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Information Appliances

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1. Introduction

The desktop computer seems to be at the end of its glorious and victorious march into people’s households. Today’s computers are to various in its features and too complex in use and thus cannot reach more diffusion. What is needed is a complete new approach that leads to a new generation of computers so easy to use they seem not to be computers any more but every day items people use without questioning or complaining. The user must step in the middle of all design considerations and usability has to come first.

This work explains of what kind an information appliance should be and why we are supposed to need it. It gives an overview of recent developments and describes some basic principles concerning the design of information appliances. Style guides and expert’s ideas are explained and critically discussed. The reader is presented some conceptions where information appliances are supposed to come into action and what conflicts might arise.

Because of the current struggle of car manufacturing companies for bringing information appliances into driver’s cockpits, this work’s main part concentrates on in-car information systems, especially car navigation systems. The reader is guided through basic design considerations and the regard on usability principles as well as he is shown dangers and conflicts which arise when drivers are distracted by on-board information appliances. The presented guidelines and problems are reflected during a focus on navigation systems made by DaimlerChrysler and BMW.

Examples are used to continuously point out the differences between interaction with a computer and the design of dialogues as they have to appear on information appliances in order to make ubiquitous and invisible what people dislike: the computer behind it.

Keywords: information appliance, user Interface, electric device, personal digital assistant, information system, car navigation system, design principles, human-computer-interaction, usability, user centered design, evaluation.
2. Overview: Information Appliances

2.1 What Is An Information Appliance - Definitions And Explanations

Today’s personal computers are often as complex to use as the tasks and problems they are able to solve. The PC has to be able to do a great amount of tasks, highly different in its kind.

The term information appliance stands for small devices that fit to a special task so well that the device becomes a part of the task itself. The appliance should fit to one task only, supporting the task by a very fitting design, form and the features it provides. The definitions for the term information appliance did mainly inherit from definitions for normal household appliances. According to Donald Norman, an information appliance is “a device or instrument designed to perform a specific function, especially an electrical device, such as a toaster, for household use.” [ND 1]

You will also find other wordings for an appliance, which are synonyms like tool, instrument, implement or utensil. An information appliance thus is a tool, which is “…specializing in information: knowledge, facts, graphics, images, video, or sound.” [BE 1]

As a conclusion of the different definitions, the term information appliance obviously does not only – as one might presume - apply to hand-held computers and personal data assistants (PDAs), but to the vast amount of small and easy to use devices in general.

Thus, an electrical information appliance has to fulfil two hard tasks. On the one hand it is to fit close to users needs and a very special task and its prime goal “is to break through the complexity barrier of today’s personal computers...”[ND 2]. On the other hand it must not loose some advantages of desktop personal computers. In order to reach this target, any electrical appliance should be able to communicate with other tools and devices of the same or a different domain, using predefined communications standards.

An information appliance should be able to help any kind of user, from beginner to expert, anywhere and any time. This is why one of the main concerns when designing an information appliance is to hide PC-like interiors, which would remember the user of a hard to use personal computer. The user should only see a very easy to use surface providing all functions in an intuitive and usable way. He should at no time suppose that he might use and interact with a computer. Most prominent proponents of the so-called post-PC movement already see the PC at its end and being replaced by ubiquitous information appliances. These appliances are supposed to be easier to use and of less complexity compared to today’s desktop machines. Even Bill Gates from Microsoft argues that the PC will face a new competitor but he also underlines that the PC will continue to play a central role, but that it “will also work in tandem with other cool devices,” and that we will be able to share our data across different machines in a seamless fashion. [OA 1].

2.2 Invisible And Already There

Referring to how the term information appliance is defined, you can easily understand that we almost have information appliances everywhere in our society. If you open the manual of a modern car, you will find terms like fuel injection, ignition timing, or antilock braking system (ABS). Every of these functions are controlled by small electrical devices which consist of microprocessors and special programs. If you get out of your car and step into your home, you will perhaps find a microwave or a dishwasher. When you put a meal into your microwave and you trigger the time how long you want it to be heated, you configure an invisible computer.

Most probably, your dishwasher will not offer you the possibility to translate from English to Japanese, although its built-in microprocessor could perform this task easily. Both the dishwasher and the microwave and also some functions of your car are information appliances.
But according to the definitions above, they do only offer functions, which apply to their task domain and thus do only offer a small but easy to use amount of keys and buttons.

In a best-case scenario, you will be able to use a device if you understand the task it supports. Thus, “switching the task means switching devices” [ND 3], as you can see when reconsidering the dishwasher and microwave example.

2.3 Types Of Appliances

There is a vast amount of information appliances, which are already used today without being named a computer. “The average middle-class American household already has around 40 microprocessors, in cell phones, microwave ovens, and self-focusing cameras” [OA 2].

2.3.1 Already There Devices

The calculator is one of the most frequently used information appliances in our modern world. It is very wide spread, but poorly, designers have stopped to develop better calculators and when the calculator is seen as an appliance you have to point out to the fact that it does not support the exchange with data with other devices of same or different kind. The calculator thus limits itself in activity and functionality.

Also already widely spread are a very high amount of digital cameras differing in functionality and price. This appliances offer communication possibilities with other devices such as personal computers. Users can send the pictures they took to their desktop computer to store the images or send them directly to a printer. Digital cameras are the most spread and successful appliances besides calculators.

Reconsidering how many electrical and microprocessor controlled devices you are able to find in a modern car, you will also have car navigation systems and onboard information systems coming up to your mind. We will have a closer look to these highly modern devices in several of the later chapters.

2.3.1 Current Developments

[Image 3]

At the beginning of the 21st century, the most developments are made in order to improve PDAs and mobile phones. Most improvements consist of developments concerning connectivity and the availability of the internet through PDA or mobile phone. Very linked to these developments are those which try to melt different devices to a single one as both tools seem to fit together because of being used in a common context or in related activities. The NOKIA Communicator is a great representative of those devices that try to be mobile phone, timer, address book, note pad etc. all in one instruments.

Other high-tech companies try to bring the development of internet tablets forward and to spread them under people, which do not want or have a desktop computer but which want to use the internet. Even on the jewelry sector the term information appliances becomes more and more interesting. The Japanese CASIO concern recently built some small watches which did not only show time, but also were able to display the owners exact position because of a built in GPS navigation device. Other models were combined with digital cameras and MP3 players. All models can be plugged into a desktop computer via the USB port and exchange data with it.

Another great struggle is fought on the sector of car navigation systems. Car companies try to fit out their cars with highly
interactive and informational systems that provide the driver important and supportive information. Currently, the DaimlerChrysler concern and BMW are – together with their partners like SIEMENS VDO or BOSCH - two of the most competitive designers of car navigation systems.

2.3.3 Fiction

If you leave home with one or several appliances, you might leave some appliances behind which could be affected by changes you make on the devices you took with you. Therefore, it might be interesting of having an all time available connection to a main storage device at home, with receives the changes you made elsewhere and sends updates to all devices which are affected. If you think of digital cameras and the upcoming UMTS communication standards in Germany, you could consider cameras that will no longer store pictures on memory sticks but send every taken image to your personal storage server at home or at your storage service provider.

Scientists think of medical advisors with which the patient can make home blood tests, blood sugar tests, urinalysis or other medical support that makes it possible to make some important checks at home. Others dream about home shopping lists which are electrical accessible from under way with your shopping assistant. Forgetting your shopping list at home would no longer be a problem as the list will be stored on your server and always available while you are shopping. House owners might be interested in the gardening appliance that automatically analyses your garden’s soil and ground moisture. If your garden is ill or needs anything, the owner will be informed. Inside the house the financial appliance takes care of bill paying, family financial reviews and computes the income tax declaration. The internet appliance makes it possible to browse through the web wherever installed: on refrigerators, computers and other devices.

But appliances do and will not have to be portable. They can also be fixed on walls or furniture, clothes or jewelry. In classrooms pupils would no longer have to write down what the teacher writes on the board, but the teachers writings are automatically transferred from the white-board to the pupils appliance. And your watch can tell you every time where exactly you are and is even able to play music or take pictures.

2.4 Why Needing Information Appliances ?

“Computers are general-purpose devices, designed to do everything. As a result, they can’t be optimized for any individual task.” [ND 5]

The desktop computers we use today reached a very great amount of households all over the world. The PC consists of standard hard- and software components and has to fulfil various tasks for its users. Thus today’s desktop machines are not at all designed to do specific tasks only, but made to everybody’s needs. „This means, there must be something for everyone, which leads to an ever-increasing number of features, an ever-increasing number of specific applications, and a result, an ever-increasing complexity”. [BE 2]

Usability expert Donald Norman explains that designers of computers have to do what for instance happened during the development of household appliances. At the beginning of the 20th century people only had one single electric motor at home as such devices were large and expensive. People could attach many different extensions on that machine in order to use the motor for different purposes. You could compare this functionality to our desktop computers. Today you can find various electric motors in modern households, every single device having its own machine with specific power for a special task. Donald Norman believes we have to do „the same kind of transition…. with computers” so that we have „a wide range of devices that fit to tasks we wish to do”. [BE 3]

As consequence, when thinking about future devices and the tasks they could support, you must always keep in mind that the main subject of any information appliance should be to
move away from the hard to use personal computer and to come to simplicity in both design and usability.

What is needed is a user-centered design instead of a technology based one. Appliances are built for special tasks and to support them as simple as possible. For sure, the concentration on one single task means to have better usability "at the cost of flexibility and power" [ND 4].

As the definition of information appliances points out, every appliance should be able to communicate with other devices. Communication standards have not yet been developed but are a must-have function of every appliance. Designers and developers all over the world have to find this standard to make the devices easy to use and connective. Without having this standard, updating different devices with shared data is hard and uncomfortable.

Regarding present publications, digital information exchange via cordless infrared connections (IrDA) is recommended for high speed short range, line of sight, point-to-point cordless data transfer - suitable for HPCs, digital cameras, handheld data collection devices, etc. [IRDA 1999]

2.5 Designing Information Appliances

The design of current user interfaces of desktop computers cannot be transferred to the domain of information appliances. For devices that have to be user friendly, of very well usability and simple to use, new design considerations have to be done.

According to Donald Norman, there are three basic principles for information appliances.

- Principle number one is simplicity. The term means that even if the task the user wants to delegate to its information appliance is of very complex kind, the interaction between user and device must be kept simple at all costs. The user interface must provide support that makes even very hard tasks easy to solve.
- Second, the device should offer new possibilities of interaction between user and appliance. Interaction designs should be derived from the ones of desktop computers (versatility).
- Third principle is to guarantee that the appliance’s design support the completion of tasks in such an easy way that the user enjoys working with his device (pleasurability).

Developers at SUN Microsystems have formed “...some key characteristics for information appliances that differentiate them from PCs” after they made first experience in designing software solutions for small devices, for example by introducing the Java2 Micro Edition for mobile phones or televisions [BE 7]. Information appliances have to be

- “limited in purpose and functionality”
- “not necessarily extensible or upgradeable”
- “replacement expectation (the user may have to replace the entire device within a few years)”
- “perceived as less expensive (versus PC)”
- “perceived as less complicated to run and maintain (versus PC)”
- “very easy to learn and use”
- “no expectation of expert users”

Very close and connected with design considerations are expectations about the group of people which are supposed to buy, use and like information appliances. The users in the cross wire of the designers are those who do on the one hand unlike today’s personal computers and have only minimal computer experience. On the other hand this user group most probably uses items like microwaves or remote controls every day without having severe usability problems. In addition, usability evaluations showed that neither experts nor beginners like to read any manual in order to know how a device can work and to learn about its capabilities. They all expect the device’s user interface to be self-explaining and intuitive. If not, they will never use the functions they do not find or understand.
The target group of information appliances’ users thus expects any information appliance has been designed to fit into the target domain perfectly. They want an item they can easily use every day like their phone or television. If the user sits in front of his television the possibility of being interrupted during switching channels with the remote control is probably very high. When using a ubiquitous computer such interaction delays can also occur and must not be a problem. In addition, the user of a television does not have to be much concentrated when he toggles the volume of his TV as interaction with it is very easy. It has to be exactly the same with small gadgets. Dialogues and interaction must be so easy to understand and follow that it will not be a problem when you do one or several other things simultaneously. Therefore, the design of the interaction interface is much more important than all other issues.

An information appliance that is designed for one special task domain will mostly have to fulfil one task at a time only. For example, if the user searches for a notice he recently made or for the address and phone number of a friend, he will have to do these two operations at the same time very seldom. In addition, the total time for one single interaction has to be very short – users of an internet appliance want to be able to surf the web and find what they need very fast. What they definitely not need are long lasting steps of interaction or boring booting sequences which would destroy the add of value compared to non-electric items and make the appliance unattractive. All interactions have to lead to a result fast. If there have to be some important dialogues, they have to be clear and easy to learn. Only by having a high ease of learning more complicated tasks can be solved in appropriate time. Another important issue concerning the design of dialogues deals with the interruptability of dialogue structures and the feedback all interactions provide the user. "Designers should not require users to deal with modal dialogues” [BE 9]. There should not be a greater amount of question and answer dialogues. As the user expects to be able to use his device easy and fast, such dialogues would only harm the owners’ satisfaction about the product. The appliance should believe the user to be very responsible and expect that most user commands are well decided. At the same time the appliance should provide the user feedback for the command he decided for. Usability studies showed that users are in great need for feedback that assures them their task was executed successfully even if everything works fine and as usual.

The ease of use and learning has for sure a very high priority compared to all other design considerations. But nevertheless, asking for an ease of learning conflicts with the need of having a user interface design which fits the task and domain at its best. If you think about an application for surfing the internet, the call for a high ease of learning would mean that a user should be confronted with the same user interface design whether he uses this application on his large television screen or on his digital assistant. If the application design differs, users might not be able to switch between the two devices, as they are no longer used to both application’s look and feel. But another problem is that you simply cannot spread an application over several types of devices without altering the design of its interface. This gets particularly clear if you think about a remote control as interaction device on the one hand and a pen for interaction with your PDA on the other hand. A user would not like to stand in front of his TV with a pen, but to send commands while sitting on the couch. A program which has to hear on commands sent by a standard remote control has to be designed differently e.g. according to the location and layout of elements for navigation. For browsing on the television’s internet appliance the user has to navigate with e.g. four arrow buttons and a track ball, while he can just give commands by touching the screen of the PDA with his pen. Therefore you need the best-suited input device for every appliance. Deeply connected with the problem of choosing the right input device for an information appliance are considerations about which functions could or should be accessible via hard- or software. When you have to decide whether a function key should be available by e.g. touching the screen of an internet appliance or by pressing a button on its hard cover, you have to regard how often the function might be accessed and how important the function is.

At any design level it must always be kept in mind that the device has to be as simplified as possible. Designers must no be implementation-driven – a tendency which is very often responsible for complexity because of a rising amount of features. Adding new functions must never thread the simplicity of the appliance. If it would, designers have always to decide for the user and against any simplicity trade-off. Michael F. Mohageg and Annette Wagner from SUN Microsystems propose to “think of the 80/20 rule. For each application or feature set, it’s
helpful to identify the 20% of functions that will meet 80% of the users’ task needs. Those are the functions to support in the product...the remaining 80% of functions...may be necessary to (be) excluded” [BE 8]. The key to a well-designed information appliance may be found when concentrating on this 80/20 rule, namely by designing the tool with a primary focus on the 20% of most important functions and choices.
2.6 Visible Problems With The Invisible Computer

The call for having both an easy to use, but also flexible and inter-connectable device raises new problems and elsewhere also new complexity. Building complicated systems that work is hard. Building ones that work and are user-friendly is much harder. And obviously, it is necessary to balance the demand for user-friendliness with the demand for more features.

2.6.1 Flexibility, Usability And Separation

A main problem is that experts must not only think of single and stand-alone information appliances. Those can be made to appear simple through careful design and in particular by limiting their functionality.

In his book *the invisible computer* Donald Norman talks about the development of radio devices which are nowadays very easy to use and which can be found in almost every household. Today radio frequencies can be switched so easily even young children do already own a radio device. Mr. Norman tries to make a connection between the development of radio devices and information appliances. As the radio devices, he thinks information appliances will continue to develop and continuously become easier in use. However, there is a substantial difference between radios and information appliances. People will need a much greater variety of small gadgets than of radio devices. The services a radio device offers are stable, but we are in danger of not seeing such stability for information appliances. Instead, we probably experience very frequent updates and extensions. Even the Palm Pilot - frequently cited as the ideal outcome of the human-centered engineering - is not stable. “Not only is there a succession of new models from its manufacturer, but there are myriads of accessories offered by outside suppliers for wireless communication, control of other devices, and so on.” [OA 3]

In the last years of software and hardware development new features have always won when the choice was between new features and ease of use. The victory of the PC over the Apple Macintosh is an example for this phenomenon. Microsoft has won because it developed constant novelty coupled with acceptable stability, rather than the other way around. People talk about their need for simplicity but buy new features instead and pay for new complexity. In the evolution towards the information appliance era, we can – in a worst-case scenario - expect a similar result. The premium will continue to be on being first to market with the latest innovation, not on ease of use. Therefore, against a scenario in which every user can access an interface which is best suited for him stands the fact that during all development process only some companies will be able to take part in the race continuously. Normally you could suppose that products offering the best usability while meeting the requirements would make the race. But history taught something different. At first there may be many devices which many different operating systems and interfaces. Later, some of the designs will fail and with them, some companies will stop producing the hardware. Then, for devices which succeeded only a small amount of available user interfaces will remain. As it was on the computer sector, those interface designs could then be accepted as best and standard even though they are not.

An addition problem is that there does not exist a trade-off of flexibility versus ease of use, which is optimal for everyone. A person who learns a new system will understand and use more and more features. Therefore you might suppose information appliances cannot just have one single and general standard. The full range of users, from experts to non-technical people, would have to operate within the same command and communication infrastructure. But there are many people who like to use text commands to execute programs much faster than a graphical user interface would let them. At the other extreme, about half of the households in the developed world still do not have any computer. Even owners of video recorders (VCRs) are ignoring the ability to program their devices, as they do not know how to set time and date. This is the standard response of consumers to features that do not provide enough value compared to the hassle of learning and using them.

In contrary, usability guru Donald Norman argues that a network consisting of pretty much home information appliances won’t bring at all any complexity to users life like the computer did. He explains that we have so many different items in our life we use without problems or questioning behind it. He points to the sofa we sit on, the shoes we wear, the pen we write
with and the list continues. We use such items everyday as they were designed well and feel natural to us. Norman says that information appliances will be taken up in our life as well as these items did when they were designed well and usable.

But Norman also is against having too many appliances forcing the appliance’s networks grow bigger and more unstable. This is why he underlines that he is “not in favor of single-purpose devices” [BE 4]. There should rather be gadgets that are designed for activities that depend on another or belong together in any way. “This also means that the correct set of devices will vary with the person” [BE 5].

### 2.6.2 Connectivity And The Whole System

Design that is focused on human factors and combines powerful processors and software, can provide information appliances that are an easy to use. But that does not mean that we will be in advantage of a new electronic environment full of such gadgets, even if each is excellent by itself. Comparing some information appliances to programs on desktop computers, each application maybe great itself, but the interaction with other software products creates complexity and frustration. Developers have to be concerned with the whole system, which is likely to be complex.

Don Norman’s definition a “distinguished feature of information appliances is the ability to share information among themselves.” The car information system should tell our house control system to warm up the house in time for our arrival and “the refrigerator (to) know it was low on milk and eggs and place an order with the local supermarket” [LP 1]. Once all the radios, refrigerators, dishwashers, clocks, coffee pots, and other devices in our houses and cars are replaced by information appliances, the amount of devices will dramatically raise and all devices will for some reasons have to communicate with each other. Designers will have to consider the difficulty of setting up such home networks. Once the number of devices to be connected increases, and wireless communication expands, the difficulties will increase as they do in normal PC networks. Although, Norman thinks that with a radio system like Bluetooth it will all work fine and easily. A person’s information appliances “will just silently detect each one another through Bluetooth and Jini and synchronize themselves. That’s what’s needed.” He argues “all this pieces exist today, but have not been put together yet” [BE 6]. But Don Norman also sees the connectivity problem and forecasts that a solution can be achieved through global standards. Even Bill Gates promises that “when you buy a new device, you’ll know it will function with your existing equipment”, although everybody knows that most Microsoft products do not even support easy transfer of information from one Microsoft product on a PC to another copy of the same package on a different PC. [BG 1]

The home information appliance environment is thus likely to be more complicated than the office environment today. Many users will be less knowledgeable about electronics than the typical office worker and therefore it will be essential to outsource the setup and maintenance of home computing and electronics to experts. Therefore all devices will have to be designed for remote administration. For sure, this will reduce users’ freedom to modify their systems. But there also remains a big question mark whether ideas like that could help to widely spread information appliances into our society. Owners may first have to check with your system manager whether new devices will interoperate with all the other information appliances in the house.
3. Car Navigation Systems

Car manufacturing companies face a great struggle for successfully bringing information appliances into driver’s cockpits. According to what you know about desktop computers and early small digital devices, let's have a look what disasters already have taken place because engineers built in invisible computers into automobiles.

Alan Cooper [AC 1999] described a fatal computer error that occurred in the first PORSCHE Boxster models. When fuel was low and the car drove a sharp turn, air could enter the fuel lines. The computer interpreted this as a change in the incoming fuel mixture and supposed it to be a catastrophic failure of the injection system. The computer shut down the ignition, stopped the car and did not let the driver restart the engine. But bad errors in in-car computer systems cannot only cause the car to stop, but can also cause dangerous accidents. Some years before, a German BMW driver obediently following the satellite-guided navigation system of his car drove straight into the Havel River in eastern Germany. Luckily the 57-year-old driver and his passenger were not hurt. The driver reported he was following the navigation system, which had evidently failed to note that the road in the town of Caputh near Potsdam ended at a ferry crossing. "Normally accidents like this shouldn't happen," said police spokesman Frank Heinichen. "But that sort of thing can happen when people rely too much on technology." [RS 1]

The main part of this work focuses on in-vehicle information systems and especially on car navigation devices. It takes a closer look what developments have taken place to design invisible appliances which claim to work fine and which provide reliable information in a way that is user-centered and easy to understand.

3.1 What’s Behind Navigation Systems

3.1.1 The History Of In-Car Information Systems

In the early 80’s car engineers recognized for the first time that there is a need to reduce a car drivers mental overload by reducing the amount of buttons and triggers and by combining many displays into a single one. Designers developed a LCD display, which was capable to show several different information, but only then when they were needed. The display showed the speedometer all the time and dynamically added information like fuel status or time only when required [HW 1984].

Bouis et al [BGHH 1985] investigated the CIS information system that combined radio, tape recorder, trip computer and telephone. The CIS was designed to reduce driver distraction and support safe driving. First graphical information displays were built into cars of Toyota and into the American Buick in 1986. Since then several prototypes were developed and some of them even came to product status. But designers try to reduce complexity and enhance usability up to know – real style guides and standards have not yet been developed.

3.1.2 The Technique Behind In-Vehicle Navigation Systems

The technique behind today’s car navigation and positioning devices is called GPS. The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations (see image no. 6). GPS uses these satellites as reference points to calculate positions accurate to a matter of meters. In fact, with advanced
forms of GPS you can make measurements to better than a centimeter. In a sense it’s like giving every square meter on the planet a unique address. GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. And that makes the technology accessible to virtually everyone. These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, and even laptop computers.

3.1.3 Influences From Other Domains

As over half of aviation accidents are caused by human errors, the performance and reliability pilot-cockpit systems is of even greater importance than those of in-car systems [NDC 1988]. In modern fighter jets you are able to find high-tech HUDs and HMDs (Head Mounted Displays). This techniques project important information directly into the pilots view. For sure, this kind of display may also cause some distraction, but the pilot is nevertheless able to see the flight path behind the displayed information any time. HUDs are not wide spread due to factors of cost. But with more research and development, this technique is expected to become more prevalent.

What can be learned from aerospace research are experiences how to fusion data on small displays while not forcing the driver to take eyes off the road. But the HUD’s cannot simply transferred from fighter jet cockpits into cars, because jet HUDs are much more complicated and their use affords special training.

3.2 Current Developments And Visions For Future In-Vehicle Systems

The car and information technique industry for sure has not yet stopped developing in-vehicle systems but just started. More ideas and services which should surround car navigation systems have recently come to life.

3.2.1 Telematics

The term is literally defined as the wireless exchange or delivery of communication, information and other content between the automobile, occupants and external sources. It’s a system that provides safety and security to car owners, a customer relationship management tool for car companies and dealerships, a diagnostic tool that can spot vehicle weaknesses and improve vehicle reliability, an enabling technology for location-based services and an important part of future intelligent transportation systems.

The term telematics thus describes a package of services for drivers.

This package for example includes information about traffic jam, dynamic auto-route computing, break down help services or information about nearest gas stations, hotels or other attractive locations.

In order to be able to use telematics services you need a modern car radio together with a mobile phone and a device that is capable to receive global positioning data (GPS). By pressing
a service button the system dials the number of the service center of your provider that is able to give you all ordered information and help for exactly your position. [BMW 2001b]

Telematics is supposed to be capable of a vast amount of opportunities and experts forecast great business for the coming years. „Telematics has begun as an automotive industry phenomenon, but we believe it has substantial implications beyond the automotive industry. Ultimately, Telematics will seamlessness and simultaneously deliver real-time, on-demand mobile, portable, wireless connectivity of voice, data, video, and commerce via a single Telematics Control Unit (TCU)“ [LJ 1]. The Global Autos Team of UBS Warburg in New York City „...believe telematics is set to explode. (They) estimate end-user telematics revenues will grow from $4.2 billion in 2000 to $47.2 billion in 2010“ [GA 1].

At the moment, most telematics systems are built in consoles. But it may become possible to run telematics through a mobile wireless device, like e.g. a Palm Pilot. Different telematics players have different preferences for the outcome of this issue. Companies that build the vehicle consoles —DELPHI, SIEMENS VDO, BOSCH or ALPINE — would like to see their devices in every vehicle on the road. Similarly, companies like ERICSSON or NOKIA would like telematics to run through their wireless products.

On the one hand, running telematics through mobile wireless devices offers consumers the advantage of mobility and independence of the vehicle. In addition, customers would be able to contact their service providers at any time and everywhere that would also allow services when outside the car.

On the other hand, no matter how powerful mobile wireless devices become, onboard computing systems will always be more powerful. In-vehicle consoles have access to a greater power source, have room for much larger screens, and do not face the same size limitations as wireless devices.

There are many services that are supposed to be able to raise the attraction of telematics. M-Commerce, voice driven services, messaging and e-mail services etc. are possible and partly already on the market (see BMW iDrive features for example).

3.2.2 The Way To Speech Recognition

Providing speech recognition in the car is a very hard task. One complex factor is background noises, which disturb the driver’s voice. In the European project VODIS two different approaches, namely the command word approach and the spontaneous speech approach, were investigated. VODIS aims to control not only the car phone and audio components like radio, but also the navigation system.

In the command word approach a set of predefined commands is available to the driver. The commands are usually just single words that are connected to special operations. The visual interface of an information system which implements this command approach could support the driver by showing all possible commands in the current situation. In this case, the user would not have to know allow commands but would be able to make his choice out of the systems proposals. But by having to take a look at the visual display, the advantage of speech recognition gets lost again and this approach becomes unattractive.

In the spontaneous speech approach, the driver speaks to the device in natural speech, forming real sentences as if he would talk to a human. For sure, this is the approach, which would lead to the aim, but it is very hard for a computer to learn the speech of one or several drivers because a person's speech varies because of influences like stress, illness, background noise etc.

There are many scientists who work on this task, but a solution for the consumer market is still far away. Until talking to a car is possible, like e.g. David Hasselhof talked to his KITT in the series “Knight Rider”, the command word approach is a solution you will probably find in several systems as intermediate solution.
3.3 Dangers Of Driver Distraction When Using On-board Information Appliances

Today’s traffic density caused driving to become more than a full time job and therefore driving a car requires the full attention of the driver. In addition, it seems that cars are fit out with more and more extra devices, which also require a high amount of driver’s attention. How much distraction is acceptable before doing other things than just steering the wheel becomes dangerous is an important question that concerns the design of in-car information systems very much. In order to understand how technology contributes to problems of driver distraction developers need a good understanding of how people act and react to the increasingly complicated driving environment. And as about 65% of drivers are supposed to do a poor job in deciding whether it is safe or dangerous to use in-vehicle systems [NHTS 2001], the driver support system has to take care of the driver’s security, too. Accident statistics emerging from Japan indicate the very real need for innovation and evolution with respect to the design of the next generation of route guidance HMIs (Human-Machine-Interfaces). In the first six months of 1998, fifty-nine accidents had resulted from drivers being distracted by the information on route guidance displays [IH 1998].

![Image 11]
Eye movement in the BMW 7 series cockpit.

The more tasks a person has to undertake at the same time, the more difficult it is for a person to achieve the tasks. People can in some cases do more than one thing at the same time without having problems. For example, drivers can speed up the car by press down the accelerator while scanning for oncoming traffic. But drivers can only do that so easily because different resources – foot and vision - are used for the different tasks. It’s much more complicated if tasks need to share resources. In such a case task-switching has to occur. If tasks have to be switched so completely that the main driving task is ignored, driving a car safely is impossible. A car going 70 miles per hour travels over 100 feet in a second. Therefore it doesn’t take long for a disaster to happen.

It is also important to mention that “…for people who are 60 years or older these processes take longer and thus older drivers spend more time than young drivers acquiring information from an in-vehicle display” [MTSJ 1].

Normally we might assume that the primal goal of designers and engineers is to minimize the number of tasks and task switches that have to take place when driving a car. For sure, the usage of mobile phones in cars was strongly restricted. But there are still many other devices left and more new appliances added which enforce driver distraction. The new in-car information systems may enhance mobility and comfort, but some may also distract drivers and undermine safety. Some experts argue that “… any navigation function that is accessible by the driver while a vehicle is in motion shall have a static total task time of less than 15 seconds.” [GP 1] As Alan Stevens [AS 2000] points out, most driver looks on the screen of an in-vehicle information system take 14 times longer than reading the speedometer. Therefore, the 15-second border is supposed to be broken very often.

There are a variety of things that can be done to minimize driver distraction caused by information systems. Vehicles and in-vehicle devices must be designed with safety in mind, and paying regard to usability is crucial. There is some research indicating that speech-based interaction for controlling in-vehicle devices may help minimize distraction, perhaps because it
allows the driver to engage in multiple tasks simultaneously (i.e., simple talking/listening while scanning the road). Although a speech-based interface allows drivers to keep their hands on the wheel and eyes on the road, it’s a very complicated issue however, with lots of confounding variables. For example, it is a well-known ergonomic principle that listening to long speech segments requires a high cognitive load (because of short-term memory rehearsal requirements), and thus the ability to multi-task may decrease because thinking what’s being said interferes with thinking about driving.

The next chapters therefore analyze whether the design of current information and navigation systems takes the risks of driver distraction into consideration. When talking about in-vehicle information appliances it is of great importance whether designer undertake efforts to keep driver distraction low and whether companies follow the recommendation to integrate safety evaluations into the life cycle of a product as e.g. demanded by the East Liberty Transportation Research Center [LT 1999].

3.4 Components Of A Car Navigation System

"User interfaces conceptually consist of metaphors, mental models, navigation, appearance and interaction” [BE 10]. Transferred to the domain of car navigation systems metaphors could be maps (roads, scales), trips (planning, destination entry), dashboard, typewriter keyboard and sometimes also pop-up control panels with labels and buttons.

You can differ between four types of operations for using integrated systems. At the beginning there a set-up operations the user has to do e.g. in order to define a route target in the navigation system. Then there are bridging operations that have to be carried out to be able to reach functionality deeper down in the systems navigation structure. Third, the user is faced tasks of decision, namely in situations in which he gets feedback from the systems and has to decide whether to follow a systems recommendation or not. In situations like this, the user has to evaluate how he should react by making changes in driving or to the state of the system. You talk of task of integration if the user has to carry out changes affecting driving.

A navigation appliance has to support the needed operations by providing a mental model which enables the user to reach his targets simple and without problems. In addition, navigation has to be easy and must not need too much space. The appearance of the screen contents must pay regard to readability and legibility “even of small map symbols under varying light conditions” [BE 11]. Interaction has to be user centered, easy to understand, unambiguous and leading to results fast.

Input devices do play a great role according to an easy usage of the appliance. It is likely that hard keys are not a very practical solution for the configuration of the device. With increasing functionality it is important to have reconfigurable input devices that support a case-dependant appearance. Designers therefore thought about touchscreens and joysticks, others preferred soft keys on the steering wheel allowing to make actions without having to take hands off the wheel. In-vehicle information appliances should use input devices that are familiar to drivers such as push buttons, sliders, rotary controls. Driver may be in advantage when they find controls they are used to in the hard- or software of the digital support system. Output devices could be LCD displays or HUDs (Head Up Displays) and both often in combination with audio support.

A complete list of interaction devices is keyboards, joysticks and pointing devices, soft keys, touch screens, sliders, column switches, push buttons, rotary controls, smart cards and speech recognition.

There are several ways to provide feedback to the driver. Especially when the drivers visual system is overburdened and fast action is required, auditory conversation between information appliance and driver is of great advantage. Simple tones build the basic of auditory feedback and could be completed by speech and haptic information which addresses the sense of touch.
3.5 Designing Car Navigation - Style Guides For In-Car Navigation Systems

3.5.1 Psychological Issues

The use of an integrated display during drive is a timesharing activity. Drivers must share their attention between tasks necessary for secure driving and tasks related to the use of the information device. If the information appliance was badly designed, some characteristics of the device may even lead to a mental overload, for example when too much or ambiguous information is presented.

Designers have to pay attention to several psychological issues when creating user interfaces of in-car information systems, especially to avoid too much driver distraction as mentioned before.

First, they have to consider functions of attention. Attention is a capability with limited resources. We know focused, selective and divided attention and thus describe a user's capability to pay attention to one single, some well chosen or several tasks simultaneously.

Next, developers should regard the differences between controlled and automated processing. When trying to design in-vehicle systems, the system must be easy to learn to allow the user to switch from controlled to automated processing fast. Controlling processes means drawing attention to them and needing resources. Users need controlled processing when they are confronted with novel and inconsistent information. Automated processing can take place without control, but mostly automated processes have to share resources with others. When designing in-vehicle appliances, designers should nevertheless take care that most of the interactions between human and computer only need divided attention and can be processed automatically. If the driver would need focused attention and controlled processing for configuration of the integrated system, his distraction would be much too high and concentration on traffic would go down dangerously. However, by supporting automated processing you also buy the unavoidable disadvantage of automation, namely that sometimes nevertheless a novel and not automated driver response may be required.

Third, designers are ought to know what differs serial and parallel processing. Drivers have to switch tasks very often, also if not using in-car information systems. Therefore, drivers have to process many information parallel in order to carry out some reactions simultaneously. When adding information appliances to the drivers environment, the amount of information which has to be processed parallel increases. All devices should support parallel processing as it is faster than serial processing and thus the time for uptake of multiple information is reduced.

As already mentioned, tasks are often to share time and attention with others. There exist some influences on how well two or several tasks can be timeshared. There is the process of scheduling and switching, meaning the person changes focus at special time. Apart of switching operations there can also be processes that cause confusion, e.g. when the sound signaling the driver has to turn in 500 meters equals to the sound for a collision warning. Both sounds will most probably cause the same reaction, namely a step on the brakes. In addition, processes can not only cooperate but also stand in competition, meaning timesharing works well or the driver cannot decide which process he should give more attention – a stress situation.

Another important principle is the one named Compatibility. This principles describes that a driver expects that visual information on a display is compatible with the operation - the response - the driver has to carry out. For example, if the navigation system wants to driver to turn left, the driver expects to see an arrow-left on the display as this sign fits the mental model he has of driving directions.

The principle of proximity describes that if two sources of information must be integrated to a part of a task, then there will be benefits in ensuring high display proximity. Thus related information elements must not be separated by more than two degrees in space (foveal vision). Proximity will encourage parallel processing and co-operation between tasks. But designers have to take care not to place such displays near areas where focused attention is needed. Information Displays would become dangerous distracters there.
3.5.2 Style Guides and Rules

Blume [BW 1991] described six human factor rules during his work on the development and testing of an in-vehicle information appliance. As you will see, this early work already payed attention to psychological issues like cognition and attention.

Blume’s display did only show information relevant for increasing safety – data which pointed out to dangers and problems or which reduced stress.

- The display must not be overcrowded with information and colors were only allowed to improve understanding.
- Each operation must easily be understood and allow an intuitive use. The display should be close to the driver’s normal line of sight.
- For giving commands to the system, interaction elements which could be used without looking at them were preferred.

One year later the EC Drive II program started and Janssen et al. [JKMV 1992] were involved in order to determine requirements and style guides for intelligent driver support systems. In the design criteria of their research prototype,

- The ordering of messages and expected driver actions should remain consistent over time. Messages should be given in a consistent format (use the same wording and display).
- If some related information has to be displayed simultaneously, the information should be shown in a proximate format, location and modality.
- Messages characteristics should be chosen such that their attention-attraction properties match the priority of the message.
- The driver should only be able to change the appliance’s look and feel when these personal settings will not interfere with the assimilation of the system’s messages.

But although in many research prototypes “…the key words ‘integration’, ‘combination’ (and) ‘multifunction’” [RBGMA 2] were mentioned, these mostly dealt with technical matters rather than HCI considerations. Nevertheless quite a great amount of older prototypes paid attention to physical ergonomics - location of the display near the driver’s line of sight, legibility under various light conditions. In most cases the main problem was that there did exist a lack of controlled testing. Most considerations were only made in theory and only seldom any experiments took place that could have proved them to be better than traditional designs. Another fatal error in many research prototypes was that there was too less attention paid on the organization of information, like structuring, prioritizing or limiting data on the screen. Thus some of the designs of older prototypes would have led to unsafe driving conditions and would have been inefficient in the use of the driver’s attention resources. Nevertheless, there are some research studies that can be used as real design guidelines.

3.5.3 The UMTRI Design Guidelines

The following principles of the University Of Michigan Transportation Research Institute (UMTRI) are taken out of a technical report of Paul Green et al. [GLPS 1993] which is based on “…field and lab experience with pre-competitive interface designs, as well as the human factors engineering literature” [GLPS 1].

3.5.3.1 Basic Design Principles

A basic principle is to be consistent regarding the input, output and the compatibility of both with each other. In detail, screens which request user input should be equal in design and provide the same structure.

Controls and displays should work the way the driver expects them to function. This means action to control devices must be consistent with changes on the screen.
Controls must be arranged in a way they support reading, e.g. in Germany from left to right and from top to bottom. The driver should only have to remember a few of commands. The user should be able to choose most instructions out of a set of all possible at a special time and place. All operations which occur very often or which are very important should be the easiest to perform. Related controls, displays and information should be near to each other. Designers should use metaphors and conceptual models to simplify the use of the system. For example, the most intuitive navigation device is a 2D map on the screen. The system must provide both support for beginners and experts. Experts might for example want to store navigation targets while beginners use the system so rare they only like to input targets manually. The driver must always be the one who is in control. The system's performance therefore must not suffer from interaction delays which are likely to occur very often when the user is concentrating on driving.

3.5.3.2 Manual Control Guidelines

The need for manual inputs during driving should be reduced or even be impossible. The system should be able to anticipate what the driver might want to see on the display and the device should present that information automatically. For example, drivers do in some situations not want to see the trip map, but the arrow display when they are close to a turn. When manual actions are needed, the input devices should be near the driver and easy to reach. Critical functions should therefore be available near the steering and wheel and the predominant position of the driver's hands. The entrance of user inputs should be designed flexible, e.g. the driver most probably likes to input street or city in flexible sequence. User errors should be forgiven and the system should not provide feedback which would accuse the driver of having made a bad error. In contrary, the system should be designed in a way inadvertent errors are difficult to be made. Therefore, control devices must not be located too close to each other. For each task, there should be an appropriate interaction device. Although the list of possible devices may be long, the one which forces less driver distraction should be chosen. Input devices should be capable of providing feedback of a kind the user realizes a successful operation. Buttons must have enough way to travel and must require some force in order to be switched. Controls should use color-coding to group items and represent their function.

3.5.3.3 Spoken Input And Dialogue Guidelines

Interaction dialogues should be easy to learn and the operations they require easy to remember. If the system accepts speech input, it should signal whether it is in a state in which it can accept spoken commands or not. Spoken system feedback should in no situation have a threatening tone. If dialogues present prompts or messages, there should be the possibility to cancel interaction and interrupt the dialog sequence. Every spoken or manual input of the driver should be answered with immediate feedback. But the feedback for commands should differ from the feedback after the input of data. Every feedback should be context sensitive and unambiguous.

3.5.3.4 Guidelines For Visual Displays

On every display, the amount of information the driver has to read must be kept at a minimum. Commonly used displays and those showing important information should be integrated near the driver's line of sight. The information screen should provide best possible legibility. The size of the characters should be of a kind the driver does not need to observe the display for a long time. Designers should therefore use plain typefaces like Geneva or Helvetica. There should be enough space between textual elements to allow text to breath. Designers should use light colors for text and dark backgrounds in order to minimize glare. The
information device should use symbols to supplement words, abbreviations should be common and follow predefined rules.
Concerning the organization of information on the screen, free text should be left justified and numbers should be right justified. Parts of text, which belong together, should be grouped, others separated. In order to underline priorities and importance, natural structures of hierarchy, to which the driver is used to, should be used.
3.5.3.5 Guidelines For Auditory Feedback

When using audio feedback, the background noises during drive must be considered. Audio information by the driver information system must be heard and therefore exceed all other sounds in loudness. Designers should keep the number of different warning tones low. There should not be more than three different sounds. The sounds should be designed taking auditory information processing capabilities into consideration. Auditory feedback should be consistent with the urgency and importance of the information. If possible, the system's speech should remember of a human voice.

3.5.3.6 Guidelines For Navigation – Visual Displays

When the user switches over to the navigation system, there may be a great value in providing both visual and auditory navigation information.

As turn indications there should be simple arrows or simple maps to tell the driver where to go. Turn arrows should approximately be the manner in which drivers think of turns. Turn displays should be available near the driver's normal line of sight, such as on top of the main console or the system should use a HUD. The amount of detail on the map should be as minimized as possible. The information on the map display should be reduced to the required, such as the road being driven, direction and approximate angle of the next turn, the name of the road after the next turn and an indicator for the distance until the next turn. Countdown bars could show remaining distances. For complex areas, there should be an abstract map of e.g. the intersection to offer better support and to keep information unequivocal.

When drivers have reached destination, there should be a special arrival screen that underlines the successful navigation. The computed route should be distinctive from other roads.

3.5.3.7 Guidelines For Navigation – Audio Interaction

Auditory instructions should be limited to four chunks to keep information simple. Therefore, auditory navigation instructions should only consist information about the distance to the next turn, the name of the street in which to turn in and the direction of the next turn. If there is a series of messages about an oncoming maneuver there should be three kinds messages. Early messages, preparation messages and approaching messages.

<table>
<thead>
<tr>
<th>Message</th>
<th>Information Provided</th>
<th>When Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early (always given)</td>
<td>“In” {distance} “at” {location} {action}</td>
<td>5 s after turn</td>
</tr>
<tr>
<td>Prepare (only given if enough dist. after early message)</td>
<td>{distance} {location} {action} - or - {distance} {landmark} {location} {action}</td>
<td>1 mi before turn</td>
</tr>
<tr>
<td>Approaching (always given)</td>
<td>“approaching” {location} {action} - or - “approaching” {landmark} {location} {action}</td>
<td>0.1 mi before turn</td>
</tr>
</tbody>
</table>
### 3.5.3.8 Navigation Input Guidelines

For entering street addresses, designer should provide a touch screen or keyboard. Some interactions may only be allowed at a certain time (Image 12).

<table>
<thead>
<tr>
<th>Tasks carried out while moving (or at other times)</th>
<th>display brightness and contrast adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>voice volume</td>
</tr>
<tr>
<td></td>
<td>repeat last voice message</td>
</tr>
<tr>
<td></td>
<td>zoom in/zoom out</td>
</tr>
<tr>
<td></td>
<td>&quot;route hop&quot; (resetting the navigation system</td>
</tr>
<tr>
<td></td>
<td>when the known and displayed positions differ</td>
</tr>
<tr>
<td></td>
<td>declutter (show fewer map details)</td>
</tr>
<tr>
<td></td>
<td>switch between turn display and overview map</td>
</tr>
<tr>
<td>Tasks carried out at zero speed (e.g. stopped at</td>
<td>map scrolling (may be possible while moving)</td>
</tr>
<tr>
<td>traffic light) or predrive</td>
<td>switch between north up and heading up display</td>
</tr>
<tr>
<td></td>
<td>(may be possible while moving)</td>
</tr>
<tr>
<td>Predrive tasks (when the vehicle is in park)</td>
<td>destination entry</td>
</tr>
<tr>
<td></td>
<td>accessing business listings (yellow pages)</td>
</tr>
<tr>
<td></td>
<td>setting voice (male vs. female voice, etc.)</td>
</tr>
<tr>
<td></td>
<td>infrequently used system options</td>
</tr>
<tr>
<td></td>
<td>system calibration such as setting the compass</td>
</tr>
</tbody>
</table>

[Image 14]
3.6 Car Information Systems By DaimlerChrysler

3.6.1 The Designers About Their Product

In contrary to BMW, DaimlerChrysler did not invite me to offer some information on their in-vehicle information system called COMMAND. Only thing I was told via email was that they suppose their system to be the best, adding a link to an article about the COMMAND in the German Focus magazine. Thank you so far. Therefore, testing and evaluating of the COMMAND system for this report was a one-man-job without any support by the manufacturer itself.

There are many hints that DaimlerChrysler was obviously when BMW presented the iDrive (see chapter 3.7) and I just asked at the wrong time. But nevertheless it is very poor that a company so proud of its own product does not offer some detail information about the philosophy behind COMMAND or which usability concerns DaimlerChrysler paid attention to.

3.6.2 Testing The COMMAND System

The COMMAND user interface consists of a color display and three groups of buttons and controls besides and above it. The buttons on top of the display are to switch between all different features the fully extended COMMAND offers: telephone, radio, CD, tape, and television. The upper right group of interaction controls consists of a button to switch over to the navigation system and a conventional number field with digits from 0 to 9. Some digit buttons are also labeled as cursor keys. The button group at lower right position is the main control device of the COMMAND system. It contains the rotary control which is used to do most of the interaction by turning and clicking operations. Besides the rotary control, there also is the important RETURN (RET/C) button, two buttons for increasing and decreasing loudness, two buttons for switching forward or backward between CD tracks, one button to turn mute audio output and one "ON" button.

As already mentioned, the rotary control can be turned to browse through the menu structures of the COMMAND software. It can also be pressed to invoke a kind of click operation, similar to a mouse click. With the mouse click, you can step into menu elements, by pressing the RET button you can leave the submenu and go back one level.

In the test of the COMMAND system which was coupled to this report, the features radio and navigation were placed at my disposal.

In radio mode, buttons you should interact with are the number pad, the rotary control and the two buttons for toggling loudness. In the software interface you see by default the name of the current radio sender (German RDS system). Below you find menu choices for sender storage, tone, sender list and to alter radio frequency mode (German FM/AM system).

In the sender storage submenu you can see a list of all current available senders in the environment of the car. You can directly chose one of the senders in the list by browsing to its name with the rotary control and by pressing the rotary control button afterwards (invoke a click).

In the sound menu, the driver can change settings for balance, fader, treble and bass. Using sliders alters all settings.
In the sender storage menu, the driver can see all previously stored senders and the storage position they reserve. Position numbers without a name besides mean that the storage position is still empty. The driver can store new senders by filling free positions or by overwriting an existing sender at a special position. But the user can also chose a sender he would like to hear by selecting a sender’s name or by pressing the corresponding digit on the number pad.

The last menu allows the driver to switch between the different types of receiver mode available in German, namely AM and FM.

When switching over to the navigation mode, the driver has to input a navigation target first. The driver can enter a target manually or choose one from a list of previously stored targets. The manual entry of a route target is done by using a keyboard. The driver has to browse the keys, which are arranged like on a real computer keyboard, with the rotary control. By turning the rotary control, a kind of magic lens moves over the keys and thus identifies the one which is currently selectable. While the driver begins to enter the destination city, the systems proposes names which would fit the user’s entry so far. After the driver has entered the target city, he can proceed by telling the system the name of the road he wants to reach in exactly the same way.

When navigational support begins, the user can switch between different modes. The driver can choose to see just the direction in which he drives (north, south, etc), he is able to switch to an arrow display and he can also access the total map including the route. The arrow mode displays arrows which tell the user in which direction he has to turn next. In addition, there is a so-called countdown bar which decreases until the turn must be carried out by the driver. Above and under the arrow there is the name of the street in which the car currently moves and the name of the street the driver is about to turn in. On the left of the arrow there are the menu items which allow the driver to switch over to other display modes, to change the scale of the map or to display information about the route, like e.g. the name of the target, distance between current position and target, and the targets exact position as computed by GPS. The arrow mode is the one which can be displayed both on the integrated display and besides the car’s speedometer. The display above the speedometer is much smaller so that here the mode’s appearance only envelops the arrow, the countdown bar and the name of the street to turn in respectively the distance to the target (when no turn is near). When using the rotary control, textual elements (mostly menu choices or related objects) which are selected appear surrounded by a blue colored rectangle. When pressing the rotary control while above a selectable item, the tint of both the blue rectangle and the text get darker for about one second to signal successful selection. Afterwards the menu item was selected and either corresponding changes have already taken place or the user now can change an items configuration in detail by e.g. using sliders.

The display changes its colors and its brightness according to light conditions in the car. By doing so, optimal readability respectively legibility should be guaranteed any time.

During the test it was very significant that using the rotary control during drive lead to leaving the driving lane again and again for some seconds. But as the COMMAND system also provides a small display near the car’s speedometer and thus near the drivers normal line of sight, the usage of the COMMAND can be safe. The system might even be safer if some operations to the main display would be disallowed when the car reaches higher speed.
3.7 Car Information Systems By BMW

3.7.1 The BMW iDrive Information System Of The New 7 Series

Since the new BMW 7 series was recently presented, criticism comes down on the BMW concern. The US magazine *Fortune* questioned, “Do you consider this car to be ugly?” and answered, “If yes, you are not alone” [DS 2001]. There are obviously many people who do not agree that the new BMW is symbol for progress and jump forward in design matters. This opinion does not only concern the outside appearance of the new BMW. When you sit down in the car you will see a strange silver colored button in the right of your driver seat. This button belongs to the BMW iDrive, the new BMW in-vehicle information system that was designed to be a breakthrough in the design of control and usage of driver support systems.

The iDrive control concept offers access to over 500 features. All of this feature can be configured by the silver iDrive control button. The philosophy of the BMW designers was to reduce the amount of buttons in the driver environment. Older BMWs had up to 700 different functions, many of them available by different buttons.

The iDrive system contains – in a basic version – a radio control, climate control and a board computer. Everything else, like TV, navigation system, access to 3D village view, telephone control, or internet access (WAP) is an extra feature and can be added to the system separately.

One design consideration behind the iDrive was the separation of components for driving from those necessary to trigger extended functions. Thus, the left of the cockpit only contains control devices that are familiar to the driver – steering, speedometer etc.. The middle console offers controls to support the drive and to increase luxury. There has been made a distinction between usual interaction devices, e.g. to toggle radio volume or to adjust the cockpit climate, and the iDrive control system. The usual controls should guarantee that the driver could also access the most important features without having to use the information appliance. Thus the iDrive concept tries not to shock older customers by offering familiar and non-computer control on the one hand, but on the other hand also high tech driver support for those interested.
3.7.2 iDrive Usability: Opinions and Comments

BWM uses aggressive advertising in order to bring the iDrive to public interest. They show a woman's breast and title the spot with the words "Intuition brings human to their first aim". Comparing the iDrive button to a woman's nipple the advertiser adds "Why not to all other things, too?". That the usage of the iDrive button is less intuitive than BMW promises became clear shortly after its promotion. Mr. Wolfgang Schneider, owner of a BMW central in the German city of Kitzingen, in an interview of Auto, Motor & Sport, said that "...several clients will want us to set some basic configurations and will then come back again and again if something has to be changed" [AMS 1]. Schneider underlines that some functions had easier been available in the older model by pressing simple buttons and said, "...yes, the control of the radio is not optimal, it had been better before" [AMS 2]. Mrs. Silke Greiner from a BMW car dealer in Würzburg, Germany, failed to successfully demonstrate the iDrive speech recognition during a visit of the magazine Auto, Motor & Sport. Mrs. Greiner accused the almost empty battery of being responsible for the systems failure. Other colleagues of Mr. Schneider and Mrs. Greiner already fail when clients like to see how radio frequencies can be set manually. Mr. Reinhard Hellmich from the Euler BMW service point in Frankfurt, Germany, even points out to the fact using the iDrive during drive should be avoided. Not only demonstrations fail, but also the first drivers experience usability problems. A female driver mistook the SOS button for the button to open the sliding roof and some minutes later the fire-station called her asking whether she is "...doing a test drive with her new BMW" [AMS 3].

The iDrive revolution is in many opinions a step into the right direction. But although the system tries to be revolutionary, designers still made some faults concerning basic usability principles. As the magazine Auto, Motor & Sport comments, most drivers of the limousine do not know what's behind the term "RDC". RDC is a technique that controls the air pressure in the vehicle's tires. Why the menu entry is not simply named "Tire Pressure Control" cannot be explained by anybody, maybe because RDC is the shorter term, maybe designers expected their drivers to know all the names of all new techniques in the new BMW. By doing so, they are most probably wrong. Alexander Bloch, test driver at Auto, Motor & Sport complains that the iDrive control is much too sensitive and even if you are very careful in turning the button, the systems cursor continues moving although you already stopped moving the control button.

In summary, even a system like this still has some greater usability errors. Although the idea for iDrive was already born in 1995, designers were obviously not able or did not like to do some usability testing in outside institutes. This may be the greatest error BMW committed. Their product could have been much better, if they had asked for some more objective expert opinions.

Thus, again it was not the user, who was center of the iDrive design, but finally the angst of giving too much information to third parties. And again, a technical and idealistic advantage (most probably as against DaimlerChrysler) was considered to be much more important than to take the chance of designing real usability.
3.7.3 iDrive Usability: BMW Engineers In Personal

Investigations for the BMW iDrive lead to an invitation by the head of the BMW department for ergonomics. Aim of the visit was to find out about BMW’s usability engineering lifecycle. The following explanations are resulting from a personal conversation with the BMW ergonomic department’s leader, Mr. Hermann Künzner.

BMW developers did neither know about Deborah Mayhew nor about her usability engineering lifecycle. Designers were not able to name resources they might have used, therefore you might assume that they did neither take a great amount of popular design principles into consideration, nor did they consider fundamental style guides.

Basic usability tests did not include persons of the iDrive’s target group, namely drivers of the new BMW 7 series model. Designers pointed out to the fact that people of the car’s target group could not be considered as they - most probably managers - are rare in free time and were not at the designers disposal.

Concerning driver distraction during drive, I pointed out to the difficulty of triggering the stereo fader during a highway drive at great speed with two complaining children in the back. I was explained that drivers simply have to decide whether they really have to trigger the fader at 150 km/h and should do it at own risk. There are many other functions that designers suppose to be only used at own risk during drive. I also asked whether they did consider that older people might be slower in using the iDrive display while driving, having in mind the study of Mourant et al. [MTSJ 2000]/[Image 18]. Engineers underlined that tests have taken place, but did not tell results in detail. At least, they did not find out a difference in driver distraction between younger and older drivers.

According to the design idea of the iDrive to separate strictly between usual and the modern iDrive controls, Mr. Hermann Künzner, head of the BMW team for ergonomics, regrets that there have been some inconsequence, e.g. some old-style controls give visual feedback not in their area but in the iDrive display and therefore break the separation pattern.

The iDrive does not give audio feedback. BMW engineers believed audio communications from appliance to user to be distracting and disturbing. To include the audio feedback in the set of user-preferred options that can be switched on and off, was not discussed during the
development process. But the iDrive accepts phonetic commands by the driver and understands about 270 different words. The wordings are textually equal to the menu entries and functions offered visual in the iDrive display to support better learning.

BMW did not use a HUD instead of the integrated system because of its high price and problems of projection into the front window. In addition, Mr. Künzner does only favor HUDs for temporary information, like navigational hints or warnings, but not for all time display of data, as the driver would have problems in switching between a view on the street and reading the HUD. BMW decided for an integrated display that was placed very high in the car's cockpit after tests proved that to be more usable.

Finally, a demonstration of the iDrive system was impossible as the car was out of order for any reason.
4. Summary And Conclusions

Information appliance, including in-car information systems, will really have to be extremely attractive and very easy to use to gain wide acceptance or at least any greater acceptance at all. Regarding the difficulties of how to achieve devices that fit a great amount of users, a solution may be found by providing the possibility to switch between beginner and expert features optionally. In addition you could think of an ability to adjust the device’s look and feel according to an individual user e.g. by identifying the user by fingerprint or voice. This idea simply derived from Norman’s comparison between an information appliance and items we user everyday, like a pen, a coffee cup or television. Most probably not everybody in a household likes to use the same coffee cup, writing with the same pen or watching the same channels. Some might rather like to write with smaller pens and in color red, others prefer writing with ink. The children like to watch cartoons at high volume, the parents dislike soap operas and simply switch over channels. But nevertheless, the family most probably does not own several TVs, as the device is able to adapt to the users taste by allowing switching channels and toggling volume or brightness. Transferring this metaphor on the design of information appliances leads to the result that the devices have to allow the same possibilities to adapt in order to be really ubiquitous and accepted.

By consequently separating tasks on special devices, which are best, suited to fulfill them, we will soon see a vast amount of appliances in our entire environment. Like Donald Norman proposed, designers will perhaps have to move away from the idea of having one device for one single task. They probably have to accept that it may be better to split not by task but only by activity in order to keep the number of appliances low and home networks simpler. But nevertheless it is most probably becomes necessary for many households to give the administration of the home network into foreign hands because of a lack of knowledge about computers and networks. Many users will not accept such restrictions even if they would make life for them easier. But who likes to give up privacy and the foreign administrator to know everything what’s in the users storage?

Normal PC users mostly do only know a small amount of an application’s features and they avoid situations they could not deal with by just not using the functions that might create them. Such a disaster must not be continuing in the future with information appliances. Designers should not do that error when designing information appliances and always try to enhance the practicability and usability of input devices. The focus has to stay on the user for all reasons. If not, information appliances will fail.

The integration of driver displays raises much issues of cognitive psychology. “Poorly designed systems may significantly distract drivers from primary task activities and may lead to situations of mental overload” [RBGMA 1].

Current in-vehicle systems are careful to use conventional controls where possible. This means to rely on input devices drivers are used to. When experts design novel control devices they must take into consideration that drivers have to concentrate on the traffic in front and not on the device at their side. “Given that many integrated systems in the vehicle may mean a considerable amount of functions to control, this means that the number of input devices must be minimized whilst providing the flexibility to control the systems efficiently” [RBGMA 3]. Future systems should provide interaction using natural speech and include well-designed head up displays to reduce driver distraction. But because recognition of natural speech is a hard to implement and HUDs are still very expensive, the introduction of such systems is still far away.

In a summary, BMW and DaimlerChrysler have to enhance their usability testing methods and have to outsource the evaluation of their systems to third party specialists. At the moment, monetary and market oriented considerations still weigh more than the usability a system is supposed to reach before a new car is coming out. But both companies will learn to improve their systems according to basic guidelines and psychological issues as in any other case many drivers will change the brand.
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