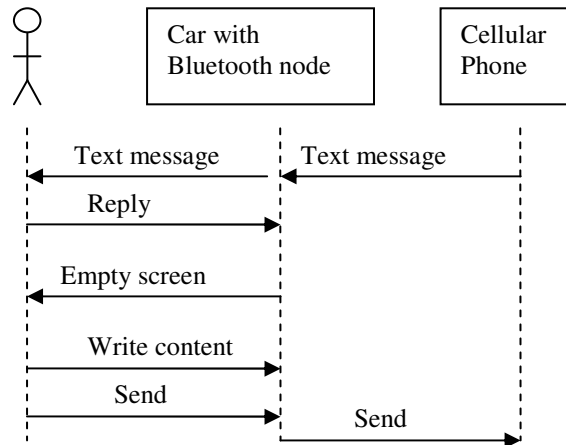
2.17.2 Post conditions

1. A new entry is saved in the phonebook.

2.17.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users choose the phonebook.
3. The users choose to write new entry.
4. The users give in the name and number.
5. The new entry is saved in the cellular phonebook.
6. Use Case ends.

2.18*** Use Case 20: Reply to a SMS/Text message (with buttons)



2.18.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).
3. A text message is active.

2.18.2 Post conditions

1. The written reply is sent.

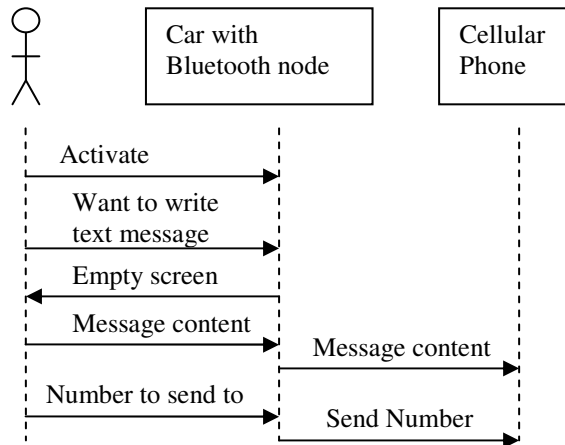
2.18.3 Main success scenario

1. The users tell the system they want to reply to the (active) text message.
2. The system gives the users an empty screen.
3. The users write the text message using the buttons on the interface.
4. The users choose to send the text message.
5. The system uses the cellular phone to send the reply.
6. Use Case ends.

2.18.4 Alternative scenario

4. The users interrupt the writing of the text message.
5. The system does not send the reply.

2.19*** Use Case 21: Write and send SMS/Text message (with buttons)



2.19.1 Preconditions

1. The Bluetooth node and cellular phone is paired (Use Case 1).
2. The Bluetooth node and cellular phone is connected (Use Case 2).

2.19.2 Post conditions

1. The written text message is sent.

2.19.3 Main success scenario

1. Users activate the Bluetooth node.
2. The users tell the system they want to write a text message.
3. The system gives the users an empty screen.
4. The users write the text message using the buttons on the interface.
5. The users decide to what number to send the text message
 - a. and give that number in.
 - b. or find the right entry in the phonebook.
6. The users choose to send.
7. The system uses the cellular phone to send the text message to the provided phone number.
8. Use Case ends.

2.19.4 Alternative scenario 1

5. The users want to interrupt the writing and continue later.
6. The users save the text message.

2.19.5 Alternative scenario 2

7. The provided number is not a valid telephone number.
8. The system does not send the text message and gives the users the feedback that the text message was not send since invalid number.

Appendix D:

Implementation in the XC90 boxcar

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1 Implementation in the XC90 boxcar

The design proposal were developed in two sets, one set for the newer screen and one set for the XC90 boxcar screen. The main difference is found in the status information since the smaller XC90 screen made it hard to fit the status information in the standby screen. These differences are described in this appendix and it is also shown how some screens look for the XC90 to show the difference. The screens are taken from the implementation on the boxcar that was finished after the evaluation. The implementation was made by Eyvind Sandström, also a master student in this project at Volvo Car Corporation.



Figure 17 The boxcar.

1.1 Status information

The plan was that the Bluetooth connection symbol would also show in the XC90 screen but there were problems with adding new symbols in the boxcar therefore it was not implemented. The signal strength is shown in the XC90 screen and since there were problems getting new symbols in, the receiver that was meant to be part of the signal strength symbol also functions as a Bluetooth connection symbol in this implementation. The operator was decided that it would not be shown in the standby screen for the XC90 since then it would be too cluttered. It should though be shown in the active mode, this was although not possible to implement in the boxcar. Therefore we have the following active screen:



Figure 18 The Bluetooth Active Screen.

1.2 Screens for some Use Cases

Use Case 1: Pairing

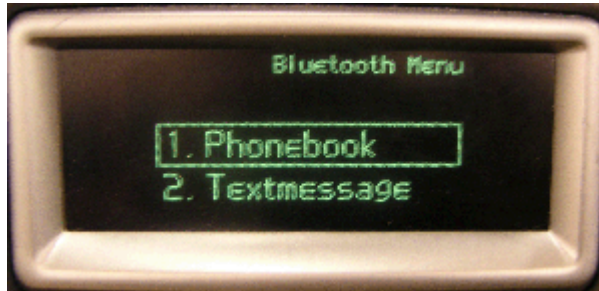


Figure 19 The two first menu alternatives in the Bluetooth menu.



Figure 20 The two first menu alternatives in the Settings menu.



Figure 21 The devices found that is possible to add to the Bluetooth node

Use Case 3: Making a call (with buttons)



Figure 22 The number is given in and the users have pressed the Enter button to call the number