Context-aware services bundling for motorcycle police officers

The design of a business model offering context-aware service bundling to increase value for motorcycle police officers

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Foreword

In April 2007 I started my Master Thesis research for vtsPN. From the moment Harry Bouwman explained me he had an assignment for me at the police organisation I got excided. Although I never had a specific interest in policing, the nature of the organisation attracted me. The police is a public organisation constantly trying to make sure society remains safe for everyone. Any aid I can give in achieving this goal is worthwhile to me. During my work at vtsPN I have seen a lot of interesting aspects of policing work and met many police officers showing me details about police work that was completely new to me. This augmented my enthusiasm considerably. Meeting the people you are working for is an essential aspect to increase the energy you are able to put in your work. During the 10 months I worked on this thesis I have learned incredibly much. My girlfriend refers to me as a statistics freak, which is probably the last thing I would have expected someone to call me when I started studying. But there is much more. Working alone, but at the same time working together, going to people to find the information you need, being able to put things more in perspective, learning how to build a fake motorcycle, etc. All my work has been put together in this thesis, which feels strange, but fulfilling.

Although I wrote most of the words, a considerable part of the knowledge behind those words come from others. During my project I have had many people helping me directly and indirectly for which I am very grateful. I will start with the people that helped me from close by. First of all I have to thank the four members of my commission. Mark de Reuver is my first supervisor from the University and I am very thankful he supported me throughout the thesis. Always replying, always helpful. He was able to clearly explain what I did wrong and increased the level op this thesis considerably. Also on a personal level the relation with Mark was pleasant, which made it easy for me to turn to him for any question. At vtsPN Evert Schut supervised me. Although we are different people resulting in different approaches, he supported me throughout the project. He gave me advise on different more practical issues and did his best at pulling me away from the computer screen once in while, which was needed. Harry Bouwman is my main supervisor. An interesting person who uses a strict and thorough approach, but certainly fair. He requires the student to seriously work hard and think things through (something many student are not always really keen to do), which may seem tough in the beginning, but results in a much higher level of knowledge and quality. Always busy, but always available for questions and answers to your questions. He clearly showed interest in my work and thereby motivated me to work harder. Ellen Jagtman was my second supervisor from the safety science department at the University. I had less contact with her, but her criticisms were very useful to me. She provided clear explanations on what I did wrong and pushed me in correct thinking directions. As she stood a bit further from the project, she showed me things that are unclear to people who are not in the same project. I wish her all the best with her coming child.

There are also many people outside my commission that supported me and deserve a few words. First of all Timber Haaker from the Telematica Institute. He assisted me with any question and clearly showed interest in my work. From vtsPN, I have to specifically thank three people. The first is Kees Verweij who is not only a very funny man putting a smile on my face, but also helped me with his knowledge and with any question I had about any topic. Secondly, Maarten Nacinovic who always supported me with all my needs to execute my research. He gave me clear advise, and also supported me financially in setting up the experiment without any problems. Lastly, Anna Garghetti, my roommate. She is a kind, funny and intelligent person, who cheered me up everyday while we were sitting in the office. We spoke about many things, which would take my mind of motorcycle police officers once in a while. I am very thankful for her support during the 10 months I worked at vtsPN and I wish her all the best in her new job (at vtsPN). Of course, I want to thank all people at vtsPN and the different police departments that assisted me during all the research I have done.

Lastly, a few close friends and family have to be thanked. Martijn Magré who created the application for the experiment. I am not only thankful for all the time he put in, but also because he is just a very funny person who made me laugh while working at the same time. Hylke Kuyper also needs to be thanked, as he worked on the application as well without any reward (just my cooking…). He even worked on the application at 2 o'clock in the morning before having to go to work the next Monday. Also, just as Martijn, he is a funny person providing the same laughter. My parents need to be

thanked as they seriously are the coolest parents. Always helping and supporting me during my long studying period. And then Marta Faneca Sanchez, who I am crazily in love with. She is already waiting for me to finish my studies for a very long time, but never complained. On the contrary, she always supports me, even when I am tired, grumpy and annoying. She is the most special person to me and I am happy to tell her the end of her boyfriend being a student has finally arrived.

I sincerely hope that everyone who reads this thesis will understand the ideas and thoughts I present and that I maybe even managed to put a small smile on his or her face.

Wibout Roukens

Delft, February 2008.

Summary

Background and problem situation

Providing the right information to police officers on the right moment plays a crucial role in successfully executing policing tasks (Politie Nederland, 2005). The use of information and communication systems plays a vital role in delivering the right information at the right moment. Since 2004, the Dutch Police organization and other interested parties are executing research in the field of mobile information provisioning for police officers in the streets. But no specific research has been executed which focuses on the motorcycle police officers (MPO's). The working situation of MPO's makes the use of information systems complicated and most currently available systems have a considerable negative influence on the MPO's safety making them impossible to use. Technical failures of the available communication equipment and an under capacity of the control room make the resulting information provisioning for MPO's problematic. A promising combination of concepts is 'context-aware services' and 'service bundling', defining and grouping needed information provisioning for each context-situation the MPO is in. The design of such a service concept however is unknown and is defined as the basic knowledge gap to be answered by this thesis. The aim of the service is to increase value to the MPO, which also requires a technical architecture for the service to function, feasible organizational arrangements and solid financial arrangements. The latter is not included as a research objective for this thesis due to time restrictions. The described problem situation is translated to the following research question:

How can context-aware service bundles and its business model aspects be designed in order to create value for motorcycle police officers?

Approach and instrumentation

In the first phase the exact problem and research objective is determined. Based on the research objective, a number of promising theoretical concepts are chosen. The first is to choose a solid business model providing the structure in which the service needs to be designed. Consequently, a selection is made of promising and easily interpretable concepts of context-aware services and service bundling.

In the next phase a first concept of the context-aware service bundle is developed. The development started by a number of interviews providing detailed information on the work MPO's perform. The interviews and the chosen theoretical concepts of phase I provided information to define the essential context factors influencing the information provisioning of MPO's. Next, a general study of communication system acceptance for MPO's is measured. To get a more detailed image of the demands of MPO's regarding information systems to support their work in changing context-situations a conjoint analysis is executed. The demands provided the basic requirements for a conceptual model of context-aware service bundling for MPO's to increase the value for MPO's.

The designed model is further developed into a touchscreen mock-up and a head-up display mock-up as a comparison information system. By letting the MPO's use the mock-ups, the difference in value is measured between both mock-ups, and the current communication system used by MPO's. Also, qualitative observations and discussions with MPO's are used to provide more detailed reactions on the designed service. Lastly, video footage is used to get a first impression of the effect of the service on safety.

In the last phase the required technical architecture and organizational arrangements have been researched. This is partly done by performing interviews and partly based on experience and available literature.

Conclusions

A total of eight context-factors influencing the information provisioning are defined: location, time, status, speed, group communication, network availability, control room availability and task. The task plays an essential role as it determines the information needed to support the task. The intention to use a communication system is mainly influenced by the advantage of using the system and the information exchange possibilities of the system. The most valued information system in general is build on a touchscreen presenting the information to the MPO, but the current system remains important to support the MPO in more complex situations. The service itself is build around a context manager controlling the different context sources which are based on the eight context-factors. By using different networking technologies and altering the user interface to the context the value of the service is increased. More information can be provided, increasing efficiency and effectiveness of the MPO. This means the service automatically creates value to the departments as well. For vtsPN, the increase in customers acquiring the service and a knowledge increase provide the most important value.

Testing the service concept on a touchscreen mock-up with MPO's presents promising results. There is an increasing appreciation as opposed to the current system, and also when compared to a head-up display version of the designed service concept. The main problem of the service is safety related. The ratings of the tested service are insufficient, even when the test is performed in a static environment. A real-life situation test is necessary to get a grounded image of the effects the service has on the safety of the MPO and what happens if the system fails. Secondly, the service is assumed to work flawlessly. Testing with a real prototype must ground to what degree this flawless functioning is achievable and how non-functioning affects the value of the system.

Focusing on the technological architecture a few conclusions are drawn. The supporting infrastructure is an existing mobile information provisioning platform from the police organization, with the addition of UMTS and data over C2000. A number of devices need to be installed on the motorcycle: a computer, C2000 equipment, a GPS module, a touchscreen, a control-button on the handle-bar and a camera. The required applications are: a solid operating system, a middleware layer functioning as context manager, C2000 software, hybrid networking software, license plate recognition software, navigation software and text-to-speech software.

The organizational arrangements consist of a few proposed methods to tackle current service development problems: a national guidance structure, an increasing effort in problem representation, a spiral model for development, increase voluntary and collaborative behaviour of all stakeholders and implement a process management approach to include the end-user in the development process.

PHASE I

1. Introduction

1.1 Background

Recently, the Minister of Justice indicated "all police officers need to be equipped with a Pocket PC giving them direct access to all police databases" ("Minister wil zakcomputer", 2007). Apparently, mobile information provisioning projects for police officers in the streets have an agenda-setting among politicians. "Police work is mostly driven by knowledge. Knowledge of persons, situations, norms and processes determine the work being executed. The aim of the Dutch police force is to make sure information and knowledge obtains an increasing role in performing the daily tasks of the Police." (Politie Nederland, 2005). As a result, "police officers will have to spend more time in the streets and less time from behind the desk in an office. The amount of time spend in the streets by police officers has to be used as advantageous and effective as possible. The usage of ICT aids in achieving these goals by supporting the retrieval of required information and performing administrative tasks" (Politie Nederland, 2006).

Since the beginning of this century there is an increasing amount of attention given to information provisioning for police officers working in the streets, both on a national level as by the police departments themselves. This goes from research exploring the possibilities in a general manner (CIP, 2004), to actual solutions being tested in practical circumstances (Stijnman & TNO Telecom, 2004). However, research focussing on the latter is aimed at police officers working by foot or by car, and not at the officers working on a motorcycle. Though motorcycle police officers are briefly mentioned in the general research executed (CIP, 2004), no further knowledge is available on how mobile information provisioning should be designed for their specific work environment. Due to this lack of knowledge this research is focused on the exploration of mobile information services for motorcycle police officers (from now on referred to as MPO's). Before narrowing down to the problem situation, an overview of the goal and the organizational structure of the Dutch police force are given to place the reader into the organizational setting of the research.

1.1.1 The execution processes of the police in The Netherlands

According to article 2 of the Police Law "The Police has as its duty, in subordination to the authorized power and in coherence with the valid rule of law, to take care of the actual control of legal order and the assistance to those requiring it." (Politiewet, 1993). The police organization performs all tasks based on the police law, meaning that there is no other organization which e.g. performs detective tasks (www.minbzk.nl, 2007). The tasks are divided into four categories as shown in figure 1.1; only two are executed by MPO's:

- *Assistance*: The process 'emergency aid' is the reaction of the police on incidents (announcements of events and/or a request for help) requiring a direct physical response from the police. The police has as its task to stabilise the situation at which direct response and resistance against crime and nuisance is needed. The most important products of an emergency aid are a start assignment, request for emergency aid (to other executing partners), feedback to the reporter, mutations, statements of findings and an evaluation report. (VVP, 2006)
.
- *Control*: Control is a more widespread task compared to emergency aid. Its aim is to maintain laws and rules and to maintain public order by building and preserving contacts with citizens, private and public institutions. The police organization refers to the preservation of contacts as 'networking'. Means used by the police to control are: surveillance (by being present in the streets, directed controls, cameras), trace down criminal offences, accident investigation, granting licences and tasks for the ministry of Justice. The most important products of control are feedback to the reporter, fines, mutations, statements of findings, capacity request, controlling assignment, progression and evaluation reports (VVP, 2006).

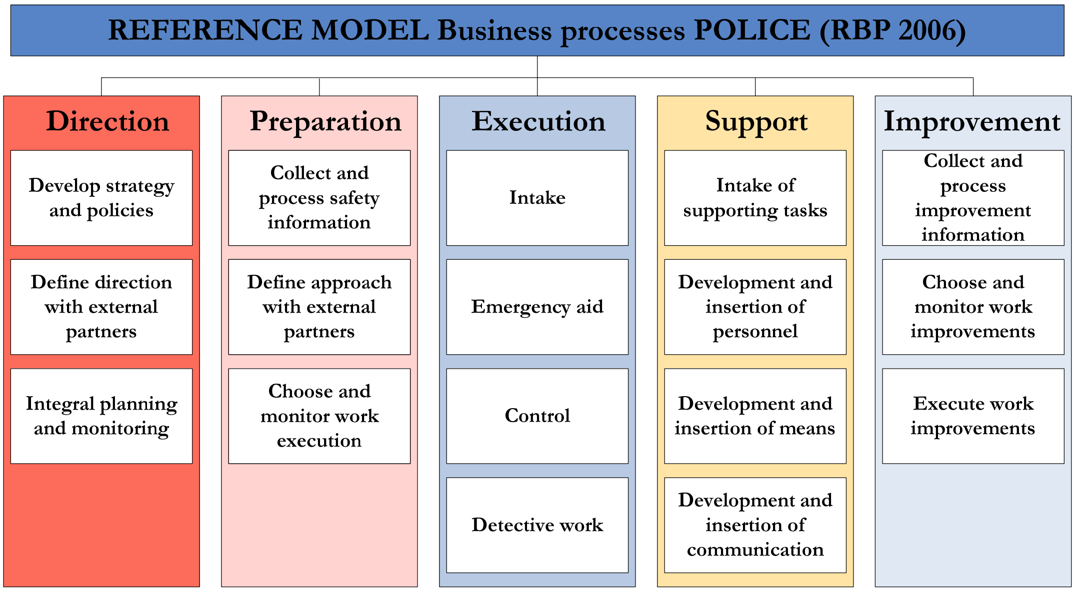


Figure 1.1: Reference model business processes for the Police (VPP, 2006)

Motorcycle police officers are trained as a police officer performing basic police work, which officially means that they perform tasks in the assistance and control work process (Interview Veendam, 2007). The practical tasks performed by MPO's will be clarified in chapter 3.

1.1.2 The organizational structure of the police in The Netherlands

Since the establishment of the Police Law in 1993, article 4 states that the police is divided into 25 regional departments and one national department (Politiewet, 1993). A regional department is managed by a regional Chief constable. The board of a regional department consists of the Mayor of the largest municipality in that region (as 'force manager'), the regional Chief constable and the Public Prosecutor. A region consists of several district bureaus, with each their district head manager. Inside a district there are several quarter bureaus. The national police department operates independently to support and coordinate tasks on a national level for the Dutch police and has the Minister of Internal Affairs as force manager. Examples of their geographic focus are traffic controls covering different regions (highways), railway controls, aerial controls, water controls and international matters. (www.wikipedia.org, 2007).

The number of police officers working for each region depends on the number of citizens registered in that specific region. Accumulating all regional departments and the national department comes to a total of 35.812 executive police officers (working in the streets) in The Netherlands in 2006 (Ministerie BZK, 2007). Though official numbers of the amount of MPO's are not available, experts believe the number lies around 1000.

The principal organization of the assignment is the police Shared Services Organization (vts Politie Nederland). Vts Politie Nederland is specialized in offering adequate, reliable and fitting ICT solutions for police, justice and the chain partners of the public regulation and safety domain in The Netherlands (www.isc.nl, 2007).

This introduction chapter contains a research plan elaborating the exploration of possibilities for a service design capable of improving the information provisioning for motorcycle police officers in The Netherlands. First the research problem is explained, followed by the research objectives. Thirdly, the exact research question is defined for this thesis. Subsequently, the design approach and the research methods are explained. The final paragraph describes the structure of this thesis.

1.2 Problematic information provisioning for MPO's

When comparing the general police aims with the information provisioning of motorcycle police officers (MPO's) at the moment of writing, improvements are necessary. Most tasks carried out by MPO's in practice are based on their own tacit knowledge. Though information provisioning methods exist, they are rarely fully applicable (Interview Veendam, Doorwerth, Breda, 2007). The *information* for MPO's referred to throughout the project is defined as: "Knowledge or data communicated or received aiding the execution of a task an MPO has to perform at that moment". The information can be hard (e.g. digital information stored on a database) or soft (e.g. information a colleague has in his or her mind about a specific task). An important aspect in the improvement of information provisioning, is the enhancement of access channels to the desired information sources, setting the necessity of *mobile* and fully *available* information. According to Savimaa (2006): "the police officer needs necessary data to be available at all times for correct decision-making. This means quality and correctness of information are essential". The lack of information provisioning is defined as the basic problem of this research, which will be elaborated more thoroughly in this chapter.

Though MPO's can officially be assigned to all tasks police work entails as mentioned in chapter 1.1, the characteristics of the motorcycle naturally pushes them in a specific role. Based on interviews held with MPO's (see total list of interviews in Appendix A) it seems a large part of their duties fall in an active environment. The active environment is defined as: "one that requires constant attention to the physical space of interaction. The physical space dictates the line of action to be followed by the police officer. Therefore usage of mobile devices is troubling and information pulling applications difficult to execute." (Allen, Pica & Sørensen, 2004). The cause of the active environment comes from the maneuverability and speed characteristics of a motorcycle compared to other police transportation means. Although maneuverability and speed are positive characteristics in the work field, they simultaneously provide the input to the problem of mobile information provisioning. As one MPO put it: "When I'm driving 180km/h I can not and do not want to focus on anything else than the road with both hands on the handle-bar" (Interview Veendam, 2007).

The means of providing the information to the officer are slim. As Pica and Sørensen (2005) clarified it: "we become a big ear or a big eye with less peripheral awareness and not a fully engaging individual with the ability to engage with all our senses". At this moment, the only source of information for MPO's is through the C2000 mobile digital communication network for the police, the fire department, ambulances and the royal military police (www.c2000.nl, 2007). The motorcycle officers have a C2000 receiver to their disposal, which is attached to the motorcycle. A microphone and a speaker located in the helmet are normally connected to it through a cable, though cases of wireless Bluetooth connections exist. In case the officer has to leave the motorcycle, he or she can disconnect from the system and use a portable C2000 terminal for communication (Interview Zeist, 2006; Interview Veendam, Doorwerth, Amsterdam, 2007).

The problem of the information provisioning for MPO's can be split into three parts. The first part concerns the *availability of vocal information* (soft information). Requesting information through speech is done directly to the control room, from where tasks are managed for all police officers in the region of that specific control room. In practice, the control room is often busy when needed, forcing police officers to wait or work without further information on their task at hand. Motorcycle officers present this aspect as their biggest problem, although differences in the degree of annoyance exist (Interview Zeist, 2006; Interview Veendam, Doorwerth, 2007). An important notion to be made is the fact that some MPO's claim the technology used (C2000) for vocal communication does not work sufficiently either. A probable reason is that the equipment used has not been tested for motorcycle usage (Interview Driebergen, 2007).

The second problem is the *lack of data-retrieval* possibilities (hard information). While working on the motorcycle, no means of data searching is available to them. Whereas police officers working by car have the possibility of searching through Police databases (referred to as registers), MPO's can not as they have no device providing a database searching functionality. A PDA with a touch screen seems unusable while driving because of the need for attention on the road. Also, the MPO wears thick gloves making the touching of very small buttons on the screen inconvenient. An example showing the need for a data retrieval system is the inefficiency of licence plate checking at this moment. The officer has to wait for the control room to check a licence plate for any criminal offence, making the task very time-consuming and sometimes even cancels it (Interview Veendam, 2007). Providing the MPO with a functionality to check databases directly would greatly improve the efficiency of the task performance (Interview Zeist, 2006; Interview Veendam, Driebergen, Den Haag, Amsterdam, 2007).

The last aspect takes a broader look on the service, by focusing on the *organizational embedding of the services* into the various police departments. When considering the service development of ISC (former part of vtsPN) for the police up to now, the level of success is low (e.g. P-info, the mobile information system for officers in the streets has about 400 subscriptions sold after 3 years of operation). Failing technology plays a role, financial backing and agreements thereof play a role and the lacking organizational cooperation between parties is seen as an important blockade of successful service implementations. (De Reuver, 2006). These aspects also need to be investigated when thinking of information provisioning for MPO's. The basis of the service embedding is the STOF business model of Faber, Ballon, Bouwman, Haaker, Rietkerk & Steen (2003) which will be elaborated further in the next chapter.

1.3 Research objective

In 2006 a Master Thesis research was executed by Vergouwen (2006) for ISC (formerly a division of vtsPN) and the Police, exploring the possibilities of hybrid services and the way these services can aid police officers working on the streets. The user focus lay on officers by foot, by car and by motorcycle. Hybrid services are defined as: "the provision of services spanning multiple, existing, as well as forthcoming, network technologies." (Gbaguidi, Hamdi, Hubaux & Tantawi, 1999). The grouping of hybrid services is a form of bundling. Vergouwen (2006) concluded his research by stating that mobile hybrid services can provide efficient and effective advantages for the officers on the streets in the area of services, networks and devices. Mobile hybrid services improve the autonomous capabilities of the police officer as the system provides him or her with more specific information.

The work of Vergouwen (2006) was executed as part of the FRUX Freeband project, aimed at advancing our understanding of how to design, realize and deliver service bundles (Faber, Haaker, Reitsma & Steen, 2006). From the work of Vergouwen (2006) a higher lever of details is taken by focusing on the MPO's. The MPO is chosen to extend the research of Vergouwen (2006) further into a conceptual model which could be the basis of a running prototype. The research goal of this extension is defined as: "finding the optimal path towards required services or information, based on available infrastructure and contextual information" (Faber et al., 2006). This definition is the starting point of this Master Thesis research project executed for vtsPN. The assignment is slightly modified by taking a broader perspective on the matter. By expanding the assignment it is not just a design of a service on its own, but a design of a service incorporating the important exogenous factors which increase the value of the service. The term 'value' plays an important role and is the central issue of a service. The customer value for MPO's is defined as: "the perceived benefit of using a service which assists in performing their work. The service offering must be considered better, and deliver the desired satisfaction more effectively and efficiently than current services used" (Chen & Dubinsky, 2003; Petrovic & Kittl, 2002; Bouwman, Faber & Haaker, 2005). The model used to deliver the service, and thereby defining the different research aspects, is now explained.

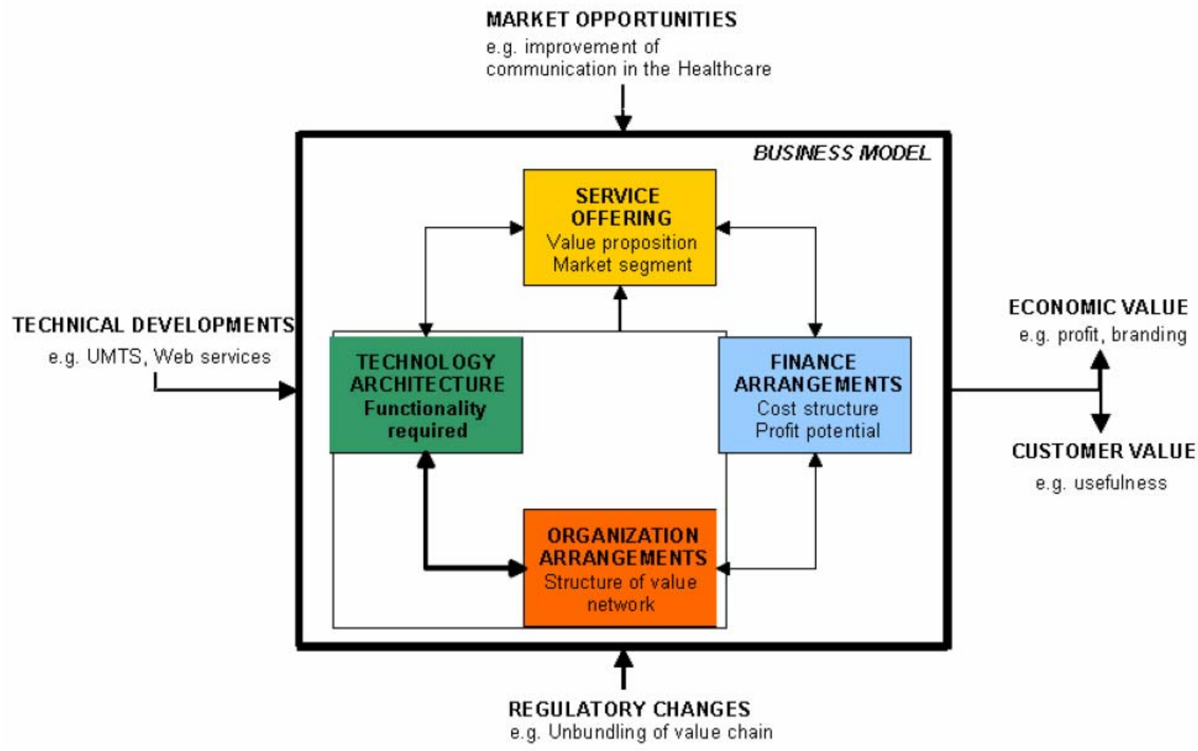


Figure 1.2 STOF-model (Faber et al., 2003)

Offering customer value to the MPO by presenting a new service requires an architecture in the form of a business model covering the technology, the organizational arrangements and the financial arrangements (Bouwman et al., 2005). The model is shown in figure 1.2. "The challenging aspect of analyzing and designing business models is that it requires managers to connect and balance design choices in different business model domains (service, technology, organization, and finance domain) in the face of technical, market, and legal developments, the ultimate aim being to create sufficient value for service providers and customer value for end users" (Bouwman et al., 2005), the latter being illustrated in figure 1.3. As a result, these aspects need to be designed together but also to create value of the service to vtsPN and the departments. If both values are high it is easier for vtsPN to sell the service to the different police departments (De Reuver, 2006). Due to time constraints the choice has been made to remove the financial arrangements from the research planning. The financial part is seen as the least interesting part given the author's background.

Having the three basic problems of communicating information to MPO's determined (see chapter 1.2), a more thorough investigation is required in order to determine the exact research objective and questions for this thesis. This part clarifies the knowledge gaps that need to be researched in order to design a successful solution to tackle the information provisioning problems of MPO's.

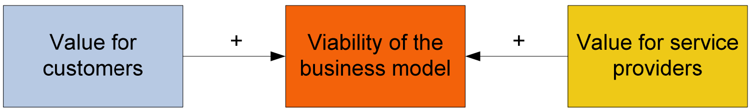


Figure 1.3: Value creation and viability (Haaker, Oerlemans, Steen & de Vos, 2004)

The work environment of MPO's is taken as a starting point to define the exact research objective. Pica and Sørensen (2005) explicate the danger of interaction overload, a problem also acknowledged by motorcycle officers themselves (Interview Veendam, 2007). When located in an active and highly complex situation, improvisation is essential as most of the officer's concentration goes out to the situation itself. Consequently, information is difficult to capture by the MPO while working. For tasks where complexity is lower and needed steps are more routinized compared to a complex situation, a different mean of information provisioning is required (Allen, Pica & Sørensen, 2004). The MPO is able to focus more on the information, meaning that more information can be transmitted and presented. Both situations require the needed information to be precise, relevant and applicable to the situation. Quality is much more important than quantity (Pica & Sørensen, 2005). To clarify the term quality of information an example is given. According to MPO's, when they ask about a licence registration number and the control room is able to respond, the MPO usually gets all the information available on different databases. The amount of information is too extensive, as the needed information to perform the task they have in mind just needs a small part of the available information. Therefore the time difference between the moment of asking for information and receiving the needed information for the task is too large. In some cases this leads to a task not being executed (Interview Veendam, Doorwerth, 2007). The solution to this problem is to transmit 'information that is accurate and at a level of quantity and richness which fits the task and circumstances'; this is defined as 'qualitative information for MPO's'.

Considering both work environments and the usage of a single information system, the provisioning of information to MPO's has to adapt to the context an officer is in and the system must be usable in all context situations. By adapting to the context, the system could be fully usable in any situation. In literature this adaptation of the service to the context is called "context-aware", as briefly mentioned before. Dey (2001) defines the context as follows: "Context is any information that can be used to characterise the environment of a person that is considered relevant to the user, the device or the service". Context-aware computing uses this context definition to provide relevant information and/or services to the user, where relevancy depends on the user's task (Van Eijk, Mulder, ter Hofte & Steen, 2004). Based on the adaptability of context-aware computing, the first hypothesis of this thesis states that *context-aware computing increases the value to the MPO*.

Comparing context-aware computing to traditional computing, figure 1.4 models the difference between both systems. It shows that besides functional inputs, also contextual inputs (defined as 'MPO-context') determine the systems output (Van Beijnum et al., 2004).

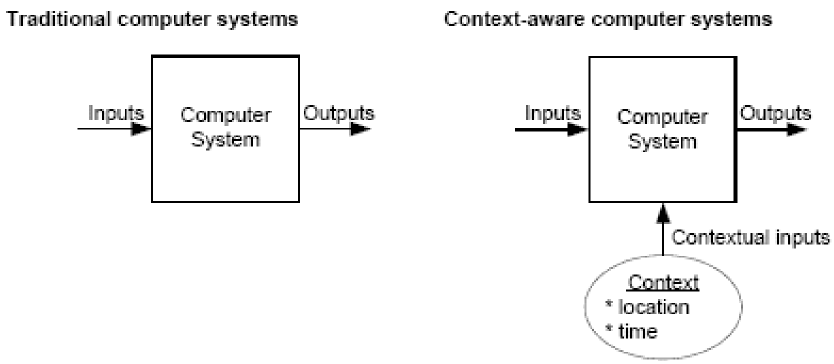


Figure 1.4: from traditional to context-aware computing (Van Beijnum et al., 2004)

The definition of Van Eijk et al. (2004) and the model of Van Beijnum et al. (2004) are correct clarifications for context-aware computing in general, but not specific enough to determine the exact context factors determining the information need of MPO's. The context aspect referred to in the final designed model will be renamed to 'MPO-context'. In this way confusion of the term 'context' is avoided. A first definition of the word MPO-context used throughout this research is as follows: "the location of the MPO, the task he or she has to execute, the status (e.g. busy or available), the time and the speed" (MIRA, 2004). Exactly *defining the MPO-context factors* is the first step of this research project to design and measure the value of a context-aware service for MPO's.

The proceeding step is to design the *dynamic context-aware service bundling model* itself. It must provide a paradigm showing how qualitative information is offered in the right MPO-context. Before going into the choice of including 'bundling', a definition of 'services' is required, due to the extended meaning the term has throughout knowledge fields. The definition used for this research comes from Grönroos (2000) who states services are: ". . . activities . . . of a more or less intangible nature that normally . . . take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems". The customer referred to is the MPO for this research.

Now focussing on the 'bundling' term; it is a form of versioning whereby two or more distinct products are offered as a package (Shapiro & Varian, 1999). In this research the 'product' Shapiro & Varian (1999) mention is defined as a service. The term bundling is chosen because of the need to couple different information services, over different networks, through different devices and possibly by using different user interacting technologies (e.g. speech or text). Just using a context-aware service is insufficient as it defines the needed output based on context factors, but does not join them as explained in the bundling definition. The bundling of the information itself requires a composition method joining the relevant information from the bundled sources. Due to the large variety of information sources within the police network and the hybrid characteristic of the infrastructure, bundling is the only way to satisfy the qualitative information for MPO's definition. The previous hypothesis is expanded by stating that *service bundling further augments the value of the context-aware service to the MPO*. For that reason, it is chosen as a supporting theory. The way in which the bundle is composed by the MPO-context and creates the value the MPO demands, has to be researched and designed.

Thirdly, needed information must be transmitted, received, handled and presented to the user through *a technological architecture*, the next aspect focussed on. The contextual approach of information provisioning discussed above consequently increases technological complexity. Considering the technological aspect of mobile information provisioning for police officers, the research executed by Stijnman & TNO Telecom for the police force of Amsterdam-Amstelland (2004) provides a good starting point. In their research different devices, functionalities of services, network architectures, support services and security issues have been pragmatically tested. The target groups (no MPO's where included) of the tested services in the report were various, with the offered services being the same. An important conclusion made regarding the target groups within the police force is that each group needs a different approach regarding mobile information provisioning, also when focussing on the technologies used. The tasks of each group define the services, the organisation behind the work processes and therefore the technological architecture. Examining the technology more thoroughly, problems on various areas arose. The influence of security of the ease of user, the limited network connectivity, the devices used and the response times of the services are the main factors mentioned not on par with the requirements of the users (Stijnman & TNO Telecom, 2004). These technological flaws play an important role when thinking of mobile service provisioning for MPO's and need to be incorporated when designing new service bundles.

An important focal point of the technological aspect is the *system safety* due to the difficult work environment of the MPO. The safety of the system is defined as: "a quality of a system that allows the system to function under predetermined conditions with an acceptable minimum of accidental loss" (Moriarty et al., 2000). The safety aspect is bipartite. The first targets at the effects of information loss. Comparing with a previous communication system for police officers (C2000), the main reason for developing the new C2000 network was to ensure a totally reliable and robust mobile communication network. "For public safety officers, communication is of vital importance. Failure of their communication system can have disastrous consequences." (www.c2000.nl, 2007). Because of the C2000 aim elaborated above, complexity was kept low by allowing only voice communication over the network. Mobile information provisioning for MPO's based on the hybrid theory presented by Vergouwen (2006) increases complexity considerably. Whether this complexity amplifies safety issues has to be researched. The second safety aspect aims at the extent in which direct physical safety of the MPO is affected by using the system. Referring back to Pica & Sørensen (2005), an information system moves the focus of the user from the physical world to the system itself. Taking away this focus increases dangers to the MPO, as unforeseen circumstances may occur at any time.

Considering both safety problems of mobile information systems for MPO's, requirements need to be set. These requirements need to make sure technical reliability, information quality and the system's usability in any situation ensuring physical safety are guaranteed. Keeping the safety in mind, while designing the system it has to be assured that the hazards of a new system are known before the system is operationally used (Moriarty & Roland, 2000). Ensuring the defined safety also increases the customer value of the service, thus adding to the overall acceptance of the organizations involved.

The *organizational arrangements* behind the mobile information provisioning service for MPO's describe the structure of the multi-actor value network required to create and distribute the service. At the moment ICT systems for the police vary per region throughout the country, making connectivity between databases difficult (e.g. BPS, XPol, Genesys (Politie Nederland, 2006)). A centralized approach is being implemented, but because some of the region's use different or older hardware, connectivity from a central system is not possible yet (Schop, 2007). This is a technological issue, but also concerns the organization when considering the actors involved. At the moment, information resources are mostly put before organization processes, whereas the processes should become the first step from where the resources are chosen (Politie Nederland, 2006). The required information resources of a new information provisioning system need to be streamlined with the work processes. Successfully implementing an information system for MPO's on a national level requires a thorough representation of the work processes, the value network the system is in and issues the actors present when using a new mobile information provisioning service. Especially because of the standardizing ICT vision the national board of the police is setting up (Politie Nederland, 2006), coherence with this vision is necessary.

Considering the amount of MPO's employed in The Netherlands, a national agreement on the acquisition of a service seems necessary. An important factor in assuring a national implementation is by finding an answer to the question how to localize the critical mass wanting to use the system. The service itself must create value to the MPO, though usage of new services must also present value to vtsPN and the departments, either by cost reduction or quality improvements (De Reuver, 2006). Designing the development process of the service in the organization clearly needs attention in order for it to be successful. This factor is related to the organization and the financial arrangements. The structure of the Dutch police force makes creation of the critical mass complicated. When looking at the C2000 execution, Bouwman explains: "Integral solutions are always difficult, but for organizations like the police and health care it is almost impossible." (Mudde, 2003). De Bruijn proposes process-oriented decision-making instead of a tight project management approach for large technological projects (Mudde, 2003). The design of a process approach matching the business case development is required.

When concluding the research objective, several knowledge gaps are identified. It starts from the service which requires a bundling model in order to provide the exact qualitative information as required by the MPO, based on the context of the MPO and the available resources. The exact choice of service bundling based on the MPO-context and the available means to provide the information is unknown and needs to be researched and designed. Secondly, the organization behind the service and the procedures required for the service to be implemented need to be created according to the decision-making rules of vtsPN and its partners. The last step is required to define technological possibilities. A new service requires a technological architecture to ensure services and the bundling methods to function flawlessly, fitting the organizational possibilities. The main objective of this thesis is to present a grounded context-aware service bundling model and its business model aspects in order to create value for motorcycle police officers. Based on the explained problem exploration that is given in the previous chapters, the following chapter will present the main research question and the related sub-questions.

1.4 Research question

1.4.1 Main question

Based on the problems, the knowledge gaps and promising concepts that have been identified, the following research question needs to be answered by the execution and thesis of the research:

"How can context-aware service bundles and its business model aspects be designed in order to create value for motorcycle police officers?"

1.4.2 Sub-questions

The main research question is divided in several sub-questions that need to be answered in order to find a solution to the main question. The sub-questions are based on designing the service, the technical arrangements and the organizational arrangements. The problems with these three aspects are explained in the research problem chapter and need to be designed. By finding solutions to these three domains a design of a final model is presented. The sub-questions are defined as follows:

- *What promising theories and concepts provide basic knowledge for the design of context-aware service bundling increasing value to the MPO?*
- *What are the context factors defining the information provisioning of MPO's?*
- *What influences MPO's intention to use mobile information systems and which mobile information system provides the highest value increase in different context situations?*
- *What is the conceptual design of context-aware service bundling and what are its requirements to increase value to the MPO?*
- *To what degree does the conceptual service design increase the value to MPO's when evaluating using a prototype?*
- *What technical architecture is required for a performable implementation of context-aware service bundling for MPO's?*
- *What organizational arrangements are required for a feasible development of context-aware service bundling for MPO's?*

1.5 Design approach

Based on the research objective and the questions elaborated above, a set-up of the research design is provided. By executing the set-up, answers to the different research questions are found. The different steps in the set-up require different research methods in order to retrieve the data needed to ground answers to the questions. But before going into each method that will be used, a general design methodology is presented. The goal of this research is to design a model giving a conceptual image of the way a new mobile context-aware service bundling information system for motorcycle police officers must function. An important rule set by the MIRA (2004) group for mobile service development for the police is "to first define *what the user wants*, followed by *what the possibilities are* and *within which frames*" (MIRA, 2004). The model must give value to the MPO, the police departments and to vtsPN as supplier of the service.

1.5.1 Research set-up

The design methodology is based on the work presented by Verschuren and Hartog (2005). They illustrate the different steps of design and the evaluation schemes needed to ensure each step is successfully executed. Verschuren and Hartog (2005) use six steps in the total designing phase, from the first hunch to the evaluation of the finished product or service. Given the scope of this research project and the time available to execute it, the focus will be on the first four steps:

1. *First hunch*: initiative for constructing a new material or immaterial artifact. The main result of this stage should be a small set of goals to be realized with the artifact to be designed. This chapter presents a first set-up for the first hunch of the project.
2. *Requirements and assumptions*: A specification of the requirements to be fulfilled within the frame that is defined by the goals in stage 1. The assumptions specify what qualities the user must have in order to make as fruitful use possible.
3. *Structural specifications*: the characteristics, aspects and parts that the material or immaterial artifact must have in order to satisfy the whole set of requirements and assumptions of stage 2. The result of this stage is a blueprint that allows direct implementation of the outline into a prototype.
4. *Prototype*: Normally the prototype is the first realization of the design into a working product or service used for testing. Because of the time constraints of the project a fully functioning prototype is not achievable. For that reason a mock-up will be created. This must give an impression of the service bundling model without the technical architecture behind it. In this way users can give their input on the design.

As mentioned in earlier paragraphs, not only the service has to be designed, but also the technical arrangements and the organizational arrangements to ensure a successful implementation. In Verschuren and Hartog's (2005) designing methodology the implementation step comes after the prototype. If the first four steps are not well executed, the chances of a successful implementation are negligible as it won't fit the demands of the users and supplier.

The research methodology is united with the different goals of this research project. The model showing the different steps to be taken throughout the project is presented below in figure 1.5. Shown in the model are four phases that need to be executed in order to produce a conceptual design of a context-aware service bundling model for mobile information provisioning to motorcycle police officers. The arrows in figure 1.5 show the dependency between different parts of the research. As can be seen the number of arrows is large, making it a complex task and a challenge to design. Although the four design steps of Verschuren & Hartog (2005) are used as a basic design methodology, some changes are made to fit this research project. The changes are made explicit in the explanation of the research phases.

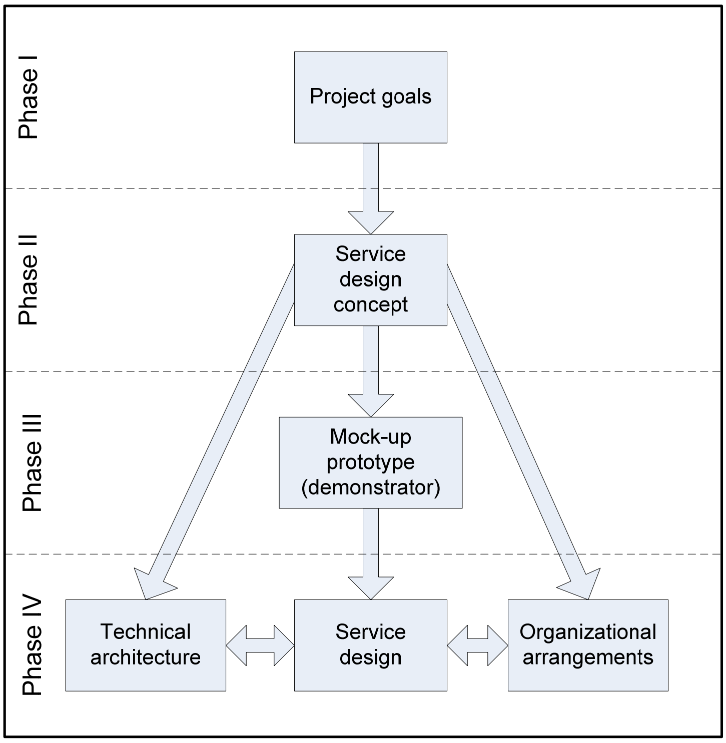


Figure 1.5: Model of research set-up for the design

The different phases shown in the figure are explained as follows:

Phase I: In the first phase the first hunch with its goals is set. The goals need to be clear as following steps in the design are based on the goals. The main goal of the project is presented in the research question, which is based on the research objective as clarified in chapter 1.3.

Phase II: The second phase must deliver a concept of a service design based on the goals of phase I. The design will be in the form of requirements for the context-aware service bundling model for MPO's, the main deliverable at the end of the research. The service design influences the technical architecture and organizational arrangements of phase IV.

Phase III: Thirdly, the service design will be the basis of a first mock-up prototype (or demonstrator) for the service offering. This step is different to the third step in the model of Verschuren & Hartog (2005) as the specification phase is skipped. The reason for this change is that creating a mock-up prototype is possible from the requirements and basic service design, making testing possible in this phase. A real prototype would require the specification phase to be executed first. The mock-up is used to get a first impression of the user's opinion on the service design. The feedback can be used to alter parts of the design. In this way important inaccuracies are illustrated by the users themselves.

Phase IV: The fourth phase must result in a translation of the concept design into basic service design, a technical design and an organizational design. Interactions between the three domains play an important role, as they are all dependent on each other.

1.6 Research methods

The research set-up being clear, methods needed to find the data to answer the different steps require further clarification. Three research methods (interviews, conjoint analysis and prototype testing) are explained in relation to the different parts of the research.

1.6.1 Qualitative method

Interviews

Throughout the project the usage of interviews plays an important role. The topics covered by the goal of the research are still unclear because of the focus on mobile information provisioning of MPO's. Until now, research on mobile information provisioning has been executed on other parts of the police organization. Some of these parts have coherent factors regarding the work of MPO's, but a large part is still unclear. Another problem is the lack of structural documentation within the police organization, making the search for reliable information difficult. Because of these problems, talking with the MPO's gives the clearest image of their tasks and consequently, their needs. It also gives a more pragmatic view on their work, making the chance of a new design fitting into their tasks more probable.

Considering the technical and especially the organizational arrangements, interviews with people who possess knowledge about these topics will also be needed. The technical architecture of police information and communication is needed to interpose the new design into the architecture. Although documents are available, lots of tacit knowledge is available at vtsPN in various departments. People with experience on mobile information provisioning projects are used to retrieve information about the organizational feasibility of the design. As explained before, the structure of the police and the decision-making on large ICT projects is complex. Talking to the people with knowledge about this aspect is essential in order to make sure the organizational arrangements can be successfully implemented. The MPO interviews are the basis of phase I and a part of phase II of this research. The interviews with vtnPN employees and external partners provide part of the knowledge for part IV.

1.6.2 Quantitative methods

Structural equations modeling
The first quantitative method used for this research thesis is structural equations modeling (SEM). SEM is a statistical technique that is used for testing and estimating causal relationships using a combination of statistical data and qualitative causal assumptions (www.wikipedia.org, 2008). For this research SEM is used as a method to test a predetermined theoretical model for the MPO case. The model tries to capture specific communication system aspects that influence the acceptance of the technology, which is defined as the intention to use the system. The SEM technique is only used in phase II.

Conjoint analysis
"The objective of a conjoint analysis is to explain and predict preferences that result in an assessment of achievements. Achievement profiles, both real as well as hypothetical ones, are created by varying specific attributes. The test persons evaluate these profiles." (Bouwman & van de Wijngaert, 2005). Projecting the conjoint analysis objective onto the service design case of MPO's, several distinct attributes need to be set. These attributes provide part of the context in which the MPO must operate, retrieving knowledge on the context-aware service. The contexts are presented to the MPO's as the profiles Bouwman & van de Wijngaert (2005) mention (independent variables). The conjoint analysis measures combinations of a device, an intermediating party and a modality on all context profiles. These are the dependent variables of the research and present grounded knowledge on the way information needs to be provisioned to MPO's in different contexts.

The results of the conjoint analysis are the start of the context-aware service bundling model. A large amount of MPO's will provide the ratings of the conjoint analysis, making it a useful statistical tool to ground basic information system requirements. The translation of the conjoint analysis results into the different service requirements needs to be done 1 on 1, as they represent the needs of the user. In case the needs are not properly clarified the final model will not be supported by the user. The conjoint analysis is used for phase II and in part III as a comparison of the results.

Experimental research
As explained in the research set-up, the prototype being developed is a mock-up version due to time and financial constraints. The mock-up is based on the service design of phase II. By translating the design into a demonstration tool, the first possibilities of context-aware service bundling for MPO's can be shown to users. The users provide the opinion on the usage and the improvements the tested system gives while executing their work in different situations. The MPO's will provide input through quantitative research as well as individual qualitative opinions. The input gotten from the MPO's in this research part is used to alter the service design into a service achieving higher customer value. The exact description of the research techniques used for testing is given in chapter 6.

1.7 Structure of the report

This thesis is structured as follows. The next chapter presents an overview of the different theories used throughout the thesis. Chapter 3 provides a description of the MPO-context definition and the task analysis based on the interviews. The fourth chapter explains the quantitative research executed with the MPO's and the results coming out of the research. The service design and requirements are clarified in chapter 5. The chapter ends with a brief explanation of the different design issues for the service. Chapters 3, 4 and 5 represent phase II of this thesis. Chapter 6 presents the experimental research executed with MPO's from different departments. The results show whether the design of chapter 5 is capable of increasing the value for the MPO and ends with changes that need to be made to the design. This prototype testing step is phase III. The required changes to the service concept design are presented at the end of phase III instead of phase IV to avoid confusion. The technical architecture needed to support the service is explained in chapter 7. The last aspect of the business model for this thesis is explained in chapter 8, the organizational arrangements required for a feasible development of the service. The last two represent phase IV. Finally, we conclude this thesis with an overview of the conclusions made throughout the thesis, reflect and briefly present the recommendations for further studies.

2. Overview of relevant theory and concepts

At the basis of this thesis stands a selection of general theories used to ground choices made for the design of the service. The theories are chosen on its applicability given the research objective and its clarity in providing a basic starting point for the design of the service. Brief explanations about the used theory provide the reader more detailed information of the exact knowledge of the theory and makes the design more understandable. This chapter finds an answer to the following sub-question of this thesis:

> *What promising theories and concepts provide basic knowledge for the design of context-aware service bundling increasing value to the MPO?*

Four areas of knowledge are explained in this chapter. An overview of business model theory is given first. Secondly, available theory on service bundling is provided to clarify the methodology. The third paragraph explains two different views on context-aware services and finally an introduction is presented on the theory of technology acceptance models. The latter provides a basic model statistically measured in further steps of this thesis.

2.1 Business models

In chapter 1.3 a first impression is given on the term 'business model'. Here, a more detailed explanation is given of business model theory. A general explanation of the term 'business model' is given by quoting Timmers' (1998) definition as it is extensively used in electronic business model literature: "An architecture for the product, service and information flows, including a description of the various business actors; a description of the potential benefits for the various business actors; and a description of the sources of revenues." The focus is on "electronic" business models, meaning business models aimed at electronic markets. Although the work by Timmers (1998) is seen as an important step forward in electronic business model (eBMO) thinking, more elaborate models have been developed since.

An important eBMO ontology comes from the work of Osterwalder & Pigneur (2002). They define an eBMO as a description of the value a company offers to one or several segments of customers, the architecture of the firm and its network of partners for creating, marketing and delivering this value. Lastly, they include relationship capital generating profitable and sustainable revenue streams. Subsequently, they present four domains to support their definition: product innovation, customer relationship, infrastructure management and financials. Although the mentioned eBMO's have contributed considerably to business model theory, we prefer using a model with a broader perspective.

The eBMO used throughout this thesis is based on various definitions of business models and is named "the STOF business model framework" presented in figure 1.2. Like Osterwalder & Pigneur's (2002) model, Faber et al.'s (2003) eBMO consists of four components all interconnected and therefore influencing one and other. A brief explanation is given (Bouwman et al., 2005):

- Service domain: a description of the value proposition (added value of a service) and the market segment at which the service is targeted;
- Technological domain: a description of the technical functionality required to realize the service;
- Organizational domain: a description of the structure of the multi-actor value network required to create and distribute the service, and to describe the focal firm's position within this value network;
- Financial domain: a description of the way a value network intends to generate revenues from a particular service and of the way risks, investments and revenues are distributed among the various actors within the network.

All four domains need to be well designed to deliver the proposed value to the end-user and the supplying organization. However, the financial domain is left out of this thesis. Developing a solid financial description requires a lot of time and cooperation from the stakeholders. The time needed to design the financial domain was unavailable. That does not mean the financial aspect plays no role; on the contrary. Its design is as important as the other domains. Providing a perfect service through perfect technical and organizational arrangement which is unaffordable will never result in value for all parties. In follow-up research to this thesis, the financial domain must be included to make sure the proposed service is financially feasible.

2.2 Service bundling

The first chapter of this thesis briefly mentions the idea and usage of service bundling in this research. A short explanation of the reason for using the theory is given, followed by relevant concepts on the matter. The theory behind context-awareness provides knowledge on the way the context defines services fitting the contextual needs of the user. However, just providing a list of services is insufficient to provide the qualitative and accurate information the MPO requires in performing its tasks. E.g. when a service composition based on a context provides an information source like a police register, information from other registers might be needed as well in order to provide all information needed to support an MPO more effectively. "Services are often interdependent in demand, meaning that a customer is often interested in more than one service. This is mostly the case for related services" (Baida, 2006). Service bundling is a theory which might provide a solution to this problem as it groups different services, offering it as one package to the user. An important part of the bundling methodology has an economic nature. Bundle prices are usually lower compared to the sum of the various bundled services (Haaker, de Vos & Bouwman, 2006). Though the costs of the designed service play a role, profitability of the bundled service offering does not for this research. As a consequence, parts of service bundling theory are not mentioned nor used in this research.

Service bundling is explained by proposing two different concepts in this chapter. The first offers a basic structure of the service bundling design process. The second concept is chosen as it gives a clear overview of how a service bundling model functions.

In 1999, Chiasson provided a formal process to structure service bundling. Even though it is with a commercial aim, it provides a solid bundling design process. His concept is sometimes slightly altered to make it fit the case of MPO service bundling. The first step of Chiasson's (1999) bundling design process begins with a statement of strategic intent, which defines the bundle's goals. Based on the goals set, user research provides the raw information with which to define the bundle's focus and composition. Ground rules define what the carrier can achieve with a bundle within a realistic time frame and within existing constraints - legal and regulatory restrictions, channel limitations and the abilities of internal systems to support the bundle operationally. Once the potential inputs have been assembled, a team of product designers and channel managers can begin determining which components to bundle. This process involves identifying the user, their needs and determine the bundle components that will satisfy those needs. The result of the design process is a bundle concept: a concise statement that captures the essence of the bundle (Chiasson, 1999).

Comparing the bundling process Chiasson (1999) proposes with the structure of this research, similarities exist. The need and goal of the bundling strategy have been set in the introduction chapter. Also, retrieving knowledge about the user's needs is performed with the conjoint analysis with MPO's explained in Chapter 4, setting the basic user requirements. The technical and organizational arrangements provide the 'ground rules' Chiasson (1999) refers to. These ground rules are required to assure a functioning bundling model and are provided in the chapter 7 and 8.

Though the process of designing a bundle is clear, the bundling formalism itself is not treated until now. Service bundling is a complex operation based on several factors deciding what the composition of the bundle looks like. Starting point is the process of Chiasson (1999) as explained above. Baida (2006) explains as follows: "Users have to formulate their customer needs (requirements) to arrive to meaningful bundling. Terminology of customer's can be different, which requires a thorough check of the meaning of their needs". One could state that the user's needs set the goals of the services bundling. The main concept used for this research will be the service bundling concept of Akkermans, Baida, Gordijn, Morch and Sæle (2005). Figure 2.1 shows the general methodology of configuring service bundles based on customer demands.

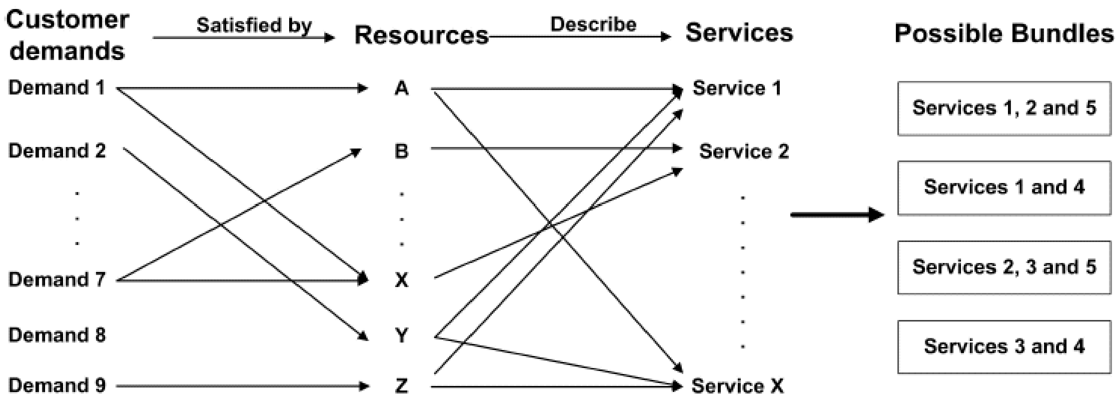


Figure 2.1: configuring service bundles (Akkermans et al., 2005)

The configuration methodology starts from the customer demands. Links between the possible resources that suffice the demands are set. The resources referred to could be composed out of technical and organizational specifications which are defined at the end of this research. Based on these resources and the requirements, links are made to services that can provide the needed 'good'. This results in possible bundles to be called upon by the user given the requirements and the resources set for that bundle. A link can be seen as a production system consisting of production rules with the form: if situation X is encountered then select solution Y (Baida, 2006).

2.3 Context-aware service composition

The term 'context-aware services' is growing in importance, and so is the amount of research being executed on the topic. Many scientists create their own architecture, though inspired by previous research. A large part of the literature available is focussed on the technical implementation (MIRA, 2004; Park, Lee & Kim, 2005; Ahmed, Kyamakya & Ludwig, 2006). This technical focus will also play a role in this research, but before going into technical details a more conceptual view on the context-aware methodology is needed for the service design. The conceptual view is able to explain the fundamental thought better than a technological perspective. Due to the variety of concepts available the choice is made to start from the FrUX freeband innovation projects. The reason for choosing this starting point is because this thesis is part of the FrUX research objectives. Afterwards two more elaborate models are described providing a clear context-aware service representation.

2.3.1 Freeband context-aware services

In the introduction chapter of this thesis the FrUX definition of context-aware computing was presented. The definition comes from the 2004 document Van Eijk et al. have written to define the main concepts of the FrUX project. The system sensing and collecting the context factors can play essentially three roles (Van Eijk et al., 2004):

- Context mediation: The system only mediates context information from one user to one or more others, but does not interpret this context information. I.e. each user has its own interpretation of the information the context-aware system transmits to them.
- Context aggregation: The system mediates context information from users to users, aggregating the information from multiple persons in the process. I.e. users are able to see context-aspects of other users as well, affecting the decision making of each individual user.
- Context interpretation: The system needs to be able to interpret context information of one or more users in order to adapt an information or communication service. I.e. the context-aware system uses other technical systems to define proceeding steps to be taken to increase the ease of use for the user.

A large part of FrUX's context-aware focus is on the user experience and the sharing of information between users, also referred to as the 'We-Centric' concept. The 'We-Centric' concept falls in the 'context aggregation' role. An example is the WijkWijzer, where police officers working in the streets by foot mostly need soft information. In the case of MPO's, the focus is different. As explained in the introduction, MPO's require qualitative and accurate information which is both hard and soft. From the interviews held with MPO's it became clear that hard information plays a more important role in executing their tasks successfully. The soft aspect is more related to being able to communicate with colleagues working on the same task. Comparing the usage of context-aware computing for MPO's to the three roles defined by FrUX, the design focuses on 'context-interpretation'. The context-aware service is used to make an information system usable on a motorcycle. Due to the decision of focusing on a different role compared to other FrUX research, more concrete concepts outside the FrUX project are needed to provide a basic context-aware service model. A choice of two basic models is made for this thesis, explained below. The models are chosen for their ease of interpretation and clarity. They are therefore seen as promising models to be used for the design of the context-aware service.

The first promising concept is related to the FrUX project from a project organization point of view. The FrUX innovation project is part of the freeband project, a national project research program aimed at situating the Netherlands as a leader in intelligent communication (www.freeband.nl, 2007). Another project part of Freeband is the AWARENESS project. "The goal of the Freeband AWARENESS project is to research and design a service and network infrastructure for context-aware and pro-active mobile applications" (van Beijnum et al., 2004). Regarding the FrUX and AWARENESS projects, the latter aims much more at real context-aware mobile information provisioning, whereas FrUX aims more at the "user experience". The AWARENESS project has defined an architecture for context-aware services (van Beijnum et al., 2004) which is a useful basis for this research.

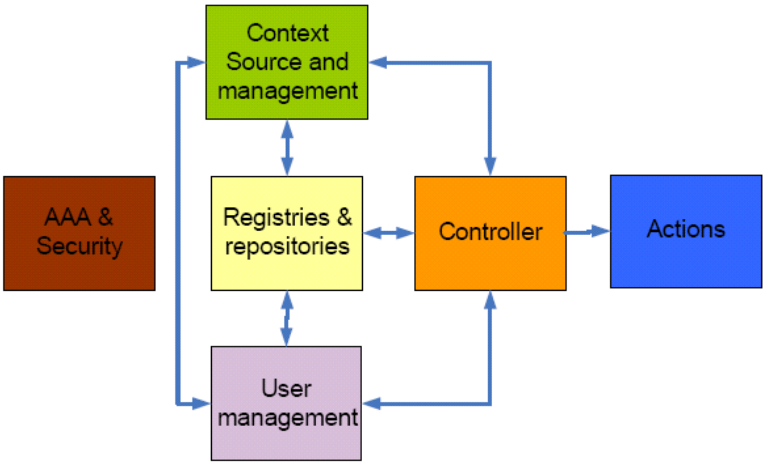


Figure 2.2: AWARENESS' high level functional view of the Awareness service infrastructure (Van Beijnum et al., 2004)

Van Beijnum et al. (2004) define a context-awareness as follows: "Context-awareness is a property of a system that uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task and situation". AWARENESS' focus is on the user's task and the situation, whereas the MPO-context definition is more extensive and will therefore be used in this research. The central concept AWARENESS presents is the context-aware service infrastructure architecture overview (figure 2.2). The focus of the architecture is not on the technical architecture, but on the conceptual model of context-aware service provisioning.

The different blocks of figure 2.2 are explained as follows:

- The functional block *Context Source* and *Management* are responsible for dealing with contextual information. Context Source covers domain specific sources, such as an agenda or a GPS, while Context Management potentially involves different domains, such as the integration of an agenda, GPS and the weather forecast hence contextual information objects provided by context providers from different administrative domains (e.g., coming from different operators).

- The *Controller* module contains the application-specific functionality that is executed within the service infrastructure. The main function of this module is to monitor and execute the reaction rules defined by the supported applications.
- The *Actions* module concentrates the functionality to trigger actions in response to context changes.
- The *Registries & Repositories* module contains information on context types, event types, services and other (meta) information on types and services within the service infrastructure.
- The *User Management* module contains functionality related to access control, privacy and group management. User profiling and preferences functions are managed by this component.
- The *AAA & Security* module includes the functions associated with security, privacy, authentication, authorization (including 3rd party access control), accounting and federation issues.

By using the different modules shown in figure 2.2 and explained above, a basic context-aware service provisioning map is defined for our design. It demonstrates what functions are needed when designing a context-aware service and how these functions are dependent on each other to work correctly. A problem with the AWARENESS functional view is that it does not incorporate a concrete role for the user interaction. How a system is operated and information is presented has a considerable effect on the ease of use. Due to the absence of the user interaction a second context-aware service model is used and explained below. Adopting a second model also presents the opportunity to see whether large differences do or do not exist in the functioning of context-aware service models.

2.3.2 Dynamic composition of context-aware mobile services

The second context-aware model from Alonistioti & Panagiotakis (2006) is selected due to the incorporation of the user interaction aspects, an absence encountered in the model of the AWARENESS project. Alonistioti & Panagiotakis (2006) present a framework for dynamic composition of context-aware mobile services and define it as follows: "to provide flexible and context-aware services, a system must be able to know at any given time the network status, user location, profiles of the various entities (users, terminal, network equipment and services) involved, and system policies". As with the AWARENESS model, the framework is of a conceptual nature instead of a technical nature. The framework is presented in figure 2.3 and is briefly clarified.

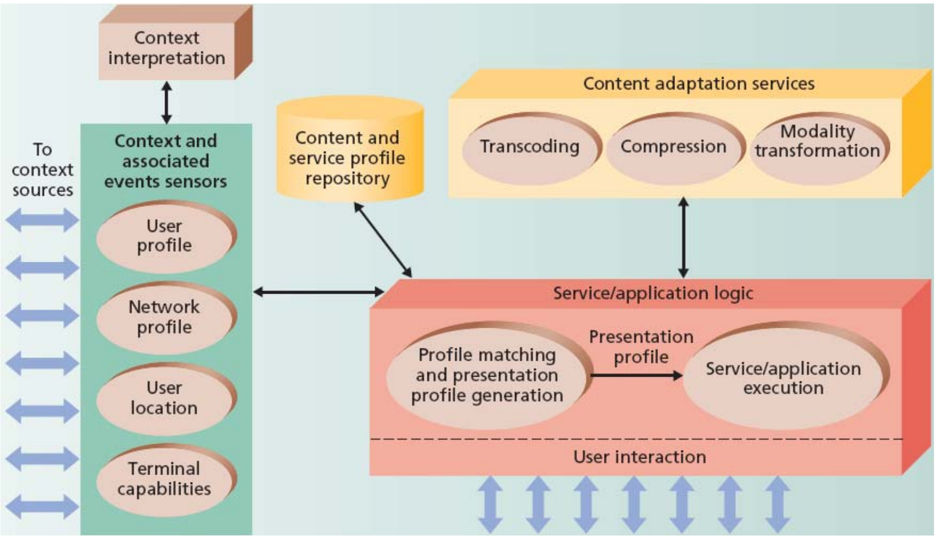


Figure 2.3: Dynamic composition of context-aware mobile services (Alonistioti & Panagiotakis, 2006)

The framework adapts to the context in the following manner: special mediating services sense the context, model changes in the contextual environment as events and communicate these events to the applications for real-time service re-adaptation. The context-sensing services should collect contextual information from underlying sensor networks automatically (without the user's intervention), which lets the application designer decide what information is relevant and how to deal with it. Context retrieval takes place with respect to the user privacy policies given by the user and included in his profile.

Though some different terminology is used, like Van Beijnum et al. (2004), Alonistioti & Panagiotakis (2006) create different modules which communicate between each other in order to define the correct service composition based on context parameters. Many similarities between the different modules of both frameworks exist, though an important difference is also revealed. As indicated before, the addition of user interaction to the framework of Alonistioti & Panagiotakis (2006) defines the presentation based on context sources and individual profiles. Alonistioti & Panagiotakis (2006) define service dependent and service independent preference profiles. In these profiles aspects like QoS requirements, content and media presentation characteristics, font sizes, privacy and security, user history and agenda play an important role defining the final service composition choice.

Concluding both concepts; the AWARENESS view focuses on the purely needed concept behind context-aware services and is capable of clearly indicating the different functions that are required. These functions are also shown by Alonisitioti & Panagiotakis (2006), but with a focus on the adaptation of the service to the user. Including the user interactions is an important aspect as it improves the ease of use of the service. Using both frameworks provides a solid base to design a first conceptual model of context-aware service provisioning for MPO's.

2.4 Conclusion

In this chapter a selection is made of promising theories and concepts capable of providing basic knowledge for the design of a context-aware service bundling model. All theories and concepts are chosen for their conceptual frameworks, offering a clear and simple representation of the main factors of the theory. These characteristics make them highly useful for proceeding steps in this thesis. The starting point is the definition of a business model to be used throughout the thesis. It helps to structure the different domains needed to offer a service capable of deliver a value increase to MPO's. Electronic business model theory claims not only a service needs to be well designed, but also the technical architecture, the organizational arrangements and financial arrangements determine the feasibility of the service. The latter is excluded from this thesis due to time constraints. The technical architecture sets the technical functionality required to offer the service. The organizational arrangements define and structure the value network needed to develop and deliver the service.

Designing a context-aware service bundling model capable of increasing value to the MPO is based on general frameworks available on service bundling and context-aware service provisioning. These frameworks need to be transformed into a model applicable to the case of the MPO. The design process of service bundles consists of defining the bundles goals, determining the user needs, specify bundles satisfying those needs and finally define the different production rules that exactly compose the bundles. Based on the research objective of this thesis, the context-aware service model takes on the role of a context interpreter. The model is build out of certain functions: a context source manager function, controller functions, action functions, register functions, user management functions, AAA & security functions, user interaction functions and presentation functions.

PHASE II

3. Qualitative research with MPO's

3.1 Introduction

Going through various official police documents does not result in clear information on the work environment of MPO's. To fill this knowledge gap several interviews with MPO's from various police regions are performed. The first function is to define the MPO-context based on a combination of interviews and available literature on context-aware services. The second use of the interviews is more extensive. A task-analysis is performed to structure the tasks performed by the MPO's and is build-up from the knowledge gotten from the interviews. The task is an important factor of the MPO-context factors. This chapter finds answers on the following sub-question for this thesis:

What are the context factors defining the information provisioning of MPO's?

First an explanation is given on how the interviews are performed with MPO's. The following paragraph uses the interviews to define the context factors relevant to the context-aware service for MPO's. The last paragraph presents a detailed description of the various tasks performed by MPO's based on the interviews.

3.2 Interviewing method

To find answers to the sub-questions above, a total of 11 interviews are held with MPO's. Table A.1 of Appendix A presents the date of the interview, the MPO, of which region the MPO is and for what use the interview was held. Due to the general lack of knowledge about MPO work, the first seven interviews were of a semi-structured nature asking open questions. The last interview joins the open interview group as it was an unplanned interview. By using semi-structured interviews, a large amount of information is obtained. All MPO's fully cooperated with the interviews and have answered all questions asked. The questions focused on the following topics:

- general work characteristics of MPO's;
- the tasks to be executed in their region;
- the functioning of their current information provisioning and its problems;
- administrative tasks to be executed;
- usage of new technologies to support their work;
- what their future vision is on information provisioning for MPO's.

Although an idea of the various tasks performed by MPO's is gotten from the 8 interviews, some indistinctness remained. To clarify the various task and the differences between MPO's, three additional task analysis interviews were held. During the three task analysis interviews the author developed a list of tasks in cooperation with the three MPO's. The choice is made to use one region for the task analysis interviews so that differences between the types of MPO, not regional differences.

Given the amount of interviews held with the MPO's no conclusion can be drawn on whether the reactions can be used as a national opinion of MPO's. An interesting aspect is that the general reactions are similar between the regions, though the degree differs. Some MPO's claimed mild problems with the current information provisioning (Interview Veendam, 2007), where others mentioned similar problems but on a higher level of annoyance (Interview Doorwerth, 2007). Some interviews are held with two MPO's at the same time. The positive result is that it created discussions between them further précising the answer. During the interviews the answers of the MPO's were written down and later entered in a document. The interviews are added to Appendix A.

3.3 Definition of the MPO-context

Chapter 1.3 of presented a first definition of the MPO-context. The different context aspects defining the MPO-context provide the basic set-up of the context-aware service. As the word 'context' is a broad concept it is important to define the aspects that are essential in providing qualitative information to MPO's. Based on literature and the interviews held with MPO's a selection is made. The selection is kept to an absolute minimum to make sure complexity is kept as low as possible. It is important to indicate that each context aspect is uncontrolled for by the MPO, assuming he or she performs the duties as ordered by the superior. Each context aspect is mentioned and briefly explained:

- *Location:* The location of a police officer is chosen as an important aspect by the MIRA (2004) project. Other context-aware paradigms name location as a defining aspect of the service (Van Beijnum et al., 2004; Alonistioti & Panagiotakis, 2006). Adding navigation functionalities also requires the system to have an up-to-date status of the location (e.g. via GPS).
- *Task:* As defined by Mulder, ter Hofte & Steen (2004), providing relevant information depends on the user's tasks. Each task requires different information to act adequately. MIRA (2004) supports the important role the task plays in a context-aware service for the police. A more detailed specification of the tasks performed by MPO's is presented in chapter 3.4.
- *Status:* The status of the MPO already plays an important role in current information provisioning (Interview Veendam, 2007). The control room uses the status to determine whether an MPO is busy or not.
- *Time:* The aspect of time is needed for systems to synchronize, meta-data, logging, etc. It is also used for other physical context specifications if needed (e.g. daytime or night).
- *Speed:* The last aspect mentioned by MIRA (2004) is speed. According to MPO's, on average 80% of their work is on the motorcycle (Interview Veendam, Driebergen, 2007). The research is focused on information provisioning during this 80%. Pica & Sorensen (2004) state geographical mobility restricts the provisioning of information as it forces the user to divert attention from the space of interaction Speed is primarily used as a determinant of mobility. Knowing whether an MPO is moving or not largely determines the ability to use an information system.
- *Group communication:* Sharing knowledge is done by communicating. MPO's have the possibility to communicate with colleagues by the C2000 network, though the possibility depends on the location and availability of colleagues. Some tasks require constant communication between MPO's performing the task (Interview Driebergen, Den Haag, 2007), some tasks are performed alone (Interview Amsterdam, 2007). Future systems must support group communication.
- *Network availability:* Including the network availability is based on the work of Vergouwen (2006) and the AWARENESS project (Van Beijnum et al., 2004). Vergouwen (2006) proved that hybrid networking increases the efficiency and effectivity of police officers. The idea behind it is that no networks offer a 100% coverage (MIRA, 2004), meaning that the availability of networks changes. The system must constantly update the status of the networks available, and decide whether data or speech transmissions are possible or not.
- *Control room availability:* At this moment the control room is the only supplier of information to the MPO when operating alone. As became clear from interviews with MPO's (Interview Doorwerth, Driebergen, Den Haag, 2007) the availability of the control changes constantly. If the control room is available and functions well it mostly provides usable information to the MPO. However, if not available, the MPO's information provisioning is insufficient.

Although the selection covers a large amount of context-factors defining the information provisioning to MPO's, the choice is made to leave some factors out of the definition. Examples of removed factors are weather properties, road characteristics or even health characteristics of the user are named in some literature (van Sinderen, van Halteren, Wegdam, Meeuwissen & Eertink, 2006). The factors not included into the definition also influence the possibilities of information provisioning, though not to the same extend as the selection presented above. When testing the service in a real-life prototype, the effect of other factors on the usage of the information system can be measured as well. If the influence of non-included factors turns out to be highly affective on e.g. the usage or safety, including them in the design must be possible. Therefore, the design of the service must include the possibility of extensions to the service.

3.4 Task-analysis for MPO's and the information needs

Having the MPO-context factors clear, the proceeding step is to research the exact structure of the various tasks performed by MPO's. Though one of the many MPO-context factors, the task plays the most important role in the service design. It defines the needed information to be transmitted to the MPO at the needed moment. Considering the main goal of this thesis is to design an information provisioning system, connecting the information to the task is essential. Before explaining the exact tasks performed by MPO's, a brief mentioning is made on a concept capable of structuring the relation between the context of work and mobile information system usage. This concept is used to place the final information needs in the correct work context (based on the task), thereby influencing the interaction of the MPO with the information system. Getting a clear structure of the different information needs to support the tasks in relation to the information system interaction, makes the usability of the system concrete.

3.4.1 Interaction with mobile information system perspective

Pica & Sørensen's (2005) context of work and mobile information usage relationship analysis was based on general mobile police work. This makes it partly suitable for the MPO task analysis. Using the theory of Pica & Sørensen (2005) provide an important basis to understand whether or not a mobile device will serve the role of an efficient supporter of mobile MPO work. Pica & Sorensen define two significant aspects of mobile device interaction in the context: "information interaction" and "environment tasking" work. *Information interaction* is based on the nature of work that needs to be executed. It entails two utmost work categories in which the interaction takes place:

- The first is <u>structured work</u>. Hereby a high degree of routinized steps is needed so that complexity of the task stays low. Due to the low complexity, the information access for resolving problems has a repetitive character.
- The contrary is the <u>unstructured work</u>. The officer is not aided by routine anymore, but requires a high degree of improvisation in order to fulfill its tasks successfully. The complexity consequently means information interaction has to be supported dynamically and through multiple channels.

Environment tasking focuses on the work relation with the environment the police officer is in. The environment influences the attention a police officer can give to the device used to provide information. The two categories are active or passive:

- An <u>active relation</u> can be characterized as one that requires constant attention to the physical space of interaction. The physical space dictates the line of action to be followed by the police officer. Therefore usage of mobile devices is troubling and information pulling applications difficult to execute.
- In the <u>passive relation</u> more interaction with the mobile device is possible and devices can be used without dangers of losing control of the physical space of interaction. Pulling applications can therefore be used in these situations.

The nature of work partly determines the success of mobile devices. Pica & Sørensen (2005) conclude that in active work environments only voice-supported services can be adopted, which is important to keep in mind when designing the service. The next step is to define the different tasks MPO's perform.

3.4.2 Tasks of MPO's based on interviews

A task is defined as: 'a definite piece of work assigned to a person'. The tasks executed by MPO's vary, which makes information provisioning highly dependent on a correct representation of MPO tasks and the information needed throughout the whole process of executing each task. As mentioned in the introduction, the tasks executed by MPO's are officially similar to other police officers, though pragmatically vary between them throughout the Netherlands. The police does not offer official documents stating the different completions of MPO tasks, as both are defined per bureau employing the MPO. The task analysis is based on all interviews performed with MPO's (Interview Veendam, Doorwerth, Driebergen, Den Haag, Driebergen, Amsterdam, Amsterdam, Breda, 2007), where three were used to fine-tune the task analysis. It is assumed that the interviews provide enough information to define the tasks of MPO's, except for military police MPO's. The latter are excluded as no interview opportunities with them were available.

The first aspect of MPO tasks focused on is from an organizational perspective, entailing four different categories using MPO's. Inside the different district bureaus, quarter bureaus and the KLPD bureau there is a traffic control team. MPO's part of this team perform controls based on what MPO's call "HelmGRAS" facts, which stands for helmet, seatbelt, red-light, alcohol and speed control (Interview Veendam, Doorwerth, Driebergen, 2007). Some of the MPO's that are part of the traffic control teams also perform transport controls, as an extra task (Interview Veendam, 2007). Although officially the MPO's of traffic teams (from now on referred to as traffic MPO's) can be used for assistance tasks (see fig 1.1 chapter 1.1.1), it does not happen in practice (Interview Veendam, Interview Doorwerth, 2007). Traffic MPO tasks are planned beforehand and they mostly work in teams of two or more, supported by a police car.

The information interaction of traffic MPO's falls in the structured work category. The tasks they perform are highly routinized and straightforward. The environment tasking is mostly passive. The controls are executed when standing still and reaction is needed if malpractices arise. Based on both classifications, the interaction with an information system is repetitive and the pulling information by the MPO is possible in most cases.

The second organizational category focused on are the quarter bureaus for general police work. MPO's employed at a quarter bureau (from now on referred to as quarter bureau MPO) stand closer to the people living in the neighbourhood of the bureau's responsibility. They know the people and can therefore better anticipate to disturbances. Compared to traffic MPO's, the work of a general MPO at a quarter bureau is much more extensive. A large part of their working time he or she drives around controlling the neighbourhood, while at the same time being ready to anticipate to an emergency aid request. Due to the manoeuvrability and speed of the motorcycle compared to a car, they are used e.g. to hunt down offenders moving by foot, scooter, motorcycle or car. The MPO's of a quarter bureau know the neighbourhood by heart, which is essential to perform their work successfully. On beforehand determined controls are also part of their work, though the objectives are mostly different from traffic MPO objectives. An example is the usage of enticements to attract criminals to places (Interview Amsterdam, 2007).

Categorizing the tasks of quarter bureaus is more complicated than those for traffic MPO's. Most control tasks are structured, but both passive and active. Controls similar to the traffic MPO controls have corresponding characteristics. However, the MPO's also control by driving around and a constant attention to the environment is required. This makes the use of an information system more difficult and requires a pushing character from the information system. Then emergency aid situations can occur making the work unstructured and active. The MPO does not know what to expect and depends on his or her tacit knowledge and skills. Information provisioning becomes troublesome as complete attention to environment is required.

The third category shows similarities with the second, though on a geographically larger scale. The MPO's are stationed at district bureaus and have a district as their working area. Many of the tasks performed by district bureau MPO's are basically the same as for quarter bureau MPO's, but more focussed on larger roads and distances. An example is a traffic accident on a highway going through the district. District bureau MPO's have an additional task to quarter bureau MPO's which is guidance. Most guidance tasks executed are to assist an ambulance in travelling from one place to another as fast as possible; others are the guidance of VIP's or special events where extra security is required. As far as known enticement tasks are not performed by district bureau MPO's. A last notion about the quarter bureau MPO's and district bureau MPO's is that communication between both types exist and they assist each other when needed. (Interview Den Haag, Amsterdam, 2007)

Even though the scope of district MPO’s is different than quarter bureaus, the characteristics of their work are almost identical. The only difference is the addition of guidance tasks, which are highly structured but also active. Summing up, work of district MPO’s is both structured and unstructured, in an active and passive environment covering the whole scope of interaction aspects.

The last group of MPO’s is employed by the national police department (KLPD) and is further split in two sub-groups. Located centrally in the Netherlands, the whole country is their working area. One group of KLPD MPO’s (called geo-unit) mostly operate on the highways thereby focussing on all traffic issues. The most important controls involve speed, seatbelt, vehicle regulations and drivers licence. The same group must be stand-by for emergency aid tasks like accidents on highways. The second group of KLPD MPO’s are employed for guidance. The guidance task is mostly for VIP’s, cycling races and exceptional transport control (Interview Driebergen, 2007)

For the geo-unit MPO’s tasks fall mostly in the same category as traffic MPO’s. The addition of emergency aid tasks is not very different. This is because highway accidents are fairly structured and these are normally the only emergency aid tasks they perform. The work of the guidance group is highly structured, but both passive and active. Guidance of cycling races is fairly passive (driving in front of cyclists), but guiding V.I.P.’s requires more attention to the environment.

3.4.3 Connecting the information needs to the task

The next step is to connect the various specified tasks to information types needed to support the task. Ultimately, the goal of an information provisioning service is to deliver the right information to the MPO for the right task. Table 3.1 presents the explained MPO types, their tasks executed and the primary information need to fulfil the task. By ‘primary’ information we mean the basic information needed to start the task. During the execution of the task different types of extra information might be needed, but this depends on the circumstances and can therefore not be defined for now.

MPO type	Task	Primary information type need
Traffic MPO, including KLPD Geo-unit	Helmet control	Vehicle info, Person info
	Seatbelt control	Vehicle info, Person info
	Red-light control	Vehicle info, Person info
	Alcohol control	Vehicle info, Person info
	Speed control	Vehicle info, Person info
	Transport control	Vehicle info, Transport document/regulations, Goods info
	Road accident	Accident info, Persons info, Vehicles info
Quarter bureau MPO	Control of neighbourhood	Person info, Vehicle info
	Emergency aid requests	Emergency situation info, Emergency type, Danger level, assistance info
	Hunting down offenders	Person info, Vehicle info, Danger level, assistance info
	Pre-defined controls	Vehicle info, Person info, Event info, Enticement info
District bureau MPO	Control of district	Person info, Vehicle info
	Emergency aid requests	Emergency aid info, Emergency type, Danger level
	Hunting down offenders	Person info, Vehicle info, Danger level, Assistance info
	Pre-defined controls	Vehicle info, Person info
	Ambulance guidance	Guidance info (Communication group info, route info)
	VIP guidance	Guidance info (Communication group info, route info, danger level)
KLPD special unit	VIP guidance	Guidance info (Communication group info, route info, danger level)
	Cycling race guidance	Guidance info (Communication group info, route info)

Table 3.1: MPO type, tasks and primary information type need

The usage of the table is explained by the following example. A traffic MPO is carrying out a speed control. The MPO sees a car which is speeding and decides to assert the car. Before asserting the person the MPO wants to know who the registered driver of the car is and if the car has any illegal properties. The MPO therefore has to check the car by sending the license plate number to the person or register storing the concerned information. The driver details are finally retrieved through the car's registration owner information. Table 3.1 displays that some information types play an important role in many tasks to be executed. Especially person information and vehicle information are often needed. The service design must take this importance into consideration.

Having defined the various primary information needs, a mapping of the information needs onto the mobile interaction aspects explained in paragraph 3.4.1 can be performed. The mapping is presented by using two axes (the two aspects explained in the introduction of this paragraph) and placing the information type in the corresponding quadrant. The placement of the information type is based on the tasks presented in table 3.1. Defining the placement is done by using the knowledge retrieved from the interviews with the MPO's. The result (figure 3.1) gives an overview of information needs in the different work contexts and provides an important information usability scheme for the design of the context-aware service bundling model of chapter 5.

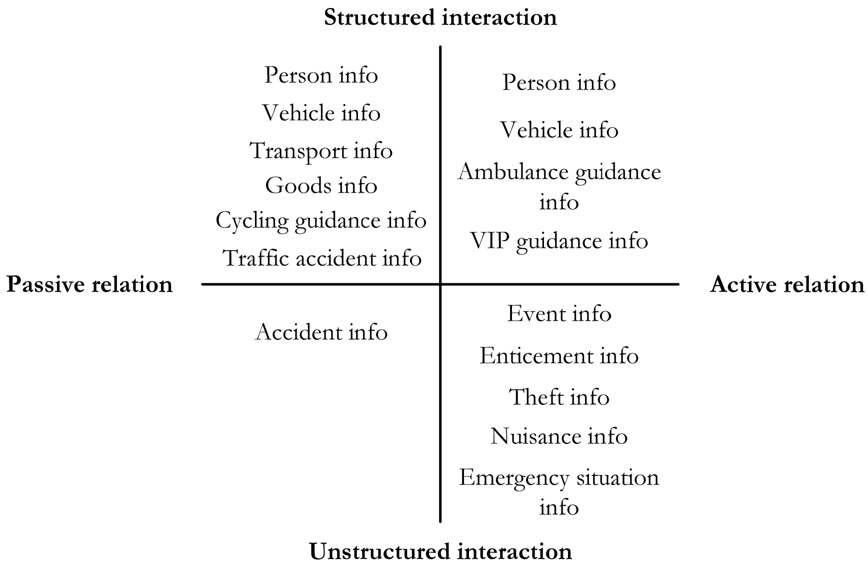


Figure 3.1: Information need for the MPO in different work contexts

Primarily, figure 3.1 shows that a large part of the information needs for MPO's fall on the active tasking side. Here, the MPO has to maintain his or her eyes on the road and information provisioning must therefore be pushed to the MPO if possible. When the interaction with the system is structured (first quadrant), the focus of the information is more on exchangeability and not so much on processing capabilities of the MPO. In an active, unstructured interaction context, the processing of information by the MPO becomes more important while simultaneously the environmental influences on the MPO increase. The latter situation is the most difficult situation to operate an information system. The information needs mostly originate from the emergency aid tasks.

Reviewing quadrant number two, a large part of 'control' information is found here. The tasking relation is passive, meaning that the MPO has the opportunity and time to operate the information system as less attention to the surroundings is required. At the same time, the interaction with the information system is structured. Routinized steps are required to retrieve the information and more data can be accessed. The latter situation makes system usage easiest for the MPO compared to the other three types of figure 3.1. The remaining quadrant to discuss is the passive tasking relation combining an unstructured interaction with the information system. Here, only accident information is defined. The information is needed when the MPO arrives at an accident and is partly dependent on his own tacit knowledge and skills in making sure the situation is handled, backed by information about the accident for support. Usage of the information system in this situation is not very difficult, but the type and time of information is unclear.

3.5 Conclusion

In this chapter a definition of the information provisioning context factors of MPO's is set. The basic knowledge needed to define the different factors comes from the MPO's themselves. Eight interviews with MPO's have been held to get as much information on the work MPO's perform in general, the problems they have with current information provisioning methods and what their needs are regarding information provisioning. The following MPO-context factors are defined based on the interviews and literature on context-aware services and service bundling: location, status, time, speed, group communication, network availability, control room availability and the task. As the list of factors might change, adding the possibility to extend the final service with other factors, or maybe remove factors, is a requirement.

The task factor plays the most important role in the design of the service. It requires a lot of attention in order to specify the tasks of MPO's well. The role of tasks is so important because it further sets what type of information is needed at what specific moment in time. As the final design is an information provisioning service, defining the information needs is essential. The task-analysis is created by using the eight interviews and further clarified by three interviews focused solely on the tasks of MPO's. The information needs are mapped on a coordination system: the X-axis represents a work environment relation which can be 'passive' or 'active'. The Y-axis represents the information system interaction from 'structured' to 'unstructured'. By placing the various information needs, the usability of the information system is defined according to task and connected information.

The task analysis showed that traffic MPO's (including the KLPD Geo-unit) mainly execute control tasks, needing person information and vehicle information. The information types fall in the structured information system interaction side. This means that the information access is not so complex. It can be in a passive work relation setting or an active one. In a passive setting, the MPO is capable of controlling the system, but in an active one more attention to the environment is needed. Quarter bureau MPO's have a wider range of tasks and consequently information needs. They perform control tasks and need control information, but are also busy with emergency aid tasks which require a larger variety of information. The latter information falls in the active work environment and unstructured information system interaction, making the use of an information system by the MPO almost unusable in order to ensure safety. Pushing information seems necessary. The district bureau MPO's perform tasks similar to the quarter bureau MPO's, but on a larger geographical scale. A second difference is the addition of guidance tasks. The guidance tasks are active and the information system interaction is structured, as with some control tasks. The last information type is accident info at the moment of arriving at the scene whereby the work relation is passive, but the information interaction is unstructured as each situation can be different.

4. Quantitative research on information systems for MPO's

4.1 Introduction

The interviews of the research project provide a qualitative overview of the various problems MPO's deal with in executing their daily tasks. It also presents a structured positioning of the various tasks that need to be executed by MPO's throughout various police departments. However, the aim of this thesis is to design a service providing information for all MPO's. As with any design, the design phase "should begin with a complete understanding of the customer's needs" (Bahill & Dean, 1999). An important role in information provisioning is played by the information system running the service and presenting the information from a certain source, the focus of this chapter. The problem however is that assessing the acceptance and usage of information systems is not an easy task as the MPO does not have any practical experience with future information systems. Our interviews have shown that providing information to MPO's is highly important, but that does not mean any information provisioning system will automatically be used. An example clarifying this is the current usage of C2000 and the mobile phones by MPO's. All MPO's in the Netherlands have a C2000 terminal or portable device through which information can be exchanged. They also carry a mobile phone with them in case it is needed as a back-up. The C2000 network theoretically connects all police officers and control rooms with each other, and even private channels can be set to communicate between each other. In practice however, the MPO's often reach for their mobile phone to call colleagues or even the info desk (a different info channel from the police). Apparently some part in the design of the C2000 service did not focus enough on information exchange between colleagues. The possibility exists, but for some reason the MPO prefers to stop driving, take the mobile phone and use it instead of talking through the C2000 system. Presumably, using the system for that purpose is too complicated. Concluding, the intention to use a service for MPO's is greatly determined by the design of the information system and how it fits the work of MPO's. Researching the influences on the intention to use future mobile information systems for MPO's is our first focus in this quantitative chapter.

The focus on the acceptance of future mobile information systems provides a basic opinion of MPO's on mobile information system usage, but is insufficient to design a context-aware service for motorcycle police officers. It does not provide needs of MPO's on the value of information systems in different MPO-contexts. Chapter 3 has shown that tasks are executed in changing work situations, setting the need for information provisioning to adapt to the situational changes. By adapting to the work environment, the usability can be put on par with the information need. To clarify this second quantitative research aim further another example is given. The mobile phone of working MPO's is frequently used when the MPO is standing still and requires more detailed information from a colleague. While driving, using the mobile phone is impossible given the fact that he or she is wearing a helmet and gloves. Attributing value to the mobile phone in both situations, a considerable difference exists. Presumably, the value of the mobile phone is high when standing still, but low if driving. Knowing which type of information system, or combination of information systems, is most valued in the different context situations an MPO is in, is our second research focus of this quantitative chapter.

Getting a grounded answer on the needs of MPO's to use an information system in the different context situations is found by the two research parts. The needs can be concretized into demands or requirements (Baida, 2006), used in following design phases. Given these two research goals, our research question is defined as follows:

> *What influences MPO's intention to use mobile information systems and which mobile information system provides the highest value increase in different context situations?*

As the quantitative research has a dual aim, the structure of this chapter is also split in two parts. The first part is focused on getting an answer to the first part of the research question. The theory used to set-up the research is explained, followed by the method used to research the data and finally the results of this research part are given. After having presented the results on the first part, the focus is on the second part of the research question of this chapter. Again, the theory is presented after which an explanation is given on the method. Then the results of the second research part are presented and discussed. We conclude this chapter by grouping the results of both quantitative research parts executed with MPO's.

4.2 Technology acceptance and task-media fit for MPO's

4.2.1 Theoretical basis for the acceptance study

In this paragraph a clarification is given on the theoretical basis used to discover which communication system characteristics play a role in the decision to use the system. Although the interviews provided a direction to think in regarding influences on the intention to use communication systems, they can not be scientifically used as a general opinion from MPO's in the Netherlands. In order to find out what influences the intention to use a communication system by MPO's, a grounded theoretical model is needed defining the basic research design. This model can then be measured statistically by using data gotten from a large number of MPO's.

A review of research performed on information system acceptance and usage suggests that the Technology Acceptance Model (TAM) of Davis (1989) has emerged as one of the most influential models in this stream of research (Malhotra & Galetta, 1999). "TAM is tailored to information system contexts, and was designed to predict information technology acceptance and usage on the job" (Venkatesh, Morris, Davis & Davis, 2003). TAM claims that 'perceived usefulness' and 'perceived ease of use' determine an individual's intention to use a system with 'intention to use' functioning as a mediator of the actual use of a system. Perceived ease of use is also seen as a direct impact on perceived usefulness because "the easier the system is to use, the more useful it can be" (Venkatesh et al., 2003). Perceived ease of use is defined as "the effort required by the user to take the advantage of the application". Perceived usefulness is defined as "the extend to which an application contributes to the enhancement of the user's performance" (Davis, 1989). The TAM model plays an important role throughout this thesis. This role is proven by fact that the easier a system is to interact with, the less effort is needed to operate it and the more effort one can allocate to other activities like the environment an MPO is in (Davis, 1989).

Since the introduction of TAM several modifications have been made. In 2000, Davis & Venkatesh studied and grounded a theoretical extension of the technology acceptance model. The extension consists of social influences and cognitive instrumental processes significantly influencing the perceived usefulness. The social influences are outside the scope of this research as they focus on the usage of systems based on what others or referents think they should do (Davis & Venkatesh, 2000). Also, including the social influences would require a large extension to the research resulting in too little time for more important parts of the thesis. The cognitive processes are assumed relevant as they take 'job relevance' and 'output quality' into consideration, aspects highly important when investigating the connection between the MPO and mobile communication systems. 'Job relevance' is defined as: "an individual's perception regarding the degree to which the target system is applicable to his or her job. In other words, job relevance is a function of the importance within one's job of the set of tasks the system is capable of supporting" (Venkatesh & Davis, 2000). Though related to the job relevancy, output quality stands on a higher aggregation level as it explains how people will take into consideration how well the system performs those tasks. The difference between both effects is slim, but lies in the fact that job relevancy aims at compatibility between system and task, whereas output quality judges the profitability of the system in relation to the task (Venkatesh & Davis, 2000).

A relevant theory in explaining both cognitive processes is the Media Richness Theory (MRT) of Daft & Lengel (1986), who propose that task effectiveness will be improved when task needs are matched to a medium's ability to convey information. MRT and the cognitive processes of Venkatesh & Davis (2000) are related in the sense that both theories incorporate the effect of the 'user's task' on the usage of information systems. The difference between both theories however lies in the level of detail. MRT's usage goes a step further as it adds the role of media through the information system. According to Daft & Lengel's task-media fit hypothesis, communications are most effective and satisfying when the media richness matches the level of uncertainty (lack of information creating the need for more information) and equivocality (absence of clear definitions of situations setting the need for richer information) in a task. This difference is important due to the placement of the variable inside TAM, i.e. the causal relation between the constructs. The match Daft & Lengel (1986) define in their hypothesis is closely related to the information quality definition given in chapter 1.3.

Using the TAM and Task-Media fit theory requires the researcher to develop the model beforehand, as it is as a causal relations measurement tool. Our aim is to use the theory, not alter it, so it can not be used to test different models based on different causal relations (Molin, 2006). Venkatesh & Davis (2000) claim that the cognitive processes influence the perceived usefulness, which is logical as a task considered as such, influences the usefulness of an information system. However, the task-media fit hypothesis is more detailed compared to the cognitive processes and the different used media are defined. Due to this difference the general perceived usefulness of an information system influences the choice for certain media in performing required tasks. If the media choices were open and could be determined by MPO's themselves, the influence would be the other way round. Joining the task-media fit into TAM results in the following model used:

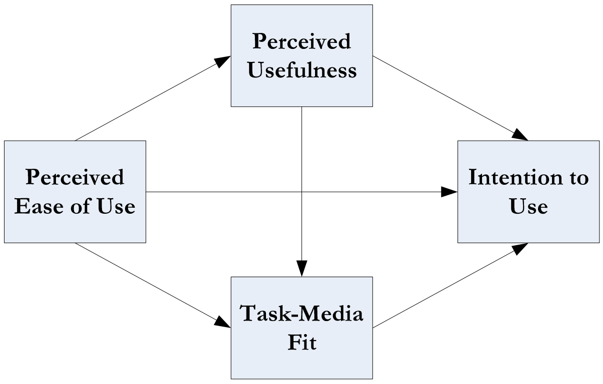


Figure 4.1: Technology Acceptance model with task-media fit (Davis, 1989; Daft & Lengel, 1986)

Defining the four constructs

Basically, the information we want to retrieve from this research part is to what extend the four constructs of figure 4.1 influence each other given the causal relations indicated by the arrows. The four constructs (referred to as conceptual variables) of the TAM/TMF model are latent, meaning that it is impossible to measure them by asking a single question. For that reason, indicator variables (observed variables) are used to measure the conceptual variables. This means a number of questions are asked to the MPO's which as a group define a conceptual variable. The questions used to explain the conceptual variables "…tend to have a lot of overlap in their meaning, which is consistent with the fact that they are intended as measures of the same underlying construct. The multi-item approach reduces any extraneous effects of individual items in order to yield a more pure indicant of the conceptual variable" (Davis, 1989). The list of indicator variables used to define the conceptual variables is presented in Appendix B and are based on standard indicator variables used in TAM research. As can be seen when reading the indicator variables, the term 'information system' has been changed to 'communication system' to make the term broader. A communication system is also an information system, but not vice versa. The constructs of the TAM/TMF model used remain the same. The ease of use is measured by eight indicator variables, the perceived usefulness by twelve indicator variables, the task-media fit construct is defined by twelve different types of media relevant to the MPO's tasks and the intention to use is measured by four indicator variables. By using the TAM/TMF model we hypothesize that for MPO's:

- H1. the perceived ease of use, perceived usefulness and task-media fit have a positive influence on the intention to use a communication system.
- H2. the perceived ease of use has a positive influence on the perceived usefulness and the task-media fit of a communication system.
- H3. the perceived usefulness has a positive influence on the task-media fit of communication systems.

4.2.2 Research method

The objective of this research is to measure the influences on the intention to use an communication system by MPO's given the TAM/TMF model defined above and the three hypotheses. Measuring the influences is done by using statistical research methods which are usually the standard scientific research methods used to measure the TAM model (Davis, 1989).

Data collection

The data is collected by a questionnaire completed by MPO's through the internet. The questionnaire used for the TAM/TMF research was part of a larger questionnaire. The other part of the questionnaire is used to answer the second part of the quantitative research explained in paragraph 4.3. The questions of the TAM/TMF part are created by turning each indicator variable (see Appendix B) into a statement that had to be rated on a 7-point Likert scale (from 'totally disagree' to 'totally agree').

Sample

The final number of respondents is 91. Although no official figures of the population are known, experienced police officers state a total of around 1000 in the Netherlands. The respondents were directly approached through email or indirectly through their Chief or a general police intranet site. Of all 172 MPO's approached directly, 6 are women (3.5% of known population). From the final 91 respondents 3 are women (3.3% of sample); this seems to fit the gender proportions of the population (assuming the directly approached MPO's represent the population proportions). The MPO's in the sample are from 15 different regional departments throughout the Netherlands. The average age of the respondents is 40. Looking at work experience the average is 15,4 years and the minimum is 5 years, so all have enough experience to assess mobile communication systems in relation to their work. Regarding the knowledge of mobile communication systems for police officers: 12% of the respondents has never heard of P-Info or Mobile Blue, 70% has just heard of it, 10% has seen it, 3% has touched it, 3% has used it occasionally and 2% has used it regularly. Apparently, a large part of the group does not have experience with the usage of mobile communication systems for police officers.

Operationalise the constructs

As with most TAM research, the causal relations of the TAM model are measured by using Structural equations modelling (SEM). "SEM is a statistical technique for testing and estimating causal relationships. It starts with a theoretical model, operationalises the constructs with a measurement instrument (indicator variables) and tests the model" (www.wikipedia.org, 2008). A problem however with SEM is that it requires a large sample (n > 100), especially if a large number of variables is used to get a model fit. Due to the fact that our sample consists of 91 cases, no model fit could be found. To get a model fit, modifications to the model need to be made. These modifications are aimed at the indicator variables determining each construct.

Given the high number of indicator variables for some constructs, dimensions inside the group of indicator variables might exist. This means these dimensions measure a different aspect of the underlying construct. If joining these groups the model does not fit, but taking them apart and measuring per dimension might result in fitting models. The statistical procedure is shown in figure 4.2. The first step is to execute an explorative factorial analysis (EFA, using Principal Axis Factoring) grouping highly correlating indicator variables as dimensions of the conceptual variables. Figure 4.2 shows the procedure for the 'perceived usefulness' construct as an example, but all indicator variables are measured for dimensions. Table 4.1 shows the results of the factorial analysis with the different factors (used as dimensions). 'Intention to use' and 'ease of use' have no underlying dimension.

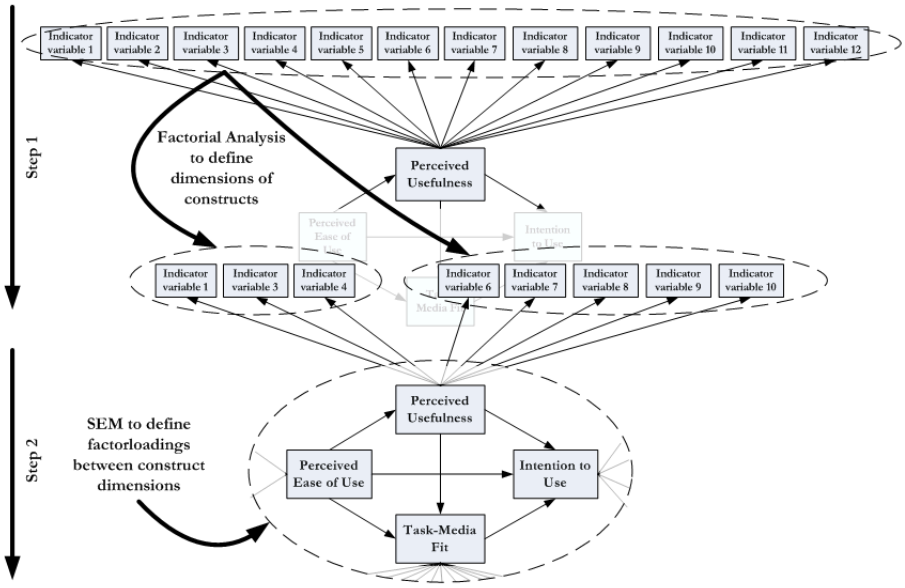


Figure 4.2: steps in SEM development for measurement

Conceptual variable	Dimension	Mean	Std. dev.	# Items	KMO MSA	Bartlett's test sig.	Cronbach's alpha	Lowest factor loading
Intention to use		6.15	0.89	4	.816	.000	.896	.725
Ease of Use		4.64	1.38	2	.711	.000	.840	.786
Perceived Usefulness	**Resource advantage**	5.78	0.97	5	.886	.000	.940	.760
Perceived Usefulness	**Productivity**	5.48	1.12	3	.886	.000	.857	.687
Task-media fit	**Decision-making**	5.26	1.12	5	.800	.000	.858	.581
Task-media fit	**Information exchange**	5.90	0.92	2	.800	.000	.805	.571
Task-media fit	**Location overview**	5.54	1.22	2	.800	.000	.758	.726

Table 4.1: Overview of the explorative factorial analysis showing dimensions of TAM/TMF constructs (n=91)

The selection of dimensions based on the factorial analysis is defined by a number of criteria, shown in table 4.1. The KMO MSA states the measure of sampling adequacy. According to Molin (2006), an MSA higher than 0.7 means that the adequacy of the used data is acceptable, higher than 0.8 is a good adequacy result. Only the 'ease of use' construct is average, but still acceptable. Bartlett's Test is always significant, meaning that correlations are high enough for a factorial analysis. Cronbach's alpha test indicates to what extend the indicators of the dimension measure the same. The score must always be higher than 0.7 (Molin, 2006), as is proved when looking at the results presented in table 4.1. For each dimension applies that removing an indicator variable results in a lower alpha. Another reliability check is to see whether the factor loadings are above .55 for n > 90 (Hair, 1998). Examining table 4.1, the task-media fit for decision making and information exchange are just sufficiently high, so the decision is taken to use them for the model. Lastly, the results have been checked by executing a confirmative factorial analysis in Amos 7.0 and all dimensions resulted in a model fit for the construct and all loadings for the indicator variable on their dimensions are large and significant. The final list of indicator variables used to define each dimension of the constructs for further analysis is presented in table 4.2.

The 'intention to use' construct is defined by all four indicator variables. The 'perceived ease of use' only has two indicator variables loading sufficiently on the construct, focused on user-friendliness and ease to operate. 'Perceived usefulness' consists of two different dimensions. The first is defined as resource / information advantage. Four indicator variables are clearly aimed at the advantages a communication system has for MPO's, the last indicator (with the highest factor loading) aims at the information necessity. The second dimension of the 'perceived usefulness' construct is defined as productivity, based on three clear indicator variables. The last construct is the Task-media fit, divided in three dimensions. The first is decision-making, constructed out of five indicator variables which aim at decision-making (with the highest factor loading) and contact needed to support decision-making. The second is clearly defined as information exchange as the two indicator variables are focused on requesting and exchanging information. The last dimension of the media fit construct is the location overview which consists of two indicator variables both stating an overview of a situation.

Construct	Dimension	Indicator variables
Intention to use		- MPO's will use mobile systems in the future - Future mobile communication systems will make the work of MPO's easier - MPO's will keep on using mobile communication systems - Others than MPO's should also use mobile communication systems
Perceived ease of use		- Mobile communication systems are user-friendly for MPO's - Mobile communication systems are easy to operate by MPO's
Perceived usefulness	**Resource / information advantage**	- Mobile communication systems are very usable to execute MPO tasks - Mobile communication systems are a good addition to existing systems - Mobile communication systems have advantages over other systems MPO's use - Mobile communication systems are an important aid to MPO's - The info received on mobile communication systems is needed by MPO's
	Productivity	- Mobile communication systems make MPO's execute their tasks faster - Mobile communication systems make MPO's more productive - Mobile communication systems can make MPO's execute their work more efficiently
Task-Media fit	**Decision-making**	- Communication between each other - Sharing of time-critical information - Taking decisions - Maintaining contact - Asking questions
	Information exchange	- Information exchange - Information request
	Location overview	- Receiving a location overview of other MPO's - Receiving a situation overview (e.g. during a calamity)

Table 4.2: Final indicator variables per construct dimension

Having defined the dimensions of the TAM/TMF model constructs, the statistical technique used to measure the causal TAM/TMF model influences is explained (step 2 of figure 4.2). Where step 1 is defined as a measurement model in order to see how the constructs (latent variables) are defined by the indicator variables, step 2 consists of the structural (or path) model analysed with SEM. This second step has a different purpose. It is not used to alter the TAM/TMF model, but uses the model to measure the causal relations between the constructs and see to what degree constructs influence each other as defined by the TAM/TMF model. Combining the measurement and structural parts is also referred to as a hybrid model (Krabbe, 2005). The models are constructed by setting the different constructs per group of indicator variables and draw the paths between the constructs as defined by the TAM/TMF model in figure 4.1 and the hypotheses as defined in paragraph 4.2.1. The SEM technique empirically estimates the strength of each relationship (path) depicted in the path diagram (Hair, 1998). Considering the number of construct dimensions, a total of 1 x 1 x 2 x 3 = 6 models can be developed.

The structural models are specified in Amos 7.0 and estimated using the maximum likelihood (ML) technique. Although the data is not normally distributed, it is assumed usable for ML estimation. "Simulation studies suggest that under conditions of severe non-normality, ML parameter estimates are still consistent but not necessarily efficient. Using the χ^2 as a measure of model fit will lead to an inflated Type I error rate for model rejection" (Schermelleh-Engel, Moosbrugger & Müller, 2003). A second consideration is the sample size dependence of the χ^2. Even though the sample size of our research is small, it is not considered a problem. First of all, as sample size decreases, the χ^2 values decreases as well. Secondly, the 'Root Mean Square Error of Approximation' (RMSEA) goodness-of-fit measure is included, which is regarded as relatively independent of sample size (Schermelleh-Engel et al., 2003).

All six models proved to fit according to Model chi-square fit test (measured by χ^2 at a $p<0.05$ significance level). This means that a significant chi-square indicates lack of satisfactory model fit. Looking at the additional measures of fit (Hair, 1998; Molin, 2006), all six models are above or considered close enough to the criteria: Goodness-of-fit index (GFI) >.90, Comparative fit index (CFI) >.90, Incremental fit index (IFI) >.90, Normed fit index (NFI) >.90 and RMSEA <.07. These figures support the acceptance of the proposed models. The only problem is found at the 'ease of use' construct, as the t-value of variable 7 is not significant. Consequently, ease of use is determined by variable 6, giving the highest factor loading. Even though using one indicator is not preferred, it is allowed (Hair, 1998). No other justifiable combination of indicators is available to represent the construct. All other calculated t-values in the six models for each coefficient are significant. All factor loadings are standardized and the significance level is set at $p<0.05$. The six models are presented and discussed below.

4.2.3 TAM / TMF results

The resulting models (see figure 4.3) are explained per construct, not per model. First the influences of the constructs are elaborated, followed by the explained variance if applicable. We start by reviewing the perceived ease of use construct. The perceived ease of use never has a direct effect on the intention to use the communication system. However, it does influence the intention to use indirectly through the resource / information advantage construct dimension. Therefore, by improving the ease of use of the system design, the advantages of the system and needed information are increased which leads to a higher intention to use the system. Although the perceived ease of use of a communication system has a positive influence on the resource advantage of the system, it never significantly influences the perceived productivity. Finally, the perceived ease of use of the communication system only has a positive effect on decision-making of MPO's. The ease of use however does not influence the media-fit assumption of information exchange and of a location overview directly. The task-media fit assumptions are indirectly influenced by the perceived ease of use through the resource advantage of the system. As perceived ease of use is a exogenous variable no explained variance is calculated.

The perceived usefulness (resource advantage and productivity) always has a positive influence on the task-media fit (decision-making, information exchange and location overview). Especially the resource advantage of a mobile communication system has a very high effect on the information exchange. This further grounds the assumption gotten from the interviews that exchanging information is seen as an essential aspect of MPO work which must be supported by the communication system. As indicated above, the resource advantage also has the largest influence on the intention to use. The inclusion of the information necessity indicator presumably augments this high influence further. Only model four shows a non significant influence of the productivity construct on the intention to use, but does indirectly through the information exchange task fit. Looking at the explained variance of the perceived usefulness constructs they are all very low, especially for the productivity dimension. Considering the construct influence on the intention to use the system, a persuasion towards MPO's of the usefulness of the system is highly needed.

Only one task-media fit dimension positively influences the intention to use, where it is influenced by the perceived productivity and the perceived ease of use and assumes information exchange to support the task. This shows the importance of information exchange, an essential aspect to be supported by the designed service. Going over the various explained variances, a gradation of importance can be noticed. Information exchange is highest in general, followed by the decision-making dimension and the least importance is given to the location overview task support. The explained variance of the information exchange in model three is highest, showing the importance of the system to be easy to use, so that the system is advantageous in exchanging information so the intention to use is influenced.

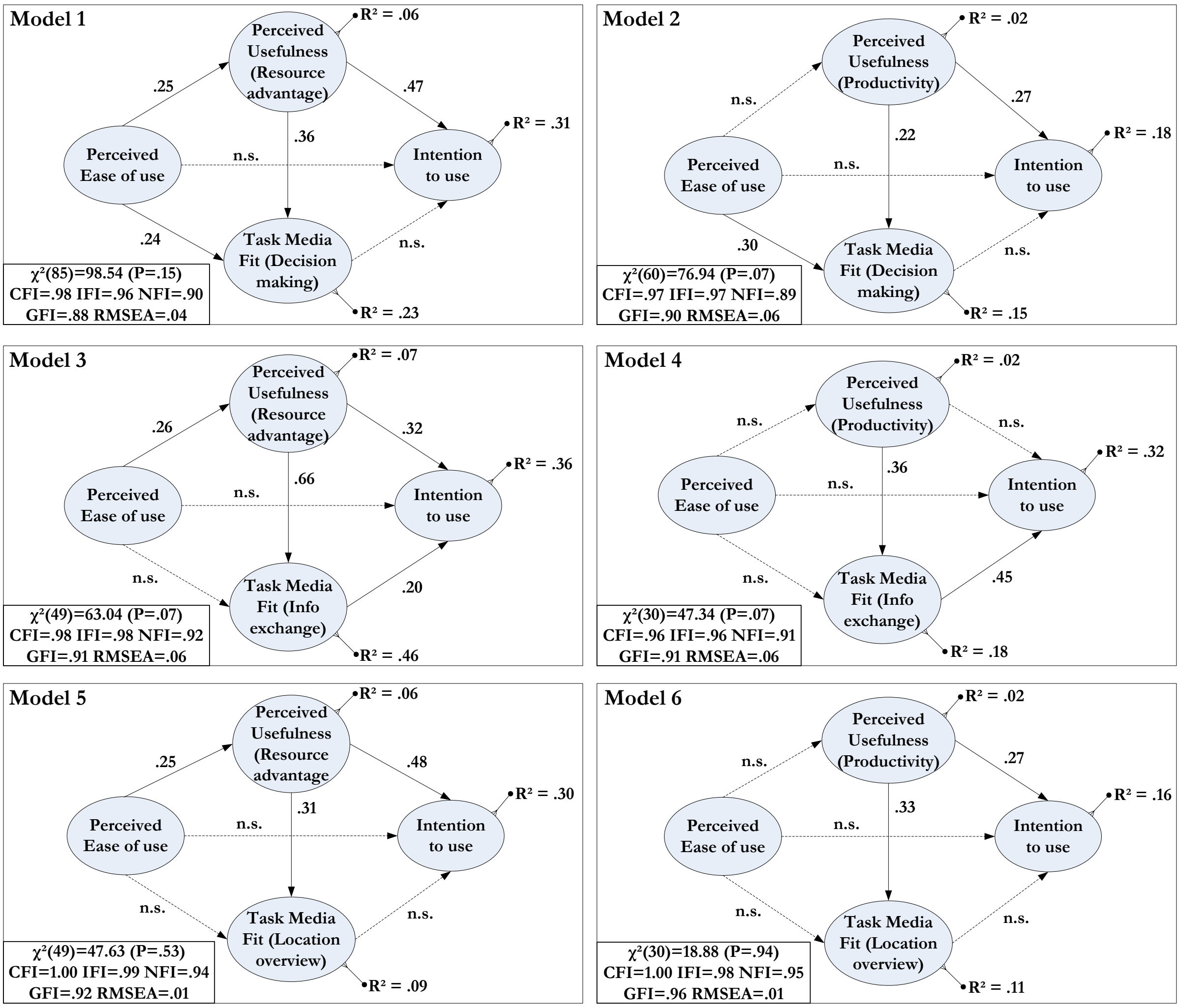


Figure 4.3: the six TAM/TMF models calculated using SEM (n=91)

The information exchange importance conclusion is further grounded by the explained variances of the intention to use construct. It is clearly highest for model three as clarified above. For all three models where the perceived usefulness is the resource advantage, the explained variance is higher in general when compared to the perceived productivity of the system. Considering the factor loadings influencing the intention to use, this makes sense. Model four shows a comparable explained variance, due to the influence of the information exchange media fit.

4.3 Defining the information system with the highest MPO value

4.3.1 Theoretical basis

The previous paragraph focused on researching the intention to use communication systems for MPO's in general and showed the main drivers influencing the intention to use. The communication system must provide an advantage over current systems and increase the possibility to exchange information. The focus has slightly changed from 'communication system' to 'information system', as we know information provisioning is the essential aspect of the system. It is still unclear however which information system type is capable of providing the highest level of advantage. An information system is defined by three parts: a device, a modality type to transmit the information to the MPO and the information source.

As proved by the TAM/TMF model research, the system must be easy to use to further increase the resource advantage and thereby augment the intention to use. The ease of use however of an information system for MPO's is dependant on the context. The example of mobile phone usage in the introduction of this chapter demonstrates this context dependency. In chapter 3 we concluded that the information needs depend on the tasks of the MPO, which are various and performed in different context situations. The change of context posits a changing mobile information system interaction need. Therefore, the aim of this second quantitative research part is to find out which possible combinations of the three information system parts provide the highest value to MPO's in the different context situations they work in.

The answers gotten from this research part provide the information system requirements for the context-aware service bundling design for MPO's. The difficulty arises in the question how different information systems - that MPO's have never experienced - can be assessed in changing context situations? Building a number of information systems and testing them in different situations is not an option as it is too costly. A statistical method can be used to reach a large amount of MPO's in a relatively short time. An important requirement however, is that the chosen method has to measure the value of different information system alternatives based on realistic context situations. The different context aspects influence each other and consequently the value of the system. E.g. an MPO rates a system differently when the proposed situation is 'driving', than when the proposed situation is 'driving' but at the same time 'executing an emergency aid' task. This means that the defined MPO context aspects of chapter 3.3 can not be questioned individually and need to be presented as groups to the user, creating realistic working situations.

Given the effects of factors on each other, conjoint analysis is chosen as it identifies consumer preference in a multi-attribute decision-making setting. Though the technique is mostly used for product testing in marketing studies (Hair, 1998), it proves to be very usable for this research. "The objective of a conjoint analysis is to explain and predict preferences that result in an assessment of achievements. Achievements profiles, both real as well as hypothetical ones, are created by varying specific attributes. The test persons evaluate these profiles." (Bouwman & van de Wijngaert, 2005). The usage of profiles in a conjoint analysis furnishes the ability to capture real-life situations, and simultaneously provides the possibility to identify a subjective judgment of preference of each individual factor that created the profile. The conceptual basis for measuring the individual value in conjoint analysis is referred to as 'utility'. As it encompasses all service features, it is as such a measurement of overall preference (Hair, 1998). By altering the 'service features' Hair (1998) refers to into the MPO-context aspects (attributes), it is possible to present different profiles of context situations. The value of different information systems can be measured for each context situation. Finally, these ratings are used to determine the utility of each information system per individual context factor. This research part is explorative, as no clear knowledge is available of the value MPO's give to different information systems to support their work.

Creation of the context cases

Designing a conjoint analysis research requires a creation of profiles (based on independent variables) and the definition of entities that are to be valued for each profile (dependent variables). First the creation of the various profiles is explained, followed by the selection of entities. A profile is defined by factors (attributes), further specified by levels for each factor. "The critical aspect in specifying attributes (factors) and attribute levels is that a product cannot be accurately simulated if the product is not adequately defined." (Mclennon & St. Everald, 2002). In this case the "product" Mclennon & St. Everald (2002) talk about is the context situation that needs to adequately represent situations that MPO's are in.

According to Hair (1998) there are two fundamental criteria that need to be considered when defining the factors and corresponding levels. The first one is the *communicatability* and the second is the *practical relevance*. The first criterion considers if every respondent understands the same meaning out of the chosen term for the factor or level. By practical relevance Hair (1998) means that the chosen factors and levels need to be contextual aspects recognized as truly happening in practical situations while performing work as an MPO. In order to make sure the chosen factors and levels comply with the second criterion, they are primarily based on the quantitative research performed for chapter three. The starting point of the definition of factors for the creation of cases is the group of MPO-context factors. These factors are defined as crucial influences on the usage of information systems, which make them applicable to research the value of different systems in possible MPO contexts.

There are however some changes that need to be made. Chapter 3.3 states eight different factors which define the MPO-context factors for the service design. That means some needed factors for the functioning of the service are not essential for the creation of situations, whereby the relation with the system is of interest. Secondly, more factors results in more combinations and consequently more situations. The amount of factors needs to be kept to a minimum. Three factors are removed: the status of the MPO, the location and the time. The status is not relevant as we want to measure the usage of the system in a task performing situation. The location is removed as it is not usable for this research. An exact street would result in a more detailed situation, but this would reduce the possible amount of MPO's to be used for this research as they would all need experience of this exact street. The third removed factor is time. The time of the situation does not matter in relation with the information system. A difference could have been day or night use, but this aspect is also assumed as a minimal information system usage and would result in more factors.

Although three factors are removed, one has been added. The information aspect is missing in the choice of factors. In chapter three a connection has been made between task and information type, but this connection can not be made for the construction of context cases. This would e.g. result in a speed control task requiring emergency aid information. As information does play an important role in the ability of an information system to transmit the information, some information types have been selected which are applicable to all tasks. The levels of all factors are explained below.

The level is defined as the value a factor can take. When executing a conjoint analysis each level derives a utility. Levels must suffice the same criteria as Hair (1998) states for the factors. Also, choosing too many levels leads to an excessive amount of context situations to measure, whereas an insufficient amount of levels results in an inadequate amount of information for the research. The choice of levels is a balance made by the researcher and is clarified per factor:

- *Mobility*: refers to the 'speed' factor of chapter 3.3. The most important effect is when an MPO is *standing still* or *driving*. While standing still the hands are free and attention can be on the system. If driving the hands must be on the handle-bar and the attention is needed to the surroundings.
- *Task*: MPO's have different types of tasks as shown in chapter 3.4, and setting every task as a level would create too many levels. Four levels are advised as a maximum (Molin, 2006). Hair (1998) advises to use levels which are to the extreme, though still practically relevant. The three main task groups defined are control tasks, emergency aid tasks and guidance tasks. The last two are clear to the MPO as can be seen according to the categorization of figure 3.1, but the control task is clearly present in two quadrants. Therefore the choice is made to select 'speed control' as a third level. Speed controls are assumed the most common control task. The three chosen levels are: *emergency aid, speed control and guidance*. All three are very different in the way the MPO needs to execute them, making them suitable for this research.
- *Group communication*: For group communication two levels have been selected: *I-Centric* and *We-Centric*. In an I-Centric situation the MPO works alone, meaning that he or she does not communicate with other colleagues. The term We-Centric is explained as: "the MPO operates in a group and communicates within that group over a designated line". Both levels are to the extreme, making them applicable.
- *Information type*: The type of information has been added to the list of factors. As indicated before, the levels need to differ from each other, but must be applicable to all tasks. The following four levels are chosen: *Route information, information from Police registers or systems, briefing information and giving an announcement*. Route information is a basic need for many MPO's. It is constant and easily interpretable. Information on registers or systems is more aimed at detail level information which is more detailed and focused on aiding the specific task performance. It requires more processing capabilities from the MPO. Briefing information is aimed at covering general knowledge of tasks, but also knowledge that is shared between colleagues and never written down (Interview Amsterdam, 2007). Lastly,

giving an announcement is chosen as it aims at sending information instead of receiving information, thereby covering both branches of information exchange.

- *Data channel availability*: The idea behind 'data channel availability' is that high bandwidth data networks (e.g. Wifi) do not offer a 100% coverage (MIRA, 2004), meaning that the availability of high speed data networks changes. It supports the network availability factor of the MPO-context definition. For respondents the term "data channel available" is vague, so in the questionnaire an example is added to make it clear to respondents. The two levels are *data channel available* and *data channel not available*.
- *Control room availability*: The control room availability is the last factor of the defined MPO-context factors that has not been discussed. Primarily the choice was made to define the levels as: *available* and *not available*, in order to cover the extremes. However, many interviews (Interview Doorwerth, Interview Driebergen & Interview Den Haag, 2007) indicated that many situations arise in which an MPO is put on hold. This situation also needs to be incorporated in a level to claim practical relevance. The result is a third level stating that the control room becomes available after a *maximum waiting time of 5 minutes*. In total three levels are chosen to cover the control room availability.

The final choice of factors and levels have been checked during interviews with MPO's and by Timber Haaker (member of FRuX) before presenting the final version of the enquiries to all MPO's. A second check to measure the accuracy of the presented profiles based on the factors and levels was added by asking the MPO whether the proposed situation was recognizable or not. The result of this question presented in paragraph 4.3.2.

Defining the information systems to measure

The starting point of the creation of information systems to measure (referred to as items) is defined by three parts playing a role in information and communication systems for MPO's. The first factor is the device used to communicate the information, the second is the modality of the information and the third is the intermediation or source of information. As with the independent variables, levels are created for each factor. The levels are based on available knowledge of police information and communication systems in the Netherlands and completed by knowledge of the author on promising information and communication technologies available. The different levels are presented in table 4.3 and assumed clear.

Type of device	Type of modality	Information source
Touchscreen	Text info	Control room
UMTS phone	Speech info	Back-up officer
Head-up display	Short code	Registers or systems
Mobile terminal	Image info	

Table 4.3: the information system parts and respective levels

By creating 16 combinations of these three factor levels at random (more would result in too many items) a list of information systems is created. As some combinations of the information system parts resulted in an impossible information system, they were removed. Finally, 11 plausible items are set as dependent variables presented in table 4.4. For some context situations some of the 11 items are removed. The reason for the removal is that some items are practically impossible according to the proposed context situation. The consequence of removing items is that for some items no data is available for some context situations. The CONJOINT method of the SPSS software package used can not analyze the data, as it removes all cases with a missing value. Due to this problem, a missing value analysis is performed which is explained in Appendix C.

Item #	Device	Modality	Information source
1	Touchscreen	Text info	Control room
2	UMTS phone	Speech info	Control room
3	Head-up display	Text info	Control room
4	Mobile terminal	Speech info	Control room
5	Mobile terminal	Speech info	Back-up officer
6	Mobile terminal	Text info	Registers (database)
7	UMTS phone	Text info	Back-up officer
8	UMTS phone	Speech info	Registers (database)
9	Head-up display	Short code	Back-up officer
10	UMTS phone	Image info	Control room
11	Touchscreen	Image info	Registers (database)

Table 4.4: final 11 dependent variables rated by MPO's

4.3.2. Research method

Having the factors, their respective levels and the different information systems to be measured clear, a brief explanation is given on the conjoint analysis design. First the choice of measurement is clarified for the dependent variables. Then, the creation of profiles is explained, followed by the final design of the conjoint analysis and the different profiles defined as independent variables.

For conjoint analysis, there are three types of preference measurement of the dependent variables. "Characteristic of the conjoint preference approach is that respondents are asked to rate or rank hypothetical alternatives, while in the conjoint choice approach respondents are asked to make a choice between two or more profiles" (Kemperman, 2000). The ranking method demands a lot of effort from the respondent considering all 11 information systems need to be ranked for each context situation presented. The choice measurement method does not satisfy either, as our aim is to present differences in response scales on all dependant variables. Evaluating on a rating scale however does fulfil this aim as it provides information on both order and degree of scale per dependant variable. Also, the information systems can be rated one by one. The result of using the rating method is interval scale data, in this case from 0 (totally unsuitable for this context) to 10 (totally suitable for this context).

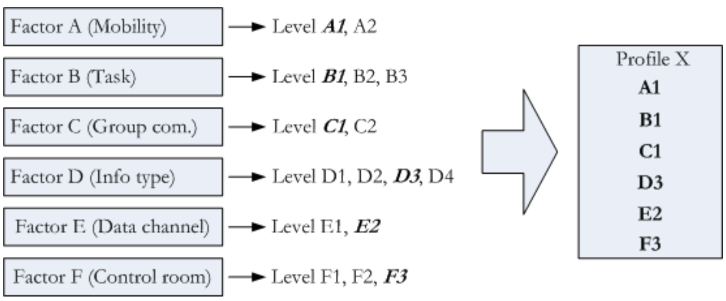
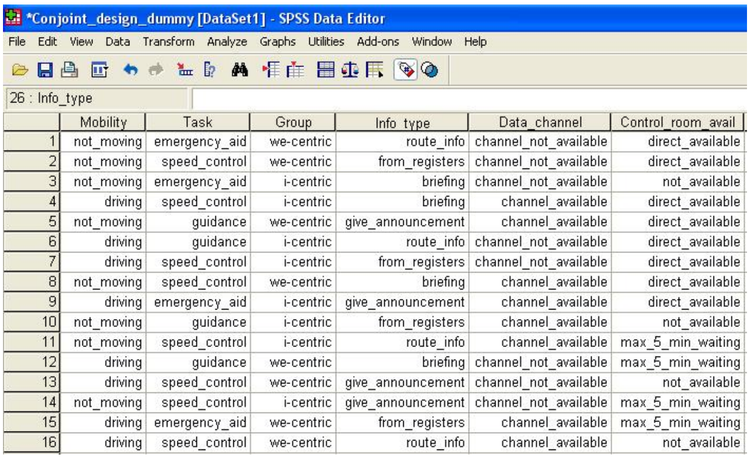


Figure 4.4: Creation of a profile for conjoint analysis

Next, the profiles need to be created based on the factor levels. The way profiles are created is shown in figure 4.4 and it is assumed that no further clarification is required. A full factorial design of the conjoint analysis uses all profiles that can be generated and would result in 2x3x2x4x2x3 = 288 profiles. Presenting this amount of profiles to respondents is impossible. To reduce the amount of profiles a 'fractional factorial design' is made. This design ensures enough data is available for statistical analysis, resulting in a carefully controlled set of profiles for the respondent to consider (www.wikipedia.org, 2007). The fractional factorial design is created out of an orthogonal selection of profiles out of the full factorial design. Orthogonality is claimed if no correlation exists between the factors levels of all profiles created. Based on the demand to ensure orthogonality and minimize the amount of profiles created out of the 6 factors and levels a design of 16 profiles is defined. The final design of the conjoint analysis is presented in figure 4.5, also showing the different levels per profile. For analysis the levels are effect coded and tested for orthogonality.



*Conjoint_design_dummy [DataSet1] - SPSS Data Editor

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26 : Info_type

	Mobility	Task	Group	Info_type	Data_channel	Control_room_avail
1	not_moving	emergency_aid	we-centric	route_info	channel_not_available	direct_available
2	not_moving	speed_control	we-centric	from_registers	channel_not_available	direct_available
3	not_moving	emergency_aid	i-centric	briefing	channel_not_available	not_available
4	driving	speed_control	i-centric	briefing	channel_available	direct_available
5	not_moving	guidance	we-centric	give_announcement	channel_available	direct_available
6	driving	guidance	i-centric	route_info	channel_not_available	direct_available
7	driving	speed_control	i-centric	from_registers	channel_not_available	direct_available
8	not_moving	speed_control	we-centric	briefing	channel_available	direct_available
9	driving	emergency_aid	i-centric	give_announcement	channel_available	direct_available
10	not_moving	guidance	i-centric	from_registers	channel_available	not_available
11	not_moving	speed_control	i-centric	route_info	channel_available	max_5_min_waiting
12	driving	guidance	we-centric	briefing	channel_not_available	max_5_min_waiting
13	driving	speed_control	we-centric	give_announcement	channel_not_available	not_available
14	not_moving	speed_control	i-centric	give_announcement	channel_not_available	max_5_min_waiting
15	driving	emergency_aid	we-centric	from_registers	channel_available	max_5_min_waiting
16	driving	speed_control	we-centric	route_info	channel_available	not_available

Figure 4.5: final design of the conjoint analysis

Naturally, the profiles are to be explained as a 'situation' according to the levels of the profiles created in the conjoint design. In order to give an idea of how the profiles are presented to the respondent, two examples are given below:

Profile 1:
You are next to your motorcycle and standing still. You are requested to assist in an emergency aid situation. You are operating as a group and communicate with your colleagues over a dedicated channel. You need route information to get to the location of the incident. The control room is immediately available to support you with information through speech.

Profile 6:
You are driving on your motorcycle. You are requested to guide a special transport. You operate alone. You need route information. The control room is immediately available to support you with information through speech.

For all profiles, the respondents were asked to state if the proposed situation was recognizable or not. This resulted in the following percentages of recognized context situations (figure 4.6):

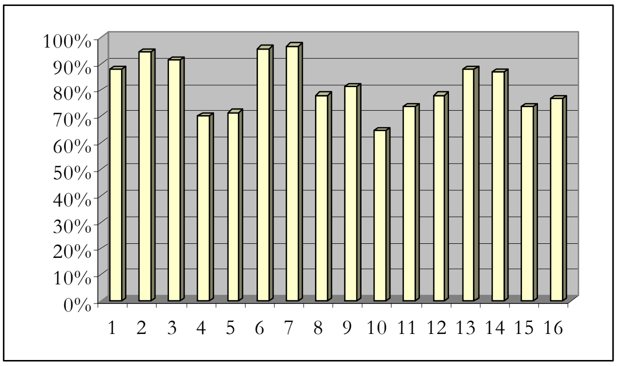


Figure 4.6: percentages of recognized context (n=91)

The first impression is positive. All percentages are above 60%; 14 context situations are above 70%. The context with the lowest recognized percentage is where the MPO is not moving, has as its task to guide, communicates in an I-Centric mode, requires information from registers, has the data channel available but does not have the control room to ask for information. As 64.5% do recognize the context situation it is valuable to our analysis. Based on the positive percentages the decision is taken to use the data of all situations.

Data collection

As with the data collected for the TAM/TMF research part, a questionnaire is used through the internet that is completed by the same MPO's as for the TAM/TMF part. For the conjoint analysis part the 16 context situations are explained (in the form of the examples shown), followed by three questions for each situation. Question one asked the respondent if the situation is known, question two required the respondent to rate each item (on a 1 – 10 scale from 'highly unsuitable' to 'highly suitable') and for question three the respondent needed to choose the most suited item. The last question is seen as a check in order to determine whether similar results can be observed between the most valued information system for question two and three. As the sample of this research part is the same as for the first part, it is assumed clear. A last important mentioning is made about the named tasks the MPO's of the sample perform. The most mentioned tasks fall in the traffic control, emergency aid or guidance tasks groups. This is coherent with our selection of task levels for this research.

4.3.3 Conjoint analysis results

In order to develop requirements for a context aware service bundling, combined with the TAM/TMF results, a large part is provided by the results of conjoint analysis with MPO's. The results are presented in two parts. First, the means of the different ratings for the items per context are clarified. The means are put in graphs, shown in Appendix E. The second part explains the most important utilities that resulted from the conjoint analysis based on the utilities table. In Appendix D, the utilities are presented in graphs as numbers are not always easy to interpret. The quantitative research chapter is closed with a general conclusion.

The means of the different items per context

In the inquiry all respondents were asked to rate (on a scale of 0 to 10) each item for 16 different context situations. The means of these ratings provide an image of how suitable each item is (rated by the user) for each context presented. An advantage of studying the means over the conjoint analysis is that the results are only based on real data without missing value analysis. It does not show however which factor of the context determines the suitability like in a conjoint analysis. The means are used to give a general idea of how suitable the items are found. Scanning through the different graphs most show a similar pattern. Of the 16 graphs three main groups can be defined. Firstly, there is a group of graphs which have all 11 items rated. The context situations of the first group are 1, 2, 4, 6, 7, 8, 11, 12, and 15. These approximately show a pattern discussed in order of most suitable to least suitable:

Most suitable: items 1 and 11: the device used is a screen on the handle-bar, the modality is text or an image and the intermediation is through registers and systems or the control room. The ratings are between $M = 7$ and $M = 8$.

Reasonably suitable: items 4 and 5: the device used is the mobile C2000 terminal with speech as its modality and the intermediating party is either the control room or the back-up officer. The control room is slightly preferred in most context situations. The ratings are between $M = 6$ and $M = 7$.

Not so suitable: Items 3, 6 and 9: Although the ratings of these three items are seen as a group, the head-up display are a bit more suitable than the mobile terminal using text from registers. The ratings are all between or close to the interval of $M = 5$ and $M = 6$.

Least suitable: Items 2, 7, 8 and 10. These four items are rated between $M = 3$ and $M = 4$, with the exception of the items with speech as the modality being rated slightly higher in two context situations, whereby the 'emergency aid' task seems to be the reason why. All four items use a UMTS phone as the communication device making the higher ratings of the speech modality logical.

The second group shows a similar pattern of means as the group mentioned above, but has fewer items due to the removal of some items. The context situations in group two are 3, 10, 13, 14 and 16. As the results are the same as for group 1 they are not discussed separately.

The third group shows different results compared to groups one and two. These differences occur in context situations 5 and 9. In these situations the mobile terminal is used by talking to the control room and is rated with an *M* = 8 being higher than all other items. Although the context situations 5 and 9 are very different, the level they have in common is 'giving an announcement'. Sending information is apparently most suitable through the traditional way of communicating for MPO's. In the other two context situations where the level 'giving an announcement' occurs, the control room is either not available or the MPO has to wait for the control room. That explains why the mobile terminal using speech towards the control room is not rated as high for those situations.

The final choice per context
All respondents were also asked to choose the most suitable item for each context. The results can be used to see if differences between both results arise. Items chosen most are equal to the ratings of the most suitable items discussed above. The touchscreen systems are mostly chosen, except for context situations in which an announcement has to be sent. Here, the current system (speech contact to the control room through the mobile terminal) is distinctly chosen as most suitable.

Utilities per level of the conjoint analysis

As in regression analysis, the result of a conjoint analysis is an estimated model which gives the relation of a dependent variable (items rated by the MPO's) to specified independent variables (the factors). The mathematical model of their relation is the regression equation. The equation is build out of an intercept (the constant), the β's of each variable creating the slope of the vector and the error term which picks up the unpredictable part of the dependent variable (www.wikipedia.org, 2007). The difference with regression analysis is that the equations are determined from different profiles rated by the respondent instead of separate variables. Going back to the results of the conjoint analysis, the constant represents the general rating of the item and the utilities represent the increase or decrease of that constant for that level.

The first focal point is the constants of the items. As was expected, the constant of each item shows similar values as the means clarified above. The next step is to analyze the utilities that result in significant differences to the constants (i.e. when the ranking of items (almost) changes). The utilities are presented in table 4.5 and clarified below.

Mobility
An MPO standing still does not present high utilities (<0.212) resulting in a highest rating for the touchscreen with text information from the control room (0.169). A driving MPO shows opposite results, making the suitability of the mobile terminal using speech with the control room the only item to increase (by 0.041). This is not enough to change the value ranking order of the items.

Task
Looking at the figures of the different tasks there are two high utilities, both for the mobile terminal using speech communicating with the control room. In executing an 'emergency aid', the mobile terminal/control room combination gains considerably in suitability (increase of 0.415). Seen that coordination during an emergency task is executed from the control room (Interview Amsterdam, 2007) this results was expected. Also, the UMTS phones show a utility increase for an emergency aid task (especially when it connects to the control room by means of speech, 0.255). Examining the utilities of a guidance task the only item with a considerable negative utility (-0.481) is the mobile terminal/ control room combination, which makes sense considering the task, where usually no contact with the control room is needed. The screen on the handle-bar remains most suitable, also for the last task which is 'speed control'.

Table 4.5: Utilities of each factor level per information system

Item	Touchscreen / Text info / controlroom		UMTS phone / speech info / control room		Head-up disp/ text info / control room		Mobile termin / speech info / control room		Mobile termin / speech info /back-up off.		Mobile termin / text info / register_system	
	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error
Not moving	0.169	0.081	0.160	0.103	0.146	0.050	-0.041	0.170	0.130	0.077	0.161	0.052
Driving	-0.169	0.081	-0.160	0.103	-0.146	0.050	0.041	0.170	-0.130	0.077	-0.161	0.052
Range	0.338		0.320		0.292		0.082		0.260		0.322	
Emergency aid	-0.046	0.127	0.255	0.162	0.033	0.078	0.415	0.264	0.016	0.120	0.180	0.081
Speed control	-0.124	0.108	-0.199	0.138	-0.040	0.067	0.066	0.226	0.076	0.103	-0.136	0.069
Guidance	0.170	0.127	-0.056	0.162	-0.007	0.078	-0.481	0.264	-0.092	0.120	-0.044	0.081
Range	0.294		0.454		0.073		0.896		0.168		0.316	
I-centric	0.153	0.081	0.045	0.103	0.138	0.050	0.278	0.169	0.146	0.077	-0.019	0.052
WE-centric	-0.153	0.081	-0.045	0.103	-0.138	0.050	-0.278	0.169	-0.146	0.077	0.019	0.052
Range	0.306		0.090		0.276		0.556		0.292		0.038	
Route info	0.307	0.141	0.061	0.179	0.011	0.086	-0.153	0.293	-0.191	0.133	-0.044	0.089
From registers	0.253	0.141	0.031	0.179	0.031	0.086	0.346	0.293	0.284	0.133	0.150	0.089
Briefing	0.335	0.141	-0.082	0.179	0.097	0.086	0.230	0.293	0.169	0.133	0.009	0.089
Announcement	-0.895	0.141	-0.010	0.179	-0.139	0.086	-0.423	0.293	-0.262	0.133	-0.115	0.089
Range	1.202		0.143		0.236		0.769		0.546		0.265	
Channel available	-0.068	0.081	-0.020	0.103	-0.040	0.050	-0.065	0.169	-0.017	0.077	0.081	0.052
Channel not-available	0.068	0.081	0.020	0.103	0.040	0.050	0.065	0.169	0.017	0.077	-0.081	0.052
Range	0.136		0.040		0.080		0.130		0.034		0.162	
Direct availability	-0.121	0.108	-0.153	0.138	-0.070	0.138	0.458	0.226	-0.003	0.103	-0.171	0.069
Max. 5 minutes waiting	0.501	0.127	0.160	0.162	0.094	0.162	-0.504	0.264	-0.041	0.120	0.132	0.081
Not available	-0.380	0.127	-0.007	0.162	-0.024	0.162	-0.046	0.264	0.044	0.120	0.039	0.081
Range	0.881		0.313		0.118		0.962		0.085		0.303	
Constant	7.660	0.090	4.296	0.114	5.928	0.055	6.723	0.187	6.601	0.085	5.379	0.057
	Value	Sig.	Value	Sig.	Value	Sig.	Value	Sig.	Value	Sig.	Value	Sig.
Pearson's R	0.965	0.000	0.778	0.000	0.921	0.000	0.868	0.000	0.875	0.000	0.923	0.000
R^2	0.931		0.605		0.849		0.753		0.765		0.852	
Kendall's tau	0.767	0.000	0.510	0.003	0.628	0.000	0.717	0.000	0.700	0.000	0.783	0.000

Item	UMTS phone / text info / back-up off.		UMTS phone / speech info / register_system		Head-up disp / short code / back-up off.		UMTS phone / image info / control room		Touchscreen / image info / register_system	
	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error	Utility	Std. Error
Not moving	0.166	0.062	0.212	0.109	0.034	0.072	0.132	0.074	0.087	0.064
Driving	-0.166	0.062	-0.212	0.109	-0.034	0.072	-0.132	0.074	-0.087	0.064
Range	0.332		0.424		0.068		0.264		0.174	
Emergency aid	0.203	0.097	0.172	0.171	0.001	0.113	0.113	0.115	-0.010	0.100
Speed control	-0.235	0.082	-0.106	0.146	0.044	0.097	-0.166	0.098	-0.076	0.085
Guidance	-0.032	0.097	-0.066	0.171	-0.045	0.113	0.053	0.115	0.086	0.100
Range	0.438		0.278		0.089		0.279		0.162	
I-centric	0.160	0.062	0.039	0.109	0.103	0.072	0.029	0.074	0.085	0.064
WE-centric	-0.160	0.062	-0.039	0.109	-0.103	0.072	-0.029	0.074	-0.085	0.064
Range	0.320		0.078		0.206		0.058		0.170	
Route info	-0.073	0.107	-0.067	0.190	0.083	0.126	0.125	0.128	0.434	0.111
From registers	0.077	0.107	0.001	0.190	-0.009	0.126	-0.023	0.128	0.190	0.111
Briefing	0.071	0.107	-0.058	0.190	0.150	0.126	-0.127	0.128	0.240	0.111
Announcement	-0.075	0.107	0.124	0.190	-0.075	0.126	0.025	0.128	-0.864	0.111
Range	0.152		0.191		0.225		0.252		1.298	
Channel available	0.030	0.062	-0.018	0.109	0.030	0.072	0.003	0.074	-0.040	0.064
Channel not-available	-0.030	0.062	0.018	0.109	-0.030	0.072	-0.003	0.074	0.040	0.064
Range	0.060		0.036		0.060		0.006		0.080	
Direct availability	-0.273	0.103	-0.275	0.146	-0.089	0.097	-0.196	0.097	-0.349	0.085
Max. 5 minutes waiting	0.159	0.120	0.182	0.171	0.108	0.113	0.182	0.113	0.312	0.100
Not available	0.144	0.120	0.093	0.171	-0.019	0.113	0.014	0.113	0.037	0.100
Range	0.432		0.457		0.197		0.378		0.661	
Constant	3.793	0.068	4.310	0.121	5.883	0.080	3.748	0.081	7.776	0.071
	Value	Sig.	Value	Sig.	Value	Sig.	Value	Sig.	Value	Sig.
Pearson's R	0.937	0.000	0.804	0.000	0.779	0.000	0.845	0.000	0.972	0.000
R^2	0.877		0.647		0.607		0.714		0.945	
Kendall's tau	0.695	0.000	0.711	0.000	0.533	0.002	0.561	0.001	0.819	0.000

Group communication
In an 'I-centric' context the largest increase is attributable to the mobile terminal using speech towards the control room (0.278). However, the screen on the handle-bar with the control room as intermediating party also increases (0.153), still making it most suitable. The 'We-Centric' concept shows opposite results, making the touchscreen with info from registers most suitable (- 0.085)

The type of information
Scanning through the utilities of all information types the first important conclusion is that the different utilities are much larger than for other factors. The type of information plays an important role in determining the suitability of the items. This can also be seen from the different ranges presented below in table 4.6. The first type of information is 'route information'. Receiving the information on a touchscreen is highly rated, especially when the modality is an image and the information comes from registers or systems (the utility is 0.434). For briefing information the touchscreen also proves most appreciated (0.335). For 'information from police registers' both screens on the handle-bar have utilities of around 0.2 and 0.25. The highest utilities are for item 4 (0.346) and 5 (0.284). This seems odd at first, but due to the fact that MPO's are very much used to retrieving register information from the control room the figures are correct. Also, the user interface plays an important role here, and this was not taken into consideration. Lastly, 'giving an announcement' is examined. Both items using a screen on the handle bar show very negative utilities (-0895 and -0.864), making them unsuitable. As the graph shows strange utilities for the mobile terminal/control room combination, we refer to the conclusion made when focusing on the means per context.

Data channel availability
For data channel availability there are two levels, 'available' and 'not available'. The factor is a bit vague compared to the other factors and this is grounded by the figures. All utilities lie between -0.07 and +0.08, making them ignorable. No conclusions are drawn from this factor.

Control room availability
As could be expected, the utility of the mobile terminal using speech with the control room is positive and high for the level 'control room available' with a utility of 0.458. The other items all show a negative utility; making communication by speech through the mobile terminal most suitable according to MPO's when it is available and other context aspects remaining equal. When the MPO needs to 'wait a maximum time of 5 minutes for the control room to become available', the mobile terminal/ control room has a negative utility of -0.504 and the screen on the handle-bar with text information from the control room has the highest positive utility with 0.501. This seems strange considering the fact that the MPO has to wait for the control room, but maybe the MPO understood that information from the control room could still be send by using text. Image information from registers on a screen has the second highest utility of 0.312. The difference between both is not that big. When the 'control room is not available' the screen on the handle-bar retrieving image information from registers is again most suitable.

Factor importance level

The last part of the conjoint analysis is to determine the importance of each factor for each item. Finding the importance requires the ranges of each factor to be calculated. The range is the difference between the highest and lowest part-worth utility of the levels of a factor. Next, the sum of each range of all factors is calculated and the contribution of each factor to the sum of ranges is expressed in a percentage (Molin, 2006). The percentages can be interpreted as the importance of each factor. Table 4.6 shows the importance levels of each factor for all items.

As mentioned earlier the importance of the information type is highest which is coherent with the results from the TAM/TMF model measurements. The second most important factor is the control room, followed by the task. The data-channel availability is clearly not important, possibly due to the vagueness of the factor. As this was more or less expected, it shows the conjoint analysis technique proves to be valuable in assessing different context aspects in relation to items used for mobile communication.

Item	Factor Mobility	Task	Group communication	Information type	Data channel	Control room
Touchscreen / Text info / controlroom	10.7%	9.3%	9.7%	38.1%	4.3%	27.9%
UMTS phone / speech info / control room	23.5%	33.4%	6.7%	10.5%	2.9%	23%
Head-up display/ text info / control room	27.2%	6.8%	35.6%	22%	7.4%	11%
Mobile terminal / speech info / control room	2.5%	26.5%	16.4%	22.8%	3.8%	28%
Mobile terminal / speech info /back-up officer	18.8%	12.1%	21.1%	39.4%	2.5%	6.1%
Mobile termin / text info / register_system	22.9%	22.5%	2.7%	18.8%	11.5%	21.6%
UMTS phone / text info / back-up officer	19.1%	25.3%	18.5%	8.8%	3.5%	24.8%
UMTS phone / speech info / register_systems	29%	19%	5.3%	13%	2.5%	31.2%
Head-up display / short code / back-up officer	8%	10.5%	24.4%	26.6%	7.2%	23.3%
UMTS phone / image info / control room	21.3%	22.6%	4.7%	20.4%	0.4%	30.6%
Touchscreen / image info / register_systems	6.8%	6.4%	6.7%	51%	3.1%	26%
Average	17.3%	17.7%	12.8%	24.7%	4.5%	23%

Table 4.6: factor importance per item (green is highest importance, red is lowest)

4.3.4 Conjoint analysis validation

This step is necessary to assure that the results from running the analysis reflect the reality. Due to the problem of missing values the validation phase requires considerable attention. The validation process involves three steps: face validity, checking the individual data and a goodness of fit test. Each validation part is explained according to the respective order.

Face validity

The first task is to revise the results from the analysis and see if the utilities fit the expected results based on common sense and talks with MPO's (Molin, 2006). It is impossible to say if numbers are correct, but some proportions of the figures can be checked against knowledge available on the topic. Due to the fact that it is a scan of the results based on available knowledge, just some comparisons can be made. Consequently, the face validity is used as a general check to see if very strange results come out of the analysis of the data.

The talks with the MPO's (Interview Veendam, Doorwerth, Driebergen, Den Haag, Amsterdam, 2007) indicated that they all found a screen on the handle-bar showing information a significant progress. Reviewing the results of the item constants (Appendix D) and all means of the ratings (Appendix E) shows that in almost all context situations the screen on the handle-bar is highly rated.

Another important aspect is the direction of the utilities for different context levels. The results which can be grounded by the results of the interviews or means are mentioned briefly to ensure valid results. When driving on a motorcycle, it is much more troublesome to use a device compared to when an MPO is standing still. The utilities show the same conclusion; the results show a positive utility for speech info from the control room on the mobile C2000 terminal while driving. Secondly, an emergency aid task requires the information to come fast and accurate (Interview Den Haag; Amsterdam, 2007). Here, the results show a large utility increase for the speech info through the mobile C2000 terminal. Staying at the factor 'task', the level 'guidance' shows a correlation between interview knowledge and the conjoint results. When an MPO is executing a guidance task, communication between colleagues and the vehicles that need to be guided is essential (Interview Amsterdam, 2007). The channel used for communication is usually a dedicated line between these actors, whereby the control room is not directly involved. Based on this knowledge, the utilities of the control room dependent items are most likely negative. The results show a similar pattern. A fourth clear proof can be seen at the 'I-Centric communication' level. In an I-Centric situation the MPO operates alone. Operating alone creates a situation in which the MPO becomes more dependent on the control room for information, as no other colleagues can be called upon. The results show an increase of all utilities for the items communicating through the control room. Focussing on 'route information' and on how this information should be given to the MPO, the results seem to be valid. In some interviews the need for route information has been indicated (Interview Doorwerth, Driebergen, 2007) and the usage of a screen on the handle-bar was proposed as the most suitable way of showing the route. The utilities for route information show a high preference for a screen on the handle-bar which fits the findings of the interviews. The last review of the results presents a problem.

The last aspect requiring a detailed face validity are the results of two levels from the factor 'information type'. At the level 'briefing information', the utility for speech information through the mobile terminal from the control room shows a considerable increase. The 'giving an announcement' level shows an opposite pattern. Although no concrete information is available from the interviews, using the means gives a different image. Making a conclusion about the 'briefing information' level is unreliable, but the 'giving an announcement' level seems to be clear. The mean of the item is highest for two of the three context situations where giving an announcement is needed. Thinking of the situation the MPO is in, this conclusion seems credible. Giving information is fastest through the mobile terminal directly to the control room, especially when on a motorcycle. In the case of the level giving an announcement the choice is made to use the means presented in Appendix E.

Concluding the face validity, results from the conjoint analysis fit the knowledge available on MPO work. One result was found that didn't fit the expectations based on the means and common sense. Given the fact that many missing values occurred an error is unavoidable. The results are chosen as valid from a face validation point of view.

Checking the individual data

The following step in validating the results of the conjoint analysis is done by checking the individual data. The conjoint analysis is executed on the individual data of all respondents, but some individual data might cause misleading results requiring the removal of that data. The statistical method used to find misleading data is called 'Kendall's tau'. The definition of Kendall's tau is the following: "Kendall's tau is a measure for the strength and direction of the correlation between two variables, resulting in a number between -1 and +1" (Hair, 1998). If the number is close to 0, a weak correlation between variables exists for the individual data, if close to 1 the correlation is strong. In order to select individual data to be removed, the significance level was used for each Kendall tau correlation and set at $p>0.05$. This means that if p is higher, the outcome is statistically not significantly different from 0. Table B.9 of Appendix B shows the removed respondents with the significance level per item.

Goodness of fit: R^2

The third validation phase for a conjoint analysis is by examining the goodness of fit of the model that comes out of the analysis. Deciding how a model fits is by checking the "proportion of variability in a data set that is accounted for by the model" (Hair, 1998). The proportion referred to is called the R^2. Using a less statistical definition: "R^2 is a measure for the homogeneity of the individual preferences" (Molin, 2006). Table 4.7 shows all Pearson's R outcomes from the CONJOINT method and the subsequent R^2 outcomes.

The interpretation can be done as follows: 'for Item 1 R^2 is 0.931. This means that 93,1% of the variance in item 1 is declared by the variables used to create the model.' According to Molin (2006), a declared variance of 45% is already an acceptable amount for a conjoint analysis with individual data. All items fall above 45% meaning that all 11 models fit. The only remark that needs to be made is an increase of R^2 on account of the MVA method used to make the data usable. As the MVA method uses the data which is available to determine new values replacing the missing values, the variance of the model decreases. As a consequence, the model shows a better fit. As the lowest R^2 value (0.605) is still considerably above the 0.45 boundary the assumption is made that all models are valid.

Item	Pearson's R	R^2
Touchscreen / text info / control room	0.965	0.931
UMTS phone / speech info / control room	0.778	0.605
Head-up display/ text info / control room	0.921	0.849
Mobile terminal / speech info / control room	0.868	0.753
Mobile terminal / speech info /back-up officer	0.875	0.765
Mobile terminal / text info / register_system	0.923	0.852
UMTS phone / text info / back-up officer	0.937	0.878
UMTS phone / speech info / register_systems	0.804	0.647
Head-up display / short code / back-up officer	0.779	0.607
UMTS phone / image info / control room	0.845	0.714
Touchscreen / image info / register_systems	0.972	0.945

Table 4.7: Pearson's R and the R^2 per item

4.4 Conclusions of the quantitative research part

This chapter finds an answer to the following question: What influences MPO's intention to use mobile information systems and which mobile information system provides the highest value in the different context situations? The answer to this question has two parts and is answered by two researches with MPO's. The first is to define how value is created by a communication system for MPO's. To answer this first part three hypotheses are defined, based on the Technology acceptance model (Davis, 1989), combined with task-media fit (Daft & Lengel, 1986). The first hypothesis is defined as follows:

H1. the perceived ease of use, perceived usefulness and task-media fit have a positive influence on the intention to use a communication system.

The hypothesis is not entirely correct when reviewing the TAM/TMF models that result from the data. The perceived ease of use does not directly influence the intention to use. Also, the perceived usefulness only positively influences the intention to use if the usefulness of the system is defined as resource / information advantage. Looking at the task-media fit, only the information exchange media fit influences the intention to use positively in the model.

The second hypothesis is the following:

H2. the perceived ease of use has a positive influence on the perceived usefulness and the task-media fit of a communication system.

As with the first hypothesis, the second hypothesis partly stands. The ease of use influences the perceived usefulness but only for the resource / information advantage the communication system delivers. For the task-media fit dimensions, only the decision-making fit is positively influenced by the ease of use of the system.

H3. the perceived usefulness has a positive influence on the task-media fit of communication systems.

The last hypothesis is completely grounded by the models measured by the data. For all dimensions of both the perceived usefulness and the task-media fit assumptions, the perceived usefulness positively influences the task-media fit.

For the second part of the research question a conjoint analysis is executed. We combined the results of the first and second part of this research chapter by stating the following conclusions:

- The perceived usefulness of mobile communication systems has a considerable effect on the intension to use such a system. However, the importance of the perceived usefulness is not founded by the MPO's themselves. In practical terms; MPO's will need to be further persuaded of the usefulness of the system for their tasks. This can be achieved by working closely together in the development phase of the mobile communication system. The intension to use will then further increase.

- The ease of use of a mobile communication system does not influence the intention to use directly, but does influence the resource advantage, consequently influencing the intention to use.
- By making the system very easy to use by MPO's, the potential of decision making increases. This requires the system to adapt to any situation the MPO is in by always finding the right ease of use in relation to the information richness.
- The information exchange media fit assumption is most the important aspect of a communication system to MPO's. It further influences the intention to use the system.
- In most situations, using a touchscreen capable of clearly displaying different types of information to the MPO is seen as the best option.
- The choice of the intermediating party and the modality depends on the context situation. Looking specifically at the information types; it seems route information is best to be send as images, whereas briefing information and information from registers is preferably received as text.
- A head-up display and the use of UMTS phones are never rated as best option.
- Emergency aid tasks always need to be supported through vocal information from the control room. A touchscreen is usable, but probably just for information presentation. Other tasks can solely be supported by the use of a touchscreen.
- Sending information by the MPO is preferably done by using speech directly to the control room. Entering information in a system is much more troublesome compared to talking directly to the control room in an MPO working situation. Also, sending the information to the control room helps in speeding up the coordination which might be needed in succeeding steps
- Receiving information from the control room when it is available is still most preferred, if other factors are ignored. Considering the fact that MPO's are used to communicating directly to the control room the preference makes sense. Consequently, for the transition from the old system to a new system to be successful requires a lot of attention, training and persuasion.
- MPO's do not want to wait for the control room to become available; receiving information on a touchscreen is clearly preferred if no direct contact is available. In case the control room is surely not available retrieving information from registers is highly rated.

5. Context-aware service bundling design for MPO's

5.1 Introduction

The previous chapters provide a variety of information on the needs of MPO's regarding information provisioning. The knowledge retrieved from the interviews, the quantitative research and the theory available on context-aware services and service bundling must now be used to design a context-aware service bundling model for MPO's. The aim of the design is to increase the customer value, requiring the following question to be answered in this chapter:

> *What is the conceptual design of context-aware service bundling and what are its requirements to increase value to the MPO?*

It is important to alter our definition of a service from Grönroos (2000), presented in chapter one, who defines services as 'intangible'. The service design of this thesis contains a large intangible part, but also a tangible part. This tangible part is the device of the information system, which is considered as an important aspect of the total service design. By altering the definition the research question for this chapter embraces the whole meaning of the conceptual service we intend to design.

This design chapter is structured as follows. Primarily an overview of the designed service is given. The service is explained by the use of a UML model and requirements stating the functions each part of the model has to suffice in order to create the increasing value to the MPO. Due to the complexity of the model the list of requirements is extensive. After the explanation of the service, the critical design issues of a service offering presented by Bouwman (2006) are discussed.

5.2 The context-aware service bundling model for MPO's

The centre piece of this thesis is to explain what the service is and how it is capable of providing a high value to the MPO's. For this thesis, a concept of the service is designed, not a final implemental version. The service concept is seen as a first version of the service which can be used to test with users in order to check whether it creates the value the user's desire. To define the service concept we make use of the theory proposed by Savimaa (2006): "The model must be accurate, inexpensive, understandable and predictive. The most suitable modeling language to present an overview of the service is UML". The objects, properties, and relationships of UML are three powerful abstractions with which we can think about and describe most of the things we encounter in our everyday world (and indeed the technical and virtual worlds too) and therefore provides a fitting modeling language for our context-aware service representation (Ariza, Rodrigues & Pascoe, 2006). UML models can also easily be used for object-oriented software programming languages based on the UML methodology (e.g. Java).

A final reason for choosing UML is its possibility to extend the model by simply adding classes and updating the production rules. Extendibility is an important requirement defined in chapter 3. It makes sure unforeseen, but necessary factors can be added in later phases of the development. Also, if factors negatively influence the service they can easily be removed. The context-aware service bundling model concept is presented in two parts. First a UML representation of the information needs is shown and explained which is based on the task analysis of chapter 3. This first part is one of the context factors as defined by the MPO-context of chapter 3.

5.2.1 Model of the information needs

Based on the knowledge retrieved from the task analysis and the information to support the tasks, a hierarchical representation is needed to be used in the total service design. As the purpose of our research is a conceptual design of an information provisioning service, information is key. By using UML each needed information group is identified as a class in which the attributes are information aspects needed to perform a task. The methods (or operations) are based on the attributes requesting the information of the attribute to execute the task successfully. By choosing UML, coupling the information needs of each task to other aspects of the context-aware service provisioning system is structured and easier to interpret. The UML structure of the information needs is presented in figure 5.1 below.

The role of time is not included in a UML diagram. In an exact task analysis, time does play an important role. However, the UML diagram provides a basic model to further develop into sequence or activity diagrams which include the aspect of time and the different steps needed to execute a task (Kirwan & Ainsworth, 1992). For this research the activity diagrams are not included, but a sequence diagram example is added to clarify the usage of the total service model in paragraph 5.3. Creating sequence or activity diagrams for MPO's takes a lot of time as each task requires a new diagram to be made. In follow-up research, activity diagrams must be created to complete the task analysis.

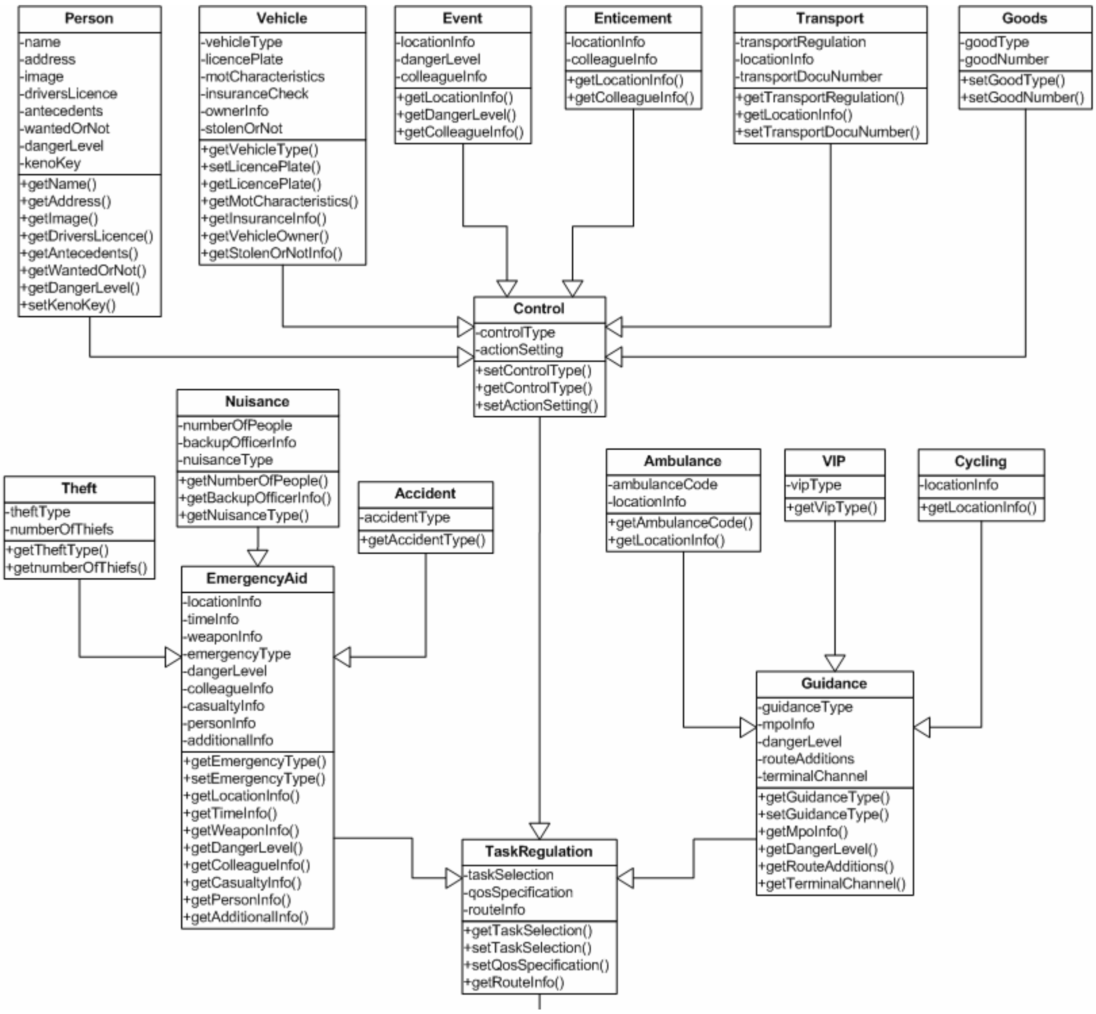


Figure 5.1: UML representation of MPO information types according to task

A brief explanation is given on how to interpret the UML diagram of figure 5.1. The main class is the TaskRegulation class, which regulates the task selection and required information support to the service. The task analysis showed that there are three main task groups (emergency aid tasks, control tasks and guidance tasks), each represented by a sub-class of the TaskRegulation class. As the sub-classes are connected through arrows (called 'generalization'), the attributes and methods account for all sub-classes of the upper-class. The three task classes are further divided in possible sub-classes based on the information needs to support the tasks for that class. An example makes this relation more clear. Traffic MPO's mostly perform control tasks, meaning that we focus on the Control class for now (regulated by the TaskRegulation class). Usually, the MPO starts by checking the license plate, thereby requesting the various Control methods of the class to retrieve information about the vehicle after having transmitted the license plate number to the system or person. In this case the received information by the MPO indicates something is wrong with the car, so the car is stopped by the MPO. After having checked the car, the MPO finds suspicious goods in the car. A 'good' is not a vehicle, therefore the Control class must now execute the methods from the 'Goods' class. The information retrieved presents the information needed to assess the legality of the goods.

Although not shown in figure 5.1, certain classes are related to each other. Usually, related classes are connected through links. In this case the UML diagram does not show possible links, as the diagram would become disorderly and very complicated for the reader to interpret. In an implemental service model, the links need to be included to indicate the relations. The reason for discussing these relations is because they form an information bundling requirement. Again, an example is given to further clarify. A required link would be between the 'Vehicle' class and the 'Transport' class. A vehicle can also be a truck transporting a transport load that has to suffice certain transport regulations. The transport documents must include the vehicle license plate number and in this way both are connected. By bundling both information classes the MPO can check whether the load of transport is coherent with the allowed load of the truck. The importance of the links as explained by the example is high and there are many. To give another example; if a weapon (from the Good class) can be checked, but not the person (Person class) registered as the owner, lots of valuable information to perform control tasks is lost. In a final design of the service, all the links are needed to suffice the qualitative information definition. The development of these links (and bundling composition) must be formed with the MPO's themselves to make sure the information richness fits their demands.

5.2.2 Model of the context-aware service bundling

The next step is the creation of the UML model representing the main classes of the context-aware service bundling model for MPO's. The model is presented in figure 5.2. It can be used as a start-up concept for programming the service in an object oriented language (e.g. Java, C, C++). The objects are formed out of the classes presented in the diagram of figure 5.2. Part of the total service design is the UML model presented in figure 5.1. The total model is complex, so the different classes are explained to clarify their function. To start with, the focus is on the red (either combined with blue or not) classes in the model. These classes (TaskRegulation, ControlRoom, Time, Location, Speed, MPOStatus, NetworkManager, MobileTerminal) represent the MPO-context factors identified in chapter 3. TaskRegulation represents the factor 'task', ControlRoom represents the factor 'control room availability', MPOStatus represents the factor 'status', NetworkManager represents the factor 'network availability' and MobileTerminal represents the factor 'group communication'.

The MPO-context classes provide the input to the ContextManager, to determine the correct information provisioning usage for the MPO. As can be seen, the ContextManager class is blue in figure 5.2, meaning that it is based on the context-aware concept of AWARENESS and Alonistioti & Panagiotakis (2006) explained in chapter 2.3. The other blue (either combined with red or not) classes are also based on the context-aware service concepts. The UserProfile class functions as user management (Van Beijnum et al., 2004).

Location is a MPO-context factor, but also named as an important source by Alonistioti & Panagiotakis (2006). The DeviceManager provides the terminal capabilities and the PresentationLayer corresponds with the user interaction of Alonistioti & Panagiotakis (2006). Finally, the NetworkManager represents the group of registers mentioned by both concepts of chapter 2.3.

The uncoloured classes remain unexplained. These classes are explained as three groups. Firstly, we focus on the classes connected to the DeviceManager class (GPS, NavigationSoftware, TempStorage, Camera, Touchscreen and AudioSystem). Each class represents a technical device needed to deliver information to and from the MPO. The exact functioning of each device is further explained in chapter 8. The second group is represented by the three network classes (UMTS, GPRS/GSM, C2000) connected to the NetworkManager class. These classes stand for the mobile networks chosen for the service. An elaborate explanation on the choice of these three network technologies is given in chapter 8. The last group is also connected to the NetworkManager class, but represents the available information sources or registers. The choice of registers is based on available Policing information provisioning platforms (P-Info) and each function is explained in chapter 8.

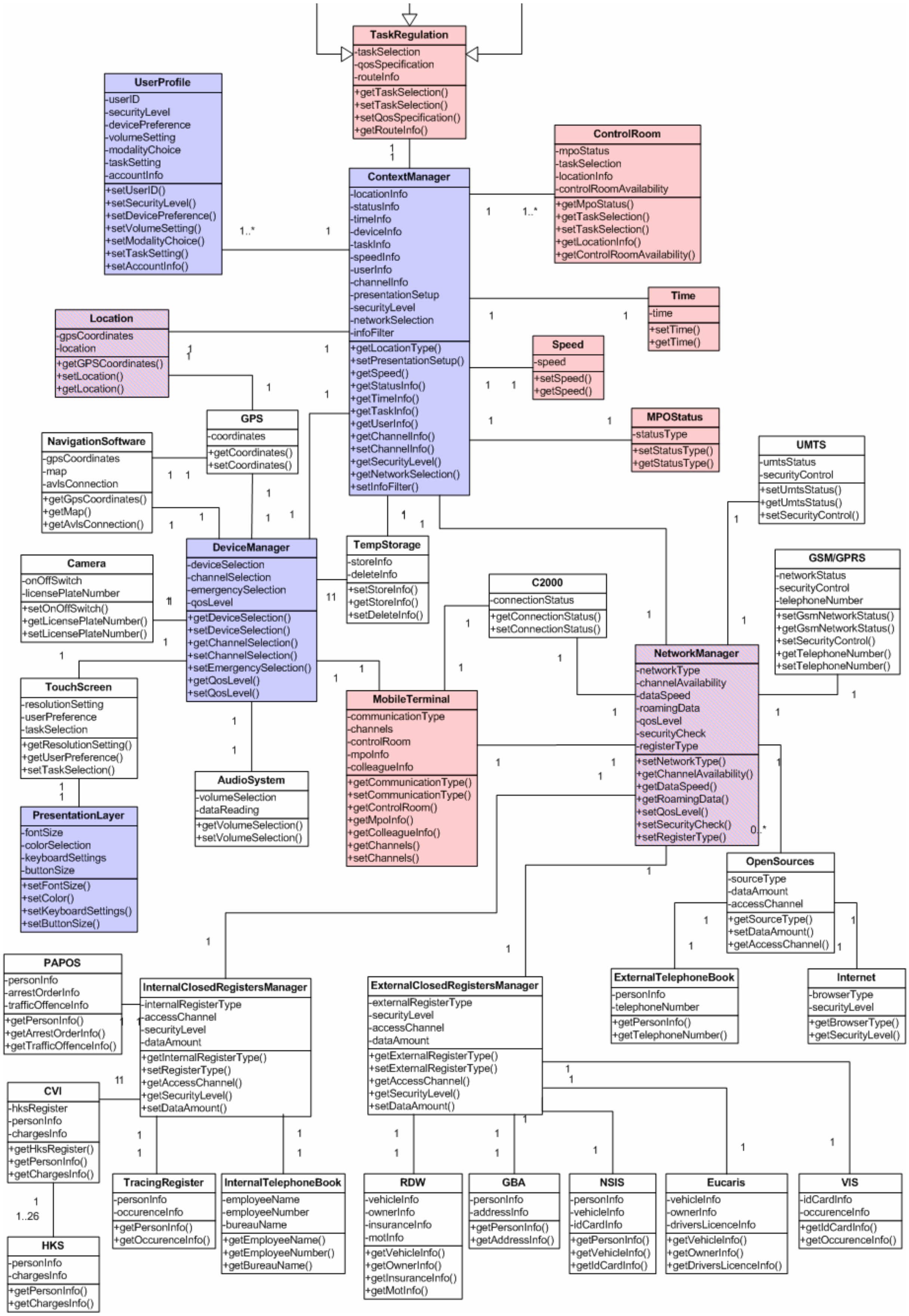


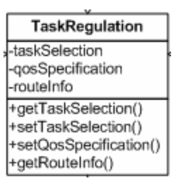
Figure 5.2: UML model of the context-aware services bundling for MPO's

Having discussed the classes presented in the UML model, a general explanation is given on the interpretation of the total model and important connectivity choices. The top class is the TaskRegulation module which sends the task selection made by the MPO to the ContextManager. The ContextManager module is the central control module of the system bundling the different services supporting the total context-aware service. It uses production rules (if-then statements) to define the correct information source and devices based on the chosen task and the different context factors it continuously receives information from. The exact choice of device used to operate the system and present the information to the user is defined by the DeviceManager. The information sources are accessed through the NetworkManager constantly updating the available networks and using the QoS levels needed to fulfil the task according to the task-defined QoS level. The NetworkManager controls access to internal police registers, external closed registers and open sources like the phone books and the internet if requested by the MPO. There are three available networks: the national C2000 network for internal police communication through speech or low bandwidth data communication C2000, the UMTS network for high bandwidth data communication and the GSM/GPRS network for direct phone calls and medium bandwidth data communication if needed. The choice of network and information sources is further explained in chapter 8. The following paragraph defines the different requirements per module in detail for the service to function.

5.3 The requirements of the model

To explain the functioning of the various UML classes, requirements have been defined according to the knowledge retrieved from the previous research phases and literature available on context-aware service bundling. Requirements are statements that identify the essential needs of a system in order for it to have value and utility. Finally, the requirements should state what the system is to do, but they should not specify how the system has to do it (Bahill & Dean, 1999). For this research the requirements define the functioning of each class of the service according to the needs of MPO's. Requirements must satisfy the following properties: atomic, unique, identifies its owner, traceable and unambiguous. If defined by the 'must' statement are mandatory. The usage of 'should' in a requirement relates to a preference. In proceeding research, the requirements can be used to develop the production rules advised by Baida (2006), Akkermans et al. (2005). According to Hale, Stoop & Hommels (1990), production rules can also be used to define human error models capable of pinpointing aspects of the design which seem to provoke error and require modifications. Each requirement has a unique code, a description and a source. The source is mentioned between brackets behind the description and is assumed clear to the reader. First the various task analysis classes are treated, followed by the other service classes.

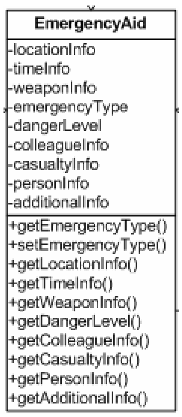
A) Task selection module:
If any task is requested:



A1. The module must set a specific task defined by the MPO. (MPO-context definition)
A2. Tasks can be pushed from the control room if MPO-status allows push (police work process)
A3. Emergency aid tasks can be pushed from a colleague requesting aid (current safety requirement)
A4. Guidance tasks must be pushed by the control room (police work process; interviews with MPO's)
A5. The module can get a specific task from the control room depending on the status of the MPO. (MPO-context definition)
A6. The module must define a QoS level based on the task selection of requirement A1. (Alonistioti & Panagiotakis, 2006; Ahmed, Kyamakya & Ludwig, 2006)
A7. The module must define the required network speed for information transmission for the QoS level of requirement A6 (Ahmed, Kyamakya & Ludwig, 2006).
A8. The module must define the lowest cost network access, giving priority to requirement A7 (Network cost reduction).
A9. The module should present route navigation whenever requested by the user. (Chapter 4 - TAM/TMF result (location overview))
A10. The module must present route navigation if destination is transmitted to system (Chapter 4 – TAM/TMF results (location overview))
A11. Information needed to be send from the MPO to the control room must always take place through the C2000 network by using speech. (Chapter 4 - Conjoint analysis result)

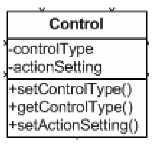
A12. The module must transmit all information to the context manager module. (Van Beijnum et al., 2005; Alonistioti & Panagiotakis, 2006)
A13. The module must present the danger level for each task if known (Interviews with MPO's; police safety).
A14. The module must show most needed C2000 channel for the region the MPO is in at a maximum of 3 channels (C2000; Interviews with MPO's)
A15. If receiving a task, the service must decide whether the task update is allowed or not based on police status regulation. (police work process; police safety)

B) Emergency aid module:
If an emergency aid is requested the module:



B1. Must set the MPO-status to "Emergency-Busy" (MPO-context definition; Police work process)
B2. Must give information through speech from the control room if available (Chapter 4 – Conjoint analysis result; Chapter 3, figure 3.1)
B3. Should present information on the touchscreen above the handle bar at all times (Chapter 4 – Conjoint analysis result)
B4. Must provide a dedicated C2000 communication channel with colleagues involved (Chapter 4 – TAM/TMF result (information exchange); Chapter 3, figure 3.1; Police work process; Police safety)
B5. Must set the type of emergency based on emergency request information. (Interviews with MPO's)
B6. Must present a button to indicate suspect is seen (Police work process automation)
B7. Must present a button to assert suspect if the button of B6 has been pressed (Police work process automation, safety measure)
B8. Must present a button to abandon motorcycle if the button of B7 has been pressed (Police work process automation, safety measure)
B9. Must send all status updates of requirements B6, B7, B8 to the 'ControlRoom' class (safety measure, service practicality)
B10. Should present specific information about casualties if casualty information is available. (Chapter 4 – TAM/TMF result (information necessity); Interviews with MPO's)
B11. Should present specific information aimed at the type of emergency aid situation based on methods of the chosen class (Chapter 4 – TAM/TMF result (information necessity); Interviews with MPO's; service practicality).
B12. Should minimize attention of the MPO to the screen (Pica & Sorensen, 2004)
B13. Should minimize operations towards any information system (Pica & Sorensen, 2004)

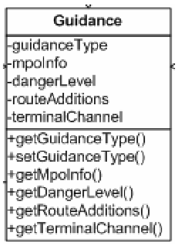
C) Control module:
If a control task is selected the module:



C1. Must set the MPO-status to "Control-Busy" (MPO-context definition, Police work process)
C2. Must present information on the touchscreen above the handle-bar, except for the 'Event' and 'Enticement' (Chapter 4 - Conjoint analysis result; Chapter 3, figure 3.1)
C3. Must present all information sub-classes of the 'Control' class if speed = 0 (Chapter 3, figure 3.1; Interviews with MPO's)
C4. Must check for irregularities by executing methods of 'controlType' class chosen (Chapter 4 – TAM/TMF result (information necessity); Interviews MPO's; P-Info).
C5. Must only present the option of a persons check directly from drivers license connected to license plate if speed > 0 (Chapter 4 – TAM/TMF result (ease of use); Police information platform standard; safety usage measure)
C6. Primarily must only show if irregularities exist yes or no if speed > 0 (Chapter 4 – TAM/TMF result (ease of use); Chapter 4 – TAM/TMF result (information necessity); Chapter 3, figure 3.1; safety usage measure)
C7. Must present the option of showing all person's irregularities found on databases is speed = 0 (Chapter 4 – TAM/TMF result (information necessity); Chapter 3, figure 3.1)
C8. Must only present the option of a vehicle check by licence plate number if speed > 0 (Chapter 4 – TAM/TMF result (ease of use); Police work process, safety usage measure)
C9. Must present license plate number based on 'Camera' class methods execution if speed > 0 (Chapter 4 – TAM/TMF result (ease of use); safety usage measure)
C10. Must present a button to assert suspect if irregularities exist in requirement C6 or C7 (Police work process automation, safety measure)
C11. Must present a button to abandon motorcycle if the button of C11 has been pressed (Police work process automation, safety measure)
C12. Must send all status updates of requirements C11, C12 to the 'ControlRoom' class (safety measure, service practicality)
C13. Must execute all methods of chosen subclass if speed = 0 (Chapter 4 – TAM/TMF result (information necessity); P-Info V2.1; Police work process)
C14. Must provide information through speech if 'Event' task is selected (Chapter 3, figure 3.1)
C15. Must provide information through speech if 'Enticement' task is selected (Chapter 3, figure 3.1)

D) Guidance module:

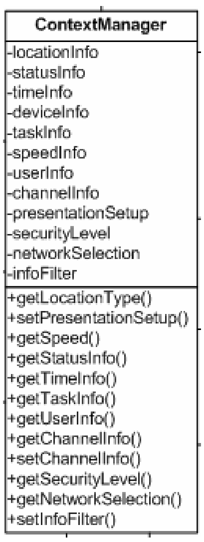
If a Guidance task is send to the MPO, then the module:



D1. Must set the MPO-status to "Guidance-Busy" (MPO-context definition; Police work process)
D2. Must present information on the touchscreen above the handle-bar (Chapter 4 – Conjoint analysis result)
D3. Must present information through speech if 'Ambulance' task is selected (Chapter 3, figure 3.1)
D4. Must present information through speech if 'Cycling' task is selected (Chapter 3, figure 3.1)
D5. Must switch to C2000 MPO-colleagues channel allocated to the same task (Chapter 4 – TAM/TMF result (information exchange); Interviews with MPO's)
D6. Should show additional information regarding the route (Chapter 4 – TAM/TMF results (location overview); Interviews with MPO's)
D7. Must present the communication channel of involved public order colleagues other then MPO (Chapter 4 – TAM/TMF result (information exchange); Interviews with MPO's, Police work process)
D8. Must execute all methods of subclasses set by control room. (Police work process)

The succeeding step is to define the various classes of the context-aware service making use of the task regulation classes. Only the most important classes are discussed. The classes of the UML model not discussed are considered clear.

E) Context source and management module:

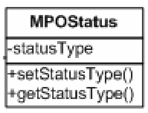


E1. Must act as the general link between information requests and the provision of information via connected classes (Van Beijnum et al., 2005; Alonistioti & Panagiotakis, 2006)
E2. Must be defined by production rules (Baida, 2006)
E3. Must be aware of the task the MPO is performing (MPO-context definition)
E4. Must continuously be aware of all context source available by executing class methods (MPO-context definition; Alonistioti & Panagiotakis, 2006)
E5. Safety requirements are always dominant over other requirements. (safety usage measure).
E6. Must present all tasks an MPO must perform defined by its regional department (Police work process; RBP, 2006)
E7. Must offer preference settings per user (Van Beijnum et al., 2005)
E8. Must use user preference settings from 'UserProfile' class (service practicality).
E9. Shall function if log-in approval is granted by 'UserProfile' class (Police security measure).
E10. Must filter information provided information based on task requirements (service practicality)
E11. Must define the user status as "Available" if the user is logged in and not performing any task (MPO-context definition)
E12. Must provide a final option of sending task information (location, time, task, retrieved information) to the 'accountInfo' of the 'UserProfile' class (Interviews with MPO's; Administration aid)
E13. Must delete all temporary data from system after each task execution (privacy regulations)

F) Time service module:

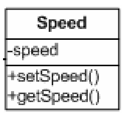
F1. Must continuously update time (MPO-context definition)
F2. Must present time when requested (service practicality)

G) MPO-Status module:



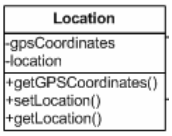
G1. Must set MPO status according to chosen task by user or control room (Police work process; MPO-context definition)
G2. Must present MPO status when requested (service practicality)

H) Speed module:



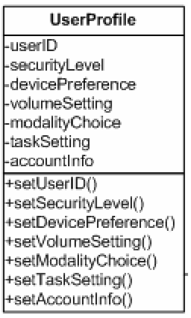
H1. Must continuously update current speed of MPO (MPO-context)
H2. Must present speed when requested (service necessity)

I) Location module:



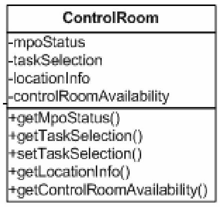
I1. Must continuously keep track of the location the MPO is at (Alonistioti & Panagiotakis, 2006; MPO-context definition)
I2. Must adapt to location change (Alonistioti & Panagiotakis, 2006; service necessity)

J) User profile module:



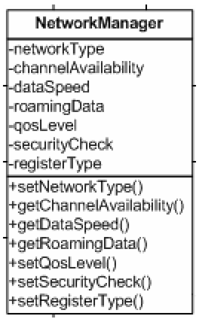
J1. Must provide presentation settings to the user (Alonistioti & Panagiotakis, 2006)
J2. Usage of service is based on correct userID and security check defined by vtsPN (P-Info V2.1; security necessity)
J3. Must execute all methods enlisted in class the first time using the system (user profile practicality)
J4. Must execute all methods enlisted in class if requested by the user (user profile practicality)

K) Control room communication module:



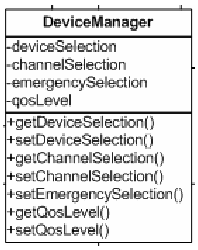
K1. Must continuously update control room availability (Chapter 4 – Conjoint analysis results; service practicality)
K2. Must send MPO-status update to control room (Police work process; Police safety)
K3. Must allow task push from control room (Police work process; Interviews with MPO's)
K4. Must send location update to control room if requested (Police safety; AVLS)

L) Network management module:



L1. Must continuously keep track of all available communication networks (Hybrid network; Vergouwen, 2006)
L2. Must switch to other network if used network signal is going to be too weak for transmission (Hybrid network; Vergouwen, 2006).
L3. Must choose communication network based on QoS demands (Information quality; Alonistioti & Panagiotakis, 2006; Ahmed, Kyamakya & Ludwig, 2006; Information safety measure)
L4. Must continuously define data speeds of available networks to assure QoS demands (Ahmed, Kyamakya & Ludwig, 2006)
L5. Must authenticate between connected information sources and user (P-Info; security measure)
L6. Must set the appropriate register type based on information requests (service practicality)
L7. Must transmit information requests to 'InternalClosedRegistersManager' class (Chapter 4 – TAM/TMF result (information necessity); Architectuur PSH, 2006; P-Info V2.1)
L8. Must transmit information requests to 'ExternalClosedRegistersManager' class (Chapter 4 – TAM/TMF result (information necessity); Architectuur PSH, 2006; P-Info)
L9. Should offer connection to 'OpenSources' class (Chapter 4 – TAM/TMF result (information necessity); Architectuur PSH, 2006; Interviews with MPO's)

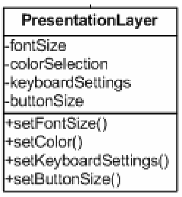
M) Device management module:



M1. Must transmit received information to 'Touchscreen' class (Chapter 4 – Conjoint analysis results)
M2. Must connect 'AudioSystem' class if requested by task selection (Chapter 4 – Conjoint analysis results; Interviews with MPO's)
M3. Must control 'MobileTerminal' class based on incoming requests (C2000 usage)
M4. Must change to any C2000 channel needed (Chapter 4 – TAM/TMF result (information exchange); C2000 usage; Interviews with MPO's)
M5. Should present most important C2000 channels based on requirement A14 (C2000 usage; Interviews with MPO's)
M6. Must control 'Camera' class if requested by task selection (service practicality)

M7. Must control 'NavigationSoftware' class if requested by user (Chapter 4 – TAM/TMF results (location overview); Service practicality)
M8. Must store retrieved information in 'TempStorage' class (avoid 'redownloading'; Service practicality)
M9. Must instantaneously connect the MPO to the 'ControlRoom' class if emergency button has been pushed (Police safety measure)
M10. Must send emergency request to all police officers in the proximity of the MPO (IPOS, 2004)
M11. Must send the location of the MPO to all police employees contacted through M9 and M10 (IPOS, 2004)

N) Presentation module:



N1. Must present all needed information sources defined by task class if speed = 0 (Chapter 4 – TAM/TMF result (information necessity); Interviews with MPO's; Information quality)
N2. Must present no more than 2 operation buttons if speed > 0 (safety usage measure; Interviews with MPO's)
N3. C2000 channels are not included as buttons of requirement N2 (service practicality)
N4. Must always present an emergency button (Police safety measure, Interview with MPO's)
N5. Emergency button is not included as button of requirement N2 (service practicality)
N6. Must present all information received by the 'DeviceManager' (service practicality)
N7. Should increase font size if speed > 0 (safety usage measure)
N8. Must provide keyboard entry if needed by task when speed = 0 (safety usage measure, service practicality)
N9. Colour usage must be coherent with content (IPOS, 2004)
N10. Sound level must be coherent with level of importance (IPOS, 2004)

As explained before, the requirements of each class indicate what function the class has to fulfill in order to create value for the MPO using the service. Of a few classes no requirements have been determined as their function is assumed straightforward given the attributes and methods shown in the UML diagram of figure 5.2. The usage of the UML diagram and the corresponding requirements are difficult to grasp. This is partly due to the absence of time. To make the usage of the diagram and requirements more clear, a sequence diagram is developed as an example. A sequence diagram shows, as parallel vertical lines, different processes or objects that live simultaneously, and, as horizontal arrows, the messages exchanged between them, in the order they occur (www.wikipedia.org, 2008). Due to the complexity of the service, security and status-update steps are left out as the diagram would become so complex by itself that it would not achieve the goal of clarification. The sequence diagram is shown in figure 5.3. It is split up in 10 phases so that the explanation is easier (phases indicated by red dotted boxes and phase number mentioned in the box). Behind the explanation, the corresponding requirements are mentioned by code. The choice is made to use the code of the requirements, as the addition of the text results in a long explanation of the phases in the sequence diagram.

The different phases explained:

1. In the first phase, the MPO stands next to the road and enters his user details, which makes the Touchscreen send the user preference to the ContextManager. This is according to requirement E8.
2. Now the MPO starts driving, so the Speed class sends a speed update to the ContextManager. This update is according to requirements E4, H1 and H2. Given the speed update, the ContextManager sends a presentation change message to the PresentationLayer which alters the maximum amount of buttons shown on the Touchscreen. This is based on requirements E4 and N2.
3. The MPO decides to check a vehicle so chooses a control task. The TaskRegulation class further selects the Control task. This step uses requirements A1 and C2. Due to requirement A4 (Guidance tasks only pushed) only the control or emergency task class is shown to the MPO.
4. In this phase the MPO chooses a vehicle control. The Vehicle class executes the getLicensePlate() method and thereby requests the Camera to get the license plate number. The Camera switches itself on, scans the license plate number and sends the information to the Vehicle class. The Vehicle class sends the information requests to the NetworkManager class (see phase 6). The requirements of this phase are C8, C9 and C4.
5. The Vehicle class is a subclass of the TaskRegulation class, which defines a QoS level based on the required information. It sends this QoS level to the ContextManager, which further

sends a network selection request to the NetworkManager, combined with the QoS level (see phase 6). Phase 5 is based on requirements A6, A7 and A8.

6. In phase 6 the diagram continues, but the continuing sequences are placed under the previous steps due to paper size. Here, the three messages of phases 4 and 5 are received by the NetworkManager.

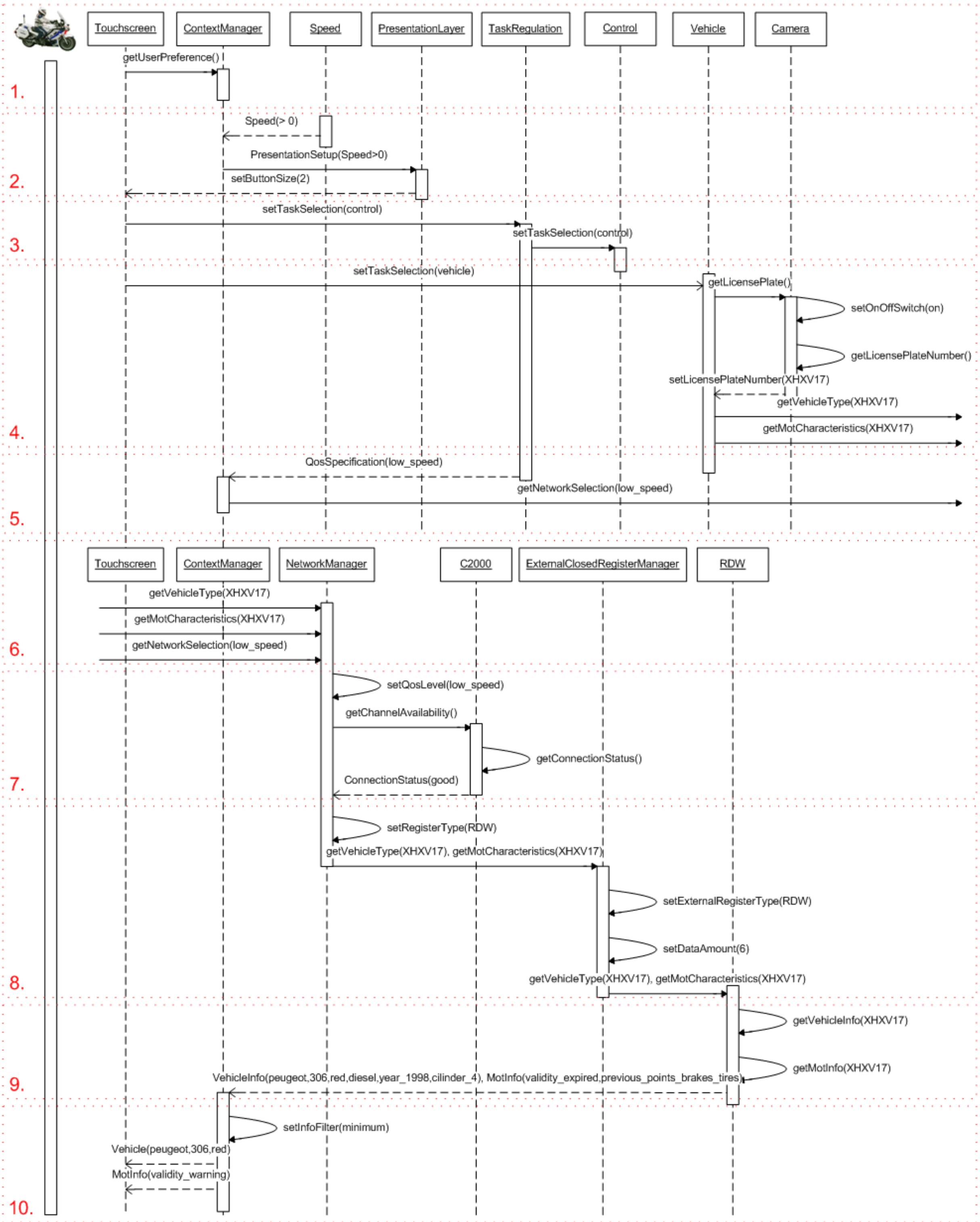


Figure 5.3: Sequence diagram of a vehicle control while driving

7. Given the QoS level, the NetworkManager first selects the appropriate available information network. The status of the network is checked and is finally chosen. In this case it is the C2000 network. This procedure is according to requirements L1, L3 and L4.
8. Having checked the available network, the NetworkManager now determines which information sources are needed to provide the requested information. It forwards the information requests to the corresponding ExternalClosedRegisterManager. From here the exact information source can be queried for information. This phase is based on requirements L6 and L8. The last step is not included as no requirements are set.
9. This phase is straightforward and is not based on requirements. The register searches for the requested information and sends the found data back, finally arriving at the ContextManager.
10. In the 10^{th} phase, the ContextManager receives a large amount of information. As the speed is still > 0, it uses an information filter and only sends basic vehicle data and a warning message. The latter indicates something is wrong and the full information is shown if the MPO stops. The requirements claiming these functions are C6 and E10.

The presented phases give an indication of how the classes of the UML classes interact with each other over time. As can be seen, complexity is very high when designing a context-aware service bundling information system. The sequence diagram shown above presents a simple vehicle control and some steps had to be left out to make it understandable. For a final service, each step must be defined and all sequence diagrams (or activity diagrams) must be developed for all tasks MPO's perform. These diagrams must be checked with the MPO's themselves in order to make sure the functioning of the service fits the work processes.

5.4 Critical design issues

Having explained the design of the context-aware service bundling model for MPO's, the next step is to compare the service design to critical design issues of the service domain. Bouwman (2006) defines five critical design issues for the service domain: targeting, creating value, branding, trust and customer retention. The 'targeting' design issue is not discussed due to a fixed end-user. For this research a different design issue is added: safety.

5.4.1 Creating value

The creation of value to the user of the service is the central reason for developing and implementing the service. The service offering must be considered an improvement over current services and deliver the value effectively and efficiently (Faber, Haaker & Bouwman, 2004). Vergouwen (2006) has already proven that hybrid networks are able to provide information more effectively and efficiently to police officers in general. The design of the service presented above aims at using the hybrid networking concept for MPO's by determining the needed services based on the context of the MPO. The 'ContextManager' is constantly updated by the various context aspects aiding the MPO in using the system in various situations and altering the presentation of information to the context. The MPO is capable of retrieving needed information individually, thereby removing the current information provisioning delays.

The results of the research explained in chapter 4 further ground these assumptions. Information is highly important to MPO's. Providing information faster than by using the current system automatically increases the value of the service. Secondly, increasing the perceived usefulness of the service further increases the intension to use. The results also show that the ease of use has a considerable positive effect on information exchange and decision making for MPO's. The service presented above complies with the request for an easy to use service by changing to the context situation the MPO is in. The ease of use is further grounded by the conjoint analysis results showing a considerably higher rating for the touchscreen over the current system. The service uses the touchscreen for each context situation and offers the possibility of communicating directly with the control room when needed. Additional services improving the value for MPO's are the automated administration, navigation option and automatic MPO-status updates towards the control setting a feeling of safety. These services further increase the value for the MPO's as their usage is easy and without any work to be executed by the MPO.

As shown in the introduction chapter of this thesis, a viable business model must not only create value to the end-user, but also to the departments acquiring the services and vtsPN (De Reuver, 2006). For the departments the increase of effectiveness and efficiency of the MPO's creates an increasing value of the MPO to the department. The amount of tasks executed increases thereby satisfying management of regional departments. Secondly, the pressure on control rooms decreases automatically increasing the capacity to assist in other tasks. For vtsPN the value increases due to an increase in contracts towards the different regional departments. Although profits can not be made by vtsPN, the general image of the organization increases if offering services which are valued by its customers. By building on an existing infrastructure platform for mobile information provisioning the development costs are relatively low. The last value aspect created for vtsPN by offering the service is the increase in knowledge on context-aware service bundling for police officers. Although this service focuses on MPO's, the methodology might be interesting for other types of police officers as well (e.g. one-man surveillance by car).

5.4.2 Branding

The promotion of the service is different than for commercial organizations as vtsPN is automatically the ICT service provider of the Dutch police force. This however, does not mean that users will automatically obtain the service from vtsPN. Current mobile provisioning services for Police officers offered by vtsPN (e.g. P-Info) indicate the problematic branding of these services. IPOS (2004) stated 98.8% of the police officers in streets show a high desire in having a device to retrieve information, but only 400 P-Info users are registered at the moment of writing. The cause of this branding problem possibly lies in the lack of cooperation between vtsPN and the end-users of services. Increasing the cooperation with end-users must lead to a critical-mass. This issue is of an organizational nature and is treated further in chapter 7.

5.4.3 Trust

Making sure end-users will want to use the service in executing their work requires a level of trust towards the service. The evaluation of the Mobile Blue pilot (Stijnman & TNO Telecom, 2004) concluded that the most important reason for not using a mobile device for police officers in the streets is the complicated security procedure. The ease of use decreases if security measures are too complicated further decreasing the desire to use the system for information exchange or decision-making.

Secondly, the service must function flawlessly to not endanger and annoy the user. Although the current information provisioning situation is not highly rated according to the interviews, not providing information in a new system must be minimized. The hybrid network concept must aid in increasing the reliability of the information provisioning speed. The QoS is defined as to assure an available network is always used. However, problems always occur. Researching the circumstances in which information loss might occur and training the MPO how to handle in such situations improves the trust level of the user. Cooperating with the MPO's during development also increases understanding for problems of the service among MPO's. Using a pilot is an absolute requirement in order to grasp operational problems (Segers, 2003).

A pilot is also needed to get an impression of the physical safety effects when using the service in a real environment. The research explained in chapter 4 is executed on paper, not taking any safety effects into account. An unsafe service has no chance of being used by MPO's and should not be implemented. The mock-up tests performed with MPO elaborated in Chapter 6 takes a deeper look into the safety effects of using the service.

5.4.4 Customer retention

The main question to answer for this design issue is "how to stimulate recurrent usage of the service?" (Bouwman, 2006). In the case of the MPO's, the situation is different to commercially available services. The development costs are high and usage is determined by the management of regional departments. The choice of using the service is determined by the customer value. If the value is insufficient, no department will use the service thereby not creating a chance of recurrent usage. On the other hand, if the value is high enough for the departments to use the service, no other service can be used automatically stabilizing recurrent usage. Formally, vtsPN provides all ICT services for the Dutch police force.

5.4.5 Safety

The safety, as defined in the introduction chapter, has a dual nature. The first safety factor is the effect of information loss. As mentioned above, the hybrid networking method must assure a minimal signal loss, thereby decreasing the loss of information. However, no system is guaranteed fail-proof. Ensuring the MPO is trained in handling sudden information loss is essential. An example is to make sure the MPO keeps on moving so that a signal is found more easily. The second safety factor focuses on physical safety while using the service. Concluding this issue is impossible. The service increases the ease of use of the system by adapting and changing according to the situation, but not having any system is always safer with regard to physical safety. Using the system always requires the MPO to take some attention away from the physical surroundings. For that reason, real-life tests must prove how safe the usage of the service is.

5.5 Conclusion

The information of the previous chapters has been the input to the conceptual design of a context-aware service bundling model. The conceptual model is seen as the centre-piece of this thesis as it is designed to offer an increasing value to the MPO's if implemented as a service. The model is created by using UML, so that it is structured and programmable in follow-up developments. Also, the UML structure provides the option to easily extend the service with other context factors if real-life tests indicate this necessity. The information needs, founded on the tasks defined in chapter 3, provide the first part of the model. The upper-class is called TaskRegulator, with three sub-classes called EmergencyAid, Control and Guidance which each have their sub-classes according to the information needs of the MPO tasks. The TaskRegulator is the main context factor of the ContextManager, controlling the service. Other context sources are ControlRoom, Time, Location, Speed, MPOStatus, NetworkManager and MobileTerminal. All sources are based on the MPO-context definition. Based on the context-aware concepts, a UserProfile, DeviceManager and PresentationLayer are created. The DeviceManager class controls the different devices needed for the service to function. The NetworkManager class has two roles: controlling the available information networks and controlling the connection to and from the different information sources.

As the UML model is a static set of classes, attributes and methods, it does not state its functions. Therefore, a list of requirements is formed. Each class has a number of requirements it has to suffice in order for the service to function and to deliver the increased value to the MPO. Due to the extensive list of requirements they are not mentioned here. Each requirement has a code, an explanation and a source so that the requirement is traceable and grounded. For the list of requirements we refer to chapter 5.3. The functioning of the requirements can be modeled by using sequence diagrams, which incorporate time. An example of a sequence diagram of a vehicle control task is presented in chapter 5.3. For a final model, all sequence diagrams must be designed of the different tasks that MPO's can perform. Cooperation with MPO's is essential to make sure the sequence diagrams fit the work processes.

The service is compared to five design issues. The first is to define how value is created by the service based on the designed model for the MPO. The hybrid networking method assures a faster and more stable provisioning of information, leading to a higher efficiency and effectiveness of the MPO. As the service adapts to the context the ease of use is increased which has a positive effect on the decision-making as shown in chapter 4. The combination of a touchscreen information system, combined with vocal information fits the conjoint analysis results and the work environment relations of Pica & Sorensen (2005). For the departments, the increase in efficiency and effectiveness leads to more work being executed. Simultaneously, less pressure is put on the control room. The service also has to create value to the supplier (vtsPN). If departments acquire the service, vtsPN obtains more service delivery and maintenance contracts. Also, the general image of vtsPN improves if departments are pleased. A last value aspect is created by the knowledge retrieved during the development and implementation of the context-aware service bundle. This knowledge can be used in other mobile information provisioning services.

Branding is more an organizational issue. Getting a critical mass requires solid cooperation with the end-users during the development. The trust of the end-users partly depends on the way security measures are implemented. The ease of use must be guaranteed. A second part of the trust is created by making sure the service functions flawlessly. The hybrid network method increases the reliability of information provisioning, but problems will always occur. The cooperation with the end-users increases the understanding of users if problems occur. An essential step is to develop a pilot project of the service to find possible problems in a real-life system.

Retaining a customer is the fourth design issue. The creation of value, combined with the role vtsPN plays as primary supplier of ICT services for the police are considered essential. Making sure the service is reliable further retains the users. These aspects must make the high investments needed to develop the service worthwhile.

The last design issue added to the previous list is safety. The safety focus in this thesis has a dual nature. The first is information loss, which is kept to a minimum by using the hybrid networking method. By training the MPO's in case information loss occurs he or she is prepared to anticipate in a correct manner. The physical safety is the second safety aspect. Introducing an information system automatically removes attention from the physical surroundings to the system. Although the service adapts to the context and alters the usability ensuring a minimum safety effect, no grounded conclusions can be made. Further tests of a service in a practical setting must provide more information on the effects of using the service of safety.

PHASE III

6. Experimental research with MPO's

6.1 Introduction

The qualitative and quantitative parts of this research have been the basis of the service design, elaborated in the previous chapter. According to Verschuren & Hartog (2005) the next step is to materialize the design into a prototype. The prototype is useful for empirical evaluation and therefore gives a practical opinion of MPO's on the design, which was based on research done on paper. Due to the lack of time and limited financial backing, a special type of prototype is developed called a 'mock-up'. It can not be used in a real-life situation, but does provide a first impression of what users might expect from the service designed in chapter 5. The aim of this experimental research phase starts by using information system rated by MPO's (the dependant variables in the conjoint research phase), which run a user interface capable of showing the service design concept. The created mock-up prototypes become the independent variables which provide the opportunity to measure the effect of the service design on information provisioning for MPO's. At the end of this chapter an answer is found on the following research question:

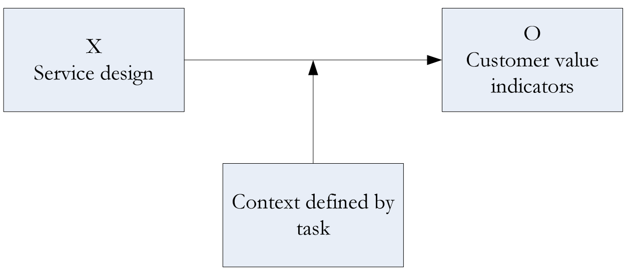
> *To what degree does the conceptual service design increase the value to MPO's when evaluating using a prototype?*

First the theoretical basis is defined by the means of the causal model, experimental design and the measurement constructions. Secondly, the research method used for this experimental research is explained. This part consists of an explanation of the prototype, the data collection and the used data analysis technique. The next step is to validate the experiment from externally, the constructs used and the internal aspect of the experiment. After the validation step the results can be discussed extensively. The results consist of a quantitative and a qualitative part. Based on the results a brief overview is presented of the required changes to the designed service concept model. Finally, the chapter is concluded.

6.2 Theoretical basis for the experimental research

6.2.1 Causal model

The goal of an experimental design is to ensure the causal effectiveness of the experiment. "The possible causes are referred to as treatments and the possible effects of the treatments are referred to as outcomes" (Cook & Campbell, 1979). For this research, the causal relationship to be investigated is modeled as follows:



The treatment (X) is the experimental variable which represents the mock-up used. 'O' in the causal model measures the influence of the treatment on the customer value of the MPO by using specific indicator variables. Due to the context-aware topic of this research, the effect of the context on how the MPO's rate the service design needs to be accounted for.

Translating the causal model to a practical and executable research delivering as much knowledge as possible requires a few choices to be made. The first problem is to define the context influencing the causal effect. A single situation in which the mock-up is tested results in too little information. On the other hand, testing many different situations with a small group of respondents is practically impossible as it would use too much of their time. Therefore, a selection of the two main tasks is chosen as a basis for the mock-up tests. The reason for choosing two is based on the available time of the respondent for testing. The choice of tasks is explained in chapter 6.3.

A second crucial matter is the information system running the service design itself. The interviews and internet research proved that the current information provisioning of MPO's is not highly rated in general. If presenting a single information system mock-up (e.g. the system rated highest from the conjoint analysis), the chance of this mock-up resulting in high ratings is assumed large. Although this would be an interesting result, testing a second information system mock-up from the conjoint analysis to compare with would result in much more knowledge on the MPO's practical opinion of using information systems running a context-aware service for MPO's. The two mock-ups can then be compared between each other. Secondly, it provides a check to see how the results of this practical experiment relate to the previous research phases. Finally, the choice for the first mock-up is logically based on the touchscreen system as designed in chapter five. The second is chosen out of the dependent variables list of the conjoint analysis, namely the head-up display system. As the second best rated system in general is the current system MPO's use, the third best rated system is used. The service design used for the head-up display mock-up is build on the same concept as the touchscreen version, though adjusted for use as a head-up display system where needed.

6.2.2 Experimental design

Investigating the causal relationship incorporating two different situations and two different mock-ups requires a proper research design. The chosen research design is based on a 'true experimental design with pre- and posttest including a control group' (Baarda & De Goede, 2001). The design is altered for this research and its notation is as follows:

R	O1	Xt2	Xt3	Ot2	Ot3
R	O4	Xh2	Xh3	Oh2	Oh3
R	O1	Xt3	Xt2	Ot3	Ot2
R	O4	Xh3	Xh2	Oh3	Oh2

The R stands for the randomization of the respondents. Randomization means that "respondents are assigned to one of the mock-ups on a basis of chance" (Baarda & De Goede, 2001). O1 and O4 represent the pretest measurement of specific customer value indicators (dependent variables clarified in chapter 6.3) of the current information provisioning services MPO's use. The reason for choosing a pre- and posttest instead of just a posttest is the following. As defined in chapter one, value is created by offering a better, more effective and efficient service compared to current services used (Chen & Dubinsky, 2003; Petrovic & Kittl, 2002; Bouwman, Faber & Haaker, 2005). When only using a posttest, it is almost impossible to give an opinion of the new service's influence on the customer value of the MPO. The pretest represents the baseline in order to determine where MPO's start out in information provisioning rating (Baarda & De Goede, 2001).

Xt2 and Xt3 represent the touchscreen mock-up for the two different context situations. Xh2 and Xh3 represent the head-up display mock-up, again for the two different context situations. The mock-ups are explained in chapter 6.3. Ot2 (context situation 1) and Ot3 (context situation 2) represent the posttest measurements for the touchscreen mock-up of the same dependent variables as used in O1 and O4. Oh2 (context situation 1) and Oh3 (context situation 2) represent the posttest measurements similar to Ot2 and Ot3, but for the head-up display mock-up. As the notation shows, the order of context situations is changed to remove a learning effect from one context-situation to another. The posttest order is also changed to make sure the order is similar to the context-situation shown.

Preferably, both mock-ups are tested by each respondent in order to get most data out of the experimental research. If doing so, a problem arises as the MPO's need to be tested while they are on duty. This means little time is available to test the system (agreed at 15 minutes per MPO). Considering the fact that each treatment takes about 5 minutes, and four treatments are to be tested, no more than two treatments can be tested per MPO. The choice is made to test one mock-up over two scenarios per respondent for three reasons. Firstly, the independent variable is the information system running the context-aware service tested in two different situations. Therefore, getting full data from one mock-up per respondent is better than getting half data of both systems per respondent. The second reason is of a more practical nature. Changing from one mock-up to the other requires much more time which increases the risk of not being able to complete the whole test. As the service design of both mock-ups is similar to some degree, a third reason arises. Two completely different groups of MPO's use the system; thereby automatically creating a check to review how the service design is rated by those two groups in the areas where they are alike.

6.2.3 Measurement construction

The following step is to define what measurement instrument can be used to get as much information as possible out of the experiment. The basic requirement of this measurement instrument is set by the experimental design. Each mock-up requires a pretest (O1 & O4) and a posttest (Ot2, Ot3, Oh2, Oh3), whereby the posttest measures two different scenarios. A second requirement of the measurement instrument is consistency. The constructs used in the pretest need to be similar to the posttest constructs in order to claim valid result when comparing both tests. Given the required 10 minutes to test both scenarios for one mock-up, only five minutes remain for measurement.

The constructs used, are based on the TAM/TMF model (Davis, 1989; Daft & Lengel, 1986) explained in chapter 4, which was tested in the internet research phase. The reason for using the TAM/TMF model is that the four constructs provide a grounded group of factors that play a role in the acceptance of the service concept. The ease of use of the service, the usefulness of the service, the task-media fit of the service and the intention to use the service are seen as vital roles the designed service needs to augment as compared to the current system. There are two problems though when applying the model as presented in chapter 4. The first problem is that the model used in the internet research phase results in too many questions in the questionnaire to be answered by each MPO. It requires each user to rate 36 x 3 = 108 statements in five minutes. Due to this problem a large reduction of variables must be executed.

In order to get a questionnaire which can be filled in three times in 5 minutes, the indicator variables with the highest factor loading of each construct in the TAM/TMF analysis of the internet research is used. Two exceptions are made; the first for the "intension to use" construct where two indicator variables have been used. This is done because the factor loadings of this construct were very high and measuring the intension to use is seen as highly important by the author. Secondly, the indicator variables of the location overview media fit assumption are left out as chapter 4 showed it does not play an important role and further reduces the number of variables. The chosen indicator variables result in the following measurement items shown in table 6.1 with its originating construct.

Construct (dimension)	Indicator variable
Intention to use	MPO's will use the information system
	The information system makes the work of MPO's easier
Ease of use	The information system is easy to operate by MPO's
Perceived usefulness (resource / information advantage)	The information received through the information system is needed by MPO's
Perceived usefulness (productivity)	The information system makes MPO's execute their tasks faster
Task-media fit (information exchange)	The information system is the right media for information exchange
Task-media fit (decision-making)	The information system is the right media for decision-making

Table 6.1: TAM/TMF variables used for measurement

As stated above, there is a second problem with using the TAM/TMF model constructs. The experimental research creates the possibility to retrieve knowledge on more specific information provisioning issues relevant to the MPO's working environment. The first issue is the influence of the service design on safety which is not included in the variables presented above. Safety plays a very important role and needs a considerable amount of attention. The safety issue is divided in three parts. The first is the influence of operating the system on safety. The aim of the service is to make usage easier, thereby minimizing the distraction of the MPO towards the service. The second safety aspect is the influence of comprehending the presented information. Information systems can use different modalities to present information and it is important to measure the effect of the chosen modalities on the safety. Lastly, variables are added which focus on the usability of the information system in four specific traffic environments. Due to the static nature of the mock-ups, the four items must give an opinion of the MPO's in which situation the system functions best regarding safety. The addition of the four items does not remove the problem of the static environment. It gives a first impression based on the experience of MPO's.

Having elaborated the safety issue, a second issue to be measured is information quantity. The chosen TAM/TMF variables focus on information in general, but no detail of information quantity is measured. The quantity plays an important role, as the service design reduces the information provisioning amount in some situations. A second information aspect not looked at is the speed of information. The interviews clearly indicated that the speed of retrieving information is a big problem. It is therefore important to measure whether the use of hybrid networks is capable of increasing the speed. The last added focus is system speed. Were speed of the information is dependent on the network, the system itself also influences the total speed of information provisioning. Especially the operation of the system might have an effect on the perception of system speed. Therefore a system operation statement is added to the total list of statements measured in the pre- and posttests. The statements added to the list of table 6.1 are presented in table 6.2.

Information provisioning issue	Statement used for measurement
Information quantity	The given amount of information through the information system fits the task of the MPO
Information speed	The time needed to receive the information through the information system is not too long
System operation speed	The time needed to operate the information system is not too long
System operation safety	Operating the information system does not influence a safe participation of the MPO in traffic
Information comprehension safety	Comprehending the information does not require too much time for the MPO to keep driving safely in traffic
Situational functioning	Standing still
	Driving in a constantly changing traffic environment (e.g. inside an urban area)
	Driving in a stable traffic environment (e.g. on a highway)
	Driving for an emergency aid situation

Table 6.2: Added information provisioning issues used for measurement

The term 'information system' of the items is changed to fit the specific information system we are interested in.

By using the statements defined in table 6.1 and table 6.2 we hypothesize that:

- H4. The conceptual service design of the touchscreen mock-up and the head-up display mock-up will lead to a significantly higher rating on the defined statements as opposed to the current information system used by MPO's.
- H5. The conceptual service design of the touchscreen will lead to a significantly higher rating on statements originating from the following constructs: intention to use, ease of use, task-media fit, system operation speed, system operation safety, information comprehension safety and the situational functioning

6.2.4 Measuring the safety of the touchscreen mock-up

The defined information issue measurement statements provide a first impression of the way MPO's perceive the effect of the designed service concept on safety issues. Getting an increased amount of knowledge requires a real-life test to be executed. Unfortunately, a real-life test is impossible to carry out due to time restrictions. For the touchscreen mock-up however, theory is available to get a more detailed view on its effect on safety, apart from the measurement statements rated by the MPO's. As figure 6.1 shows, a static vehicle simulation test results in data which is less confident as opposed to real-life tests. The results of the test are seen as a first impression of the effect on safety when using a mock-up where the MPO has to focus on a screen, thereby removing attention from the road. The reason for not using the theory presented here for the head-up display is given at the end of this paragraph.

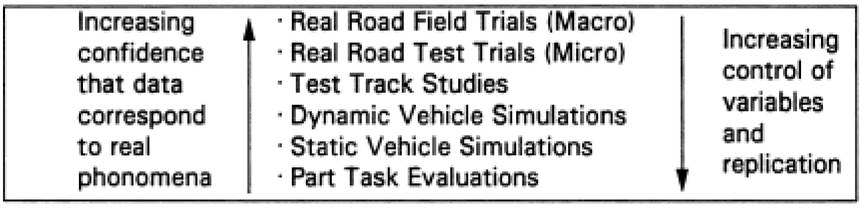


Figure 6.1: test environment differences (DRIVE safety task force, 1991)

Primarily the choice was made to use Green's (1999) 15-second rule for driver information systems because of its ease of use. The rule is used as a standard (SAE J2364) in the United States for navigation systems tested in a static environment. The rule however shows flaws. It is too simple to assume the usage of an information system is safe just by measuring the task load. Dynamic circumstances are not taken into consideration (Jagtman & Hale, 2007). Green's (1999) rule is aimed at tasks which require the driver to perform long interactions with the system (e.g. the entry of a destination address while driving). The service design however does not result in long interactions with the system thereby easily assumed safe according to Green's (1999) rule. But when driving at high speed behind a car and staring at the screen for only a few seconds could result in a crash due to an unforeseen braking of the car in front. This significant effect is not taken into account by the rule of Green (1999). Another strange aspect of the rule is that "the desire was to select a time that would represent a consensus of the experts on a subcommittee" (Green, 1999). Apparently, the rule does not reflect grounded evidence of safety, but is defined by an agreement to keep all parties involved in the decision-making process pleased.

A different view from the American standard is the European statement of principles on human machine interface for in-vehicle information and communication systems. An example is the following: "The system should not present information, which may result in potentially hazardous behavior by the driver or other road users" (European Commission, 2000). Although the principles touch on many safety issues, the example shows they remain vague. Also, the principles do not incorporate circumstances and use other than that which is intended (Jagtman & Hale, 2007). Both methods are explained to give an impression of how difficult the assessment of safety is.

For this research the choice is made to use glance duration as a measuring entity. Vision in driving is believed to constitute over 90% of information input to the driver (Evans, 1991). Zaidel (1991) believes that lane exceedance, glance frequency and duration, verbal comments, steering wheel motions, and expert judgments are the key measures to collect. Verbal comments and expert judgments are discussed in chapter 6.5. Lane exceedance and steering wheel (handle-bar) motions can not be measured by a mock-up. Therefore, the focus is on glance durations. Eye fixations data can be extremely informative and widely accepted by scientists and engineers, but are very difficult and costly to collect and analyze (U.S. Department of Transportation, 1995).

Determining the safety effect of glance durations requires comparison data. Godthelp, Milgram and Blaauw (1984) describe an evaluation of TLC or time-to-line-crossing, a measure of driving strategy. The time-to-line-crossing is how long it would take a vehicle to reach either lane edge if the steering wheel is not moved. At each moment the vehicle is assumed to have some heading error and may not be in the centre of the lane (Godthelp et al., 1984). The TLC is measured by occluding the driver. "Since looking away from the road has the same effect as occluding vision of the road ahead, it seems reasonable to propose that the results might provide estimates of the time available to view in-vehicle displays" (U.S. Department of Transportation, 1995). The results of Godthelp et al.'s (1984) research come from a real-life test (table 6.3). It is important to mention that the results can only be used as a first impression of the safety effect. External factors are not considered when using the TLC method. A car coming in the opposite direction and driving over the line can still affect the safety of MPO's. Furthermore, any road damage or speed bump can result in dangerous situations not taken into account.

Speed (km/h)	Speed (mi/h)	T Occlusion (s)	15% TLC	TLCe (s)	TLCe/T Occlusion
20	12	5.32	6.7	8.88	1.67
40	25	4.23	4.5	6.33	1.49
60	37	3.45	3.9	5.32	1.54
80	50	3.15	3.5	4.77	1.51
100	62	2.67	3.1	4.35	1.63
120	75	2.38	2.9	3.74	1.57

Table 6.3: values of occlusion and time-to-line-crossing (Godthelp et al., 1984)

The important figures to consider from the table are the 'Speed' and the 'T Occlusion'. The latter states a mean occlusion time at which a person crosses either line of the lane he or she is driving in. It must be noted that the shown times are measured using a car, not a motorcycle. Data about motorcycles is not available. The values of MPO occlusion times must be measured during the experiment in order to compare to the values of Godthelp et al. (1984). Having explained the theory, it is now clear why the head-up display mock-up can not be included in this research part. Measuring occlusion times while using the head-up display is practically impossible given the available equipment.

6.3 Research methods

6.3.1 Mock-up prototype used for testing

Before going into the various methods used to measure the effects of the service design concept, an explanation of the used mock-ups is required. This way the setting of the experiment is clear and the succeeding steps are easier to comprehend. First the choice of information and communication system used for the mock-up is explained, followed by a brief explanation of the scenarios shown to the tested MPO's.

Choice of information and communication system

The context-aware service runs on an information and communication system. As mentioned in the previous paragraph, two different systems are chosen for the creation of the mock-up prototype. The choice is based on the results from the conjoint analysis. A touchscreen system is first selected as it clearly had the highest overall rating. With the needed touchscreen system being available at ISC it is also practically executable. The final system used is a Panasonic Toughbook™ laptop which can be turned into a tablet PC and has a 10.4" touchscreen. The size of the screen is similar to the screen used on the 'brandweer 100% Mobiel' project (further explained in chapter 8), which uses a touchscreen for information provisioning on a motorcycle. The touchscreen currently used by some MPO's to control the C2000 terminal is slightly smaller. The effect of the MPO's having experience with touchscreens and those not having experience is incorporated in the research results.

Choosing the second system is not as straight forward as the touchscreen system. Going back to the results of the conjoint analysis, the mobile terminal (C2000) was rated second best overall. However, as the mobile terminal is the current system of MPO's at this moment, it is already being measured in the pretest. The use of an unknown information system results in a higher gain of knowledge on the usability for MPO's compared to the current system. The third best overall rated system in the conjoint analysis is the head-up display system. Having a head-up display to test with at ISC the choice is made to use this system as the second mock-up prototype. Furthermore, usage of a head-up display for MPO's is completely unknown which makes it even more interesting to retain knowledge about the system.

As a head-up display is only capable of projecting information, a way of operating the system needs to be found. At the University of New Hampshire in the United States, a project (Project54™) is being executed whereby speech recognition is used as a system operating technology (http://www.project54.unh.edu/). Although no official documentation is available on the success of speech recognition specifically for MPO's, email contact with Andrew Kun (the project coordinator) did result in some qualitative opinions on the usage of the technology. Kun (2007) states: "we do not have any quantitative data on motorcycle speech performance versus automobile speech performance, but qualitatively, the officers using the system on motorcycles seem very happy with the performance". Based on these experiences the choice is made to use speech recognition as a way to operate the head-up display system. The head-up display model is a Liteye™ LE-500 see through display covering one eye. The speech recognition software used is Dragon NaturallySpeaking™ version 9. A last important notion on the head-up display system is the usage of text-to-speech software. It can be seen as the opposite of speech recognition, as it turns texts into speech over the headset. In this way, the MPO does not have to read all the information from the head-up display. The used text-to-speech software is TextAloud version 2.2 with a 22Khz audio quality Flemish voice.

The user interface running on both mock-ups is created in Adobe Flash™. As mentioned before, it is not a real-life situation prototype. It is not connected to any database or other system, but it does give the MPO an impression of how a context-aware information provisioning service works. By using Flash a user interface is shown to the MPO who uses the system as if he or she was driving in a real-life situation. On the touchscreen mock-up the MPO has to press buttons while in the head-up display mock-up the NATO-alphabet is used to operate the system.

The final part of the mock-up is the total set-up in which the MPO uses the system. Although the setting of the experiment is static, a fake motorcycle is created to make sure the MPO sits as if he or she was sitting on a real motorcycle (for detailed pictures see figures 6.2 and 6.3). In front of the fake motorcycle is an LCD screen showing a movie with the shot from eyes height. In this way a more realistic situation is created. The MPO uses the system according to the occurrences in the movie. The movie is played from a DVD player, though with loops build in to make sure the situation remains correct. Skipping to following chapters at certain system executions by the MPO is controlled by the person standing next to the MPO testing. The two images below show both mock-ups in use:

Figure 6.2: head-up display mock-up

Figure 6.3: touchscreen mock-up

The scenarios used for the mock-up

MPO's work in many different situations performing different tasks, making the choice for two scenario's difficult. The basis of the chosen scenario's lies in the task that needs to be executed. Reviewing the interviews with MPO's made clear that most tasks executed by MPO's are traffic related (control task group) or emergency aid related. Traffic related controls mostly start with a license plate enquiry towards the control room as it is the first data available to the police officer (Interview

Amsterdam). The license plate enquiry control task is chosen as the goal of the first scenario. Choosing a correct scenario for an emergency aid situation is complicated as a large variety of situations can occur. It was up to the author to define a situation which was not too complicated, but capable of showing a plausible emergency aid situation. The choice is made to put the MPO in a shoplifting situation requiring the MPO to respond as fast as possible to catch the shoplifter based on available information. Both scenarios are explained in detail in Appendix G, with the corresponding UML class and screenshots of the system.

The mock-ups compared to the service concept design

The developed mock-ups are created by using the service concept design as a basis in order to measure the value of the service concept. Considering the possibilities available to build the mock-ups however, some aspects of the mock-ups are not completely coherent with the service design. It is important to remember that the touchscreen mock-up is based on the service concept as far as possible, whereas the head-up display has more differences between the mock-up and the service concept for practical reasons. Especially in the area of usability, large changes are created between both mock-ups (e.g. touchscreen vs. combination of head-up display, speech recognition and text-to-speech software; camera license plate recognition vs. speech recognition input). Here, we focus on the comparison of the touchscreen mock-up to the service concept and its requirements of chapter 5.

For the license plate scenario the following requirements are met (either as defined, or as a pure graphical representation of the requirement):

- A6. The module must define a QoS level based on the task selection of requirement A1.
- A13. The module must present the danger level for each task if known.
- C2. Must present information on the touchscreen above the handle-bar, except for the 'Event' and 'Enticement'.
- C3. Must present all information sub-classes of the 'Control' class when standing still.
- C8. Must only present the option of a vehicle check by licence plate number if speed > 0
- C9. Must present license plate number based on 'Camera' class methods execution if speed > 0
- C6. Primarily must only show if irregularities exist yes or no if speed > 0
- C5. Must only present the option of a persons check directly from drivers license connected to license plate if speed > 0
- C10. Must present a button to assert suspect if irregularities exist in requirement C6 or C7
- E12. Must provide a final option of sending task information (location, time, task, retrieved information) to the 'accountInfo' of the 'UserProfile' class
- L2. Must switch to other network if used network signal is going to be too weak for transmission
- L3. Must choose communication network based on QoS demands
- L6. Must set the appropriate register type based on information requests
- M1. Must transmit received information to 'Touchscreen' class
- N2. Must present no more than 2 operation buttons if speed > 0
- N4. Must always present an emergency button
- N9. Colour usage must be coherent with content
- N10. Sound level must be coherent with level of importance

Unfortunately some requirements are not met for practical reasons. The first group of not applied requirements are aimed at the C2000 communication role. Including a form of C2000 is impossible considering the technical needs. Secondly, user preference settings are not presented as this increases complexity and it is practically impossible for each MPO to define, considering the time available. The third group of requirements not met is the log-in procedures, which are not left out of scope of this research. One requirement is not met due to an error in the translation of requirements to mock-up creation. Requirement C11 states an abandon motorcycle button should be presented after having pressed the assertion button and is not shown during the test with the license plate scenario.

The second comparison is for the emergency aid scenario. The following requirements are met (either as defined, or as a pure graphical representation of the requirement):

- A6. The module must define a QoS level based on the task selection of requirement A1.
- A10. The module must present route navigation if destination is transmitted to system
- A13. The module must present the danger level for each task if known.
- B3. Should present information on the touchscreen above the handle bar at all times
- B4. Must provide a dedicated C2000 communication channel with colleagues involved
- B5. Must set the type of emergency based on emergency request information

B6. Must present a button to indicate suspect is seen
B7. Must present a button to assert suspect if the button of B6 has been pressed
B8. Must present a button to abandon motorcycle if the button of B7 has been pressed
B11. Should present specific information aimed at the type of emergency aid situation based on methods of the chosen class (location, person info, danger level are shown)
E12. Must provide a final option of sending task information (location, time, task, retrieved information) to the 'accountInfo' of the 'UserProfile' class
I1. Must continuously keep track of the location the MPO is at
I2. Must adapt to location change
L3. Must choose communication network based on QoS demands
M4. Must change to any C2000 channel needed

As with the license plate scenario, some requirements could not have been met for the mock-up. Again, the C2000 channels are not presented, although a C2000 channel group selection is indicated in the mock-up. An important change is to not include the information presentation through speech. This requirement is added to the head-up display mock-up as it is indispensable for its use. In order to keep the usability aspect as different as possible between both mock-ups, the touchscreen version is completely based on the usage of the touchscreen only. Another requirement not met is N2, stating only two buttons are shown if speed > 0. Although it was aimed for by using a 'more info' and a 'back' button, the addition of the 'suspect is seen' button officially makes the mock-up incorrect. The user preference and log-in procedures are not added for similar reasons as with the license plate version.

6.3.2 Data collection

For this research two different questionnaires are used. One version for the head-up display mock-up experiment and one version for the touchscreen mock-up version. The questions are based on the statements clarified above in tables 6.1 and 6.2, though slightly adjusted to fit the information system focused on. The questionnaires consisted of the following sections (see Appendix H for final questionnaires used):

1. Background questions (police rank, main task as an MPO, amount of years working for the police, year of birth, gender, knowledge of mobile information systems used by police officers by foot, experience with touchscreen / head-up display and speech recognition, participation of previous internet research)
2. Pretest questions about the current information systems, based on the measurement items
3. Question on the positive aspects of the tested mock-up
4. Question on the negative aspects of the tested mock-up
5. Posttest questions about the tested mock-up for the first scenario, based on the measurement items
6. Posttest questions about the tested mock-up for the second scenario, based on the measurement items
7. General remarks on the mock-up and research

The defined statements, except for the situational functioning statements, are used for parts 2, 5 and 6 and measured from 'totally disagree' to 'totally agree'. The situational functioning statements for the same questionnaire parts are measured from 'surely not use it' to 'surely use it'. All items are measured on a 7-point Likert scale.

Having discussed the pretest and posttest statements, only parts 1, 3, 4 and 7 require further explanation. The background questions are used to obtain relevant characteristics of the respondents and might reveal differences between groups inside the sample. The third and fourth part gives the MPO the opportunity to show general qualitative opinions on the tested mock-up. Using qualitative information results in broader and more detailed information on the tested systems. Part 7 concludes the questionnaire and provides the opportunity to give general opinions on the research which improve the researching skills of the author.

6.3.3 Sample

The mock-ups are designed to be tested individually by MPO's. According to Baarda & De Goede (2001) a rough approximation of the minimum amount of participants performing the complete experiment is 30. The final number of respondents having executed the whole test is 63 as shown in table 6.4. The location of the police department is mentioned, together with the date of the test. Figure 6.4 next to the table shows the geographical spread of the locations.

#	Date	Location	Amount of tested MPO's
1	5 november 2007	Twente	7
2	6 november 2007	Den Haag	11
3	7 november 2007	Amsterdam	15
4	8 november 2007	Maarssenbroek	3
5	8 november 2007	Leusden	4
6	9 november 2007	Delft	6
7	12 november 2007	Breda	5
7	13 november 2007	Breda	5
8	14 november 2007	Gelderland-zuid	3
9	14 november 2007	Gelderland-midden	4
	Total	**9**	**63**

Table 6.4: MPO's tested for the experiment

Figure 6.4: Testing locations

6.3.4 Statistical analysis technique

The experimental design requires the pretest and posttest to be compared to each other by measuring the difference and level of significance between both for each statement defined. According to Campbell & Cook (1979) the elementary ANOVA is perhaps the simplest model of the structure of the data for a simple pretest – posttest design with two groups. "However, an important weakness of the elementary ANOVA is that, under many circumstances, it has less power to detect true differences than the ANCOVA analysis. This relative lack of power occurs because the model 'explains' only that portion of the variation of the posttest scores that result from the treatment effect. All other variation, including the variation that could be 'explained' by the pretest is relegated to the error term against which the treatment effect is compared. Other methods which can use pretest information to remove some of the variation from the error terms increase the power of the significance test. Using the pretest (as a 'covariate' in ANCOVA terminology) provides an adjustment for initial differences between the groups" (Campbell & Cook, 1979). The theory of Campbell & Cook (1979) is developed for non-equivalent group design, whereas we are using randomized group design. However, seen that the number of cases is not that large, the randomization does not necessarily rule out non-equivalence for all items. Therefore the choice is made to use the ANCOVA test for significance. Apart from using the ANCOVA test to test for significance between both tested mock-up systems, a dependent *t*-test is used to test for significance levels between the pretest and posttests.

For this research the Kolmogorov-Smirnov test (K-S test) is used to determine whether the underlying probability distribution of the data differs from a normal distribution (Hair, 1998). Running the test on all items showed that all p-values were under the 0.05 level. This means the data is not normally distributed and requires non-parametric tests to be used on the data. Based on this assumption the ANCOVA is not applicable for data testing. However, the K-S test is seen as a very strict test (Molin, 2004). Molin (2004) states that "when the data is not normally distributed, all groups need to contain 30 cases or more in order to use parametric tests". Seen that there are 30 respondents for the head-up display mock-up and 33 for the touchscreen mock-up, this condition is only just met. As theory differs on the correct statistical technique, a non-parametric test is included to find how the results differ.

For the non-parametric test the Wilcoxon signed-rank test is used as it works in a fairly similar way to the dependent *t*-test. "It is used in situations in which there are two sets of scores to compare, but these scores come from the same participant" (Field, 2005). Although it does not provide the adjustment for initial differences between the groups, it does provide a test which gives significance levels between two groups for non-parametric data. Running both non-parametric and parametric tests will clarify if large differences between both tests exist. It is important to validate the test to use in order to project reliable results. All tests are executed using SPSS version 14 with the α-level selected at .05.

Reviewing the different p-values calculated with both the Wilcoxon signed-rank test and the dependent *t*-test concludes very similar results. Only for the 'standing still situational' variable, the *t*-test calculates a p-value of .037 and the Wilcoxon calculates a p-value of .057 between the current system and the touchscreen mock-up. When comparing the ANCOVA to the Wilcoxon test p-values are slightly lower in general. This trend is logical considering the adjustments the ANCOVA model makes based on the pretest. It is concluded that both are applicable, but the usage of parametric tests is chosen due to the higher power ANCOVA provides as opposed to the Wilcoxon signed rank-test.

The homogeneity of variances between groups is checked, which assumes the variances are the same throughout the data. To test the assumption we use a test called Levene's test" (Field, 2005). Running the test between the head-up display group and the touchscreen group shows that four of the 44 variables are significantly different ($p < .05$). Reviewing the significance levels of the 'equal variances assumed' and 'equal variances not assumed', all resulting in a similar selection of significant or non-significant. In interval data requirement (Field, 2005) is satisfied as the distance between the points of our scale are equal. Lastly, independence is guaranteed by taking the MPO's into a separate room and asking them not to discuss the test during that day at the police department.

6.3.5 Observations from the author during the tests

The author has been standing next to the participant at all times. Special observations that might be interesting for the research have been written down after each test person. An example is the usage of speech recognition software which showed very different usability results not measured by the questionnaire. Combined with the observations are the reactions given by the MPO's testing the mock-ups. The observations are treated separately in the results section.

6.3.6 Measuring the safety of the touchscreen mock-up using video

The glance durations are measured by using video footage of the eye movement while using the touchscreen mock-up. Due to the time-consuming aspect of reviewing the glance durations, video footage of only five MPO's has been used. By using video animation software (Adobe Premiere Pro 2), the very precise time-line provides an exact time-measurement tool. The times resulting from the video footage can be compared to the occlusion times of Godthelp et al. (1984).

6.3.7 Timer measuring speed of speech recognition

The touchscreen mock-up uses an automatic license plate recognition method resulting in a similar time of the whole license plate check for each test. This total time is 14.3s after having accepted the "yes" button. The same period is measured by using a timer inside the program for the head-up display mock-up. The timer measures the time needed to enter the license plate number and accepting. It is used to give an impression of the speed speech recognition is able to achieve as a system operation interface.

6.4 Validation

In this section the validity of the measures is addressed. The validation part focuses on three aspects of experimental research validation: external validity, construct validity and internal validity. Ensuring the external, internal and construct validity is based on the list of threats Campbell & Cook (1979) developed. The list of threats provides a guideline in order to check whether the experiment is valid or not. Only the problematic threats are discussed, but an elaborate discussion of threats is given in Appendix I.

6.4.1 External validity

Knowing the sample of the experiment (explained in paragraph 6.3.3), the next step is to determine the generalizability by focusing on the external validity. Simply put: "external validity is the degree to which the conclusions in this study would hold for other persons in other places and at other times" (Trochim, 2006). Campbell & Cook (1979) developed three main threats to the external validity of the experiment. All three are not entirely falsifiable.

Determining the 'interaction of selection and treatment' threat is done by asking the following question: "In which categories of persons can a cause-effect relationship be generalized?" (Campbell & Cook, 1979). The first important notion to be made is that little is known about the population making the generalization difficult. However, due to the specific aim of researching information provisioning for MPO's and only using MPO's as participants, the generalization is assumed to be correct based on gender, age and rank of the MPO's in the sample, when compared to the internet research group. If focusing on the geographical distribution, the choice is more difficult. Figure 6.4 shows that not all regions from the Netherlands are included. It is not possible to claim if the final area covered is broad enough to reflect the opinion of MPO's on a national level. Executing a similar research in other areas must ground a national opinion.

The 'interaction of setting and treatment' threat is answered by the question whether a causal relationship measured in the specific situation at the moment of testing can also be obtained in other situations (Campbell & Cook, 1979). The answer is bipartite. Firstly, an MPO works in many different circumstances and they are not all covered by the mock-ups. By using two scenarios an attempt is made to create the two most common situations task-wise. It is not possible to claim that these two scenarios can be generalized to all situations an MPO is in. The second answer lies in the static nature of the test. The mock-ups try to simulate two tasks whereby the user has to use the system. But due to the static nature of the mock-ups, external influences like traffic, road changes, weather, noise and unpredictable behavior of suspects is not measured. Also, the effect of system usage on the driving characteristics (e.g. the balance when removing one hand from the handle-bar) can not be measured. Especially when focusing on safety issues, the dynamics of a real-life situation play a role. Measuring safety is almost impossible in a static environment (Jagtman & Hale, 2007). This means that the results on system safety are not directly usable in the implementation of a finished product. Further research by performing a pilot in a real-life situation is needed to more thoroughly test the influence on safety issues. We do include the results on safety issues from the experimental research as it gives a first impression which is a start-up for further research.

The last external validity threat can again be discussed on the basis of a question: "to which periods in the past and in the future can a particular causal relationship be generalized?" (Campbell & Cook, 1979). The experiment might be influenced by specific circumstances which happened at the moment of running the experiment. During the tests, no particular effects (e.g. higher stress rate of the MPO due to work related problems at that moment) were noticed by the author. The validity of the results in the future depends on two other matters not considered for this research. The first is when other fundamental developments in the field of information provisioning for MPO's arise, requiring a replication of the experiment. The second aspect is the learning effect of using the system multiple times. Both mock-ups are tested once per respondent. Running the experiment a few times might show different results. Due to time limitations this was not possible.

6.4.2 Construct validity

"Construct validity refers to the degree to which inferences can legitimately be made from the operationalizations in the study to the theoretical constructs on which those operationalizations were based" (Trochim, 2006). The problem with validating the construct of the research is that it is very hard to assess whether the constructs developed by one person (in this case the author) might be confounding for participants. In order to make sure knowing whether confusion took place, the author paid specific attention to the reactions of the MPO when answering the questions based on the constructs. A correlation matrix also shows to what degree the indicator variables measure independently from each other. The items showing high correlations are expected:

- 'Future use' (item 1) and 'make work easier' (item 2): $r = .651$
- 'Make work easier' (item 2) and 'easy to operate' (item 3): $r = .639$
- 'Information received needed' (item 5) and 'amount of info fits task' (item 6): $r = .621$
- 'Task-media fit of information exchange' (item 11) and 'task-media fit for decision-making' (item 12): $r = .538$

The shown correlations are from the license plate scenario posttest. The data of the pretest and emergency aid scenario posttest show similar results. The high correlations should be taken into account when discussing the results.

Next, the threats defined by Campbell & Cook (1979) on construct validity are reviewed. The 'mono-method bias' is a threat to this research due to the removal of indicator variables of the TAM/TMF constructs which is clarified in chapter 6.2. Given the high standard deviations (shown in the results section 6.5), this threat seems to have played a role in the measurement. Therefore, we can not claim the results show a measurement of the construct as Davis (1989) proposed it. The results have to be considered by the exact way the statement is defined. By comparing them to the observations we can further state their applicability. The 'interactions of different treatments' threat is controlled for by the solution proposed by Campbell & Cook (1979); measuring both scenarios independently. A learning effect between the scenarios is ruled out by switching the order of presenting the scenarios.

The final threat on the experimental research is the 'restricted generalizability across constructs'. The most important side-effect the measures can not fully ground is the safety of the MPO using the system. It is for that reason that items on safety were added to the total list of items, though dynamics can not be included as indicated before.

6.4.3 Internal validity

The last validation phase to be discussed is the internal validity. The key question in internal validity is whether observed changes can be attributed to the program or intervention and not to other possible causes" (Trochim, 2006). Having MPO's use one of each mock-up on a random basis each group is similarly constituted on the average. Randomization takes care of some threats to internal validity (Campbell & Cook, 1979). Due to the relatively small groups however, it is important to be cautious with ruling out threats. Similar to the previous paragraph, only the influential threats are discussed.

The threat of 'testing' is the first influential threat. Due to the usage of two scenarios per mock-up there is a learning effect that is developed. By switching the order of the scenarios within the group the effect is balanced. Analysis of the learning effect showed no clear significant differences exist between the order of the scenario's which is strange (only two items showed a p-value $< .05$). There are two possible reasons for this occurrence. The first is that many MPO's compared answers of one scenario to the other, even after putting questions on different pages. The second reason lies in the scenario itself, influencing the first reason just mentioned as well. The emergency aid scenario does not capture the dynamics of a real-life emergency aid scenario. Therefore, the difference between both scenarios might have been too small for MPO's to assess both situations differently from each other.

‘Instrumentation’ is also an issue. Firstly, small changes in the pretest and posttest exist as different systems are measured. However, given the difference is small, the assumption is made that for this reason instrumentation is not seen as a threat. The second problem arises because the two different scenarios are not measured in the pretest. Including them would result in a longer questionnaire and in very different comparisons as the pretest answers would be based on experience, not on the scenario. This would threaten internal validity even more.

The ‘selection’ threat is due to the effect of group differences. Although randomization is used to rule selection out, an analysis is executed to check whether this is true. The check is based on the various background attributes (gender, age, amount of years working for the police, rank and the main task). Only the main task analysis presents a significant selection threat for the situation items. These items show a large gap between the means and p-values close to the .05 level. The emergency aid MPO’s rate the systems much higher in all four situations. The reason for this difference might come from the fact that emergency aid MPO’s are used to driving in more difficult circumstances, giving them more confidence about using the system in all situations.

6.4.4 Conclusion on validation

Discussing the validation showed that many threats are able to confound the participants and obtained data. But many of these threats are controlled for. Three threats need to be considered while analyzing the results. The first is that it is impossible to declare the results are applicable to all police departments. Secondly, the results on safety issues can not be directly translated to an implemental service. Considering the construct validity the mono-method bias is a threat, due to the removal of TAM/TMF indicator variables. The second is the restricted generalizability across constructs as the experiment does not present the dynamics of a real-life situation. This especially affects the safety related issues. The last considerable threat that became clear is the testing. The relatively small difference in means between both scenarios might come from the emergency aid scenario not capable of communicating the dynamic nature of a real-life emergency aid situation. The next step is to discuss the results of the experiment.

6.5 Results

First, the general trend of the results is mentioned. Next, the results on each item will be discussed based on all results from the analysis. The third step is to go through the qualitative results. This part entails the observations made by the author during tests, combined with negative and positive aspects pointed out by the MPO’s. Then the video-tapes for safety measurement are analyzed and finally the results of a timer used to measure speech recognition speed are explained.

6.5.1 General trend of the results

The results section is based on the ANCOVA models and student *t*-tests performed on the data. The resulting models from the data analysis are presented in appendix J per measured variable, including box-plots indicating the interquartile range and median to get an impression of the data structure. In order to project the results in a more compact manner, the means, standard deviations and p-values are presented in table 6.5 and table 6.6. Table 6.5 shows the results for the 12 general statements in order to measure the value of the service per current sytem and mock-up. Table 6.6 presents the results for the situational items (not measured per scenario). The p-values are used to prove whether differences are significant or not at $p < 0.05$. Table 6.5 and 6.6 are rather complex, so an explanation of how to interpret the table is presented in figure 6.8, under table 6.5 and table 6.6.

Quickly scanning the means presented in table 6.5 and 6.6 shows that the highest means (dark green) are attributed to the touchscreen mock-up. There are only four items (including both scenarios) showing a higher mean for the head-up display and speech recognition combination mock-up (the detailed results are discussed in chapter 6.5.2). When comparing to the current information systems being used by MPO’s the results are even clearer. The means are lowest (red) on all items for both scenarios except for one head-up display comparison and one touchscreen comparison.

Table 6.5: Overview of means, standard deviations and p-values for the general statements (n=30 for HUD, n=33 for Touchscreen)

Item			License plate scenario		Emergency aid scenario	
		Current system	HUD	Touchscreen	HUD	Touchscreen
Future use of the system	Mean	4.86	5.10	6.09	4.57	5.72
	Std. Dev.	1.69	2.22	.88	2.25	1.31
	Current system – HUD / Touchscreen Sign.		.951	.006	.334	.004
	HUD – Touchscreen Sign.		.023		.020	
System makes work easier	Mean	4.33	5.16 [a]	6.00 [a]	4.85 [a]	5.56 [a]
	Std. Dev.	1.63	1.58	1.57	1.74	1.74
	Current system – HUD / Touchscreen Sign.		.047	.019	.047	.019
	HUD – Touchscreen Sign.		.045		.046	
Easy to operate the system	Mean	3.37	4.47	5.97	4.70	5.64
	Std. Dev.	1.62	2.16	1.05	2.20	1.22
	Current system – HUD / Touchscreen Sign.		.155	.000	.065	.000
	HUD – Touchscreen Sign.		.001		.037	
System makes task execution faster	Mean	3.43	4.86	5.72	4.87	5.24
	Std. Dev.	1.44	2.04	1.13	1.91	1.41
	Current system – HUD / Touchscreen Sign.		.017	.000	.006	.000
	HUD – Touchscreen Sign.		.046		.391	
Info received needed by MPO	Mean	4.17	5.77	5.82	5.60	5.76
	Std. Dev.	1.56	1.25	.73	1.28	.94
	Current system – HUD / Touchscreen Sign.		.000	.000	.000	.000
	HUD – Touchscreen Sign.		.843		.577	
Amount of info fits task	Mean	4.03	5.63	5.85	5.49 [a]	5.73 [a]
	Std. Dev.	1.45	1.22	.91	1.10	1.05
	Current system – HUD / Touchscreen Sign.		.000	.000	.000	.000
	HUD – Touchscreen Sign.		.346		.395	
Time needed to receive info not too long	Mean	3.40	5.23	5.25	5.60	5.58
	Std. Dev.	1.62	1.50	1.46	1.03	1.09
	Current system – HUD / Touchscreen Sign.		.000	.000	.000	.000
	HUD – Touchscreen Sign.		.177		.258	
Time needed to operate system not too long	Mean	3.52	5.09 [a]	5.92 [a]	5.00	5.45
	Std. Dev.	1.57	1.74	.99	1.76	1.35
	Current system – HUD / Touchscreen Sign.		.000	.000	.004	.000
	HUD – Touchscreen Sign.		.022		.281	
System operation does not influence safety	Mean	3.29	3.90	4.33	3.87	4.18
	Std. Dev.	1.74	1.92	1.57	1.94	1.65
	Current system – HUD / Touchscreen Sign.		.074	.000	.087	.002
	HUD – Touchscreen Sign.		.243		.343	
Info compre-hension does not influence safety	Mean	4.46	5.37	4.60	5.03	4.39
	Std. Dev.	1.50	1.54	1.46	1.69	1.54
	Current system – HUD / Touchscreen Sign.		.041	.437	.270	.862
	HUD – Touchscreen Sign.		.048		.147	
Task-media fit info exchange	Mean	4.02	5.27	5.73	5.27	5.48
	Std. Dev.	1.56	1.93	.84	2.08	1.09
	Current system – HUD / Touchscreen Sign.		.037	.000	.043	.000
	HUD – Touchscreen Sign.		.201		.522	
Task media fit decision-making	Mean	3.97	4.80	5.12	4.83	4.90
	Std. Dev.	1.40	1.67	.96	1.80	1.10
	Current system – HUD / Touchscreen Sign.		.185	.000	.187	.000
	HUD – Touchscreen Sign.		.325		.805	

[a] based on estimated means from ANCOVA analysis.

Table 6.6: Overview of means, standard deviations and p-values for the situational statements (n=30 for HUD, n=33 for Touchscreen)

Item		Current system	HUD	Touchscreen
Standing still	Mean	6.17	5.57	6.67
	Std. Dev.	1.02	2.11	.54
	Current system – HUD / Touchscreen Sign.		.053	.001
	HUD – Touchscreen Sign.		.005	
Constant. changing traffic environm.	Mean	4.17	4.87 [a]	4.30 [a]
	Std. Dev.	1.68	1.87	1.66
	Current system – HUD / Touchscreen Sign.		.003	.003
	HUD – Touchscreen Sign.		.249	
Stable traffic environm.	Mean	4.90	5.33 [a]	5.58 [a]
	Std. Dev.	1.56	1.90	1.18
	Current system – HUD / Touchscreen Sign.		.048	.048
	HUD – Touchscreen Sign.		.602	
Emergen. aid situation	Mean	3.49	4.20	4.39
	Std. Dev.	2.08	2.31	1.85
	Current system – HUD / Touchscreen Sign.		.919	.003
	HUD – Touchscreen Sign.		.985	

[a] based on estimated means from ANCOVA analysis.

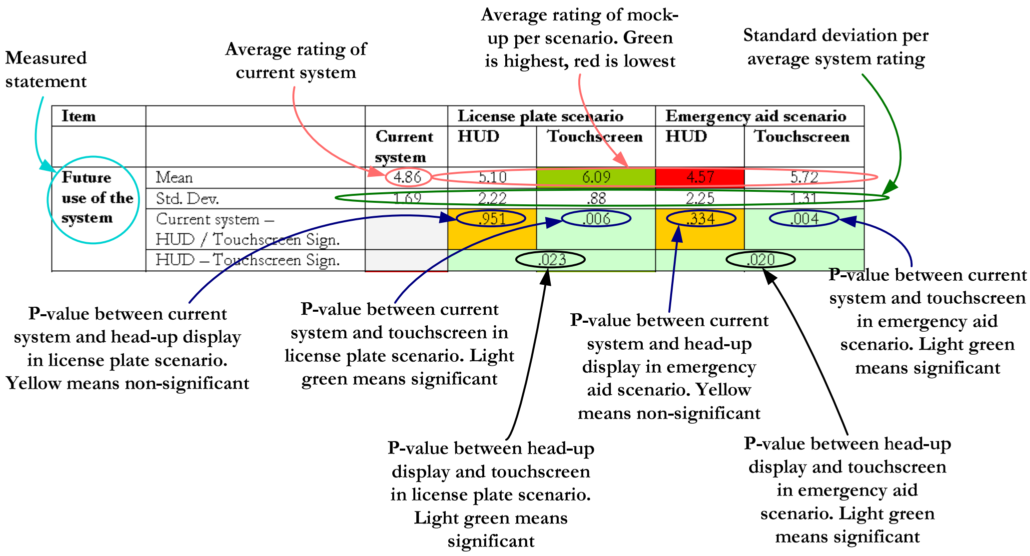


Figure 6.5: explanation of the interpretation of results table 6.5 and 6.6

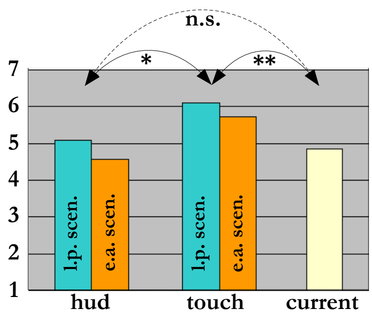
A third trend becoming clear when scanning the results, are the differences in standard deviations between the thee information systems. Given the amount of respondents (n =30 for the head-up display mock-up and n =33 for the touchscreen mock-up) high standard deviations are expected. But reviewing the different box-plots per item (see Appendix J) graphically shows that especially the standard deviations of the head-up display mock-up systems are high. Seen the differences of standard deviations between the rated systems, the participants experience the system differently. The standard deviations of the current system are lower in general compared to the head-up display mock-up, but also higher if compared to the touchscreen. These standard deviations of the current system are higher than expected. A reason might be the difference in equipment being used per region. The touchscreen standard deviations are much smaller, showing a clearer agreement among the participants of this mock-up. The general trends of the results correspond with the results from the interviews and the internet research performed with MPO's. Checking the trends between the license plate scenario and the emergency aid scenario, the difference is less than expected. The presumed reason is explained in the 'testing' threat of the validation phase.

6.5.2 Results per item discussed

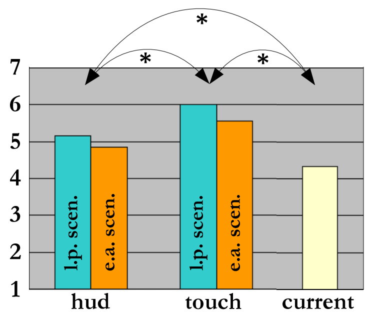
The next step is to present a detailed analysis of the results on each statement measured with the MPO's. The license plate scenario is coded as LP and the emergency aid scenario is coded as EA. For each statement a graph is presented indicating the average ratings of each system, per scenario if applicable. The arrows between systems indicate whether the difference in mean is significant or not. A dotted arrow implies a non-significant difference, an arrow with one star implies a significant difference at $\alpha = 0.05$ and a double starred arrow implies a significant difference at $\alpha = 0.01$.

The first two statements are coming from the "intension to use" construct from the TAM/TMF model. The first is defined as: "*MPO's will use the information system".* For this variable the current system has a mean of 4.9 which is higher than expected based on the interviews. However, seen that MPO's do not have other means of communicating it makes more sense. It is also important to keep in mind that the statement created some confusion in the pretest. The head-up display mock-up ($M_{LP} = 5.1$, $SD_{LP} = 2.2$; $M_{EA} = 4.6$, $SD_{EA} = 2.3$) does not show a significantly different result from the current situation ($M = 4.9$, $SD = 1.9$; $t_{LP}(29) = .062$, $p_{LP} > .05$; $t_{EA}(29) = .983$, $p_{EA} > .05$). The standard deviations are exceptionally high for the head-up display mock-up. The touchscreen mock-up shows low standard deviations and high means ($M_{LP} = 6.1$, $SD_{LP} = 0.8$; $M_{EA} = 5.7$, $SD_{EA} = 1.3$) which are significantly different from the current system ($t_{LP}(32) = -2.944$, $p_{LP} < .05$; $t_{EA}(32) = -.3.138$, $p_{EA} < .05$) and the head-up display system ($F_{LP}(1) = 5.420$, $p_{LP} < .05$; $F_{EA}(1) = 5.757$, $p_{EA} < .05$).

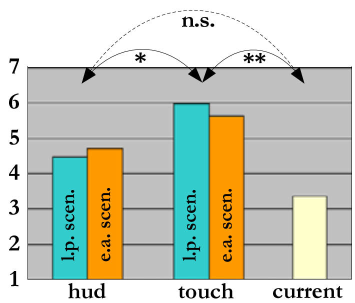
The second variable (*The information system makes the work of MPO's easier*) shows very similar results compared to the first. The biggest difference is the lower mean of the current system ($M = 4.3$, $SD = 1.6$). The effect of the pretest on the posttest is significant ($p < .05$) therefore the estimated means of the ANCOVA analysis are used. The means of the head-up display ($M_{LP} = 5.2$, $SD_{LP} = 1.6$; $M_{EA} = 4.8$, $SD_{EA} = 1.7$) are again significantly different from the means of the touchscreen ($M_{LP} = 6.0$, $SD_{LP} = 1.6$; $M_{EA} = 5.6$, $SD_{EA} = 1.7$; $F_{LP}(1) = 3.772$, $p_{LP} < .05$; $F_{EA}(1) = 5.816$, $p_{EA} < .05$). Based on the correlations between the first two variables and the results, the conclusion can be made that MPO's are generally eager to use the service concept design as presented in chapter 5 on the motorcycle in the future. The touchscreen mock-up achieves best at making the work of an MPO easier.



Future use of the system



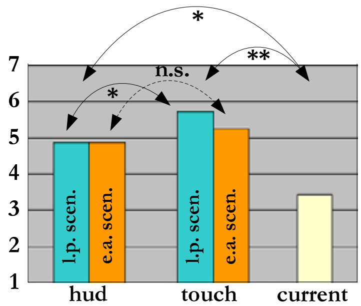
System makes work easier



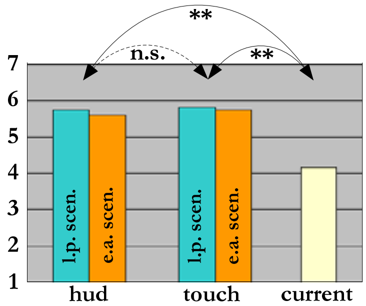
Easy to operate the system

Chapter 4 concluded from the TAM/TMF results that: 'By making the system very easy to use by MPO's, the potential of information exchange and decision making increases'. The results of the statement: '*The information system is easy to operate by MPO's*' show the steepest increase in rating between the three mock-ups of all variables. The current information systems used by MPO's are clearly not easy to operate ($M = 3.4$, $SD = 1.6$). The head-up display scores higher, but not significantly ($M_{LP} = 4.5$, $SD_{LP} = 2.2$; $M_{EA} = 4.7$, $SD_{EA} = 2.2$; $t_{LP}(29) = -1.461$, $p_{LP} > .05$; $t_{EA}(29) = -1.916$, $p_{EA} > .05$). The touchscreen mock-up ($M_{LP} = 6.0$, $SD_{LP} = 1.0$; $M_{EA} = 5.6$, $SD_{EA} = 1.2$) shows a significant difference between the two other information systems though (all $p < .05$, for all values see Appendix J). It is clearly easier to operate when compared to the speech recognition of the head-up display system. Considering the high correlations between the first two variables and the second and third variable just discussed, we see a general pattern of the touchscreen clearly scoring highest on all three statements.

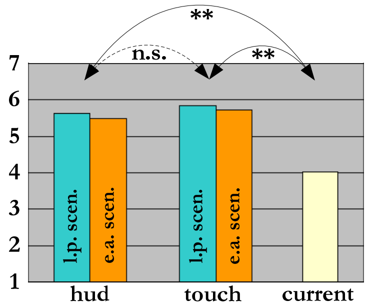
Checking whether *the information system makes MPO's execute their tasks faster* is not only interesting to MPO's, but also to police management and citizens in general. The increase in faster task execution of the head-up display mock-up (M_{LP} = 4.9, SD_{LP} = 2.0; M_{EA} = 4.9, SD_{EA} = 1.9; $t_{LP}(29)$ = -2.531, $p_{LP} < .05$; $t_{EA}(29)$ = -2.955, $p_{EA} < .05$) and the touchscreen mock-up (M_{LP} = 5.7, SD_{LP} = 1.2; M_{EA} = 5.2, SD_{EA} = 1.4; $t_{LP}(32)$ = -7.202, $p_{LP} < .05$; $t_{EA}(32)$ = -5.434, $p_{EA} < .05$) vis-à-vis the current system (M = 3.4, SD = 1.4) is significant. An interesting fact here is that the difference between the two mock-ups is significant for the license plate scenario ($F_{LP}(1)$ = 3.786, $p_{LP} < .05$) and non-significant for the emergency aid scenario ($F_{EA}(1)$ = .746, $p_{EA} > .05$). The reason is most likely the touchscreen mock-up using the camera entry of the license plate number and the head-up display using speech recognition. The conclusion is that the context-aware service makes task execution faster, and the addition of a camera to check license plate numbers is seen as a significant aid in making MPO's execute the license plate checking task faster.



System makes task execution faster



Info received needed by MPO



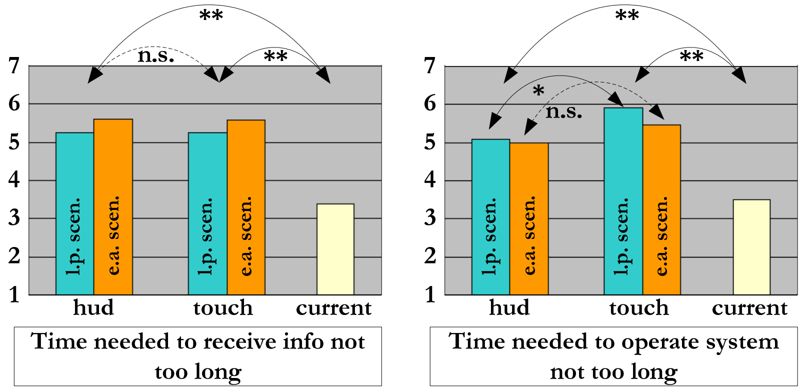
Amount of info fits task

Statement '*the information received through the information system is needed by MPO's* focuses on the information itself. It is to be expected that no significant difference between both mock-ups should arise as the information is exactly the same. Only the medium is different. The problem however is that each group consists of different people, meaning that it is a good test of validity. Reviewing the final results gives confidence about the experiment. The difference between both mock-ups is very small ($F_{LP}(1)$ = .039, $p_{LP} > .05$; $F_{EA}(1)$ = .314, $p_{EA} > .05$). The means of the mock-ups are high (M_{LP} = 5.8, SD_{LP} = 1.3; M_{EA} = 5.6, SD_{EA} = 1.3 for the head-up; M_{LP} = 5.8, SD_{LP} = 0.7; M_{EA} = 5.8, SD_{EA} = 0.9) and significantly higher than the current system (M = 4.2, SD = 1.6). The next statement: '*the given amount of information through the information system fits the task of the MPO'* shows very comparable results. This was expected seen that the correlation between both variables is high. Concluding, the information received through a context-aware service and the amount of information as designed in chapter 5 is much more needed than current information.

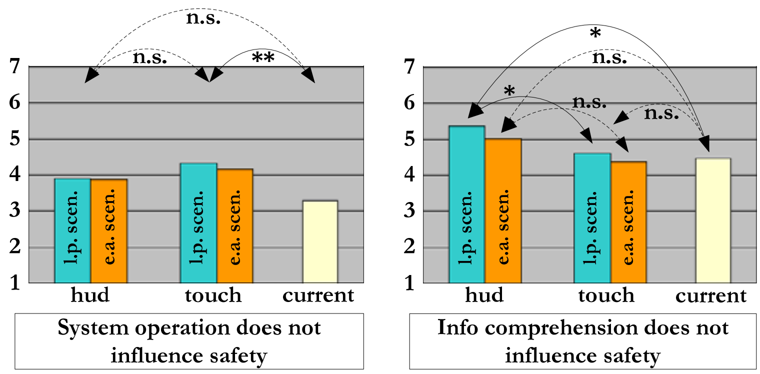
The next statement once again shows results which are similar to the last two statements. '*The time needed to receive the information through the information system is not too long'* is important as improving information time is one of the main goals of the service design. The times of both mock-ups are exactly the same, which is grounded by the fact that there are no significant differences between both mock-ups ($F_{LP}(1)$ = 1.869, $p_{LP} > .05$; $F_{EA}(1)$ = 1.303, $p_{EA} > .05$). A significant difference does exist between the current situation (M = 3.4, SD = 1.6) and the mock-ups though ($t_{LP}(29)$ = -4.493, $p_{LP} < .05$; $t_{EA}(29)$ = -4.631, $p_{EA} < .05$ for the head-up display; $t_{LP}(32)$ = -6.440, $p_{LP} < .05$; $t_{EA}(32)$ = -6.313, $p < .05$). Both mock-ups show a M_{LP} = 5.2 for the license plate scenario and a M_{EA} = 5.2 for the emergency aid scenario. As the information comes faster in the emergency aid scenario due to a high bandwidth network the higher mean was expected. The average increase of 2 points on a 7-point scale from current system to mock-up is impressive and shows that the technology is capable of presenting information much faster compared to the information systems used at the moment of testing. It has to be noted that these results are only valid if the shown mock-up system functions flawlessly in a real-life situation as well.

Checking '*the time needed to operate the information system is not too long'* focuses on the current system, the speech recognition and the operation of a touchscreen. For the license plate scenario all means are significantly different from each other. The touchscreen scores highest (M_{LP} = 5.9, SD_{LP} =

1.0). The head-up display scores considerably lower (M_{LP} = 5.1, SD_{LP} = 1.7; $F_{LP}(1)$ = 5.495, p < .05). The speech recognition proved to be well-functioning, which corresponds with the success explained by Kun (2007) in Project54, but not as well as the touchscreen. Lastly, the current system scores much lower (M = 3.5, SD = 1.6), fitting the complaints heard about operating the current information system (Interview Doorwerth, Driebergen 2007). The emergency aid shows a much lower mean for the touchscreen (M_{EA} = 5.5, SD_{EA} = 1.3; $F_{EA}(1)$ = 1.835, p > .05) and not significantly different from the head-up display mock-up. The reason for this became apparent during the tests. During the emergency aid scenario, the MPO needs to press a button to get more information. Many MPO's indicated that this was annoying and all information should be presented after each other without having to operate the system. This is important to consider in the service design.

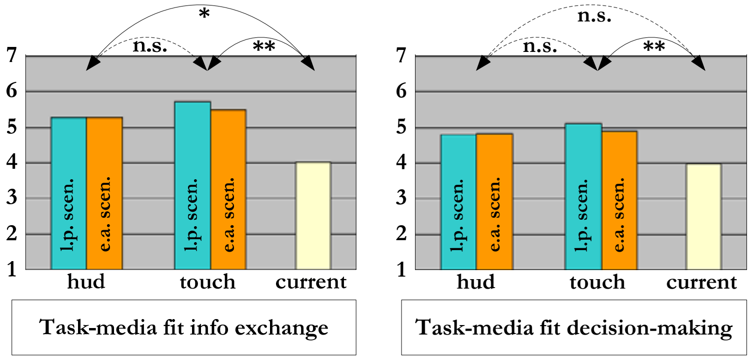


Items 9 and 10 focus on the influence of the system on MPO safety, a topic which is difficult to measure in a static environment as discussed before. Rating these statements is more based on experience of the MPO. During the tests, many MPO's named the influence of the system on safety as their biggest concern. The results of the data analysis from the question measuring *the influence of system operation on safety* did not show very high means (current system: M = 3.3, SD = 1.7; head-up display: M_{LP} = 3.9, SD_{LP} = 1.9, $t_{LP}(29)$ = -1.857, p_{LP} > .05; M_{EA} = 3.9, SD_{EA} = 1.9, $t_{EA}(29)$ = -1.771, p_{EA} > .05; touchscreen: M_{LP} = 4.3, SD_{LP} = 1.6, $t_{LP}(32)$ = -3.886, p_{LP} < .05; M_{EA} = 4.2, SD_{EA} = 1.6, $t_{EA}(32)$ = -3.387, p_{EA} < .05). As shown from the results, there is a significant difference between the touchscreen mock-up mean and the current system mean. The difference between both mock-ups is not big, therefore not significant. The conclusion can be made that in a static environment, operating the touchscreen has the least influence on MPO safety. However, the means are still to low to consider the usage 'safe' given the testing environment. Taking the hand of the handle-bar to operate the system is the most influential problem regarding the touchscreen.



The second safety statement is formulated as follows: '*Comprehending the information does not require too much time for the MPO to keep driving safely in traffic'.* The ratings of the current system, the text-to-speech and reading from a touchscreen are compared. Again, the static environment needs to be taken into consideration. The results show a different outcome compared to all previous statements. In the license plate scenario, the head-up display mock-up (M_{LP} = 5.4, SD_{LP} = 1.5) shows a significantly higher mean than both other systems (current system: M = 4.6, SD = 1.6, $t_{LP}(29)$ = -2.143, p_{LP} < .05; touchscreen: M_{LP} = 4.6, SD_{LP} = 1.5, $F_{LP}(1)$ = 3.656, p_{LP} < .05). This means that getting information through text-to-speech software has significantly less influence on safety compared to the current system and reading from a touchscreen in a license plate scenario. Although tested in a static environment, the MPO's clearly indicated after the test that they felt strongly about this conclusion. This way they keep their eyes on the road while driving and the information is clear. Although the emergency aid scenario shows a higher mean for the head-up display (M_{EA} = 5.0, SD_{EA} = 1.7) compared to the other systems (touchscreen: M_{EA} = 4.4, SD_{EA} = 1.5) no differences are significant. The license plate scenario conclusion is not applicable to the emergency aid scenario.

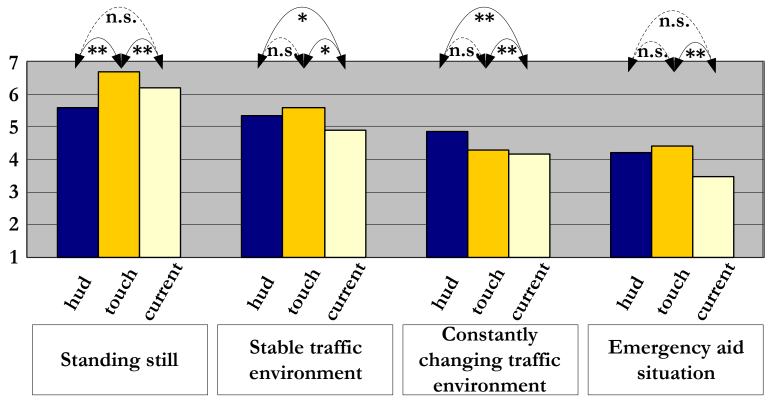
The results of the following two statements '*the information system is the right media for information exchange and decision-making'* show similar result patterns. As the correlation between these two variables is high this similarity was expected. The current system is rated similar for both variables (*M* = 4.0 for both, *SD* = 1.4 and *SD* = 1.6). For the information exchange variable in the license plate scenario, the mock-ups are significantly different from the current system (all p-values < .05) though not significantly different from each other due to a high standard deviation of the head-up display mean (head-up display: M_{LP} = 5.3, SD_{LP} = 1.9; touchscreen: M_{LP} = 5.7, SD_{LP} = 0.8, $F_{LP}(1)$ = 1.675, p_{LP} > .05). The emergency aid results are not discussed as they are very similar.



As mentioned, the decision-making task-media fit shows similar results compared to the information exchange although the means of both mock-ups are slightly lower (head-up display: M_{LP} = 4.8, SD_{LP} = 1.7; touchscreen: M_{LP} = 5.1, SD_{LP} = 1.0, F_{LP} (1) = .985, p_{LP} > .05). Similar to the previous statement, the emergency aid scenario shows very similar results. Concluding, the context-aware service design improves the information exchange and decision-making. If choosing an information system, the touchscreen mock-up presumably offers a better platform. More participants are needed to lower standard deviations and ground the choice of information system.

Results of the situational questions

For each information system tested, the question is asked to rate to what degree they would use the system in four different situations on a 7-point Likert scale. The question was asked in general, not per scenario. The results of these four situations are now briefly discussed.



First a brief review of the trend between the four situations is given. As can be seen from the four graphs presented above, from standing still to the emergency situation a general decreasing line of usefulness can be noticed. This makes sense, as each situation towards the right shows an increases need of attention to the surroundings of the MPO. The service design (using a touchscreen) does not perform well in a constantly changing traffic environment. This makes sense considering the need to read from the screen and operate on the screen. The head-up display scores better here. For all situations the current system scores significantly lower when compared to service concept as designed in chapter 5. However, the values ratings of the service for the complex situations are too low for a static test. We go more in detail now by discussing each situation.

As was expected, when *standing still* all three information systems (current, head-up display and touchscreen) score high. The data analysis shows significant differences however and the touchscreen is clearly preferred (M = 6.7, SD = 0.5). An interesting result is that the head-up display mock-up rates lowest (M = 5.6, SD = 2.1, $F(1) = 8.482$, $p < .05$). Using a head-up display with speech recognition is not as preferred when standing still. Apparently looking through a small screen and operating the system using speech recognition is more complicated then pressing a button on a screen or a mobile terminal.

The next statement (*'driving in a constantly changing traffic environment')* shows very different results. The lowest mean is noted by the current information (M = 4.2, SD =1.7) system which is not very strange considering the low ratings of all previous statements. The head-up display mock-up however shows a higher mean (M = 4.9, SD = 1.9) compared to the touchscreen mock-up (M = 4.3, SD = 1.7, $F(1) = 1.355$, $p > .05$). The difference is not significant, but is still interesting. The results further ground that reading from a touchscreen is not doable in a constantly changing traffic environment and getting information through speech is less influential on safety. These conclusions are based on a static environment.

In a *stable traffic environment*, the only conclusions that can be made is that the usage of the context-aware service design receives a higher rating (head-up display - M = 5.3, SD = 1.9; touchscreen - M = 5.6, SD = 1.2, $F(1) = .275$, $p > .05$) than the current information system (M = 4.9, SD = 1.6, $F(1) = 4.074$, $p < .05$). As the ratings show, the mean of the touchscreen is slightly higher, assuming a preference for a touchscreen in a stable traffic environment.

The last situation is an *emergency aid situation*. In this case it is rated more on experience of the MPO than on a scenario used for the first 12 statements. It therefore provides an interesting comparison. The means of both mock-ups are higher than the current system (current information system – M = 3.5, SD = 2.1; head-up display - M = 4.2, SD = 2.3; touchscreen - M = 4.4, SD = 1.9) but because of a very high amount of variance only the difference between the touchscreen and current system can be claimed significant ($t(32) = -3.266$, $p < .003$). Looking at the box-plot clearly shows the high variance graphically. Comparing the means to the variables using the scenario a clear difference is visible. The scenario used for the mock-ups is not able to project the dynamics of an emergency aid situation. Getting a grounded answer to this question requires a real-life test including all three systems.

6.5.3 Qualitative results of the mock-up experiment

Observations and remarks from MPO's

The first qualitative part is based on observations made by the author, the positive and negative impressions written down in part 3 and 4 in the questionnaire and the talks with the MPO's after having used the system. Not all observations are discussed, just the aspects returning more than once during the tests. First the positive and negative aspects of the context-aware service design is discussed, followed by the positive and negative aspects of the touchscreen mock-up and lastly the positive and negative aspects of the head-up display mock-up. The observations on the service design come from both groups. Touchscreen mock-up observations come from the touchscreen testing group and the head-up display observations from the head-up display testing group. The quotes come directly from the MPO's themselves.

Service design

Positive

The first important fact is the positive reactions gotten from almost every MPO. Almost all of them ended the session with mentioning they see it as a nice and useful system and put a smile on their faces. The results of the quantitative part ground these reactions. The usability of the system is generally positive due to the user-friendliness and logical lay-out of the service. "There are fewer actions needed to operate the system compared to the current situation". The buttons are large and not many are shown making the choice short and simple. It must be said that the touchscreen version especially resulted in this reaction, thereby grounding the results from the 'future use', 'system makes work easier' and 'easy to operate' statements. Although the screen was large, MPO's also claimed a smaller screen could be usable. The most important aspect is that the buttons are large enough to be pushed with gloves on and that the text is well readable.

The effectiveness of the system in providing information in a faster manner was also seen as a large improvement. This grounds the difference between quantitative results of the 'system makes task execution faster' statement. Some of the following quotes written down by the MPO's further prove the effectiveness: "A lot of work done for you; lots of information available; all needed information available; able to determine how much information you want for yourself". This effectiveness results in "a much higher speed of task execution" and will therefore stimulate MPO's to check more people and cars". A positive side-effect of the service is that the "MPO can get information by himself, therefore not dependent on the control room". Ensuring a fail-proof system is clearly important. The use of hybrid networking can add to the availability of connections.

Focusing on specific features of the service also resulted in positive reactions. Firstly, the addition of navigation was named by many MPO's, especially if connected to destination addresses by the control room. A second feature which proved to be very useful was a "back" button. This seems strange, but almost all MPO's mentioned that for example a license plate number is written down on the motorcycle using a marker, as they would hear it once but couldn't remember it. Having a "back" button means that they can reread or rehear the number at all times. The third feature mentioned as very positive by all MPO's was the storage of the location, time and information on the performed task which can be send to the account of the MPO. Lastly, "keeping the control room up-to-date with the actions by using the system" has two positive effects. It stops the MPO from having to connect to the control room for every action to be taken, and gives the MPO a safe feeling as he or she knows the control room is informed about the action of the MPO.

Negative

The first negative aspect accounts for the service design, as well as the usage of a touchscreen system or head-up display system. Many MPO's fear their safety when using either system in traffic. This fear can also be seen from the quantitative results on safety related statements. They said: "safety is difficult to assess in a static environment. It needs more attention and should be tested further in a real situation". The specific safety issues of each mock-up are discussed the respective chapter. But the safety issue they explain is not only related to the effect of the system on traffic safety. An important aspect taken away by the system as seen in the mock-up is the "information sharing between colleagues which is highly important and gives a safer feeling". "Speech contact with the control room in critical situations is preferred" and "in some situations sharing direct speech information between colleagues is important". Something affected by the exclusion of C2000 was the loneliness of MPO's when not communicating with the control room. Also, "the system does not think ahead. Sometimes the control room thinks with you in order to decide what to do". It must be noted that for the mock-up, C2000 communication was not included. In a real system C2000 is included, offering the MPO the choice of information provisioning.

Some MPO's questioned whether it is the total system is technically possible on a motorcycle. Most of them have bad experiences with the C2000 equipment on a motorcycle, making them highly skeptical. A related aspect not thought of before and highly important was the question: "what happens when the system or parts of the system fail?" Lastly, some MPO's thought the system was too dominant. As the MPO has to operate the system, the system is always "available". This could become annoying while driving many hours every day.

Touchscreen mock-up

Positive

The touchscreen mock-up resulted in more positive reactions compared to the head-up display mock-up. The remarks given by tested MPO's were also more constant. The touchscreen mock-up proved to be easy to operate without having to search for the right button. Where the head-up display required some explanation from the author, the touchscreen almost didn't need any to be used well. The size of the screen was good and it was very clear.

One of the features which resulted in positive reactions on the touchscreen system was the automatic scanning of the license plate. Checking license plate numbers is one of the most performed actions by MPO's and using an automatic system results in a much faster and easier check. A few MPO's also stated it is safer as there is no need to perform any actions while the system is checking the license plate number. A second positive feature was the usage of colors to present positive information (green) and negative information (red). Lastly, due to the size of the font used on the touchscreen all text was also readable by MPO's wearing reading glasses.

The last positive aspect of the touchscreen is safety related. Many MPO's were fond of the touchscreen as it gives them the opportunity to decide when to use the system. This is presumably the reason why the touchscreen mock-up rated slightly higher than the other system measured on the operation safety statement. In case the traffic situation does not allow usage the system can be ignored as it does not block the vision on the road.

Negative

In line with the negative reactions on the service design, the most fundamental negative reactions on the touchscreen are also safety related. The most important complaint is that "reading from the screen stops the MPO from looking at the road. This could specifically create problems in constantly changing traffic situations and emergency aid situations. You are very focused on the screen to get the information." This negative aspect becomes a problem if a lot of text is presented on the screen, e.g. the information on the person asserted in the license plate scenario. Again, the info comprehension influence on safety statement grounds this negative aspect. Clearly, "spoken information is missing".

Operating the system is also named as an issue by many MPO's. "Removing the hand of the handle bar is dangerous and in some situations impossible. Especially having to press the 'more information' button in the emergency aid scenario is impossible during the execution of such a task". Many MPO's proposed a simple control button next to the hands on the handle bar.

The screen itself brought up many questions, especially from the MPO's who already have experience with a touchscreen on the motorcycle. Firstly, they stated that the current touchscreen systems failed due to rain and high speeds. Subsequently they wondered if a camera scanning license plate numbers would work in a real-life situation. A second problem mentioned is that "a large screen can become distracting, especially at night because of the large source of light. During the day the touchscreen might become unreadable when the sun shines on it; a significant problem with current touchscreens" Other negative reactions are also based on practical problems. District MPO's drive on smaller motorcycles which have a small dashboard space. The touchscreen used does not fit, so smaller screens should be used. This reduces the size of buttons on the screen and the ease of use. Lastly, on all motorcycles the speedometer is blocked. All MPO's need the speedometer to define the speed of cars and fines are based on the speedometer of the motorcycle. The last question unresolved is what happens to the system when the motorcycle is left alone.

Head-up display mock-up

Positive

The head-up display resulted in highly inconsistent reactions. Some MPO's immediately mentioned the ease of use of the system as there is no need to "remove the hands of the handle-bar" and "you can see the road at all times". This group however was not very large. The large difference in reactions was also seen in the quantitative results when comparing standard deviations. Presumably, a large difference exists between the MPO's seeing the head-up display as a research object, and the MPO's judging the head-up display as a practical device to use. Most MPO's reacted with saying that: "it is a nice system, but not to be used on a motorcycle". They acknowledged that it offered "continuous information without having to look away from the road."

The speech recognition received positive reactions and was generally seen as a "usable tool to operate the system". A large part of the MPO's (83%) managed to finish both scenarios by using the speech recognition by themselves. Also the use of the NATO-alphabet was not seen as a problem. The last clear positive reaction came from the text-to-speech usage. All MPO's were able to fully understand all the information given to them through speech. Some even indicated it was much clearer than when they receive information from the control room through speech due to connection problems. This observation could be related to the higher rating of the information comprehension statement of the quantitative research. An important aspect to consider is the static environment where no external noise affected either the speech recognition or the text-to-speech.

Negative

As the reactions are inconsistent, also negative reactions are indicated. The list of negative reactions for the head-up display is rather long compared to the touchscreen. Many MPO's concluded the test by saying that they like the system, but that it is not usable for MPO's. "The attention for the road and other road users is completely gone, resulting in highly dangerous situations." The most important problem is that they need to "constantly switch in focus between the head-up display and the road; the feeling of depth is gone." Although some don't mind, most MPO's state you go crazy and start making mistakes. A second problem related to the first is a misbalance of vision resulting in instability for the driver. "Riding a motorcycle is completely different than driving a car. Your vision is very important to keep the balance on the motorcycle and the head-up display distorts the balance". As the head-up display is in front of one eye, "you are searching for the right things to do in order to use the system". Some MPO's claimed that if the head-up display can easily be turned off it would already be more usable as you can decide for yourself when to use the system.

Another problem with the head-up display model used is that it is inside the helmet, which could result in unsafe situations when a crash occurs. Especially if the MPO needs to wear glasses in order to read from the head-up display. Glasses are a problem in general, especially for people that use reading glasses. No people wearing reading glasses used the system. People using lenses mentioned that the lenses could get dry as "you are constantly opening your eyes". In general, "the head-up display could become very tiring when driving 8 hour shifts."

The speech recognition also resulted in some negative remarks. Firstly, although the speech recognition was capable of operating the system for most MPO's, some simply could not finish the scenario without help from the author. Most of the problems occurred in the regions where the MPO's have a stronger dialect and therefore a different pronunciation. The operation of a system must be 100% fail proof, something not achieved by the speech recognition in the mock-up. Also, "the usage of external noise (wind, engine, siren) will further decrease the correctness of speech recognition." Another problem might be the combination of speech recognition, text-to-speech and the usage of C2000 through speech. All combined, the different speech technologies become confusing. Lastly, many MPO's stated that the navigation should also be presented in the form of speech.

A few MPO's mentioned the strange look of the MPO when wearing a head-up display. When stopping someone with a head-up display in front of the eye, the MPO could be taken less seriously. This is important for MPO's, as they drive alone and have to be taken serious by the person being asserted or arrested to work successfully. The last negative point mentioned is that sometimes a helmet needs to be left alone. It would then be very easy for someone to steal the helmet including the highly expensive head-up display.

Safety research

The quantitative results and the qualitative observations explained above indicate that both systems have a considerable influence on the safety of MPO's in traffic. In the case of the head-up display, focusing on the road becomes more difficult and confusing which results in an unsafe feeling of the MPO. The touchscreen on the other hand forces the MPO to look away from the road, leading to unsafe situations. As explained in chapter 6.3 video footage is used to determine the glance durations of five MPO's, which can be compared to the TLC times presented in table 6.3 of paragraph 6.2.4.

The important figures to consider from the table 6.3 are the 'Speed' and the 'T Occlusion'. The latter states a mean occlusion time at which a person crosses either line of the lane he or she is driving in. It must be noted that the shown times are measured using a car, not a motorcycle. Data about motorcycles is not available. The results of the times measured from the video footage of the experiment are given in table 6.7 (license plate scenario) and table 6.8 (emergency aid scenario).

<table>
<tr><th></th><th>Read</th><th>Press Control button</th><th>Press Vehicle button</th><th>Check scan</th><th>License plate ok button</th><th>Watch process</th><th>Owner check button</th><th>Read info</th><th>Assert button</th><th>Read info</th></tr>
<tr><td>MPO1</td><td></td><td>2.8</td><td>2.8</td><td>1</td><td>1</td><td>2.8</td><td>3</td><td>1.8</td><td>3.5</td><td>< 1</td></tr>
<tr><td>MPO2</td><td>1.5</td><td>1.6</td><td>1.3</td><td>1.9</td><td>1.9</td><td>< 1</td><td>1.8</td><td>< 1</td><td>1.4</td><td>< 1</td></tr>
<tr><td>MPO3</td><td></td><td colspan="2">4.5</td><td>< 1</td><td>1.2</td><td>< 1</td><td>2.8</td><td></td><td>3.8</td><td>5.6</td></tr>
<tr><td>MPO4</td><td></td><td>2</td><td>1.1</td><td>5</td><td>1.5</td><td>< 1</td><td>3.4</td><td colspan="2">6</td><td>2</td></tr>
<tr><td>MPO5</td><td>3</td><td colspan="2">3.1</td><td>1.6</td><td>2.2</td><td></td><td>2.4</td><td>3</td><td>3.1</td><td>2.6</td></tr>
</table>

Table 6.7: Glance durations per phase for the license plate scenario (in seconds)

<table>
<tr><th></th><th>Check navigation</th><th>More info button</th><th>Read license plate</th><th>More info button</th><th>Read</th><th>Suspect seen button</th><th>Assert button</th><th>Read info</th></tr>
<tr><td>MPO1</td><td>2</td><td>2.8</td><td>3.4</td><td>3</td><td>3.3</td><td>2.4</td><td>2</td><td><1</td></tr>
<tr><td>MPO2</td><td>2</td><td>3.2</td><td>4.5</td><td>2</td><td>1.8</td><td>1.7</td><td>1.2</td><td>2.1</td></tr>
<tr><td>MPO3</td><td></td><td>4</td><td>2.6</td><td>2.2</td><td>< 1</td><td>4.4</td><td>3.7</td><td><1</td></tr>
<tr><td>MPO4</td><td></td><td>3.3</td><td>2.8</td><td>2.5</td><td>2</td><td>3.5</td><td>4</td><td>1.9</td></tr>
<tr><td>MPO5</td><td></td><td>2.8</td><td colspan="2">4.7</td><td>2</td><td>4</td><td>2.1</td><td>4.1</td></tr>
</table>

Table 6.8: Glance durations per phase for the emergency aid scenario (in seconds)

The times are calculated when a clear eye movement is made from the Television screen to the touchscreen of the mock-up, either combined with the movement of the arm pressing a button or not. The scenarios are split into clear parts which are more clearly elaborated in the scenario explanation of Appendix G. As can be seen, some phases are combined due to the fact that the MPO decides to do both steps in one glance duration. If the movement of the eye is below 1 second this is indicated as '< 1'.

Comparing both scenarios; the emergency aid scenario results in higher glancing durations. As the screen shows more information (in the form of more text and the navigation) this confirms our expectation. Taking the occlusion time 2.38s at speed 120km/h of Table 6.3, only MPO2 in the license plate scenario remains inside the driving lane. Clearly, when comparing the results of this research to the results of Godthelp et al. (1984), the touchscreen system seriously affects the safety of the MPO as speeds of 120km/h are very normal for an MPO. It must be said that some glance duration results are excessive. An example is the 5 seconds glance of MPO4 during the license plate scan. This is probably due to the fact that the idea of scanning a license plate is new to the MPO, thereby drawing his attention. A second important aspect related to the first is that the static environment of the experiment allows the MPO to glance more to the screen than in a real-life situation.

Focusing on the glance durations needed to press a button, the average of all durations is 2.55s. The average of the license plate scenario buttons is 2.26s, whereas the average of the emergency aid scenario buttons is 2.89s. The differences in time seem small, but the effects should not be underestimated. Comparing the averages to the 2.38s occlusion time of table 6.3; the average of the license plate scenario button press is lower. Although more MPO's are needed to statistically ground this conclusion, it gives an indication of the effect the easy lay-out of the service can have. The emergency aid scenario service design is more complicated with smaller buttons and pressing a button increases the glance duration compared to the license plate scenario. Seen that the lay-out of the service in the license plate scenario is simpler and with larger buttons, these attributes seem to make a difference.

Assessing the reading parts of the glance duration times is more difficult. The times are generally lower compared to the button pressing times. As the MPO does not have to press a button, he can glance at the screen in small steps. Tables 6.7 and 6.8 do not show the glance frequencies, only the durations. In case the MPO needs to read from the screen, the highest duration is entered in the table. The high durations are from MPO's clearly wanting to read all the information on the screen. An example is the information presented to the MPO at the end of the license plate scenario. All MPO's try to read the information in steps, except for MPO3 who reads all the information in once. The result is a glance duration of 5.6s. This could end up in a highly unsafe situation when driving at high speeds. Logically, the glance frequencies are high for the other MPO's. Many researchers state glance frequencies also influence safety (Zaidel, 1991; Grant & Wierwille, 1992), but no data is available to compare with.

When reviewing the videos there are some interesting findings about the glance frequencies without having data. The first is that unneeded information should be left out of the screen. An example is the download bar, graphically showing the time it will take to retrieve data This takes a lot of attention from the MPO, even though it is not needed. One MPO looked at the bar five times while doing the test. Secondly, large pieces of information should not be shown by the system when it is not needed. Going back to the license plate scenario ending, the information shown is not needed while driving. It can also be presented to the MPO when having come to a complete stop. This conclusion was also indicated by the MPO's themselves.

Timer measuring the speech recognition

As explained in chapter 6.3 a timer is installed to measure the time needed to enter the license plate number in the system. Scanning the different times measured, there is a large difference between the MPO's. During the tests it became clear that entering the license plate was much easier than for others. As the mock-up was standing in a quiet environment, the difference can only be attributed to the pronunciation of the MPO. The average time needed to enter the license plate number is 37.8s, which is more than half a minute. Although no official measurements of Automatic license plate recognition systems are available, computer calculations of a license plate image are presumably faster than using speech recognition.

6.6 Required changes to the service design

The results of the experimental research slightly changes the service design presented in chapter 5. Although many requirements seem to be well-functioning in order to improve the value of the MPO, small problems are found with the design. The new requirements presented below must be added to the design if a new code is used, and alter a requirement if the code is similar to existing requirements defined in chapter 5. Each change is briefly mentioned.

For the task regulation module a new requirement is added which tries to resolve the problem of high glance durations due to large amounts of text presented on the screen.

A16. Must only show large amounts of text when driving speed = 0

The situational item asking about the usage in an emergency aid situation shows a low rating. Therefore the following requirement is altered:

B3. Must only show the spoken information on the touchscreen if desired by the user

There also requirements that need to be added to the emergency aid class. These are based on the positive reactions on the possibility to review information and the addition of the control button:

B14. Must not show buttons to acquire more information
B15. Must provide continuous information using the text-to-speech software
B16. Must show a back button to review information when needed
B17. Must only allow button selection by using the handle-bar control button if speed > 0

For the control task class the results do not directly implicate required changes to the system. Although usage in a constantly changing traffic environment is difficult, other situations are (except for the emergency aid) are highly rated. Therefore, only the addition of text-to-speech and the control-button is included.

If a control task is selected the module:

C16. Must provide the option of using text-to-speech software based on user preference
C17. Must allow button selection by using the handle-bar control button and the touchscreen if speed > 0

The addition of the text-to-speech software and the control button on the handle-bar require the device manager to add two requirements to its list. The usage of the requirements is defined by the task classes as presented above.

The device manager module:

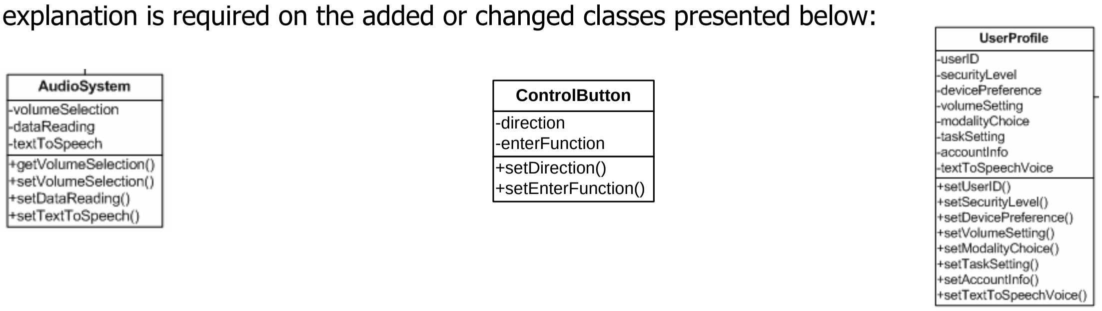
M11. Must provide text-to-speech functionality if requested by task selection of the 'AudioSystem' class
M12. Must provide the possibility to control the system with a handle-bar control button if requested by the task selection class.

Finally, a last requirement is added to the presentation class. The addition comes from the observed glance durations due to unnecessary information being shown to the MPO. An example is the downloadbar which the MPO glances at. Defining the requirement is difficult, but the following requirement is added by keeping the requirement broad. In later stages, clearer definitions of different types of unnecessary information must be developed. The unnecessary information is only removed if the speed is above 0.

The presentation module:

N11. Must avoid showing unnecessary information on the touchscreen when speed > 0.

Looking at the classes of the UML model, three changes are to be made in order to fulfil the new requirements. The AudioSystem and UserProfile have the text-to-speech software included, and a ControlButton class is added which is connected to the DeviceManager class. It is assumed no further explanation is required on the added or changed classes presented below:



6.7 Conclusions of experimental research

The service design of chapter 5 has been tested by using two different information system mock-ups, a touchscreen and a head-up display version. The first step is to compare the results of the experiment to the hypotheses we stated for this research:

H4. The conceptual service design of the touchscreen mock-up or the head-up display mock-up will lead to a significantly higher rating on the defined statements as opposed to the current information system used by MPO's.

The first hypothesis can be concluded as true. On all statements the service concept design (either as a touchscreen or head-up display) is rated higher when compared to the current system rating. This can be concluded a highly positive result in determining whether the service design increases the customer value as defined in this thesis. We do however need to include an additional aspect in this conclusion. Considering the removal of indicator variables, the results can not automatically be translated to the constructs as defined by the TAM/TMF model of chapter 4.

The second hypothesis was defined as follows:

H5. The conceptual service design of the touchscreen will lead to a significantly higher rating on statements originating from the following constructs: intention to use, ease of use, task-media fit, system operation speed, system operation safety, information comprehension safety and the situational functioning

The second hypothesis focuses on those statements that must indicate a difference between both mock-ups in order to support the choice of using a touchscreen information system supporting the designed service concept. Our results clearly show a higher rating for the intention to use, ease of use, task-media fit and system operation speed statements. For the safety related statements the hypothesis does not stand. Safety is an issue for the service design and requires further design and study.

Next, general conclusions are drawn from all research parts of the experiment. The feedback gotten from MPO's provides an interesting amount of information to determine whether the service design is able to increase the value for the MPO. In general we can claim that if the service functions flawlessly, the context-aware service bundling model proves to increase the value. Although the used variables are influenced by the mono-bias threat, the observations show similar results. The following conclusions are made based on the experimental research supporting the general conclusion:

- The touchscreen mock-up clearly showed the highest ratings in general, which is in accordance with the results gotten from the conjoint analysis in chapter 4. As the touchscreen mock-up is based on the service design presented in chapter 5, we can state the service design proves to be a promising service concept for MPO information provisioning. Adjustments and further studies are required though.
- The head-up display gave a higher variation of opinions and the general results are not sufficient to claim a head-up display increases the value like the touchscreen does. The device is seen as an interesting aid, but inappropriate for every day use on a motorcycle. Practical issues like having to change your focus while using the system, or using the system when standing still make the head-up display generally less usable compared to the touchscreen version.
- The context-aware service bundling concept significantly increases the information provisioning quality and speed over current systems. It received very positive reactions which are grounded by the quantitative part of the experiment. The ease of use and information exchange improvements are considered the foundation of the positive reactions by the MPO's.
- Speech recognition showed some positive results, but does not score high enough to be used for a final service at the moment. It is dependent on the user, whereas operating a touchscreen is not. Operation failure would lead to frustration among users. Secondly, the usage in a real-life situation probably becomes more difficult due to surrounding noise.

- The usage of text-to-speech software proved to be successful and might increase the safety of system-usage.
- Safety of the MPO when using the system is still an issue which requires further real-life tests to be executed. Especially when using the service in a constantly changing traffic situation and an emergency aid situations shows low safety ratings. For the touchscreen, taking away the hand of the handle-bar to operate the service and reading large amounts of text from the screen largely influence the safety. Using a control button on the handle-bar and letting the text-to-speech software read the text might solve the safety issues according to the MPO's.
- The need of C2000 for control room contact and communicating with colleagues remains high, especially in emergency aid situations. This conclusion is in accordance with the conjoint analysis results.
- Non-essential information must be avoided. It only increases glance durations and glance frequencies thereby decreasing the safety of the MPO.
- The glance durations are still too high when having to read information from the screen. Text-to-speech software probably lowers the glance durations.
- The easy lay-out of the buttons (using 2 buttons per menu) seems promising if looking at the glance duration measurements. A control button on the handle-bar could further decrease the durations.

PHASE IV

7. Technical architecture

7.1 Introduction

The service designed in chapter 5 and altered in chapter 6 requires a technical architecture to request, communicate and present the needed information to the MPO. A technical architecture consists of: an infrastructure or network communicating the information between devices; the devices defining the information to be sent, received and presented to the user; and the applications controlling the devices and user requests. All three aspects are explained respectively. Bouwman (2006) defines five critical design issues for the technical architecture: security, quality of service, system integration, accessibility and management of user profiles. These five design issues are not treated separately as they are mentioned throughout the chapter.

What technical architecture is required for a performable implementation of context-aware service bundling for MPO's?

7.2 The infrastructure required for the service to function

Before explaining the exact infrastructure design of the service, a brief mentioning is done on the current police infrastructures. Given the standardization aim of vtsPN the service must fit the current mobile services infrastructure for the police, also called the mobile platform. In 2004, Project MIRA was established as a reference model in which the frames, conditions and agreements are planned for a national, uniform composition of mobile information and communication facilities for the Dutch police" (MIRA, 2004). Its base is the IPOS (CIP, 2004) research mapping the wishes and possibilities of providing information to police officers working in the streets. Figure 7.1 shows the technical reference model proposed by MIRA (2004):

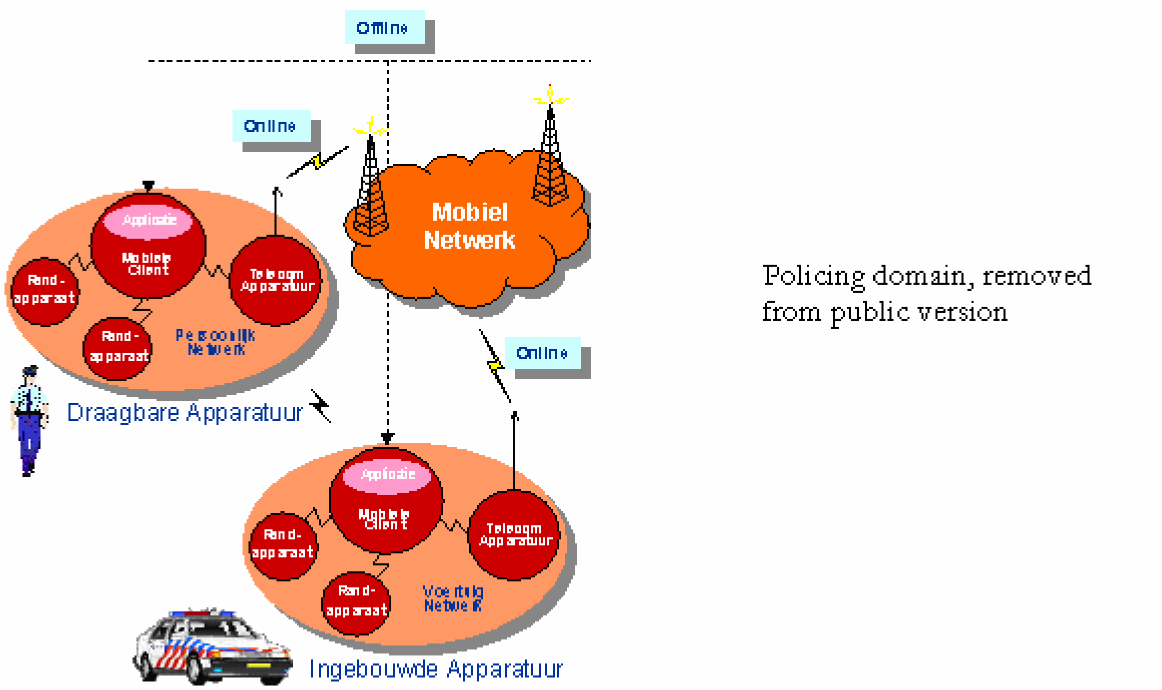


Figure 7.1: MIRA technological reference model (in Dutch) (MIRA, 2004)

The technical architecture (Figure 7.1) is straightforward. Users have a device defined as a mobile client which is able to present information retrieved and gives the possibility to enter data. The mobile client has a telecommunication device build-in to communicate with a mobile network. From the MIRA project, the following table shows the mobile communication technologies tested for the most important criteria. Table 7.1 shows that a clear choice for a mobile technology is not possible, setting the need for a hybrid networking technology.

Mobile technology / **Criteria**	C2000	RAM Mobitex	GSM	GPRS	UMTS	WiFi
Outside coverage	+	+	+/++	+/++	-/0	--
Inside coverage	0	-/0	+	+	-/0	-/0
Roaming	0	0	+	+	+/++	--
Transmission speed	-/0	-	-	0/+	+/++	++
Available in special circumstances	++	+	--	-	--	--
Security	++	0	+	+	+	-

Table 7.1: MIRA comparison of mobile networks (MIRA, 2004)

The reference model presented above is the basis for the infrastructure used by the P-Info service. P-Info is used as the standard mobile information provisioning service for police officers already being used at the moment. The official infrastructure used by the P-Info service is referred to as G2 (ISC, 2005). P-Info makes use of the GSM/GPRS networks of telecom operators to send and receive data from different police registers. The 'P-Info server' authenticates users, and controls data requests to the different police registers or external closed registers. At the moment of writing tests are executed to see whether data exchange can take place via the C2000 network (Interview Verweij, 2007). Although the possibility exists, bandwidth is low compared to UMTS and WiFi.

Table 7.1 shows low coverage of UMTS and WiFi, but the figures are from 2004. The usage of WiFi is not included in the current service design due to an increasing complexity of providers. UMTS is included as it proves to be a fast network and the coverage throughout The Netherlands is vastly expanding. The two figures below show the predicted UMTS coverage of two telecom operators at the moment of writing (December 2007, figures originating from operators):

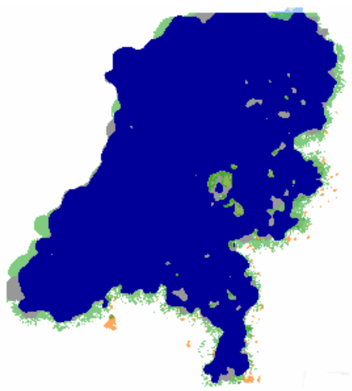


Figure 7.2: KPN UMTS coverage (blue)

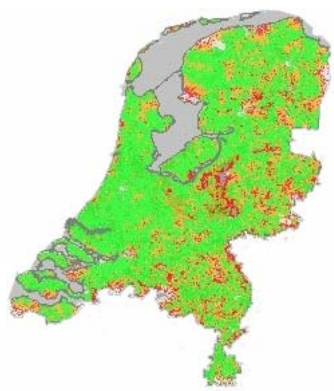


Figure 7.3: Vodafone UMTS coverage (green)

A second reason to include the UMTS network is to decrease the possibility of data loss. Hampton & Langham (2005) conducted a study of future in-car information systems for the police. One of the important conclusions of their study was that "a problem with network coverage compromised the system's effectiveness and potentially posed a safety risk if users were unable to access the system in an emergency aid situation" (Hampton & Langham, 2005). Having the UMTS network included, the final technical infrastructure supporting the service can be determined. The infrastructure is based on the G2 architecture specifications (ISC, 2005) and is presented in figure 7.4.

The GPS signal, UMTS, C2000, the possibility to connect to the internet and the internal police department phonebook are additional services not offered by P-Info V2.1 or the G2 infrastructure. The information of G2 available shows a connection to the BPS regional police information processing systems, but it is unclear whether this functionality exists. Security experts of vtsPN claimed BPS registers are not accessible via mobile communication systems yet.

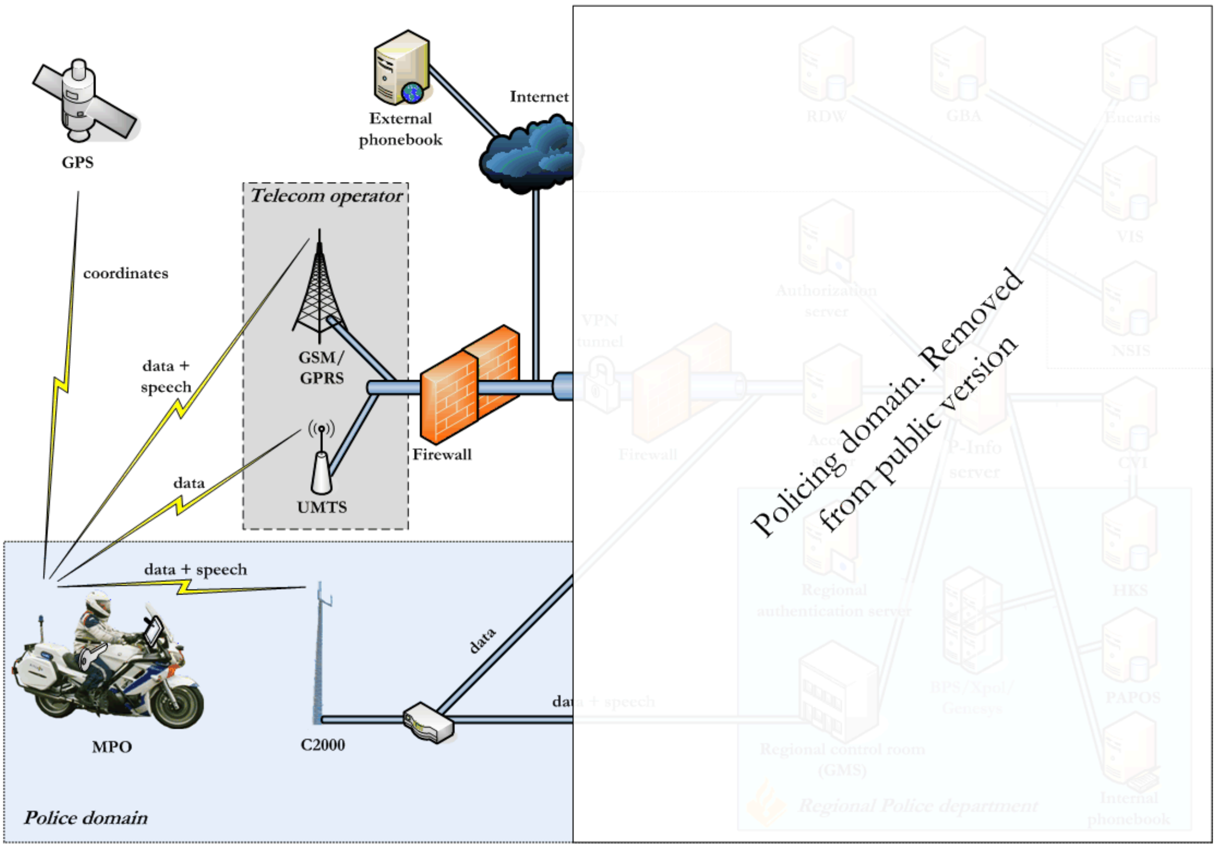


Figure 7.4: Technological infrastructure for the MPO service (public version)

The proposed infrastructure functions as follows. The MPO logs into the system with his security codes. Having been authorized via the P-Info server, the system is able to communicate with the MPO via the VPN tunnel set-up with the telecom operator or directly through the C2000 network. He requests certain information from registers. The service chooses the correct network based on the QoS of the information request and sends the information request to the P-Info server by using XML files (ISC, 2005). The P-Info server sends information requests to the registers defined by the type of information needed to support the MPO. The information is send back to the context-aware service of the MPO altering the information to the requirements defined by production rules explained in chapter 5. MPO-status updates are sent directly to the control room over the C2000 network, similar to the current situation.

The registers used by the service play an important role in the infrastructure. During the interviews with MPO's the question was asked which registers retains information useful to fulfil their task. The following table clarifies the different registers named by the MPO's and the function of the registers. As the 'tracing register' is not supported by the G2 architecture, it is left out of the architecture. Future additions to the P-Info service could also be used by the context-aware service for MPO's. The exact technical details of the communication between the P-Info server and the different registers are not discussed in more detail.

Security of data is an important aspect of the mobile police infrastructure. MIRA (2004) defines security on both the technical level as well as the organizational level. The amount of information allowed to be viewed from police registers depends on several factors, including the rank of the MPO. Due to the potential risk of sharing sensitive information about the security of police data no further details are given here. Further information can be found in MIRA (2004).

Register	Type of information
RDW	Licence plate of the vehicle, owner of the vehicle, drivers licence of owner, Ministry of Transport tests (www.rdw.nl)
HKS	Persons information, offence information of person, report about offences (CIP, 2007)
CVI	National server requesting all HKS registers (Interviews, 2007)
PAPOS	Person information, arrest orders, traffic offences (CIP, 2007)
NSIS	Person information, extradition requests of persons, foreigners not allowed in the Schengen treaty countries, missing persons, vehicles registered as stolen or missing, ID cards reported as stolen. Register used and updated by all Schengen member states. (www.wikipedia.org)
GBA	Person information, address information, ID card information (Interview Amsterdam, 2007)
Tracing register	Person information, tracing information (CIP, 2007)
BPS	Person information, crimes reported, offences reported (info is then send to national HKS) (CIP, 2007)
XPol (similar to BPS, but used by a few departments)	Person information, crimes reported, offences reported (CIP, 2007)
Genesys (similar to BPS, used by Haaglanden department)	Person information, crimes reported, offences reported (CIP, 2007)
Eucaris	Licence plate foreign vehicle, drivers licence foreign person (Fleischeuers, 2007)
VIS	ID card list reported as stolen (Fleischeuers, 2007)
External phonebook	Persons information, telephone numbers (CIP, 2004)
Internal phonebook	Police employee information, telephone numbers (CIP, 2004)

Table 7.2: All registers retaining useful information for MPO's

7.3 Devices required for the context-aware service

For the context-aware service to function properly a number of devices are to be added to the motorcycle communication systems. To explain the different devices an overview is presented below showing each device and the required placement on the motorcycle. An important aspect here is that the motorcycle presented as an example is the large type used by the Dutch police force, currently in use by departments covering larger areas. The MPO of figure 7.5 is the same MPO as shown in the infrastructure overview presented above. The six devices are explained from left to right.

The GPS module constantly reads the GPS satellite locations and determines the location coordinates based on the GPS satellite locations. The shown module in figure 7.5 is taken from the brandweer 100% Mobiel project. As can be seen, the module is placed on top of the motorcycle and not in the back compartment. According to Ybema (2007), the readings of the coordinates are much better if placing the module on the motorcycle as such. The possibility of losing the GPS position must be kept to an absolute minimum to avoid dangerous situations.

The second image shown is the C2000 system and the computer system running the context-aware service. The C2000 equipment is standard equipment being used at the moment. The computer system is a ruggedized PC, capable of withstanding rough circumstances. Several PC suppliers offer specialized equipment for these rough circumstances and in slim boxes. A sufficient amount of RAM is required given the high amount of applications running on the PC (explained in the next paragraph). Mechanical parts inside the PC must be avoided. The usage of Solid State Harddisks is advised as it offers higher reading and response speeds and does not use any mechanical parts. The C2000 is controlled by the PC as C2000 control is integrated in the service. An important safety measure is to assure a second C2000 control directly to the C2000 equipment. This must assure C2000 usability, even when the computer system running the service fails. UMTS, GSM/GPRS and the GPS module are also connected to the PC. Finally the touchscreen must be connected to the PC via a wire going to the dashboard of the motorcycle.

The placement of the equipment in the back of the motorcycle requires balancing tests to be performed. The balance on a motorcycle is essential to ensure safety of the MPO and adding equipment can disturb the weight distribution (Interview Ybema, 2007). A second important consideration is the power usage of the equipment. Batteries of a motorcycle are much smaller compared to car batteries. The motorcycle mechanics of the Haaglanden police department who install equipment on motorcycles claim power usage is the biggest problem of the system (Interview

Den Haag, 2007). Although the power usage of PC's decreases fast due to the upcoming of laptops, tests must show whether the systems can run on the battery of the motorcycle.

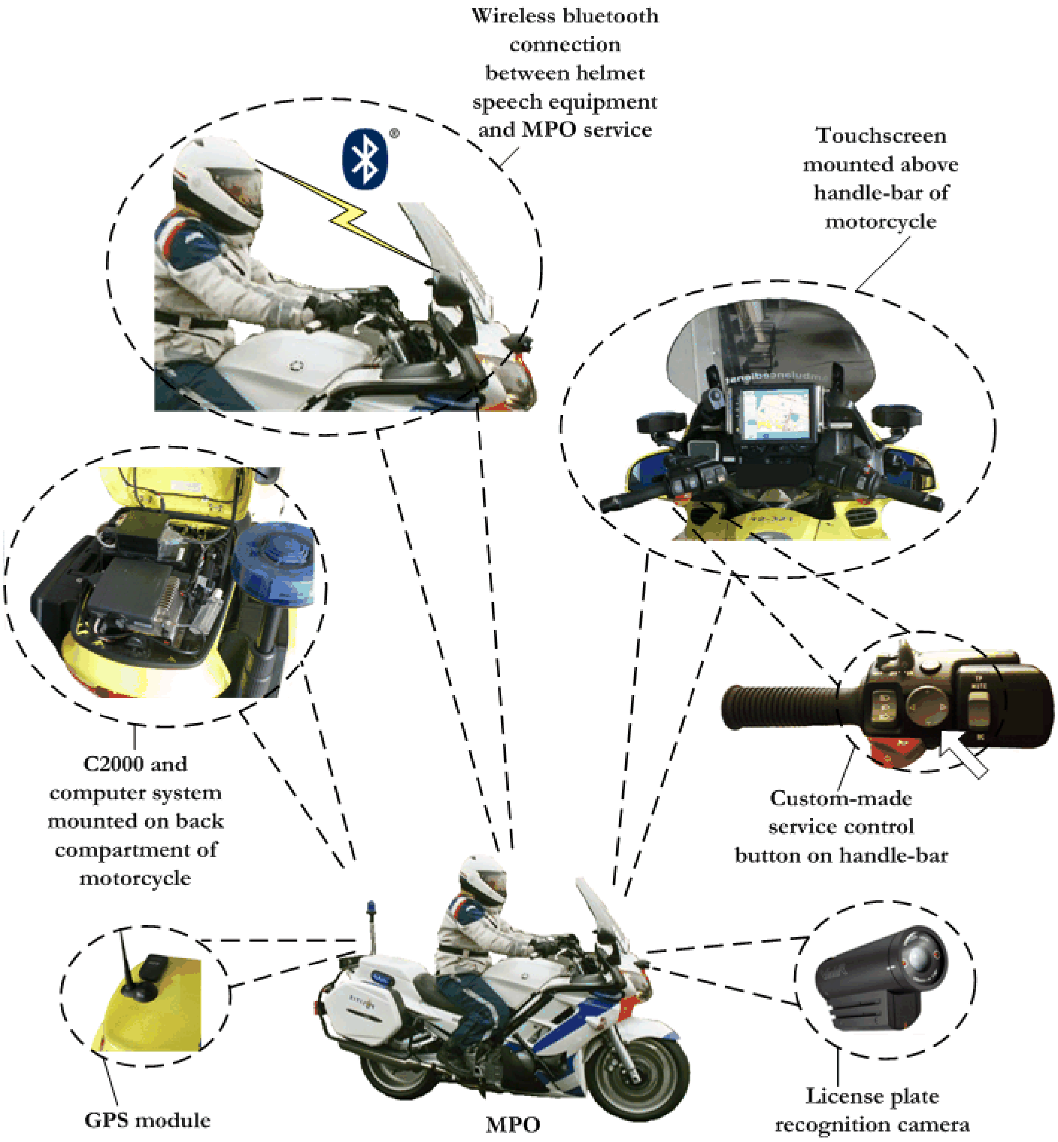


Figure 7.5: devices required to use the context-aware service for MPO's

An addition proposed by many MPO's during the interviews was the use of a wireless helmet to transfer sound between the MPO and the system. One police region already makes use of a Bluetooth wireless helmet (Interview Doorwerth, 2007). There are two reasons for using a wireless helmet. The first reason is that no cable between the helmet and the system is needed, thereby removing the problem of water inside the coupling part. Secondly, the MPO can keep on communicating if away from the motorcycle. Currently, the MPO has to disconnect and switch to the portable terminal. The biggest concern with switching to a Bluetooth connection is the security of data. A Bluetooth signal is easily intercepted by surrounding Bluetooth equipment. It is unknown how the police department using the technology managed to securely implement the technology. Further security tests need to be executed to get a clear image of the Bluetooth possibilities.

Image number four shows an example of a touchscreen being used on a motorcycle by the Kennemerland fire department (brandweer 100% Mobiel). The touchscreen is connected to the PC in the back compartment. The users of the shown model are enthusiastic about its usage on the motorcycle (Interview Ybema, 2007). It is ruggedized and has not shown any problems regarding water or shocks. However, the conditions MPO's drive in are different when compared to the user questioned about the brandweer 100% Mobiel system. The touchscreens currently in use by certain MPO's have been changed for over two years after the first implementation due to technical problems created by the rough conditions of the MPO (Interview Doorwerth, 2007). Also, Kun (2007) of Project54 states that "the motorcycles are not used in tough weather conditions". Extensive tests are needed to claim complete reliability of the touchscreen in all MPO conditions.

A second problem mentioned by a user is when the sun shines directly on the screen making it difficult to see what information is presented. This problem was also mentioned during the touchscreen mock-up tests with MPO's who currently use a touchscreen as a C2000 terminal (see Chapter 6). The choice of a certain type of touchscreen for the MPO must take the sunlight problem into consideration. A third problem is a consequence of the installation of the touchscreen above the handle-bar. The speed gauge and revs gauge are blocked by the touchscreen. Especially the speed gauge is important for the work of an MPO as it functions as an official speed measure to determine speeding. Although the signal going to the speed gauge is electronic, a connection to the system must be installed in coherence with the motorcycle supplier. In order to make the speed measurement legally valid the speed of the motorcycle must be calibrated by the National Measuring Institute (NMI).

An important safety conclusion of the experimental research is the removal of the hand from the handle-bar to operate the touchscreen. A solution to this problem proposed is a simple control button close to the left thumb of the MPO. An example is shown in the fifth image of figure 7.5. The image shows a control button that exists on current motorcycles, but is replaced to improve the ease of use. As the layout of the buttons on the screen while driving is simple the button just had a left – right, up – down and enter functionality. If not driving the touchscreen can be used to operate the system.

The last image shows a small camera to be used for the license plate recognition. It must be mounted on the front of the motorcycle to scan license plates in front of the motorcycle when driving. As the camera must function in all weather types a small cover should be installed in front of the camera. Night operation can be supported by the head-lights of the motorcycle. The camera must be connected to the PC in the back compartment via a cable.

7.4 Applications

A context-aware service bundling different services together automatically creates a complex system. The amount of devices needed to measure different context aspects is high, setting a high requirement on the software continuously updating the context sources. Explaining the applications for this thesis is done briefly, as context-aware software is still undeveloped.

The starting application is the operating system running the system. Most important is the stability of the operating system controlling the devices and the different applications running on the PC. Failure of the system can not occur. It negatively influences safety and urges annoyance among MPO's. Currently, vtsPN works with Microsoft software for devices running the P-Info service. An alternative could be a linux based operating system; however the compatibility with the devices and applications is unknown. The context-aware service functions as a middleware layer supporting the applications in heterogeneous computing environments. It acts as the central control point. The UML model of chapter 5 demonstrates the classes building the service, but it does not provide details on the exact functioning of the core class: the ControlManager. Park, Lee & Kim (2005) provide a conceptual middleware context-aware services model which is useful to give a first impression of how the application logic can function (Figure 7.6).

A brief explanation of the most important functions is given:

Build-Time part:

- *Service modeler*: defines services to be needed in the application domain
- *Sensor modeler*: collects the contextual information from the context sources
- *User modeler*: provides the personal profile (or MPO-user) information
- *Task modeler*: writes the task to be executed based on the 'task rule'

Runtime part:

- *Context manager*: It supports the mapping of data representation denoted by such ways as XML representation, File System in the operating systems or Java objects if used.
- *Event notification system*: Similar to the Event scheduler in Java. It delivers events transferred by the sensor modeler or external services to task executers or listeners.
- *Task engine*: executes the production rules based on the request and situation of the user (MPO).
- *User Interface*: plays an important role as it needs to adapt according to the sensor modeler and task rules information.

The middleware layer could be written in Java with XML and graphical user interface classes support.

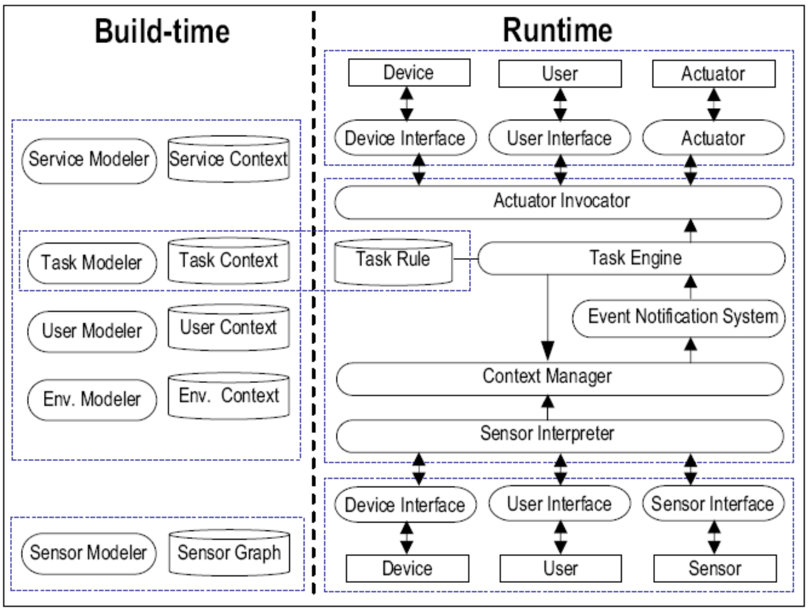


Figure 7.6: Middleware architecture for context-aware services (Park et al., 2005)

C2000 software is needed to support the usage of the C2000 network. Support must be bipartite: one part controls the normal speech usage as it is being used at the moment; the second part controls the data streams towards the P-Info server. Although applications for both parts exist, the combination of both does not. Given the interest in data over C2000 for P-Info it is expected that software combining both will be developed in the near future.

The hybrid nature of the service further increases the complexity. Off-the-shelf software suites (e.g. InfoMatrix Seamless Multi-Bearer) provide constant measurement of the network coverage and a seamless handover from one network to the other. The software chooses the network based on the QoS requirement of the Context Manager. In case all connections are lost, the software is capable of continuing the data downloading from the moment a network is available again. The software supports the Tetra standard, GRPS and UMTS (www.infomatrix.com). Additionally, some software suppliers add real-time data compression utilities to increase downloading and data sending speeds.

An application discovering the license plate numbers from the images send from the camera is also needed. The software is referred to as ANPR software and is widely available. The image received by the software is normalized and segmented. Consequently, an optical character recognition is performed which 'reads' the numbers and letters on the plate. The software is being used by several institutes in the Netherlands, including police departments (Interview Amsterdam, 2007).

The fifth application to be used for the service is the navigation software. Currently, different software suppliers are being used for public order organizations (Geodan, City-GIS, Sherpa). Sherpa is developed under the responsibility of vtsPN, meaning that a connection to Sherpa is most likely. It is currently developed to aid control room employees to provide location overviews and police officer locations. The location determination of the MPO is based on the coordinates received from the GPS module.

Finally, the experimental research with MPO's indicated that the use of Text-To-Speech increases the value and safety of the system. It stops the MPO from glancing at the touchscreen as the information is spoken through the speakers inside the helmet. At the moment of writing, many Text-to-Speech software packages are available. Combined with the software a wide choice of voices is available. It is advised to provide a selection of voices to the MPO, due to differences in preference between people. Secondly, changing the voice once in a while stops the voice from getting annoying if constantly heard.

7.5 Conclusions

Designing a new technical architecture for a context-aware service bundling model is impossible as vtsPN's main aim is to standardize ICT services. Therefore, the choice is made to develop the service on the platform of the P-Info service referred to as G2. However, some additions are needed to assure the hybrid nature of the service which assures a maximization of network coverage throughout the Netherlands. UMTS and the usage of C2000 are added to the infrastructure architecture, both planned to be added to the G2 architecture in the near future. Ensuring a secure connection is left out of scope and must be provided by vtsPN.

The devices required to fully make use of the service are numerous. A PC running the service must be mounted in the back compartment of the motorcycle, combined with the C2000 equipment. A GPS module is also mounted in the back providing the coordinates for navigation. A Bluetooth connection between the helmet headset and the communication equipment removes the cable currently creating problems for MPO's. A touchscreen above the handle-bar must be selected, keeping the size, readability in sunlight and water resistance in mind. As concluded by chapter 6, a control button on the handle-bar is needed to improve operation safety. The final device to be mounted is a camera on the front of the motorcycle reading the license plates of vehicles to be checked.

The last aspect of the technical architecture is the applications controlling the service. A stable operating system capable of running all applications is highly important. A Middleware layer functioning as 'ContextManager' of the service model must control the context sources and determine needed changes to the presentation layer and network usage. Hybrid network software controls the availability of networks and chooses the network based on QoS definitions of the service. ANPR software controls the camera and presents the license plate number to the context manager. The choice of navigation software must be based on the police standard to make sure different systems can exchange location information. Finally, the text-to-speech software must be chosen, keeping the possibility of a variety of clear voices to be installed and selected by the user in mind.

8. Organizational arrangements for the service development

8.1 Introduction

The purpose of this chapter is to identify the most important organizational arrangements to be made if wanting to successfully develop a context-aware service for MPO's. Bouwman (2006) defines four distinct critical design issues in the organizational domain: partner selection, network openness, network governance and network complexity. This chapter finds an answer to the following sub-question of this thesis:

> *What organizational arrangements are required for a feasible development of context-aware service bundling for MPO's?*

When designing the organizational arrangements needed to develop a service for MPO's it is important to realize that changing the organizational structure is not an option. Therefore, the choice is made to first identify the current organizational problems in developing services. Based on the allocated problems, solutions to tackle these problems are proposed to ensure a successful service development. The identification of problems is based on interviews with internal and external stakeholders and slightly by the author's experiences working at the organization for 9 months. Before elaborating on the organizational problems and solutions, the current organizational arrangements are described.

8.2 Current organizational arrangements

In this chapter a review is given on the formal decision-making procedures for ICT service development for the Dutch Police force combined with an organizational explanation of the various actors involved. The organizational structure of the Dutch Police force is explained in the introduction of this thesis. Explaining the development of ICT services for the police officers is easiest from a bottom-up perspective. The procedures explained are based on the 'Wenkend Perspectief' (Politie Nederland, 2006) document, the Police Shared Services Organization (vtsPN) composition documents and in accordance with Maarten Nacinovic, head of the Research and Innovation department of vtsPN. Figure 8.1 gives an overview of involved actors in the creation and decision-making process of ICT service development.

The process starts from Police officers stating their demands for information provisioning to different statesmen assigned conform the functional boards. The demands are translated to functional specifications and communicated to the CIO and Chief Constable of the police department. Each Chief Constable is part of the Board of Chief Constables. The Board of Chief Constables falls under the responsibility of the Ministry of Internal Affairs. The Ministry of Internal Affairs provides the financial support, either subsidizing directly or through the ICT budgets of the different police departments.

The Board of Chief Constables consists of several sub-boards, based on functional domains like Intake, Assistance, Control, Policy, etc. One of the boards is the Board of Information Management. "The task of the Board Information Management is to articulate the demands and then particularly to coordinate and prioritize the demands from other functional boards" (Politie Nederland, 2006). The supply side is executed by the Police Shared Services Organization (vtsPN). Its task is to coordinate the demands from the Board Information Management and provide services complying the demands. VtsPN has four main policies (Politie Nederland, 2006):

1. the migration to coherent core services supporting the primary processes.
2. the migration to the core services to support the supporting processes.
3. the inventory, assessment and the uniformity of other services
4. rationalization of maintenance and administration

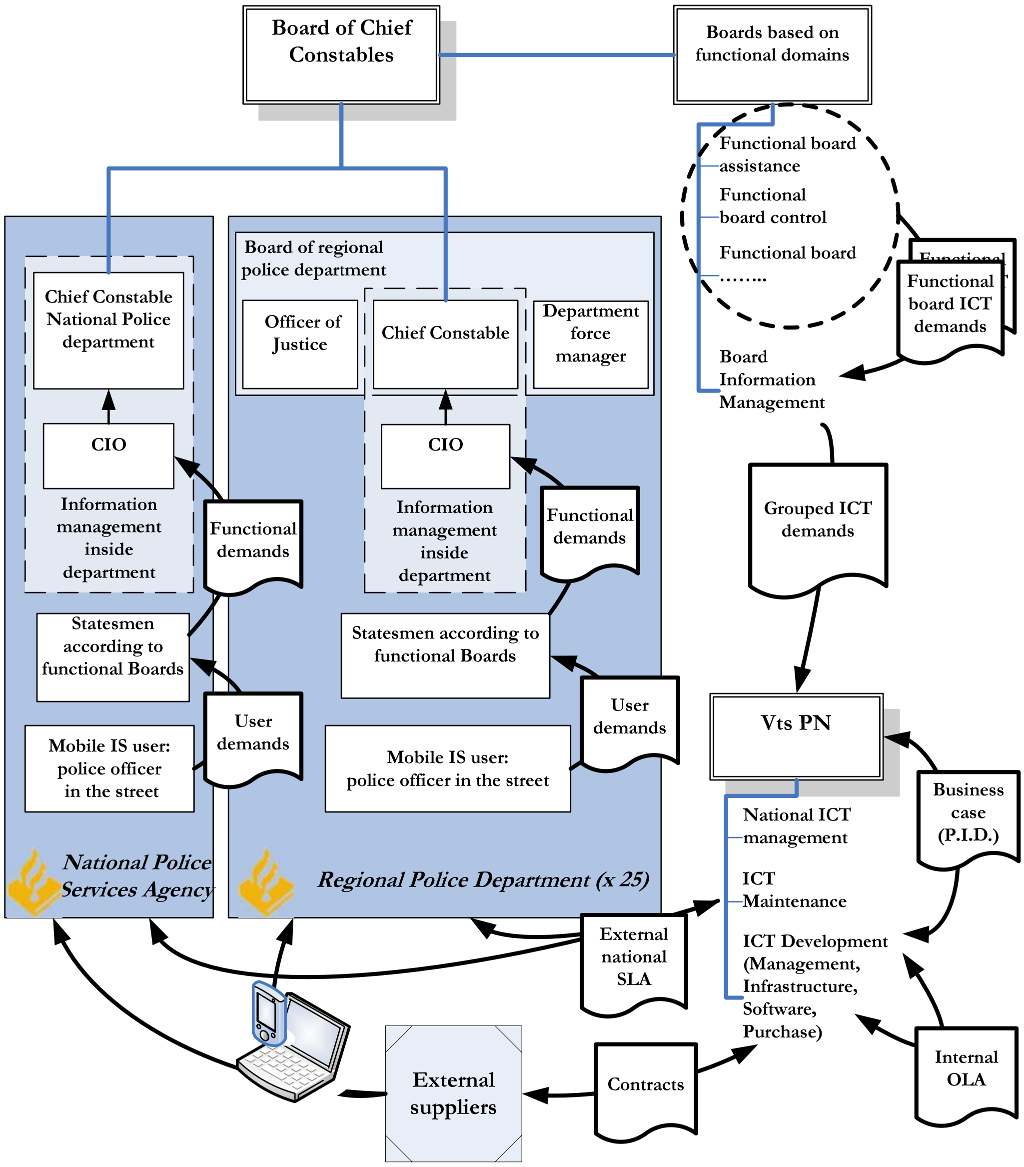


Figure 8.1: ICT development for the Dutch Police organization (SLA = service level agreement, OLA = operation level agreement)

The organizational structure of vtsPN is changing. For this thesis the organizational structure implemented from January 1st of 2008 is used as a reference (see figure 8.2). It must be noted that organizational changes after this date can not be taken into consideration and the used structure is based on the formal organization documents at the moment of writing.

The Government Board of vts PN consists of all the force managers of the police regions and the Minister of Internal Affairs in the capacity of force manager of the National Police Services Agency. The force manager of a regional police department is usually the mayor of the largest municipality in the respective region. Under the main Government Board unit is the daily board which is a subset of force managers consisting of five members. Under the responsibility of the daily management board is the actual board of directors. This board is seen as the real direction unit of the vtsPN organization and is employed by the director and the deputy director.

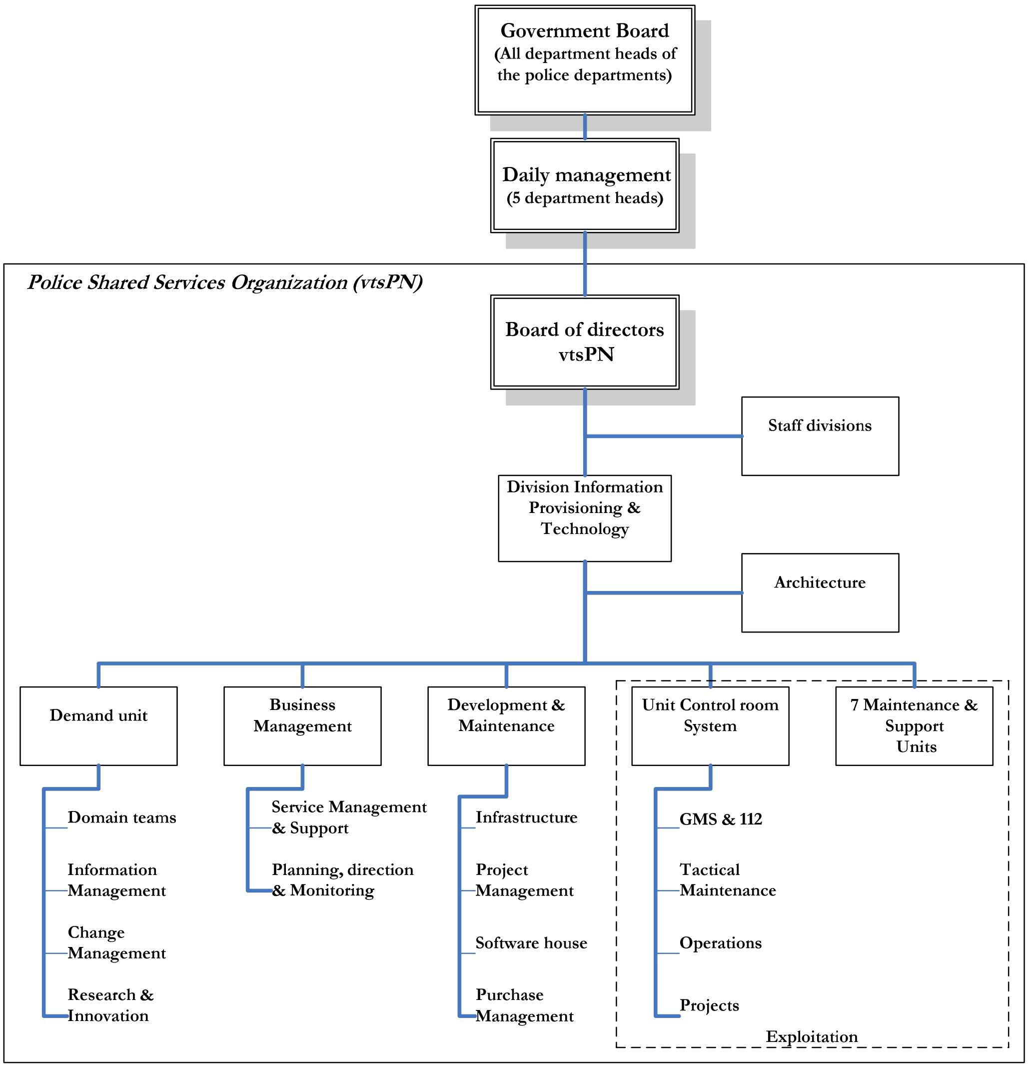


Figure 8.2: Organization structure of vtsPN

The division of vts PN responsible for mobile information provisioning of the police organization is called 'Information Provisioning & Technology'. The demand unit of this division channels the user demands coming from the Board of Information Management, the other functional Boards and the regional CIO's. Business cases are created to develop services supplying the demands. If approved by the General Management of vtsPN, the Development & Maintenance unit starts the development process of the service through its divisions. The project management method is based on PRINCE2. This means a Project Initiation Document (PID) is formed which is signed by all departments involved setting the start of the project. Project Management is responsible for general management of the project. Infrastructure is responsible for the assessment of the technical feasibility of a service through the available internal police or external infrastructures. Software House develops needed software applications or required modifications to implement the service. The final agreements stating the exact financial resources and human resources provided per department are contracted in Operation Level Agreements (OLA). Finally, the Purchase Management department arranges contracts with external suppliers of hardware or off-the-shelf software. The maintenance and support of services is executed under the wing of the Maintenance & Support units. SLA's are signed between the Maintenance & Support units and the different police departments using the service. Maintenance and support for services delivered by external suppliers are arranged between the external supplier and the police departments.

A second service development process defined by the 'Wenkend Perspectief' (Politie Nederland, 2006) document is called 'co-creation'. The general idea behind co-creation is to keep the impulse of ICT service innovation from within police departments. The line from user (e.g. police officer) to service creation is much shorter, making user-demands from one police department more usable. Many police departments have shown their potential in developing innovative services supporting their work (e.g. Mobiel Blauw in Amsterdam, www.politieonderzoeken.nl in Utrecht, Project GSM-BOMB in Rotterdam). The role of vtsPN is to assure that developed services are within the boundaries of the national information strategy. After having received the approval of vtsPN, these local developments can be added to the national integration and administration.

8.3 Organizational problems in developing ICT services

8.3.1 Interviews held to identify organizational problems

Identifying the problems is partly based on internal and external interviews. The following people have been interviewed:

- Johan Brandsma, Product Developer of P-Info at vtsPN
- Feiko Vermeulen, Product Developer of V-Info at vtsPN
- Maarten Nacinovic, manager of the Research & Innovation and Product Development departments at vtsPN
- Kees Verweij, ICT Researcher at vtsPN
- Bauke Ybema, Project Developer 'brandweer 100% mobiel' of Kennemerland fire department
- Reinder Doeleman, Police commissioner of Amsterdam-Amstelland police department.

The interviews with people of vtsPN were focused on the following topics:

- Internal and external stakeholders in the development process
- Project development methods used
- Decision-making structure and power
- Experiences with service development
- Cooperation with stakeholder
- Most important internal problems when developing ICT services
- Most important external problems when developing ICT services

Due to the lack of time the interviews were of an open nature retrieving as much information as possible based on the experience of the interviewed person in previous projects. The interviews with the external people were used to ask a few specific questions that further grounded assumptions made.

8.3.2 Organizational problem explained

The first problem focused on is the lack of contact with the end-user and regional police departments. Figure 8.1 clearly shows that the amount of steps that are to be taken in the process of user demands to service development is large and therefore bureaucratic. Project manager's state boards have to approve every step taken in the process which further slows it down (Interview Vermeulen, 2007). The organizational control structure and aim of vtsPN is 'centralization'. Although centralization leads to standardization and increasing efficiency, it has a high risk of losing the connection to the end-user (Janssen, 2005). This results in annoyance of end-users and regional police departments as they feel left out in the development in services developed for them. Interviews with project managers at vtsPN further ground these assumptions. Project managers barely speak to end-users or police departments as they rely on information gotten from account managers of vtsPN. Account managers keep the contact with regional departments, govern the project finances and control the project managers (De Reuver, 2006). A talk with a police commissioner from a regional police department learned that the communication with account managers from vtsPN is minimal (Interview Doeleman, 2007). Also, the project manager of an innovative mobile information provisioning project developed for three fire departments is interviewed. When asking the question why vtsPN was not included in the development of the service, the answer was that it would result in a slow development process and they did not want to wait any longer (Interview Ybema, 2007).

Further grounding the lack of communication between developers and users, two previous mobile information provisioning project documents (PID's) have been glanced through. The names are not mentioned as it is not our intension to discuss specific project aspects or people, only the process itself. The origin of both projects lies in one or two regional departments who developed small scale solutions. VtsPN decided to continue these projects to fulfill the need of mobile information for police officers in the streets on a national level. However, the documents read have no detailed review of national demands from end-users. Janssen (2005) states that a danger of the PRINCE2 project management method is that it does not explicitly treat user requirements. Presumably, the requirements for the services are taken over from the originating regional police department and projected as national demands from the end-users. The interviews with the MPO's from various regional departments performed for this thesis also showed that almost no MPO had any idea of the mobile information services that had been developed. Even the name vtsPN as main ICT supplier was unknown to almost every MPO.

The reason for emphasizing this lack of contact between the end-users and the project management can be explained by using the implementation consideration formula of Rau (2004). It is defined as follows:

Success = Quality of design x Organizational readiness x Participation

The formula shows that even if a service is perfectly designed for an organization which is completely conscient of the need for such a designed service, not including the stakeholders greatly reduces the overall success. The employees of vtsPN claim the variation of user demands is too large to take into account (Interview Brandsma, Vermeulen & Verweij, 2007). But it is exactly for this reason of variation that the final services do not fit the demands of the end-users on a national level, which results in a slow and costly process. The project managers also stated that the project deadlines are always largely exceeded and the costs of a project are double compared to the first budget calculations.

The second problem of the organizational arrangements comes forth from the internal decision-making procedures of vtsPN. The Information Provisioning & Technology division of vtsPN is defined as a professional bureaucracy with its units classified according to work process and function (Mintzberg, 2006). Developing a service means that all departments need to be involved (Interview Brandsma, Verweij, 2007). According to the interviewed people the result of the unit classification is an increase in bureaucracy (Interview Vermeulen, Verweij, 2007). Each manager of an involved department receives a request for resources to assist in a project and decides which resources to assign to the project. In practice however, people inside a department tend to forward the assignment to others inside the department (Interview Brandsma, Vermeulen, 2007). De Bruijn (2004) mentions one of the weaknesses of a professional bureaucracy is the lack of responsibility for the total process, otherwise referred to as the realm of islands. This weakness is a clear problem and the unit classification further strengthens the effect.

The result of the realm of islands is a general lack of commitment and people hiding behind formal procedures (Interview Vermeulen, Nacinovic, 2007). The PRINCE2 methodology can lead to a highly document centric project with too many meetings and too little actual work executed (Janssen, 2004). To make this more clear two examples are given. The first is based on the author's own experience. When asking for information to employees of other departments it almost never happened that a person could give the right information. Especially the people unknown to the author responded by saying that it was better to ask someone else. However, when going to this other person the response was again to ask a different person inside the department and so on. A second example was given by one of the project managers interviewed. Communication between departments is mostly done by using email. The problem however is that people inside the organization send an email to someone and thereby assume that the task is executed. But if the receiving person is on a holiday for example, the whole process can stop for weeks and nothing is being done. If such a situation occurs, the person sending the email responds by saying that it is not his problem and he did the job asked (Interview Vermeulen, 2007). All aid from other departments needs to be approved by the manager of that department, written down and financially compensated. These examples indicate that people inside the organization do not want to take responsibility and look outside the boundaries of their task, which is defined as a lack of commitment to the entire project.

The last organizational problem which plays a large role for the case of MPO's is the lack of national guidance of the whole service. Many of the MPO's indicated the problem of reliable communication equipment on the motorcycle. The C2000 network is a nationally guided project, but the equipment used by each regional department is purchased by the departments themselves to give them some control. The result is that many departments needed to find technical solutions to the problems, though each having a small budget (Interview Driebergen, 2007). For example, the equipment needed to be fully waterproof in all conditions an MPO is in. As the original equipment was not designed to work on a motorcycle, each department hired a different company to find a solution to the problem. Although with all the knowledge available between departments a waterproof system could be developed, a large amount of MPO's worked with faulty equipment for years (Interview Doorwerth, Driebergen, Den Haag, 2007).

8.4 Proposed organizational arrangements

The main aim of the organizational arrangements is to design the structure of the multi-actor value network required to create and distribute the service, and to describe the focal firm's position in this value network (Bouwman, 2006). For this research, a more detailed level is taken on the functioning of the value network. Due to the recently restructured organization of vtsPN and the fixed value network, no modifications can be made. Even the choice of external suppliers is defined and is organized through European tendering procedures. Therefore, the choice is made to provide solutions to the problems inside the value network clarified in the previous paragraph by using IT governance theory. Taking these solutions into consideration must aid in successfully developing a context-aware service bundle for MPO's.

The need of a national guidance structure

The first solution proposed tackles the last problem mentioned in the previous paragraph. As Segers (2003) concluded, a national project requires a national guidance structure. The C2000 equipment for MPO's problem showed that 26 parties tried to find a solution to a problem all parties had. A national guidance centralizes the budgets and money is available to work with larger and stronger parties (Segers, 2003). Technical solutions are then more easily found. A national guidance structure is also required to create the largest economy of scale. At the moment, the development of mobile services for the police is focused on officers by foot or by car, as the amount of users is much higher compared to the MPO's. Developing a service for MPO's on a national level results in the highest number of users. Also, the development costs per MPO are then lowest which increases the chance of support from decision-makers.

The need of a systematic problem representation phase

The second solution proposed is shown in figure 8.3. The figure indicates that an increase of effort and costs in planning and creating the concept reduces time and costs in later phases of the whole development process (Verbraeck, 2005). A systematic problem solving project starts with a thorough representation of the problem situation (Bots, 2002). The demands of the end-users and the participation of the end-user play a crucial role in the planning and concept phase of the service. The national guidance structure proposed as the first solution must assure the participation of end-users on a national level further increasing the planning and concept phase, but better fitting the demands on a national level.

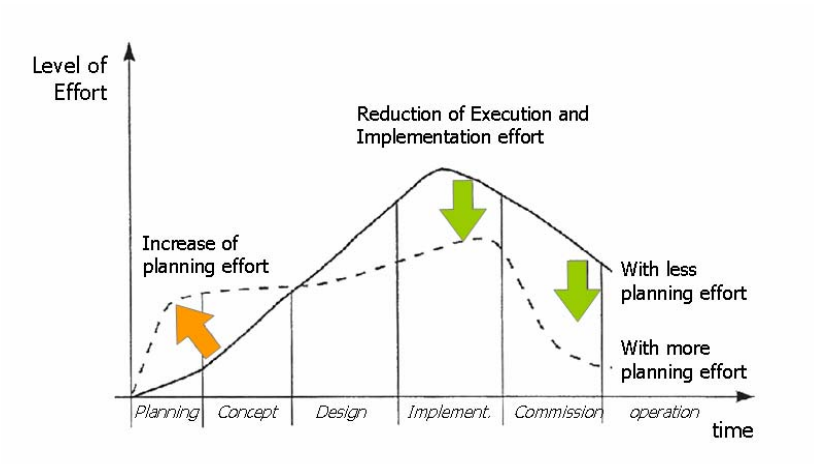


Figure 8.3: result of planning effort increase in project management (Verbraeck, 2005)

The spiral model

The current development methodology can be roughly categorized as the 'waterfall model'. It is a very systematic model first setting the requirements, followed by the design, than the implementation, after which the system is verified and lastly maintained. In order to increase the user participation a different development methodology is proposed called the 'spiral model' (Boehm, 1988), shown in figure 8.4. It is mostly used for software development, but is applicable for service development as well. The main idea behind the spiral model is that it has an iterative approach rather than a linear approach strongly enabling and encouraging user feedback so as to elicit the system's real requirements (Verbraeck, 2005). Each loop in the spiral represents a phase in the process and risks are explicitly assessed and resolved throughout the development process. The first quadrant focuses on the planning of the development process. Quadrant number two analyses the risks involved. The third quadrant is entirely focused on the user evaluation of the increments by planning different tests for each cycle. The last quadrant is the actual design of the service. By iteratively assessing the risks, inconsistencies between the user requirements and the design are detected early and changing them is not as costly.

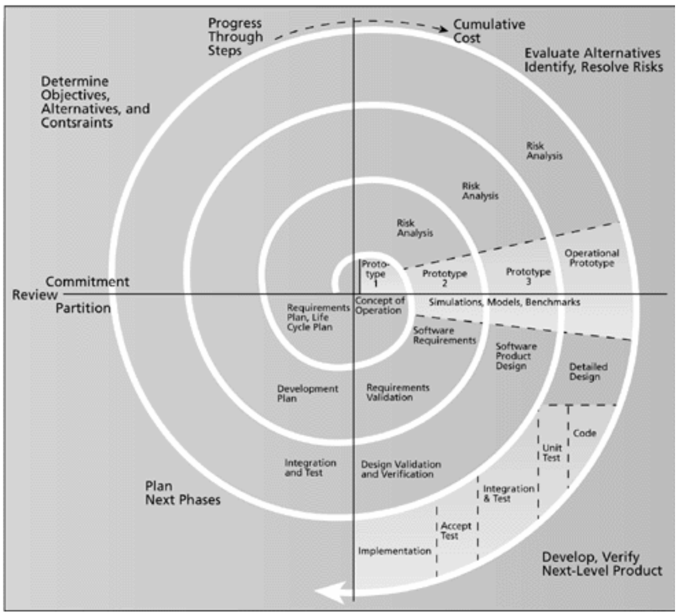


Figure 8.4: spiral model of service development (Boehm, 1988)

Horizontal governance capabilities

The next solution is based on the IT governance theory of Peterson (2004). VtsPN is highly focused on the vertical coordination and standardization for police IT systems. But as the organization problems paragraph indicated, a vertical coordination is not sufficient to successfully implement IT systems. Peterson (2004) proposes horizontal integration capabilities (HIC) which describe the ability to coordinate and integrate formal and informal decision-making authority across business departments. The HIC are classified in three categories: structural capabilities (connection), process capabilities (coordination) and the relational capabilities (collaboration).

The structural capabilities define the formal positions and integrator roles inside the development process. Although difficult to alter, we propose to give more decision-making power to project management. As the interviews made clear; project managers mostly know the problems, but do not have any authority to tackle them. Making changes results in long procedures as approvals of various management staff and boards are required. Secondly, changing the unit classification from 'work process and function' to a unit classification of 'output' (Mintzberg, 2006) might result in a faster development process. It removes the problem of internal struggles for cooperation from the different departments. Formally, the organizational structure is difficult to change, but dedicated development teams could be created over the formal structure. An example could be that dedicated teams are formed from one person per department who physically sit together for a certain time. By physically placing people together the lines between the various departments become short and the commitment for the project will increase.

The process capabilities are related to the risk analysis of the spiral model of Boehm (1988). They define the monitoring and tracking of performance in terms of cost/benefit/risk analysis, agreements between stakeholders or benefits realization (Peterson, 2004). Both the structural and the process capabilities are tangible, meaning that they are mandatory for each organization to successfully develop IT services.

The relational capabilities are more intangible and tacit which makes them more difficult to realize. Relational capabilities are related to the user involvement of the spiral model and the 'participation' role in the formula of Rau (2004) presented above. The key to relational capabilities is the voluntary and collaborative behavior of different stakeholders to clarify differences and solve problems (Peterson, 2004). The essence of relational capabilities is the integration of domain-specific expertise and tacit knowledge (including the end-users). Shared learning develops, when people in close collaboration create a 'single memory', with differentiated competencies and responsibilities (Weick & Roberts, 1993). The creation of development teams as explained above is essential for the 'single memory' effect to be created. For shared learning to have effect, the opinions of different stakeholders must be respected, captured and fed back to those responsible for commenting on the design of the service. This results in an iterative "diverge/converge" process like in the spiral model until there is convergence on a final design (Rau, 2004).

Role of process management

Project management methods are hierarchically controlled and assume stable and loyal actors in the project. Although appropriate for internal management, the organizational problem paragraph showed external parties are neither stable nor loyal. To increase the role of external stakeholders in the development of the service a process management approach is required. De Bruijn, ten Heuvelhof & in 't Veld (2002) state that process management leads to a basic commitment to support inside the value network, enrichment of the problem definitions and solutions and incorporates the dynamics of a development project. Process management also leads to earlier development aims defined by de Reuver (2006) and Segers (2003). A basis of mutual understanding is created between the stakeholders (Segers, 2003) consequently improving the trust relationship with those stakeholders (De Reuver, 2006). Secondly, by incorporating the departments as users and the end-users, the value for both types of users is created as both have a say in the process (De Reuver, 2006).

De Bruijn et al. (2002) define four core elements of a process management design which must all be guaranteed. Firstly, the project management must provide an 'open' decision-making process giving the opportunity to all parties to have a say. 'Protecting the core values' is the second element which assures parties to stay committed to the problem situation. The third element is to guarantee that the process entails sufficient relevant content. Lastly, 'progress' must be assured by agreements between parties. This stops the process from becoming too slow due to negotiations.

Commitment between all stakeholders

Even though all elements of a process design need to be guaranteed, the progress is specifically important given the problems at vtsPN in developing services. Assuring progress between stakeholders can be formally arranged, but also requires a level of commitment from all stakeholders inside the value network. The examples given in the problems paragraph show that people who are involved in the development process do not show a high level of commitment. As shown in figure 8.5 below, commitment is one of the corner stones of governing an organization. According to Rau (2004), commitment can be improved by making the people realize the need of the role they have in the development process. However, just announcing the need is insufficient. Meetings, workgroups and planning sessions in which lack of commitment symptoms are discussed and solutions sought must precede the designing phase of the project. By including all stakeholders, the organizational readiness also grows, further increasing the general success of the project.

Figure 8.5: Cornerstones and building blocks of a governance model (DCE, 2005)

A second important aspect proposed by De Bruijn et al. (2002), and later acknowledged by Segers (2003) specifically for service development in the police organization, is to create a 'sense of urgency'. All parties must be convinced of the occurrence of a problem situation asking for a solution. We believe the participation of end-users in the development process will automatically create a sense of urgency as the desire for a solution increases. Like with any marketing strategy, knowing a service is being developed for you further increases the desire for that service. The increasing request for a solution further increases the pressure on the development and therefore the commitment within vtsPN to suffice the request. One of the dangers affecting the sense of urgency is 'the burden of the past' (De Bruijn et al, 2002). If previous projects ended badly stakeholders will start off with a disagreeable feeling about the project. Taking away this burden needs to be incorporated by project management.

8.5 Conclusions

The decision-making structure of vtsPN makes the end-user involvement in developing services difficult. Secondly, the internal structure of the organization results in slow decision-making and a distance between employees who need to closely cooperate. In order to successfully develop a service for MPO's the following solutions are proposed:

- The need of a national guidance structure for the project development
- Increase the effort of the project start-up by introducing a systematic problem representation phase
- Introduce the spiral model (Boehm, 1988) as a general development methodology
- Increase the decision-making power at the project management level
- Create development teams according to the output of the service
- Introduce relational capabilities to increase the voluntary and collaborative behavior of all stakeholders (including regional departments and end-users) in the development process
- Use a process management design approach to include the requirements of the different stakeholders into the total development process.
- Increase the level of commitment of all internal and external parties involved in the development of the service by making people realize the need of the service and create a 'sense of urgency'

9. Conclusions and recommendations

In this final chapter the conclusions of all the sub questions are joined to find an answer to the main research question of this thesis. The main question is formulated as follows:

How can context-aware service bundles and its business model aspects be designed in order to create value for motorcycle police officers?

The answer to the main research question is found by the different sub questions, consequently with its answers and conclusions. For that reason, we start by reviewing each sub question and provide the answers and conclusions made based on the research executed. After having discussed the conclusions a short paragraph is allocated to final recommendations and a reflection on the research executed at vtsPN.

9.1 Conclusions

The first sub-question was the following: *What promising theories and concepts provide basic knowledge for the design of a context-aware service bundle increasing customer value?* All theories and concepts are chosen for their conceptual frameworks, offering a clear and simple representation of the main factors of the theory. The starting point was the definition of a <u>business model</u> to be used throughout the thesis. It helps to structure the different domains needed to offer a service capable of deliver a value increase to MPO's. Electronic business model theory claims a service not only needs to be well designed, but also the technical architecture, the organizational arrangements and financial arrangements determine the feasibility of the service. The latter is excluded from this thesis due to time constraints.

Designing a context-aware service bundling model capable of increasing value to the MPO is based on general frameworks available on <u>service bundling</u> and <u>context-aware service provisioning</u>. These frameworks are to be transformed into a model applicable to the case of the MPO. The design process of service bundles consists of defining the bundles goals, determining the user needs, specify bundles satisfying those needs and finally define the different production rules that exactly compose the bundles. Based on the research objective of this thesis, the context-aware service model takes on the role of a context interpreter. The model is build out of certain functions: a context source manager function, controller functions, action functions, register functions, user management functions, security functions, user interaction functions and presentation functions.

In order to find an answer to the second sub question, *a definition of the information provisioning context factors of MPO's* is set. The basic knowledge needed to define the different factors came from the MPO's themselves. By adding the knowledge retrieved from the literature study the following <u>MPO-context factors</u> have been defined:

- The location of the MPO.
- The task status.
- The time.
- The speed at which the MPO is driving.
- The group communication possibilities.
- The network availability.
- The control room availability.
- The task to perform.

As the list of factors might change, adding the possibility to extend the final service with other factors, or maybe remove factors, is required.

The task factor plays the most important role in the design of the service. The role of tasks is important because it further sets the type of information needed at what specific moment in time. As the final design is an information provisioning service, defining the information needs is essential. <u>The</u>

task analysis showed that traffic MPO's (including the KLPD Geo-unit) mainly execute control tasks, needing persons information and vehicle information. The information types fall in the structured information system interaction side. This means that the information access is not complex. It can occur in a passive work relation setting or an active one. In a passive setting, the MPO is capable of controlling the system, but in an active one more attention to the environment is needed. This requires the system to adapt. Quarter bureau MPO's have a wider range of tasks and consequently information needs. They perform control tasks and need control information, but are also busy with emergency aid tasks which require a larger variety of information. The latter information falls in the active work environment and unstructured information system interaction, making the operation of an information system by the MPO almost unusable in order to ensure safety. Pushing information seems necessary for this situation. The district bureau MPO's perform similar tasks to the quarter bureau MPO's, but on a larger geographical scale. A second difference is the addition of guidance tasks. The guidance tasks are active and the information system interaction is structured, as with some control tasks. The last information type is accident info at the moment of arriving at the scene whereby the work relation is passive, but the information interaction is unstructured as each situation can be different.

The third sub-question was defined as follows: *What influences MPO's intention to use mobile information systems and which mobile information system provides the highest value in the different context situations?* The answer to this question has two parts. The first is to define how value is created by a communication system for MPO's. The concept used to answer this first part is based on the technology acceptance model, combined with task-media fit, constructed in chapter 2.

The second part of the answer is found by using the context-factors of chapter 3 and measuring the value of different information systems in situations based on the context-factors. As the context-factors influence each other, profiles are created which all have one level of the context-factor included. A conjoint analysis is executed to measure the utility of different information system types per factor level.

After having executed both statistical methods on the data of each respective part, the most important conclusions of the quantitative research part with MPO's are the following:

- The perceived usefulness of mobile communication systems has a considerable effect on the intension to use such a system. However, the importance of the perceived usefulness is not founded by the MPO's themselves. In practical terms; MPO's will need to be further persuaded of the usefulness of the system for their tasks. This can be achieved by working closely together in the development phase of the mobile communication system. The intension to use will then further increase.
- The ease of use of a mobile communication system does not influence the intention to use directly, but does influence the resource advantage, consequently influencing the intention to use.
- By making the system very easy to use by MPO's, the potential of decision making increases. This requires the system to adapt to any situation the MPO is in by always finding the right ease of use in relation to the information richness.
- The information exchange media fit assumption is most the important aspect of a communication system to MPO's. It further influences the intention to use the system.
- In general, using a touchscreen capable of clearly displaying different types of information to the MPO is seen as the best option.
- The choice of the intermediating party and the modality depends on the context situation. Looking specifically at the information types; it seems route information is best to be send as images, whereas briefing information and information from registers is preferably received as text.
- A head-up display and the use of UMTS phones are never rated as best option.
- Emergency aid tasks always need to be supported through vocal information from the control room. A touchscreen is usable, but probably just for information presentation. Other tasks can solely be supported by the use of a touchscreen.
- Sending information by the MPO is preferably done by using speech directly to the control room.

- Receiving information from the control room when it is available is still most preferred, if other factors are ignored. Consequently, for the transition from the old system to a new system to be successful requires a lot of attention, training and persuasion.
- MPO's do not want to wait for the control room to become available; receiving information on a touchscreen is clearly preferred if no direct contact is available. In case the control room is surely not available retrieving information from registers is highly rated.

The information resulting from answering the previous sub questions has been the input to answering the fourth sub-question: *What is the conceptual design of a context-aware service bundle and what are its requirements to increase customer value?* The conceptual model is seen as the centre-piece of this thesis as it is designed to offer an increasing value to the MPO's if implemented as a service. The model is created by using UML, so that it is structured and programmable in follow-up developments. Also, the UML structure provides the option to easily extend the service with other context factors if real-life tests indicate this necessity. The information needs, founded on the tasks defined in chapter 3, provide the first part of the model. The following main <u>classes for the concept design</u> are identified:

- TaskRegulator class, with three sub-classes called EmergencyAid, Control and Guidance which each have their sub-classes according to MPO tasks.
- ContextManager class, controlling the service based on context sources, which are in accordance with the defined context-factors.
- ControlRoom class, checking availability.
- Time class.
- Location class.
- Speed class.
- MPOStatus class.
- NetworkManager class, controlling networkavailability and communicates with information sources.
- MobileTerminal class, controlling the C2000 system.
- UserProfile class, controlling specific user specifications.
- DeviceManager class, managing the different devices needed to support the functioning of the service.
- PresentationLayer, altering the presentation lay-out to the user.

As the UML model is a static set of classes, attributes and methods, it does not state its functions. Therefore, a list of requirements is formed. Each requirement has a code, an explanation and a source so that the requirement is traceable and grounded. For the list of requirements we refer to chapter 5.3. The functioning of the requirements can be modeled by using sequence diagrams, which incorporate time. For a final model, all sequence diagrams must be designed of the different tasks that MPO's can perform. If the sequence diagrams are designed, production rules stating the different services to bundle can be determined.

The service concept is compared to five design issues. The first is to define the <u>value creation</u> by the service based on the designed model for the MPO. The value increase is created by the following characteristics of the service:

- The hybrid networking assures a faster and more stable provisioning of information, an essential aspect of communication systems for MPO's. This results in an increase in efficiency and effectiveness.
- The ease of use is increased by adapting to the context of the MPO. This increase in ease of use has a positive effect on decision-making and on the advantages the system presents to the MPO.
- By including the current information system, the MPO has the choice of information provisioning. Thereby an increase in value is further guaranteed.
- The increase in efficiency and effectiveness leads to more work being executed, which increases value for the departments. Simultaneously, less pressure is put on the control room.
- The service also creates value to the supplier (vtsPN), due to an increase in service delivery and maintenance contracts, a general improved image of vtsPN improves, and the retrieved knowledge from the project.

The trust of the end-users partly depends on the way security measures are implemented. The ease of use must be guaranteed. A second part of the trust is created by making sure the service functions flawlessly. The hybrid network method increases the reliability of information provisioning, but problems will always occur. The cooperation with the end-users increases the understanding of users if problems occur. An essential step is to develop a pilot project of the service to find possible problems in a real-life system. The creation of value, combined with the role vtsPN plays as primary supplier of ICT services for the police is considered essential in retaining the customer.

The last design issue added to the previous list is safety. The safety focus in this thesis has a dual nature. Information loss is kept to a minimum by using the hybrid networking method. By training the MPO's in case information loss occurs he or she is prepared to anticipate in a correct manner. The physical safety is automatically affected as attention from the physical surroundings is moved to the system. Although an increased ease of use ensures a minimum safety effect, no grounded conclusions can be made. Further tests of a service in a practical setting must provide more information on the effects of using the service of safety.

The question: "*to what degree the service design increases the customer value when evaluating using a mock-up prototype?"* was the fifth sub-question of this thesis. In order to find an answer to this question, the service design has been tested by using two different information system mock-ups, a touchscreen and a head-up display version. To measure the increase in value three different theories are used. The first are the indicator variables with the highest factor loadings of the TAM constructs measured to find an answer on the third sub question. By reducing the constructs information is lost, but due to practical time availability issues of the MPO's no other option was available. Also, the MPO's have been observed and glance durations have been measured by using video footage to determine a first safety influence.

The following conclusions are made based on the experimental research:

- The touchscreen mock-up clearly showed the highest ratings in general, which is in accordance with the results gotten from the conjoint analysis. As the touchscreen mock-up is based on the service concept design, we can state the service design proves to be a promising service concept for MPO information provisioning. Adjustments and further studies are required though.
- The head-up display gave a higher variation of opinions and the general results are not sufficient to claim a head-up display increases the value like the touchscreen does. The device is seen as an interesting aid, but inappropriate for every day use on a motorcycle. Practical issues like having to change your focus while using the system, or using the system when standing still make the head-up display generally less usable compared to the touchscreen version.
- The context-aware service bundling concept significantly increases the information provisioning quality and speed over current systems. It received very positive reactions which are grounded by the quantitative part of the experiment. The ease of use and information exchange improvements are considered the foundation of the positive reactions by the MPO's.
- Speech recognition showed some positive results, but does not score high enough to be used for a final service at the moment. It is dependent on the user, whereas operating a touchscreen is not. Operation failure would lead to frustration among users. Secondly, the usage in a real-life situation probably becomes more difficult due to surrounding noise.
- The usage of text-to-speech software proved to be successful and might increase the safety of system-usage.
- Safety of the MPO when using the system is still an issue which requires further real-life tests to be executed. Especially when using the service in a constantly changing traffic situation and an emergency aid situations shows low safety ratings. For the touchscreen, taking away the hand of the handle-bar to operate the service and reading large amounts of text from the screen largely influence the safety. Using a control button on the handle-bar and letting the text-to-speech software read the text might solve the safety issues according to the MPO's.
- The need of C2000 for control room contact and communicating with colleagues remains high, especially in emergency aid situations. This conclusion is in accordance with the conjoint analysis results.

- Non-essential information must be avoided. It only increases glance durations and glance frequencies thereby decreasing the safety of the MPO.
- The glance durations are still too high when having to read information from the screen. Text-to-speech software probably lowers the glance durations.
- The easy lay-out of the buttons (using 2 buttons per menu) seems promising if looking at the glance duration measurements. A control button on the handle-bar could further decrease the durations.

Business modelling theory states that the design of a service requires a design of a technical architecture supporting the service. Therefore, an answer is found on the sub question: *what technical architecture is required for a feasible implementation of a context-aware service for MPO's?* Designing a new <u>technical infrastructure</u> for a context-aware service bundling model is impossible as vtsPN's main aim is to standardize ICT services. Therefore, the choice is made to develop the service on the platform of the P-Info service referred to as G2. However, some additions are needed to assure the hybrid nature of the service which assures a maximization of network coverage throughout the Netherlands. UMTS and the usage of C2000 are added to the infrastructure architecture.

The <u>devices</u> required to fully make use of the service are numerous:

- A PC running the service must be mounted in the back compartment of the motorcycle
- combined with the C2000 equipment
- A GPS module should be mounted on the back providing the coordinates for navigation.
- A Bluetooth connection between the helmet headset and the communication equipment.
- A touchscreen above the handle-bar must be selected, keeping the size, readability in sunlight and water resistance in mind.
- A control button on the handle-bar is needed to improve operation safety.
- A camera on the front of the motorcycle reading the license plates should also be mounted.

The last aspect of the technical architecture is the <u>applications</u> controlling the service:

- A stable operating system capable of running all applications
- A Middleware layer functioning as 'ContextManager' of the service.
- Hybrid network software controls the availability of networks and chooses the network based on QoS definitions of the service.
- ANPR software controls the camera and presents the license plate number to the context manager.
- Navigation software must be based on the police standard to make sure different systems can exchange location information.
- Text-to-speech software must be chosen, offering a variety of clear voices to choose from.

The last sub question focuses on the organizational domain of the business model. "*What organizational arrangements are required for a feasible development of a context-aware service for MPO's?"* is answered. In order to find an answer to the sub question a few interviews have been performed. Changing the organizational structure of vtsPN is not an option, so more detailed organizational solutions are defined to ensure a feasible development of the designed service.

First a mentioning of the <u>main problems</u> is given:

- The highly complex decision-making structure of vtsPN makes the end-user involvement in developing services difficult.
- The internal structure (teams according to function) of the organization results in slow decision-making and a distance between employees who need to closely cooperate.
- A 'realm of islands' is formed resulting in difficult communication and commitment between internal parties having to cooperate during the development.

In order to feasibly develop a service for MPO's the following <u>solutions</u> are proposed:

- The need of a national guidance structure for the project development.

- Increase the effort of the project start-up by introducing a systematic problem representation phase.
- Introduce the spiral model (Boehm, 1988) as a general development methodology.
- Increase the decision-making power at the project management level.
- Create development teams according to the output of the service.
- Introduce relational capabilities to increase the voluntary and collaborative behavior of all stakeholders (including regional departments and end-users) in the development process.
- Use a process management design approach to include the requirements of the different stakeholders into the total development process.
- Increase the level of commitment of all internal and external parties involved in the development of the service by making people realize the need of the service and create a 'sense of urgency'.

How can context-aware service bundles and its business model aspects be designed in order to create value for motorcycle police officers?

The starting point of the design of a context-aware service bundle for MPO's are the context factors influencing the information provisioning. By talking to the MPO's themselves a general idea of their work and the information needed to support the work is obtained. We define eight context factors: location, status, time, speed, group communication, network availability, control room availability and the task. The task plays an essential role as it determines the information need and the moment at which the information is needed. Three groups of tasks have been chosen in accordance with MPO's: control tasks, emergency aid tasks and guidance tasks. All three have sub-tasks which require certain information.

The service must be used on a physical information system. Many different devices, modalities and intermediating parties are available to design an information system. But an information system capable of transmitting the information to the MPO in all situations is not straightforward. The persons capable of deciding which information system functions best in different working situations are the MPO's themselves. Our research has shown that a touchscreen system capable of retrieving register information, combined with the voice support from the control room in some situations has the highest value increase to the MPO. The voice support situations are active and present an unstructured information system interaction like emergency aid tasks.

The service adapts to the context based on the defined context factors. In a passive work relation the system must show all possible information sources to the MPO, thereby providing as much information as possible. Bundling information is also required here as information is spread over different information sources. By using production rules these bundles can be composed in accordance with the MPO's. Bundling information (e.g. vehicle and person) and the different systems (voice support and touchscreen), and filtering information (e.g. just showing if irregularities occur or not) in active circumstances is also needed. Also, the presentation of the service must change according to the context situation. The service is easier to use, which results in a more information being exchanged and better decision-making. By connecting to various information networks (UMTS, GSM/GPRS and C2000), information loss is kept to a minimum as the service continuously checks the available networks and switches if needed. These aspects all increase the value for the MPO. The MPO has more and better information when needed resulting in more work executed.

The experimental research has shown us that the service increases value over the current system, but that two additional service features further increase the value of the total service concept. Both are needed to improve safety, an unanswered issue. The first addition to the service is a control button on the handle-bar letting the MPO use the system without removing the hands of the handle-bar. The second is the usage of text-to-speech software, capable of reading data to the MPO automatically. The touchscreen also presents the information, but as a back-up if the MPO is driving. By using text-to-speech, the MPO can keep the eyes on the road while also getting the information. Although both additions presumable improve safety of the MPO, safety is not guaranteed. Glance durations of a few MPO's are measured and indicate times that are too high in general. But more importantly, the static experiment is unable to test dynamic influences while driving on a motorcycle. Therefore an essential step in continuing with the design of the service is testing in real-life situations.

The effects of the service on efficiency and effectiveness of information provisioning to the MPO also increases the value of the service for departments. Targets are reached more easily and more work is executed in the same amount of time compared to using the current information systems. This increase in value is needed to make investments worth while. For vtsPN, the implementation of the service leads to a higher amount of contracts, an increasing publicity and positive image and finally a large amount of knowledge is obtained to be used in other mobile police officer services.

The service concept proposed must run on a technical architecture. Given the standardization goal of vtsPN the service must run on an existing platform. The P-Info (or G2) architecture fits best with the service as it designed for mobile information provisioning of police officers. Additional networks (UMTS and C2000) are required to support the hybrid network concept. The service also requires a number of devices to be added to the motorcycle: a GPS module, a PC running the service and connected to the C2000 equipment, a helmet connecting to the system through Bluetooth, a rugged touchscreen which is readable and usable in all weather types, a control button on the handle-bar and a camera scanning license plates. Finally, applications are needed to run the service. The basis is a stable operating system. Then, a middleware application functioning as ContextManager has to be designed. Other applications controlled by the ContextManager are the ANPR software, the hybrid network software, the navigation software and the text-to-speech software.

The feasibility of the development process of the service also depends on the organizational arrangements used by vtsPN. Several focus point are determined to ensure a feasible implementation of the service. A national implementation is necessary, a development cycle which includes the MPO on a national level is required and an increase in the level of commitment within vtsPN must lead to a more feasible development process. By using a process management approach with external stakeholders the cooperation is improved and the level of commitment is presumed to increase as well. Internally development teams should be created closely working together and project managers should be given more decision-making power to improve decision-making time.

9.2 Reflection

In this paragraph a reflection is given by the author on the work executed for this thesis. The first focus is on the used theories and concepts throughout the thesis. The business model proves its usefulness to structure the main aspects to focus on. Naturally, the lack of a financial design is a problem. Even if the design of the service proves to increase value for the MPO, it might not provide the value increase to vtsPN and the departments due to high development costs. Getting a solid image of the needed investments to develop context-aware service bundling for MPO's is an important to determine whether follow-up research is worthwhile.

The basic knowledge used on context-aware services and service bundling provided sufficient information for the goal of this thesis. The design is still a concept, and the simplicity of the used concepts of AWARENESS and Alonistioti & Panagiotakis (2006) provided a good basis to work on. Whether the designed model can easily be translated to a real service is unclear. The basic classes are defined, but an important aspect is missing. This aspect is the actual bundling composition. Although the bundling composition model of Akkermans et al. (2005) is considered a useful tool to use in this research, no concluding composition could be created for the case of MPO's. Defining the exact composition and turning the composition model into the explained production rules is an important aspect of follow-up research projects.

A third element which is missing in the design of the context-aware service bundling model is the opinion of software programmers. As can be seen, the model is highly complex, even as a concept. Getting the opinion of experts who are able to judge the feasibility of the concept as a software model is surely needed before extending the research. Also, judging whether the amount of production rules will not lead to problems is required. The complexity will result in high amounts of code to be produced and vtsPN has to determine whether it can develop such a program on its own.

The fourth aspect requiring a reflection is the quantitative research executed. The internet research proved problematic, especially due to the removal of dependent variables for some profiles. This resulted in difficult data and an MVA had to be performed. Although the reliability is automatically decreased by data with missing values, the results are still in line with what was expected from the knowledge gotten from the interviews. Concluding the internet research, more effort should have been spend in the preparation phase as these problems could maybe have been avoided. The same conclusion can be drawn from the design of the experimental research. Although time restrictions of the MPO's made the creation of solid measurement constructs difficult, more time should have been spend by the author at thinking the experimental design through in order to make a more grounded conclusion. The results of the measured constructs are in line with the observation though, and also when comparing them to the results of the conjoint analysis.

Even though mistakes have been made during the execution of both research phases, the research results proved useful. Firstly, the TAM/TMF models provide a good theoretical base to measure the way MPO's accept communication systems. The information gotten from analysing the data was already assumed, but these assumptions can now be grounded. Secondly, the results provide a solid basis for the conjoint analysis, seen that the important role of information is further supported. The conjoint analysis also proved to be a very useful technique. Again, the results were expected to some degree, but they give a precise image of the value each information system has for the different context factors. For some, unexpected results from research are more interesting, but the results gotten from our research is useful, which is the most important reason for executing the research. A minor point is that it would have been interesting to turn the conjoint design around and use the information systems as independent variables and the contexts as dependent variables. Due to the design used for this conjoint this was impossible unfortunately.

Concluding the reflection, the chosen theories and research methods to design context-aware service bundling proved useful. A first thinking direction has been created and also tested in a more practical setting which provided a lot of knowledge on context-aware service bundling for MPO's. The positive reactions of the MPO's during the experiment further ground this conclusion.

9.3 Recommendations

Having concluded the thesis, three main recommendations are given to be used in proceeding development steps based on this research. The first recommendation is to assess the financial feasibility of the service design within vtsPN. The interviews with people from within vtsPN learned that budgets are often largely exceeded. To meet with this objection, a solid financial plan is required. For vtsPN, it is important to remember that the knowledge retrieved from the development of the service can also be used for other types of police officers. This knowledge has value and must be incorporated into the financial feasibility plan. Of course, the value of the retrieved knowledge also depends on future development projects and if a fit can be defined. When looking at transferring the knowledge to other user types, it is to remember every user type requires a specific design. The design of the service for MPO's is not directly usable for the case of other police officers.

In case the needed investments prove to be worthwhile, all sequence diagrams and required production rules must be designed. These rules must be designed in coherence with the work processes and demands of MPO's per region. Each region uses different equipment and the changeover from the old to the new system is different per region. During the tests with the MPO's, the interest of the MPO's in the service was very high. All MPO's had an opinion, showing their eagerness to cooperate in developing services supporting their work. Making use of this commitment is highly important and provides a good opportunity to include the MPO's in the process. It will require a large amount of time, but the success of the service is highly dependent on this phase.

If the design and production rules of the service are developed a first version should be created for real-life testing. The system must be implemented on a few motorcycles of MPO's, from various regions, including the KLPD. The latter is needed as KLPD motorcycle are used in the heaviest conditions. As mentioned throughout the thesis, the technical reliability and safety are the main focus points. Testing the system under all circumstances is required as the conditions in which the system is used are unpredictable leading to technical complications and safety effects (e.g. rain can damage the equipment and blocks the view making the service more difficult to use). The safety should be measured first in a controlled environment where harm to the MPO is minimized in case safety issues prevail. If safety is guaranteed, reliability must be tested. A technically unreliable system is unacceptable as it diminishes the value of the service. Informing the MPO's about the developments is needed to make sure they understand the complexity of developing such as service and the need of tests. They will want the service as soon as possible, so creating a level of understanding is important to assure a feasible service. Solid agreements between departments managers have to be made in order to make sure the MPO's are allowed to cooperate during the developments.

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Appendices

Appendix A) Interviews with the MPO's

Date	Name MPO	Region	Function
25-04-2007	J. Clermonts	Groningen	General
25-04-2007	J. Kranenberg	Groningen	General
03-05-2007	M. de Jong	Gelderland-midden	General
03-05-2007	H. Nieuwschepen	Gelderland-midden	General
10-05-2007	C. van Duiven	KLPD (national)	General
14-05-2007	G. Pons	Haaglanden	General
22-05-2007	G.J. Post	KLPD (national)	General
06-08-2007	R. van Eijk	Amsterdam-Amstelland	Task specific – district
06-08-2007	P. van der Valk	Amsterdam-Amstelland	Task specific – regional
06-08-2007	J. Speet	Amsterdam-Amstelland	Task specific – regional
28-09-2007	D. Snip	Midden-West Brabant	General

Table A.1: overview of the interviewed MPO's

General interview Veendam 25-04-2007, district MPO's J. Clermonts en J. Kranenborg

Introduction

Both MPO's spend most of their working time on the motorcycle. Johan guesses about 95% of the time, Jan a little less as he also has a lot of knowledge about transportation regulation and is not always needed on a motorcycle. There are 6 MPO's in their district, but the amount is decreasing. Before MPO's were used on a motorcycle on a part-time basis, but this has changed to a full-time schedule. Motorcycle officers are very dependent on their tacit knowledge. According to both MPO's differences between regional departments are large when looking at the work processes and the technology used for MPO's. Also, motorcycles are relatively expensive, especially compared to cars. There is just room for one person which makes some tasks impossible to execute on a motorcycle. This makes the attention for MPO's from management lower compared to other police officers.

The tasks

MPO's in the region Groningen are in practise completely used for traffic control tasks. The tasks indicated by both MPO's are: checking all juridical demands on cars, checking the speed of vehicles, checking all juridical demands on motorcycles and motorbikes, guidance, stopping illegal street races, control of transportation. Officially they can be asked to aid in all tasks requiring a motorcycle, but they are not connected to emergency aid teams. The MPO's with AVLS (Automatic Vehicle Location System) are as the control room can keep track of their location. The largest part of their work is in checking cars through the enquiry of licence plate numbers.

Current information provisioning

According to both MPO's the information provisioning is reasonable. On the motorcycle all communication goes through the control room by using the C2000 network and have a special channel between them and the control room. They also have the possibility to switch the channel to a private channel between MPO's are other public safety officers. They switch the channels by using a small terminal box in front of them with buttons (just above the handle-bar), they are also able to use the system while driving. Next to using C2000, the GSM is also used to share information between colleagues and the infodesk (a special group providing information which is not in police registers).

A big problem for them is the fact that the other party they are communicating with is not understandable when driving fast, say on the highway. The reason for this lack of understanding is the background noise, mostly wind. Another problem is that the control room is sometimes unavailable for information requests. This is due to other police officers simultaneously requesting information. As they work with priority levels and emergency aid has higher priority both MPO's guess they have to wait for information for about 20% of all working time. Occasionally the waiting time is so long that nothing can be done and they have to cancel a control situation. If they have to wait they turn to the GSM, but they can only use the GSM when standing still and the helmet is off. Also, not all needed information can be obtained from the infodesk.

There are some smaller problems as well. The first is that they lose the connection when they disconnect the helmet to the motorcycle. They need to get their mobile terminal from the case to be able to communicate with the control room when not being close to the motorcycle. The C2000 connection is not always understandable.

The administration of their work
Performing administration tasks is highly disliked and resulted in some irritated reactions. They would like to see an improvement in the ease of use of administration procedures and the time it takes them to complete it. An example is given by Jan: when performing a day of transport controls, it costs him about 2 days in the office writing down reports. Although transport tasks is an extreme due to the many regulations, normal tasks requires him about 3 hours of administration work for a single day. All administration on the job is written down on a piece of paper and must be entered in a computer when arriving at the office after a day of work on the motorcycle.

The MPO's are also questioned about new technologies and how they could improve information provisioning for MPO's
A head-up display is not seen as a significant improvement. They foresee a problem with the balance while driving and looking at a head-up display. Driving on a motorcycle is very different compared to driving on a car and keeping a clear focus on the road is essential to ensure safety. A display in the field of vision would create a distraction. Driving on a motorcycle at high speeds puts them in a fragile situation and the distraction is not an option. Another problem with the head-up display is using it when it is dark outside, as it distracts even more.

Both MPO's agree that a screen on the handle-bar would be a positive aid, as they can decide when to use or look at it themselves. This makes it more applicable on all situations. Especially for navigation it could help a lot. They know many streets, but the working area is large due to the low density of population and navigation would aid. An important feature must be the entry of the destination through the control room in time-critical situations.

Using a laptop is difficult as they need to keep it in one of the cases on the back of the motorcycle. A PDA would be better, but is small and difficult to use with the gloves they wear.

Their future vision
Requesting information on license plate numbers is an important task and now they are completely dependant on the control room. Being able to request the information directly from the motorcycle in any situation would improve efficiency considerably. They know such a system works in the cars, although it was a bit slow making the efficiency lower than expected.

Another not mentioned aspect is briefing information, which could play a more important role in future information systems. They are briefed every day, but are not able to review the briefing information. This means that either have to ask, or they can not check again (an example is stolen cars). Having a system which gives them the opportunity to review briefing information would increase effectivity. They claim retrieving information from the large processing systems of the police (BPS, XPol, Genesys) is impossible on a motorcycle as searching through the registers is not possible while driving.

General interview Doorwerth 03-05-2007, district MPO's M. de Jong en H. Nieuwschepen

In the district office Doorwerth there are six motorcycle officers and three motorcycles available. Both Marcel and Henno are working as an MPO for more than 10 years. 60% of their working time is spend on the motorcycle and 40% at the bureau, but the latter could be a bit less if they wanted to. They also perform small tasks at the bureau if needed.

The tasks

In this department the tasks are arranged according to HelmGRAS facts, which stands for Helmet control, seatbelt control, traffic light control, alcohol control and speed control. The tasks are all around traffic control. Most work they do is related to motorbikes and speed, but MPO's are given the freedom to define the tasks they want to execute. Although officially the MPO's in this district are allowed to be requested for emergency aid tasks it never happens in practice. The control room does not consider MPO's in emergency aid situations. Occasionally the MPO hears about something happening close by and he or she can make the decision to help. However, due to the fact that they are not asked they are normally not eager to help.

Current information provisioning
Both MPO's do not rate their information provisioning highly. At the moment C2000 connectivity is through either the mobile terminal on the motorcycle through the helmet or by using the portable terminal when not wearing the helmet. There is also the possibility to connect to an infodesk (they call it service centre) by using the GSM. In case of an emergency (life danger) they have a separate channel through C2000, but it is rarely used.

Although they work with the C2000 communication system it fails to effectively aid in providing fast information. An important notion is that the equipment is purchased and installed from their resources. This sets the first organizational problem as not enough money is available to effectively solve problems.

The source of the technical problems is unclear to them. While driving they often lose the connection with the control room. The portable terminal seems to work a bit better compared to the terminal on the motorcycle. One of the reasons for bad connectivity is the blind spots (areas where no network is available). Connectivity from the control room to them is just as bad as vice versa, just when standing still it is reasonable. The reason could also be the equipment build into the motorcycle, which is custom made and gives problems. The touchscreen to select channels used to have problems with moist, but these problems are solved. The sound quality in the helmet is very bad and they have seen other departments where it is much better. At high speed they don't understand anything. Connecting to the infodesk is difficult as it is not always staffed or it is busy. The result is that the MPO's can often not work according to the official procedures. Officially, every action needs to be informed to the control room, but in practice this is impossible. They both claim their work is almost completely based on their own tacit knowledge and little guidance from above takes place. At the bureau some information can be searched for, but systems there are not always up-to-date.

Administration of their work
As explained above the administration work is around 40% of their total working time, but it could be a bit less. They are not really bothered with it, although some sort of automation would be helpful and speed up the administration process.

The MPO's are also questioned about new technologies and how they could improve information provisioning for MPO's
It is difficult for them to think of new technologies as the current technology lacks in solidly provisioning them with information. Some remarks are made though. A head-up display is not seen as a usable option because of the distraction. Speech recognition is a good option, but not with the current helmets and equipment they are using. The system would never be able to recognize orders given through speech due to bad sound quality. A display on the handle-bar is seen as a solid solution. They have a touchscreen on the handle-bar already with which they can select the right C2000 channel and it works well. Also while driving. For them an important issue is the connection loss when moving away from the motorcycle due to the helmet connectivity. Both have seen a Bluetooth system at the Enschede department and are enthusiastic about it. Their manager is not due to the danger of eavesdropping.

Their future vision
The paragraph above already gives a direction. For them a screen on the handle-bar presenting information would be best. An important feature must be navigation as they work in a large region and it is impossible to remember all street and area names. Entering the destination address is not an

option; it must be send from the control room using the AVLS technology already used in cars. An extension of the touchscreen they have is seen as a good option.

The largest improvement for them is achieved by improving the current communication technologies they have installed on the motorcycle. Secondly, a better training of the person working at the control room. At the moment, information richness is not always well adjusted to the needs of the MPO and it makes work difficult. Lastly, the general attention to motorcycles and MPO's is much less compared to other police officers by foot or by car.

General interview KLPD 10-05-2007 with C. van Duiven, national MPO and main manager of the motorcycle support team of the KLPD (National department)

At the national police department there are two teams of motorcycle units. One is the geo-unit which works from smaller offices throughout the country. The other unit is directed from the main office in Driebergen. This unit is called the special motorcycle unit. It incorporates around 35 MPO's. Misses van Duiven is their head-manager.

The tasks
The tasks differ per unit. The geo-unit MPO's are officially used for traffic control in the largest sense of the word, meaning that everything that happens on highways belongs to their task. This can be a control, an emergency aid or a guidance task. They operate from the different offices in the Netherlands, but can be used throughout the country.

The special unit has as its main task guidance in the whole country. Other tasks can be executed by this unit (control, emergency aid), but guidance always has priority. So if they are executing a speed control and suddenly a guidance task is required they immediately have to take on the guidance task. Most guidance tasks are for VIP's, exceptional transport (e.g. nuclear) and bicycle races. The other tasks are more to support the other unit with controls and emergency aids. An MPO works about 10 hours a day, of which 6 to 8 on the road throughout the whole country.

Current information provisioning
Like the other police departments the MPO's work with C2000 communication equipment installed on the motorcycle. They also have a portable C2000 terminal in the case on the back of the motorcycle. The equipment used is installed by different companies. In some situations a dedicated command car is used for information provisioning. The MPO communicates with the car driving close-by and there they have all resources needed to find relevant information. This system works well; also sound quality is very good, even at high speeds. Even with the helmet open, communication is still possible. They have a microphone on the motorcycle in case the helmet is disconnected. Seen their national working area a route-navgiation is also mounted above the handle-bar. This system is an off-the-shelf system, although slightly adjusted. It is possible to update maps and add points that require specific attention from the MPO. They also use a large roll mounted next to the navigation with explanations on special routes. This is still used as some information can not be added to the route-navigation. This makes the whole dashboard very full. For briefing information they use a piece of paper they can check when standing still

The main problems are with the C2000 equipment. As the conditions the MPO's work in are even tougher compared to MPO's of regional departments (8 hours in a row, speeds up to 200 km/h) the equipment is not always functioning well. Moist is seen as the main issue. Although all equipment they use is tested according to water-proof norms it still has problems functioning well on a motorcycle. The forces on the equipment are too strong. It can not be compared to just putting the equipment in a bucket of water. Also, as the total system consists of different parts coming from different companies the interactions create problems. These problems lead to loss of communication which is annoying.

Administration of their work
All tasks executed need to be written down on specific forms they take with them. When arriving back at the bureau the forms are then typed into the computer, which takes a considerable amount of

time. Giving numbers is difficult as it differs per day. Making the forms digital would mean a considerable improvement.

The MPO's are also questioned about new technologies and how they could improve information provisioning for MPO's

When questioned about new technologies and the role they could play gave a similar reaction as in Doorwerth. Due to the problems they already have for three years with C2000 equipment scepticism is high. They want the equipment which is available at the moment to work properly before looking at future technologies. When being asked about a head-up display the opinion is rather negative. As with other MPO's the distraction is given as the main reason, especially because of the high speeds her MPO's work at. A screen on the handle-bar is seen as a better option, although they wonder if it is possible to make it ruggedized and usable in all conditions they work in.

Their future vision

For the MPO's of the national department working with digital forms would increase ease of use considerably. Secondly, retrieving information on vehicles and people would make their work much easier as most of their tasks are traffic oriented. The third mentioned improvement would be if the navigation system could be further improved and the old roll-system could be perfectly incorporated. It could also save space on the motorcycle. The addition of an agenda functionality is also mentioned as an advancement. The last improvement is more specific to this unit compared to regional units. As they work on a national level it could help if information on the region they are in is shown. Every region has different procedure which makes it difficult for the MPO's to adjust as the procedures are not always clear. A good example is the way regions define the work processes of the different police officers which differs per region.
As misses van Duiven is almost never on the motorcycle anymore she advised me to talk to Gert-Jan Post, the next interview described.

General interview Driebergen 22-05-2007 with G.J. Post, national MPO for the KLPD

All-round MPO, but employed by the special motorcycle unit. The unit is explained by Misses van Duiven. This interview is used to add information not gotten from Misses van Duiven. Redundant information on the task and current information provisioning is left out.

The tasks

The official task is to execute guidance tasks, but a lot of his work is traffic control related. He is mostly on the highway doing general control and can also be evoked for accidents on highways. They are allowed to do more, but this rarely happens, less than 10% of their work is on tasks that differ from those explained.

Current information provisioning

The MPO uses both C2000 and the GSM. C2000 is used when communicating with the control room; the GSM is used to contact the infodesk for more general information. The information requested most is based on license plate numbers, persons and drivers licenses. He says a lot of the work is also based on tacit knowledge. If he has the feeling something is wrong with a car or the person behind the steering wheel looks suspicious he stops them. If they work with the command car they can request all information through Mobipol installed in the car.

A basic problem is the quality of C2000, as noted by Misses van Duiven. He adds some information though. If it works, he is happy with it, but I has lots of problems and they are not well solved. He says bad connections between systems and moist is the biggest issue. Another problem is that they sometimes have to wait for long times, also when trying to contact infodesk. A small annoyance is the bleep they have to wait for when wanting to speak.

The MPO also has a lot of problems with the person providing the information. He says most centralists do not have the knowledge to efficiently aid. If information is requested the centralist gives all information available, but this means much more information is given than needed resulting in a long talk. This also results in longer waiting times for others. The problem comes from the fact that the control room employees do not have experience with work in the streets.

Administration of their work
Regarding administration, the MPO explains more than Misses van Duiven. He claims administration work at the bureau takes about 2 to 3 hours a day. Administration is based on two types of papers. Small things happening during the day are written down on forms where the MPO explained what happened (mutations). Fines are also written down on these forms. When more critical tasks are executed (e.g. accidents, other emergency aid tasks), statements of involved people need to be written down. All information has to be entered into the computer when arriving at the bureau. Fines have to be entered and send digitally to Leeuwarden, where the central justice collection bureau is located. Most information is on the car specifications, persons involved and especially the driver of the car. Location and time are also always entered.

The MPO's are also questioned about new technologies and how they could improve information provisioning for MPO's
A head-up display is not seen as an option due to the distraction which will become annoying and the lack of possibilities and the fact that speech recognition would not work. Centralists have big problems understanding what MPO's say while driving, so recognition is too difficult. The receiving of speech information is not a problem; quality is good at all speeds. A screen on the handle-bar is seen as a solid option as he can decide when to use it.

Their future vision
He has seen a PDA system which has possibilities of Mobipol, this could help, although the screen would be small. Having a larger screen on the handle-bar would be a good solution. An important feature for him would be to have the forms digitally. When standing still information can be entered in a pda-like system. And based on the person information, vehicle information, drivers license number, location and time most information is immediately available. He says that the system must be able to incorporate all current information provisioning means they have at the moment as there is not space on the motorcycle to install additional systems. A laptop is too big and not an option.

Another important feature to have on a motorcycle is the AVLS they are installing in the cars. He knows some other departments are using it. Although he also states route navigation as an interesting feature, the most important aspect is safety. With AVLS the control room knows where the MPO is and if he is in a difficult situation he can just press the emergency button and colleagues can be send to help.
Verder moet ik dit bespreken met motoragenten zelf, een van beide teams zou handig zijn. 22 mei gesprek met Gert Jan Post van specialistische eenheid,

General interview Den Haag 14-05-2007 with G. Pons, regional Senior MPO

Senior surveillance MPO at the regional bureau of Haaglanden, which means he has different tasks compared to an MPO driving for a district bureau. At his bureau a total of 28 MPO's are employed and they have 25 motorcycles at their disposal. The managers would like more MPO's, but they are not allowed to from higher level management.

The tasks
The tasks he executes are mostly control and emergencies of traffic situations oriented, like accidents, speed control, alcohol checks. His team is also employed to aid in special guidance tasks for VIP's (as they are close to the government), ambulances, bicycle races. Furthermore, they support police officers in district bureau's when needed, are used for support during demonstrations or big festivities, but also football matches. Before executing each task the head-manager of the team creates an instruction manual for the task of that day so that it's clear to everyone what he or she has to do.

Current information provisioning
Like all MPO's they make use of the C2000 communication network. He is quite happy with the quality of the communication. A good aspect of their communication is the tight procedures for talking, keeping the system 'clean'. He has seen departments where procedures are much more loose making communication more chaotic. The control room is used for normal occurrences. Questioning of license plate numbers and persons is through a different channel, with people sitting at their own bureau

especially for them. Special notifications come directly from the bureau (emergency calls). Sometimes blind spots appear, but in general it works well. As they are a regional bureau officially they need to be able to switch between many channels. If the control room is unavailable they can also switch to the district bureaus. They use a long list of codes to remember all the channels, about 60 in total, although some are never used. He uses just a few of the channels frequently. Also, because communication between them and the district bureau's rarely occurs in practice. He also uses a GSM to communicate with colleagues, if he knows who has certain information he needs for a specific task. Like with the KLPD, sometimes a command car joins a group of MPO's to support tasks. The car has Mobipol used to access police registers.

Problems are similar to what other MPO's explained. Waiting times are long when trying to contact the control room and this can result in an unfinished task. Another problem is the person sitting on the other side in the control room. These persons do not have any experience with policing work in the streets and this results in wrong or too much information to the MPO. If the control room is unavailable they switch to the district bureau, but in some cases they do not have the needed information either (e.g. rules about transportation). Switching to district bureaus is also annoying due to the many channels and the fact that there is no solid system with names, just numbers.

The MPO is very positive about the sound quality, also at high speeds. The only annoying problem with the way C2000 works is the fact that communication is just one-way, meaning that everyone needs to wait to speak making waiting times longer. The reason for it is clear though, so he can't give a direct solution. A second fact which annoys the MPO is the waiting time to speak after pressing the speaking button. He says it takes two seconds and in time-critical situations this can feel like it's very long.

Administration of their work
When questioned about the administration he says everything works with paper and pencil. After arriving back at the bureau he needs to enter all the information he has written down executing each task. As he is a senior he is less on the motorcycle as most other MPO's at his department. Although it is hard to give figures, he says about 50% of his work is on the motorcycle, and the other 50% is at the bureau. But this is due to other organizational tasks he executes.

The MPO's are also questioned about new technologies and how they could improve information provisioning for MPO's
A head-up display sounds promising, but the distraction will be a big problem for them to get used to. A touchscreen on the steering wheel is appropriate due to their own possibility to decide when using it and looking at it. He even states that a PDA would already help, even if he can just use it when standing still. Navigation would also be an improvement for them as they work in a larger area. It would require AVLS though so that it can be pushed to them; the cars already have it. Speech recognition is seen as a good way to use systems on the motorcycle, but he doubts if it technically possible considering the background noises. Questioning registers like Xpol and NSIS would be very helpful in assisting them in a fast way.

His future vision
He begins by stating that an improvement of control room personnel is the most important issue for him. Also speeding up the response time of C2000 is important and being able to communicate with colleagues while others are also talking due to long waiting times. With the old analog system, it used to be better as they heard everything.

Regarding technology, he would like a helmet with Bluetooth in order to move away from the motorcycle and still be able to communicate. A system giving them the possibility to access registers would certainly be a welcome improvement to make them less dependent on the control room. Then the channel selection procedure must be improved for it to function well. The buttons on the terminal are small and also make it difficult to change channels while driving and wearing thick gloves.

Task specific interview Amsterdam on 06-08-2007 with R. van Eijk, district MPO.

The interview with R. van Eijk is different from the other interviews, as it focuses totally on the tasks he needs to execute, how they execute the task and what information they require to execute the task. MPO's working for a district bureau are much more concerned with the people living and working in the district. This means they have a lot of detailed knowledge about the district inhabitants not available in police registers (soft information). District MPO's usually drive on smaller motorcycles as speed is not so important, but maneuverability is. They do not have a mobile terminal on the motorcycle, so only a portable one they can connect to their helmet sound equipment. Using the system is difficult, as they have to press the button on the portable device to speak.

Control tasks

The first group of tasks in general control. Control is divided in two groups: 1) pre-planned control tasks and 2) normal surveillance.

1) Pre-planned control tasks are organized by the head-manager and are defined as project weeks. This means that the MPO is not occupied by emergency aid tasks and the control they do is aimed at a specific goal for a set period. The variety is large, but the most important cases are named: Checking cars and motorbikes on juridical demands they have to suffice, Alcohol controls, traffic light control, enticements (trying to entice a criminal and then catch him or her) and occasionally speed checks (not common due to city environment). When executing this type of task they work on a channel for themselves, but are also able to contact the control room.
2) A normal surveillance task means that the MPO drives around and anticipates to everything illegal happening around. A person can only be stopped when a reason is available. In practice this rule is taken lightly as in some cases the reason is found after stopping a person. The MPO operates alone, meaning that information and safety are essential. While driving around they normally check vehicles by giving a license plate number. 50% of their work is focused on motorbikes, as they are the only police officers able to catch them. When executing a surveillance task the MPO listens to the emergency channel as well. If something happens close by he can intervene and aid. It is important to switch between the control room of the district bureau and the regional bureau in order to keep up to date with everything happening in the area.

Both types have similarities regarding needed information. The control room is asked about person information (ID number), vehicle information (license plate number) and to receive additional information about safety. If the person is known to be dangerous this information must be given to the MPO before taking action. When a person must be stopped, the MPO tries to catch him. Usually, if the MPO is near to the person who needs to be asserted the person stops fast and no dangerous actions are needed.

After catching the person, the arrest needs to be reported with the following information: Person details, vehicle details, the reason for the arrest, the location, the date and the time. Communication between the control room and the MPO needs to be in the ear so that the person can not hear what is said about him or her. This is important regarding the safety of the MPO. If the person needs to be send to the bureau a car is called upon in order to transport the arrested person. The MPO has to go with him to fill in all forms. Normal fines are typed into the computer at the end of the working day.

Emergency aid

Emergency aid tasks are defined by the control room when a '112' emergency number is used by a citizen. This can be any problem that needs immediate response from the public order organizations. The types of emergency aid problems are various, but the most important ones for this MPO are: theft of cars, theft of material things in the streets, burglary in cars, burglary in houses, nuisance of people (e.g. large groups), neighbors fighting, noise nuisance, etc… The control room arranges the needed communication between the different involved police officers and other public order assistance. The type of emergency is indicated, the location, the time and how many people involved. Information about safety is very important (arms involved, history of the people involved) and it also given to the MPO. In many cases they can only take direct action if approved by the head-manager. If a person is caught the same procedures apply as when executing a control task. All information about the occurrence is reported and needs to be digitized when arriving back at the station.

Information sources needed to execute their work

Information systems entailing information that is required:

- RDW: All information on registered vehicles in the Netherlands
- Eucaris: European vehicle information system
- NSIS: Schengen information system stating information about registered people
- PAPOS: Information system entailing all people with open arrest orders.
- HKS: Information system entailing all people who are a suspect of criminal offences. Pictures are sometimes available as well.
- CVI: National system searching through all HKS systems.
- GBA: All registration information on Dutch citizens.
- Xpol: Information processing system of the Amsterdam-Amstelland police departments. Similar to BPS used in other departments.

Next to the information needed from the different registers, two other types of information would be helpful to the MPO's. The first is pushed route navigation information by using AVLS. The second is briefing information shown to the MPO at the start of his working day.

Task specific interview Amsterdam on 06-08-2007 with P. van der Valk and J. Speet, regional MPO's.

The interview with J. Speet and P. van der Valk is similar to the interview with R. van Eijk, as it is aimed at tasks specification. The difference between the regional MPO's and the district MPO is that the latter only executes task in its district, whereas the regional MPO's perform tasks in the whole region. Both types are chosen from the same region in order to correctly indicate differences between their tasks. A regional MPO does not have specific soft information of people living or working in the region. They operate more on large roads and highways and tasks are specified to the larger scope (covering different districts). As opposed to the district MPO's, regional MPO's have a mobile terminal on their motorcycle with a touchscreen to switch between channels. The system used also gives the possibilities to switch to the GSM network. They are content with the touchscreen, but information sharing with the control room is not always functioning well. The reason is the lack of experience of control room personnel.

Control tasks

Officially, regional MPO's execute both planned control tasks and the normal surveillance tasks. However, in practice almost all control tasks are planned. Normal surveillance tasks work is similar to the functioning of the district MPO, but as the focus is more on highways, motorbikes are not checked as often. Cars and larger transportation vehicles are more common. According to the MPO there are no other differences so no further elaboration is required. An MPO can always be asked to stop the control task in order to assist in an emergency aid task.

The planned control tasks are defined according to IGP's (Information Guided Policing). The concept of IGP (first introduced in Rotterdam) is that actual cases that still require more work are given to the MPO's and other police officers in the team. This is done through a briefing. The information of the IGP mostly defines the controls they execute for that day. An example could be that some burglaries often occur in a specific part of the city, making the police officers focus on this region and information on burglars available from witnesses. During the briefing the different couples within the team are assigned to different tasks. Working with IGP processes is probably going to be the standard for all police departments in the Netherlands according to the MPO.

The information needed to execute the tasks is similar to the information needed by district MPO's. License plate information, person information and safety information is essential. Due to the similar information and arrest procedures as with the district MPO no further clarification is needed.

Emergency aid

Regional MPO's also perform emergency aid tasks, called '112' tasks between them. The mentioned emergency situations are: traffic accidents, persons getting unwell, actual burglaries, holdups, nuisance and fights. In case an emergency happens, information on the type of emergency situation, the exact occurrence, the location, the amount of people involved, if people are wounded and what the dangers are. MPO's are normally used as a back-up to police officers by car or by foot, or asked when specific speed and maneuverability is required. In case a person is arrested the same procedures apply as when a control task is executed. A car is always needed to take the arrested person to the police department. All information is digitally filed into the computers back at the bureau. The MPO's state that one arrest takes about one and a half hours of administration work.

Guidance

An important task for regional MPO's is guidance. This task is normally not executed by district MPO's. Guidance tasks are always performed in teams of 3 or more MPO's, as the vehicle that needs to be guided can never stop. One MPO's is used far ahead of the group to stop traffic. The second MPO drives in front of the vehicle, the third drives behind. Guidance is divided in ambulances, VIP's, the royal family and special events. This means that guidance can be sudden (ambulance) or planned (VIP, royal family and events).

If the route is planned the MPO's do a test-drive of the route in order to see what difficulties can occur and what location require special attention. The MPO's are able to contact the control room, but are normally functioning with a channel between them as communication is highly important. Eye contact between the MPO's is also important to see if all MPO's are ok. Guiding an ambulance is more difficult as no planning is possible. Contact with the control room is more important, also because the control room is able to control the traffic lights in Amsterdam. The MPO needs to keep the control room up-to-date of its location.

Guidance of events is slightly different from the other guidance tasks. The reason for this is that it can turn into a control task. An example is a football match, where a bus needs to be guided to the stadium. When arrived at the destination the MPO also needs to control the crowds and interfere if problems occur. Most of their work during events is as a back-up, driving around the event but keeping a distance. This is due to the fact that an MPO is fragile when standing still.

All information about planned guidance tasks is given at the start of the day during briefing. This is done through a presentation given by the head-manager. A problem is that the information is not available after the presentation. The MPO needs to write down important parts and remember while driving.

Information sources needed to execute their work

The required information is very similar to the information required by district MPO's. The additional sources are given in *italic*:

- RDW: All information on registered vehicles in the Netherlands
- Eucaris: European vehicle information system
- NSIS: Schengen information system stating information about registered people
- PAPOS: Information system entailing all people with open arrest orders.
- HKS: Information system entailing all people who are a suspect of criminal offences. Pictures are sometimes available as well.
- CVI: National system searching through all HKS systems.
- GBA: All registration information on Dutch citizens.
- Xpol: Information processing system of the Amsterdam-Amstelland police departments. Similar to BPS used in other departments.
- *OPS: Information system containing details of open fines.*
- *AAC: A target group monitoring system with persons that the police want to keep track of. The reason is mostly because of reoccurring criminal behavior of persons.*

Similar to the needs of district MPO's, route information and being able to access briefing information while driving would be helpful.

Appendix B) Conceptual and indicator variables of TAM / TMF

Conceptual variable	Indicator variables
Perceived ease of use	Learning how to deal with mobile communication systems is easy for MPO's
	It seems easy for MPO's to make mobile communication systems do what they want
	The interaction between MPO and the mobile communication system is clear to me
	It seems easy for MPO's to deal with mobile communication systems
	It seems simple for MPO's to learn how to use mobile communication systems
	Mobile communication systems are user-friendly for MPO's
	Mobile communication systems are easy to operate by MPO's
	It is hard for MPO's to grasp the right way of using mobile communication systems
Perceived usefulness	Due to mobile communication systems MPO's execute their tasks faster
	Due to mobile communication systems MPO's execute their work better.
	Due to mobile communication systems MPO's are much more productive
	Due to mobile communication systems MPO's can work more efficiently
	Due to mobile communication system the work of MPO's becomes a lot easier
	Mobile communication systems are very useful for the work of MPO's
	Mobile communication systems are a good addition to the current systems
	Mobile communication systems have a large amount of advantages over other system MPO's use
	Mobile communication systems are an important aid to MPO's
	The information MPO's can receive through mobile communication systems is the information they need
	Mobile communication systems fit the way MPO's want to communicate
	Mobile communication systems fit the way MPO's communicate
Task-Media fit	Information exchange
	Information request
	Information entry in registers/processing systems
	Mutual communication
	Sharing of time-sensitive information
	Taking decisions
	Maintaining contact
	Receiving an overview of where MPO's are located
	Receiving an overview of the situation (e.g. during a calamity)
	Asking questions
	Exchanging confidential information
	Solving problems
Intention to use	I expect MPO's to also use mobile communication systems in the future
	I expect that in the future, mobile communication systems make the work of MPO's easier
	MPO's will surely keep on using mobile communication systems
	I find that also others than MPO's should use mobile communication systems

Table B.1: conceptual variables and indicator variables used to measure the TAM / TMF

Appendix C) Design of the conjoint analysis for MPO's

Choice of measurement

There are three different ways of conjoint preference and choice approaches. "Characteristic of the conjoint preference approach is that respondents are asked to rate or rank hypothetical alternatives, while in the conjoint choice approach respondents are asked to make a choice between two or more profiles." (Kemperman, 2000)

Ranking requires respondents to place the profiles in an order from most to least preferred, resulting in ordinal data (Molin, 2006). Using the ranking method can be difficult when the amount of options (dependant variables) is large. First of all there is no possibility to give the same position to different options and secondly, it requires a lot of effort to handle all the presented alternatives for every context. This makes the ranking option not applicable to this research.

The second method is by using the conjoint choice approach. Choice models compare two or more profiles to each other and ask the respondent to decide which of the presented compared models would be preferred. This results in a nominal scale. Considering the goal of the conjoint analysis in which different communication alternatives are compared to different contexts, choice modelling is not applicable as it compares alternatives between each other. Our aim is to present differences in response scales on all dependant variables and choice modelling does not satisfy this need. (Kemperman, 2000).

Evaluating on a rating scale however does fulfil this need as it provides information on both order and degree of scale per dependant variable. Rating conjoint modelling requires the respondents to indicate the strength of their preference for each dependent variable per context. The result is interval scale data, in this case from 0 (totally unsuitable for this context) to 10 (totally suitable for this context). An important aim of this research is to define the different service bundles to different contexts. Knowledge is needed on different alternatives per context and how they are rated by the user. To give an example, if one device comes out as most applicable for a certain context, but technological boundaries make this device unusable for that context, it is necessary to know what the second best alternative is for that context. By using the rating scale the most detailed information on how MPO's see the different communications alternatives is available. Therefore, the rating scale is chosen for the conjoint analysis of MPO's.

Conjoint analysis design

Based on the different levels of the factors different hypothetical alternatives can be created. These alternatives will be called profiles from now on. The way profiles are created is shown in chapter 4 and it is assumed that no further clarification is required. A full factorial design of the conjoint analysis uses all profiles that can be generated and would result in 2x3x2x4x2x3 = 288 profiles. Presenting this amount of profiles to respondents is impossible. To reduce the amount of profiles a 'fractional factorial design' is made. The most important disadvantage of the reduction of profiles is that interaction effects between factors can not be measured. For this reason the interaction effects between the factors are not taken into consideration during this research. In order to create the design one can use basic plans (Molin, 2006). However, because of the simplicity the design is created by the usage of SPSS statistical software. The result is the following:

*Conjoint_design_dummy [DataSet1] - SPSS Data Editor

2 : Data_channel 1

	Mobility	Task	Group	Info_type	Data_channel	Control_room_avail	STATUS_	CARD_
1	0	0	1	0	1	0	0	1
2	0	1	1	1	1	0	0	2
3	0	0	0	2	1	2	0	3
4	1	1	0	2	0	0	0	4
5	0	2	1	3	0	0	0	5
6	1	2	0	0	1	0	0	6
7	1	1	0	1	1	0	0	7
8	0	1	1	2	0	0	0	8
9	1	0	0	3	0	0	0	9
10	0	2	0	1	0	2	0	10
11	0	1	0	0	0	1	0	11
12	1	2	1	2	1	1	0	12
13	1	1	1	3	1	2	0	13
14	0	1	0	3	1	1	0	14
15	1	0	1	1	0	1	0	15
16	1	1	1	0	0	2	0	16

*Conjoint_design_dummy [DataSet1] - SPSS Data Editor

26 : Info_type

	Mobility	Task	Group	Info_type	Data_channel	Control_room_avail
1	not_moving	emergency_aid	we-centric	route_info	channel_not_available	direct_available
2	not_moving	speed_control	we-centric	from_registers	channel_not_available	direct_available
3	not_moving	emergency_aid	i-centric	briefing	channel_not_available	not_available
4	driving	speed_control	i-centric	briefing	channel_available	direct_available
5	not_moving	guidance	we-centric	give_announcement	channel_available	direct_available
6	driving	guidance	i-centric	route_info	channel_not_available	direct_available
7	driving	speed_control	i-centric	from_registers	channel_not_available	direct_available
8	not_moving	speed_control	we-centric	briefing	channel_available	direct_available
9	driving	emergency_aid	i-centric	give_announcement	channel_available	direct_available
10	not_moving	guidance	i-centric	from_registers	channel_available	not_available
11	not_moving	speed_control	i-centric	route_info	channel_available	max_5_min_waiting
12	driving	guidance	we-centric	briefing	channel_not_available	max_5_min_waiting
13	driving	speed_control	we-centric	give_announcement	channel_not_available	not_available
14	not_moving	speed_control	i-centric	give_announcement	channel_not_available	max_5_min_waiting
15	driving	emergency_aid	we-centric	from_registers	channel_available	max_5_min_waiting
16	driving	speed_control	we-centric	route_info	channel_available	not_available

Conjoint design (showing codes) **Conjoint design (showing labels)**

Orthogonality

In order to assure that the design is usable for the conjoint analysis it must be orthogonal. Orthogonality is achieved when all correlations between the factors over all profiles used in the design are "0" (Hair, 1998). The correlation between two factors being "0" means that the occurrence of one factor level in the design is independent of all other factor levels in the design. If the correlations are not "0" the effect of each predictor can not be reliably defined. To check whether the design is orthogonal a correlation matrix of the design is made. All correlations need to be "0", except the correlations between each factor which is always "1". The correlation matrix is shown in table B.1.

		Mobility of MPO	Task to perform	Group communication	Information Type	Data channel availability	Control room availability
Mobility of MPO	Pearson Correlation	1	.000	.000	.000	.000	.000
	Sig. (2-tailed)		1.000	1.000	1.000	1.000	1.000
	N	16	16	16	16	16	16
Task to perform	Pearson Correlation	.000	1	.000	.000	.000	.000
	Sig. (2-tailed)	1.000		1.000	1.000	1.000	1.000
	N	16	16	16	16	16	16
Group communication	Pearson Correlation	.000	.000	1	.000	.000	.000
	Sig. (2-tailed)	1.000	1.000		1.000	1.000	1.000
	N	16	16	16	16	16	16
Information Type	Pearson Correlation	.000	.000	.000	1	.000	.000
	Sig. (2-tailed)	1.000	1.000	1.000		1.000	1.000
	N	16	16	16	16	16	16
Data channel availability	Pearson Correlation	.000	.000	.000	.000	1	.000
	Sig. (2-tailed)	1.000	1.000	1.000	1.000		1.000
	N	16	16	16	16	16	16
Control room availability	Pearson Correlation	.000	.000	.000	.000	.000	1
	Sig. (2-tailed)	1.000	1.000	1.000	1.000	1.000	
	N	16	16	16	16	16	16

Table C.1: Correlations of the conjoint design

Effect coding

The above design of the conjoint analysis is based on discrete coding where '0', '1', '2', etc… each represent a level of a factor. In order to be able to perform other types of analysis with the design, the design needs to be changed into effect coding. In effect coding, only the values '0', '1' and '-1' are used and the constant value is the basic utility, i.e. the average rating of the dependent variable (Molin, 2006). The different utilities of the levels represent the comparison to the constant value. Coding a factor with two levels results in '1' of '-1'. A difficulty arises when a factor consists of 3 or more levels. According to Timmermans (2005) the diagonal of the indicator variables is coded as '1', and the other levels are coded as '0'. At the last attribute level the indicator variables are coded as '-1'. The part-worth utilities are calculated as shown in the tables 5, 6 and 7.

Attribute level	Indicator variable	Part-worth utility
0	1	β_1
1	-1	$-\beta_1$
Parameter:	β_1	

Table C.2: Effect coding for two levels

Attribute level	Indicator variable 1	Indicator variable 2	Part-worth utility
0	1	0	β_{11}
1	0	1	β_{12}
2	-1	-1	$-\beta_{11}-\beta_{12}$
Parameter:	β_{11}	β_{12}	

Table C.2: Effect coding for three levels

Attribute level	Indicator variable 1	Indicator variable 2	Indicator variable 3	Part-worth utility
0	1	0	0	β_{11}
1	0	1	0	β_{12}
2	0	0	1	β_{13}
3	-1	-1	-1	$-\beta_{11}-\beta_{12}-\beta_{13}$
Parameter:	β_{11}	β_{12}	β_{13}	

Table C.3: Effect coding for four levels

After recoding the different factors into the corresponding indicator variables the following overview is given of the resulting factors, their levels and the coding used in the design of the conjoint analysis for motorcycle police officers:

Factor	Levels	Coding		
Mobility	Driving	1		
	Standing still	-1		
Task	Emergency aid	1	0	
	Speed control	0	0	
	Guidance	-1	-1	
Group communication	We-Centric	1		
	I-Centric	-1		
Information type	Route information	1	0	0
	From Police registers or systems	0	1	0
	Briefing information	0	0	1
	Give announcement	-1	-1	-1
Data channel availability	Available	1		
	Not available	-1		
Control room availability	Directly available	1	0	
	Maximum of 5 minutes waiting	0	1	
	Not available	-1	-1	

Table C.4: final factors and coding of conjoint design

Removed respondents per dependent variable

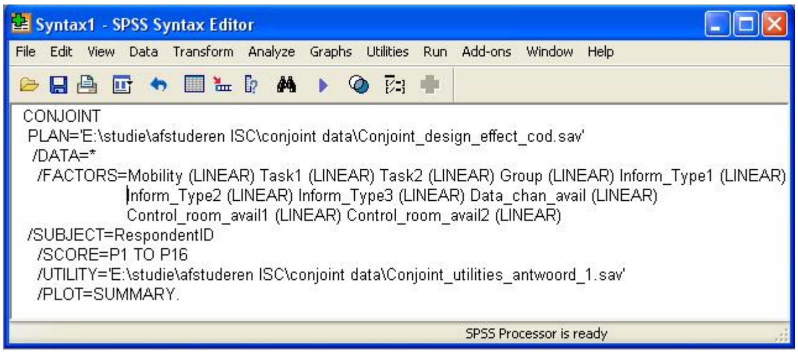
Item	Respondent (Significance) / *SPSS removal*
Touchscreen / Text info / controlroom	21(0.12), 25(0.12), 46(0.07), 48(0.11), 89(0.06) / *54*
UMTS phone / speech info / control room	3(0.06), 4(0.29), 30(0.09), 33(0.09), 45(0,06), 53(0.08), 66(0.10), 72(0.13), 73(0.20), 83(0.08) / *54*
Head-up display/ text info / control room	4(0.12), 7(0.07), 19(0.17), 45(0.16), 74(0.08), 83(0.12)
Mobile terminal / speech info / control room	30(0.09), 49(0.09), 61(0.17), 73(0.20), 80(0.13)
Mobile terminal / speech info / back-up officer	30(0.14), 73(0.20), 74(0.25), 82(0.07), 85(0.15)
Mobile termin / text info / register_system	64(0.19) / *54*
UMTS phone / text info / back-up officer	22(0.17), 30(0.14), 33(0.24), 43(0.24), 44(0.10), 52(0.08), 53(0.29), 73(0.16), 76(0.39), 86(0.20)
UMTS phone / speech info / register_systems	44(0.14)/ *43, 46, 54, 63, 72, 74, 76, 77, 90*
Head-up display / short code / back-up officer	19(0.15), 22(0.17), 24(0.10), 31(0.07), 49(0.17), 53(0.17), 74(0.06), 76(0.08), 86(0.32)
UMTS phone / image info / control room	12(0.30), 16(0.06), 33(0.28), 44(0.12), 80(0.13), 81(0.08), 83(0.32), 90(0.14) / *54*
Touchscreen / image info / register_systems	2(0.15), 48(0.06) / *6, 25, 30, 33, 54, 73, 74, 80, 89*

Table C.5: removed respondents from the data per item before final analysis

The above respondents have been removed per item for each analysis. After the removal the analysis is executed again and the results of the new analysis is used for the following steps of the research. The CONJOINT method of SPSS automatically removes respondents when "at least one case has all equal values in RANK or SCORE". These removed respondents are shown in table B.5 as italic.

Conjoint analysis utilities with missing value analysis (MVA)

When using the conjoint analysis method several design steps need to be followed for a correctly executed analysis: the choice of measurement, the design of profiles, checking the orthogonality and the choice of coding. The analysis of the results is executed by using the conjoint method offered by the statistical software package SPSS 14 from SPSS Inc. The manual of SPSS Conjoint 8.0 (SPSS, 1997) is used to aid in running the analysis on the data. Though SPSS offers many graphical user interface options, the CONJOINT method has to be entered by using syntax code. The CONJOINT method is executed 11 times (for each item), as respondents could rate 11 items after each context situation. To give an impression of the syntax, the code is given below:




```
CONJOINT
 PLAN='E:\studie\afstuderen ISC\conjoint data\Conjoint_design_effect_cod.sav'
  /DATA=*
   /FACTORS=Mobility (LINEAR) Task1 (LINEAR) Task2 (LINEAR) Group (LINEAR) Inform_Type1 (LINEAR)
                  Inform_Type2 (LINEAR) Inform_Type3 (LINEAR) Data_chan_avail (LINEAR)
                  Control_room_avail1 (LINEAR) Control_room_avail2 (LINEAR)
 /SUBJECT=RespondentID
   /SCORE=P1 TO P16
   /UTILITY='E:\studie\afstuderen ISC\conjoint data\Conjoint_utilities_antwoord_1.sav'
   /PLOT=SUMMARY.
```

For some context situations some of the 11 items are removed. The reason for the removal is that some items are practically impossible according to the proposed context situation. The consequence of removing items is that for some items no data is available for some context situations. The CONJOINT method can therefore not analyze the data, as it removes all cases with a missing value. Due to this problem, some sort of missing value analysis needs to be used. It must be noted that the term missing value is normally used when a respondent does not want to answer a certain question. This is not the case here, as no possibility existed to answer the removed items. Therefore, the usage of the term missing value has a different origin in this research, but the result is treated like a normal missing value situation.

Just taking the average of available scores on an item to fill in the missing values for the item is incorrect, as each score depends on the context situation. E.g. item 1 has three context situations which have no values. This means that 91 x 3 = 273 values of a total of 1456 are missing when defining the results of the conjoint analysis for item 1. A difficulty which arises when running missing value analysis on the data is that the missing values are not at random like in many other researches. The final data of the research is referred to as non-ignorable missingness (Gerber, 2005). A proposed missing value analysis method for such a missing value type is the expectation-maximization (EM) algorithm (Gerber, 2005). The exact mathematical procedure of EM is rather complicated and will not be discussed in detail, but a short explanation is given: "The EM algorithm is an iterative procedure that finds the maximum likelihood estimates of the parameter vector by repeating two steps" (Gerber, 2005). In other words, EM uses all relations there are between the variables to get a better prediction of the missing values. A problem with EM is that it amplifies the coherence which already exists in the data. Consequently, the determined variance is underrated.

Due to the shortcomings of EM a different method is used to get results from the conjoint analysis. The used theory explained below is not based on other theories, but is a conclusion of a few logical steps made by the author. Firstly, the average Y_{jz} of all available context answers X_{ijz} per respondent j is determined per item Z and per individual respondent by using the formula 1:

$$[1] \qquad Y_{jz} = \Sigma X_{1jz}, X_{2jz},...X_{njz} / n,$$

n is the total number of context situations (i) for which an answer is available for item Z. The average is based on the available data and gives an impression of the level at which each respondent rate's each item on average. As an example: for item 1 (Z = 1) there are 13 available answers (so X_{1j1}, X_{2j1},...X_{13j1} and n = 13), these answers are summed and divided by 13 for each respondent j.

The next step is to define the proportions between the different context situations per respondent. By doing this, an image of the way each respondent responds to the context situation is obtained. The proportions are based on the available data of all contexts available for that respondent, calculated by using formula 2:

$$[2] \qquad B_{ijz} = X_{ijz} / Y_{jz},$$

By filling in formula 2 for each item Z where the context data is available, a proportion B_{jz} is gotten per respondent for the context where the value is missing. To clarify the example is continued. For item 1 (Z = 1), answers are missing at context 3 (i = 3). For items 5 (Z = 5), 6 (Z = 6), 7 (Z = 7), 8 (Z = 8), 9 (Z = 9), 11 (Z = 11), answers are available at context 3. By filling in formula 2 for each Z = 5, 6, 7, 8, 9 and 11 per respondent j, where X_{ijz} = the rating of the respondent and Y_{jz} = the average of that respondent calculated in step 1, we have six times a B_{ijz}. So if $X_{3,1,5}$ = 8, and $Y_{1,5}$ = 7.92 the proportion $B_{3,1,5}$ = 1.0101. This method has been applied over all available items and each respondent individually.

Step 3 is to define the missing values. This is done by using formula 3:

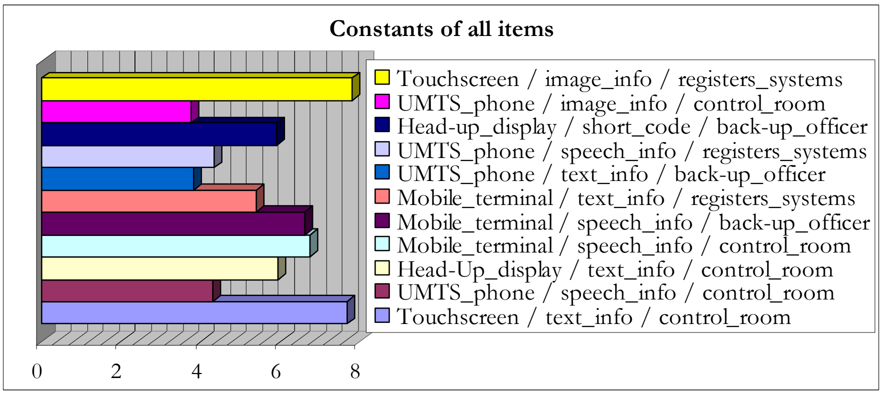
$$[3] \qquad M_{ijz} = (\Sigma B_{ij1}, B_{ij2},...B_{ijk} / k) * Y_{jz}$$

The final missing value M_{ijz} is calculated as follows: a summation of all the B_{ijz}'s calculated in step 2 is performed, dividing it by the number of items used in step 2 and multiplying this result with the average of each respondent where the missing value occurs. Referring back to the example, there are 6 proportions (B_{3j5},...,B_{3j9},B_{3j11}), 91 times (per respondent). By summing all the proportions and dividing the result by 6 an average is obtained from the proportions of context 3 for each respondent. The average proportion is multiplied by the average of the respondent Y_{j1} (Z = 1 as this is the item having missing values) having the missing value for context 3 and the M_{ijz} (in the case of the example $M_{3,1,1}$,$M_{3,2,1}$,...,$M_{3,91,1}$) is found. An important remark about the procedure; determining a guessed value to replace the missing values is never executed with earlier guessed values. This means the guessed values are always based on real values.

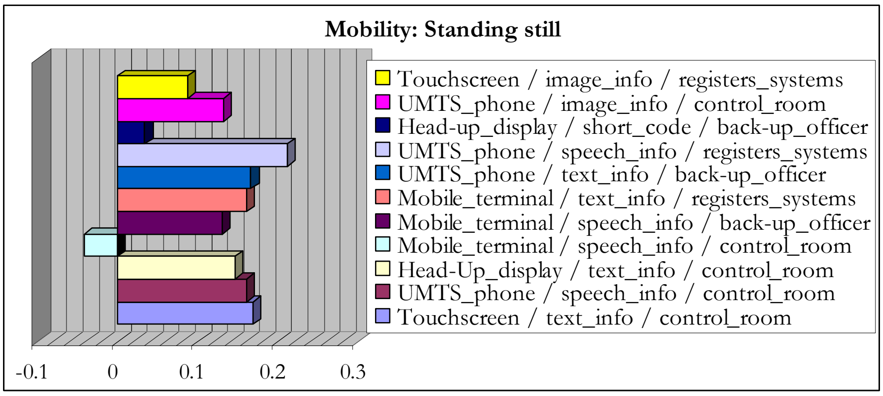
Two important drawbacks are noted with the explained method. The first is that some values are rated higher than 10. This is due to a proportion which is larger than 1 for a respondent and the average is high as well, e.g. 10. It is assumed that guessed values higher than 10 are very appreciated and therefore changed to 10. The second drawback is the fact that it is still a guess which is based on other values in the data. The validation phase must determine if the new full data is usable for analysis.

Appendix D) Overview of all attribute utilities per item (graphs):

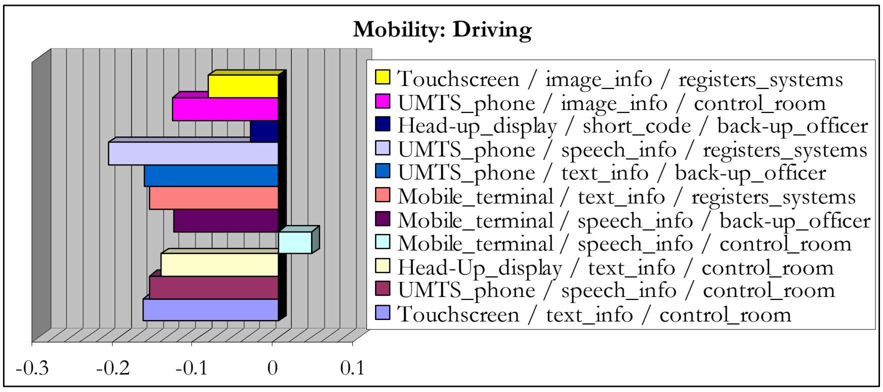
Utilities as graphs:
Constants of all items:



Mobility:
Standing still

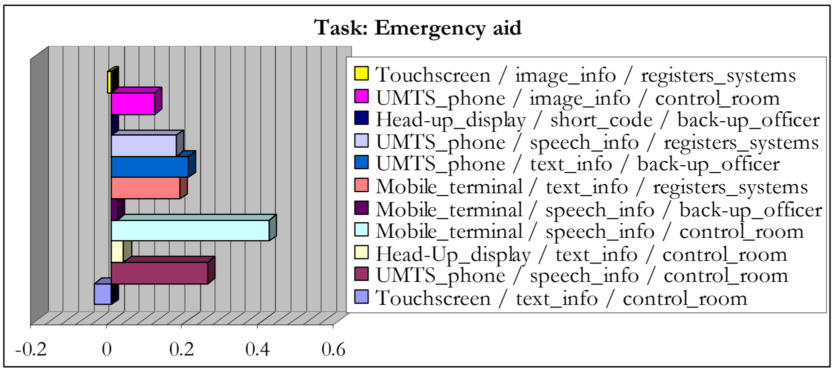


Driving

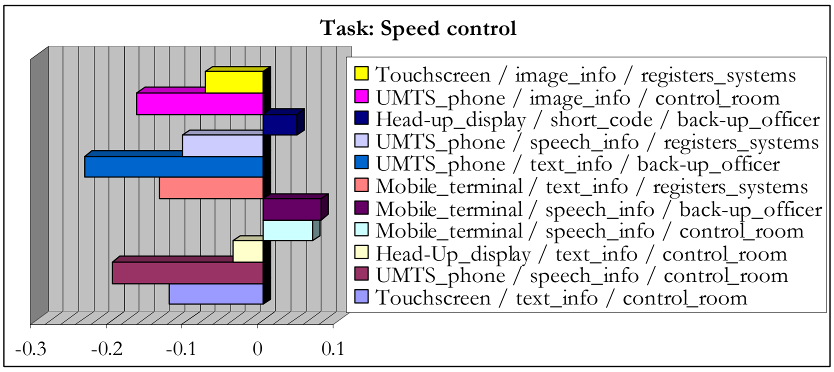


Task:

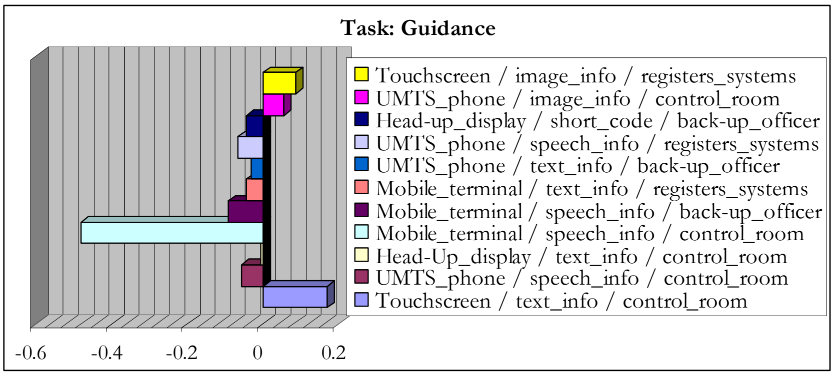
Emergency aid



Speed control

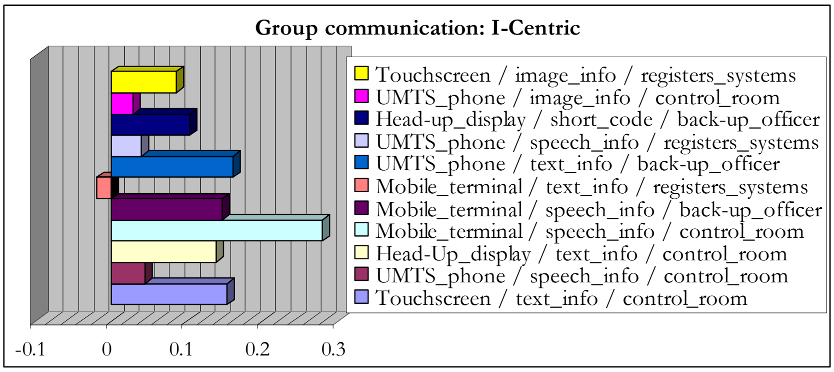


Guidance

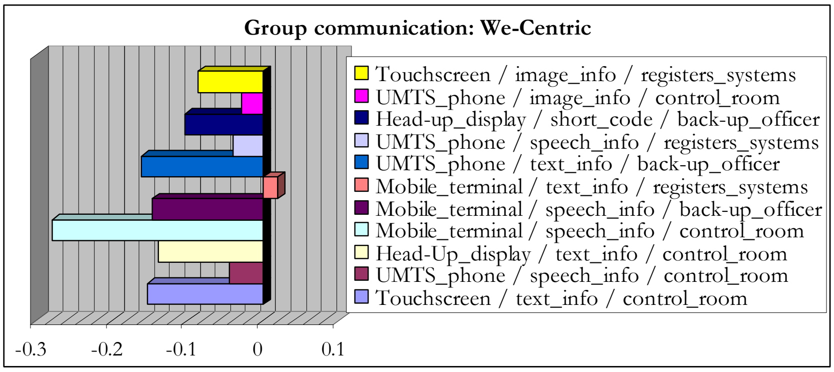


Group communication:

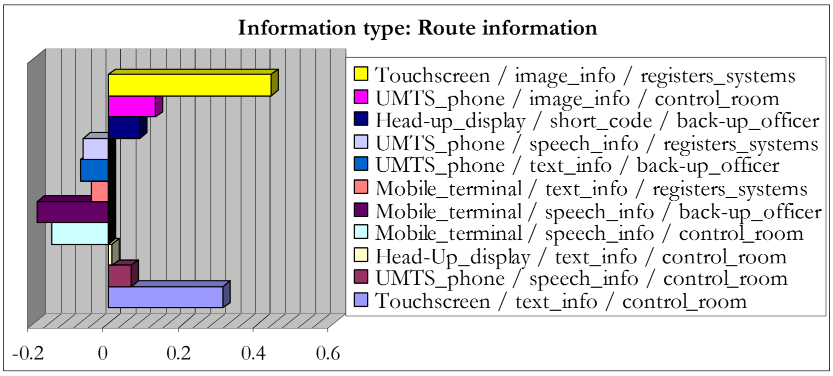
I-centric



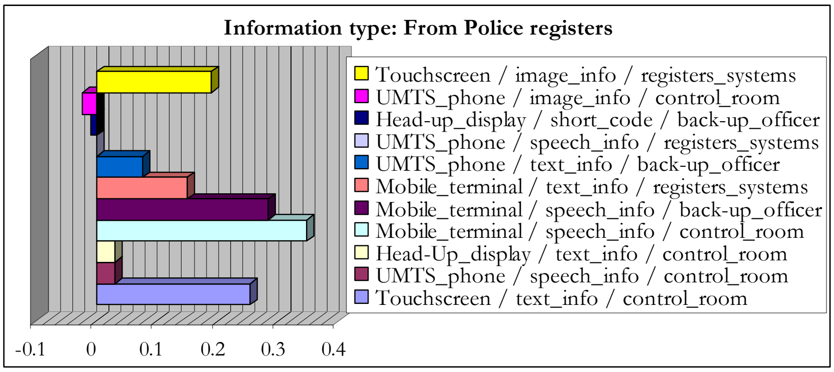
We-Centric



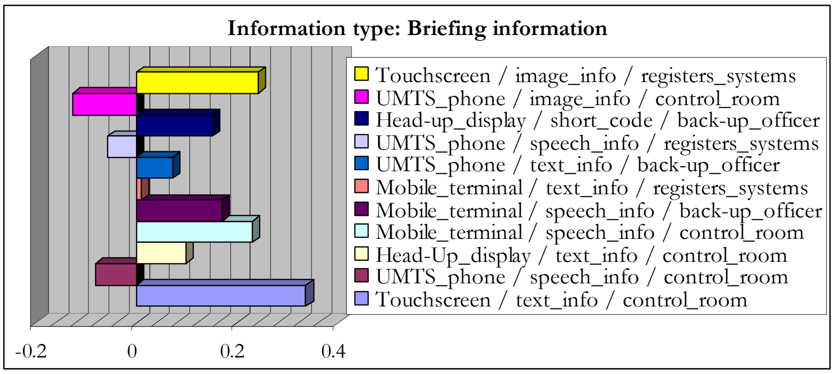
Information type:
Route information



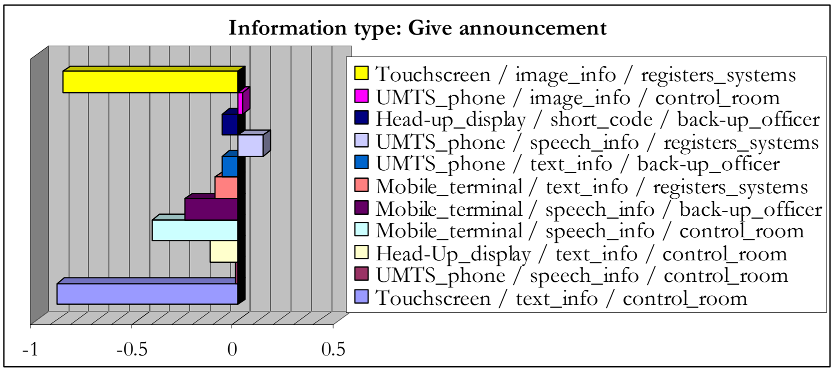
From police registers



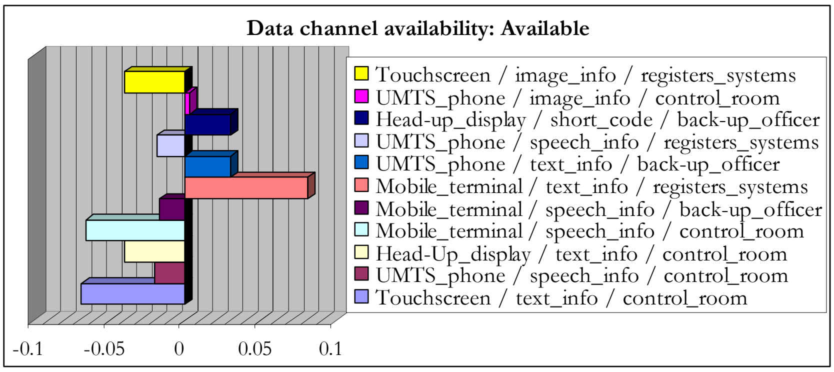
Briefing information



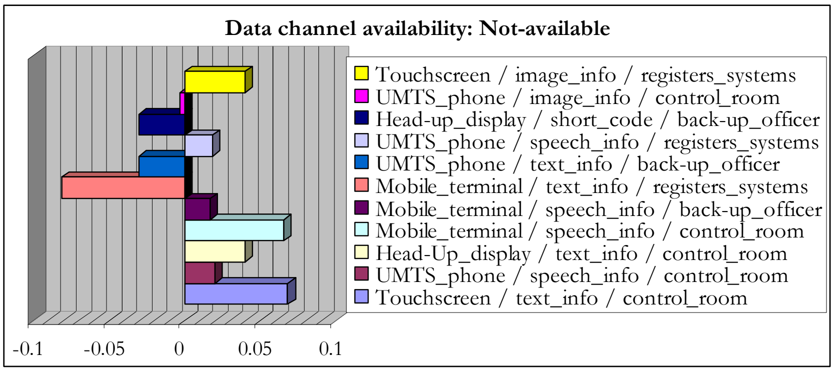
Give announcement



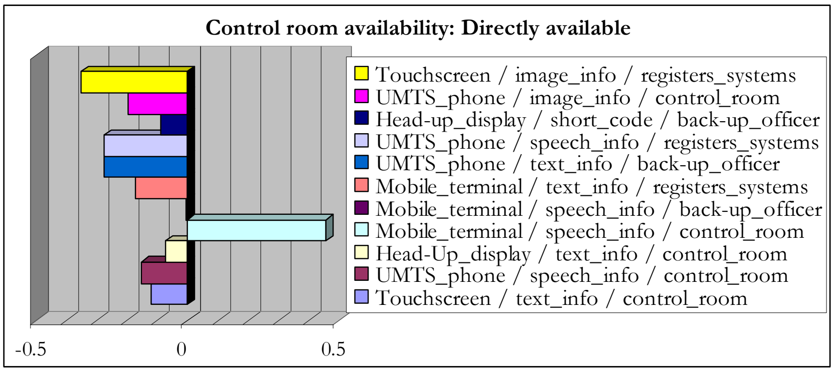
Data channel availability:
Available



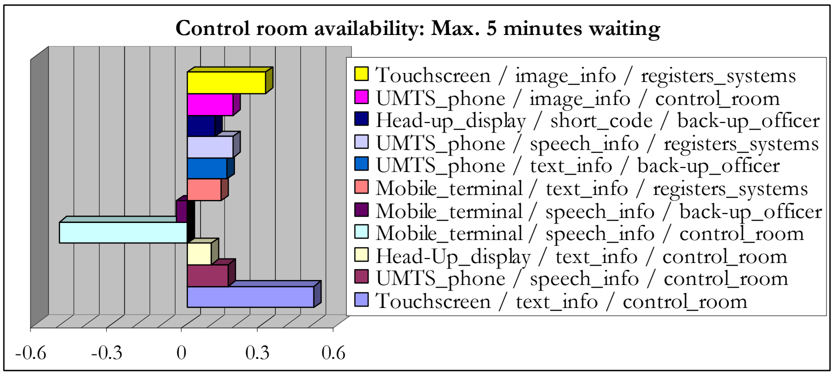
Not-available



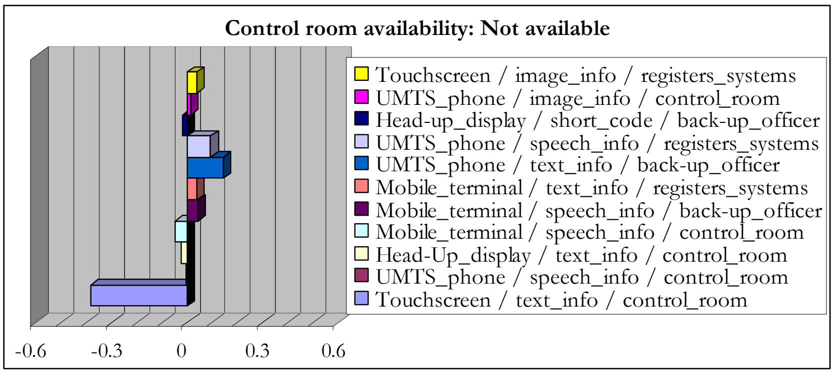
Control room availability:
Directly available



Max. 5 minutes waiting

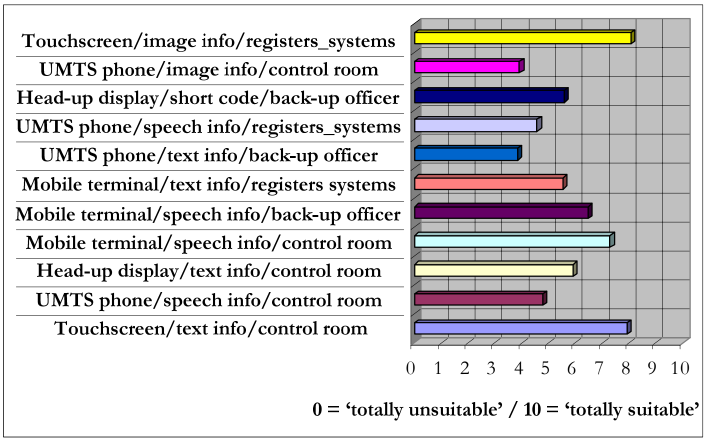


Not available

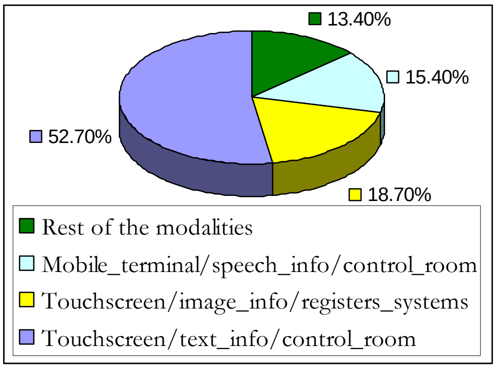


Appendix E) Conjoint data means of the different items per context

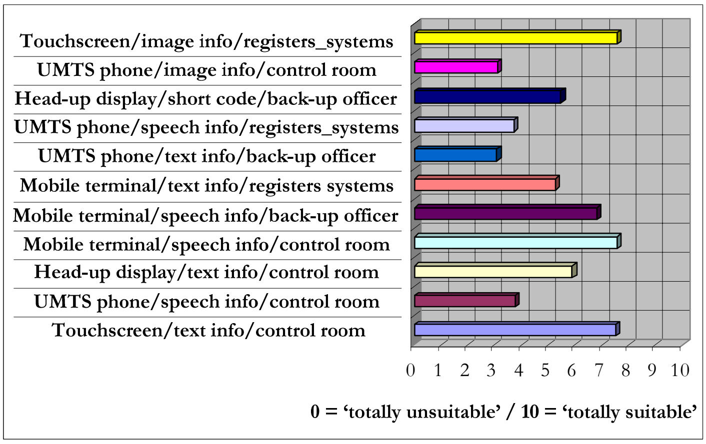
1) Not moving / emergency aid / we-centric / route info / no data channel / control room direct available



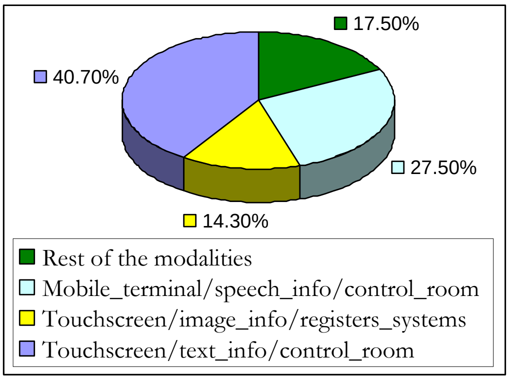
Final choice of item for all respondents (best three shown with the percentage):



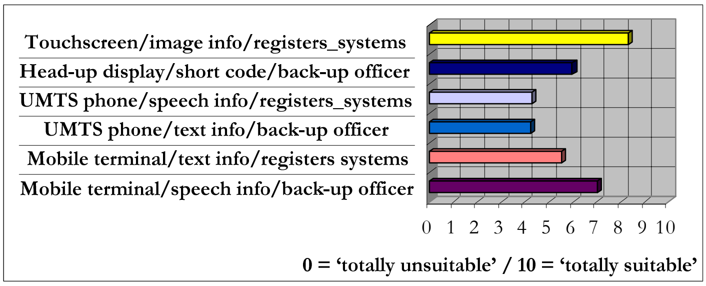
2) Not moving / speed control / we-centric / registers info / no data channel / control room directly available



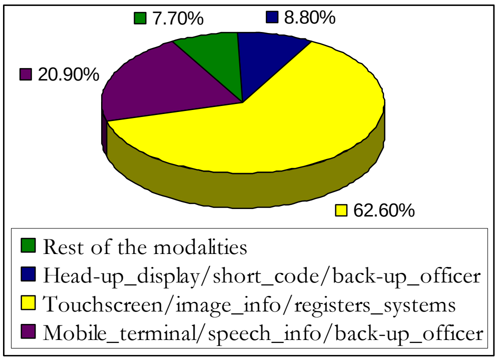
Final choice of item for all respondents (best three shown with the percentage):



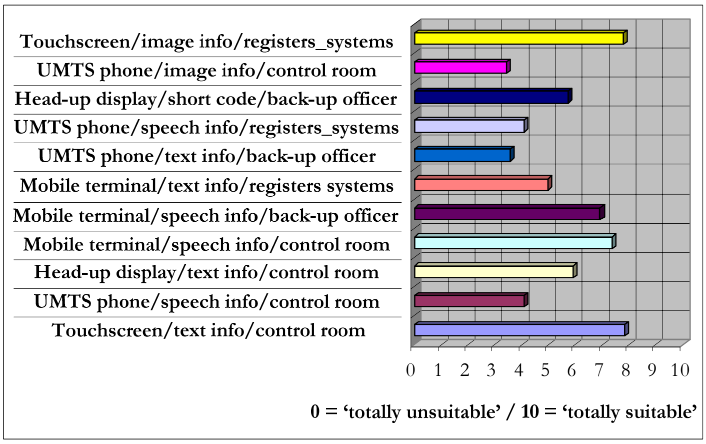
3) Not moving / emergency aid / I-centric / briefing info / no data channel / control not available



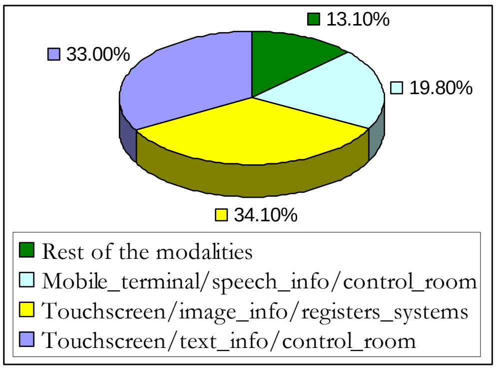
Final choice of item for all respondents (best three shown with the percentage):



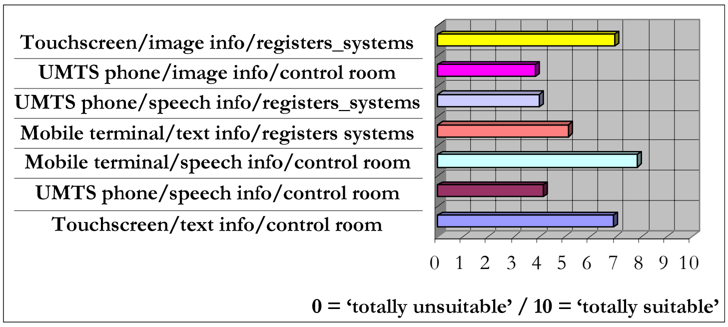
4) Driving / speed control / I-centric / briefing info / data channel available / control room available



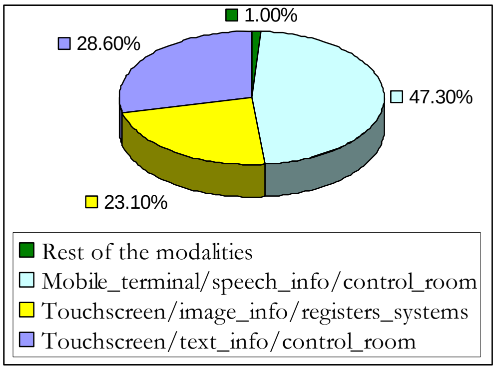
Final choice of item for all respondents (best three shown with the percentage):



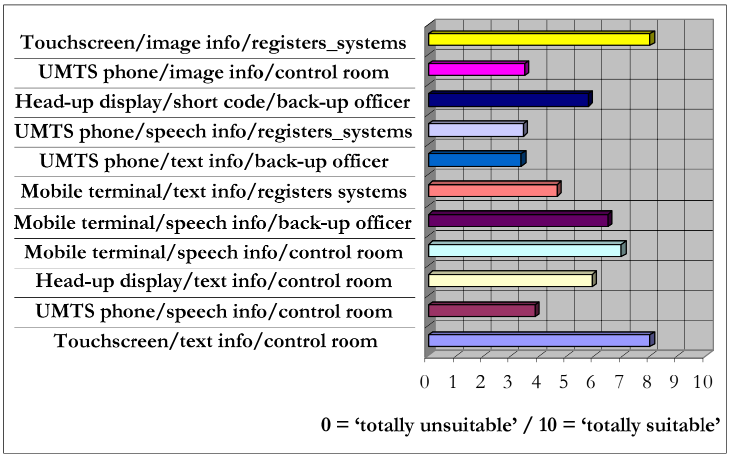
5) Not moving / guidance / we-centric / give announcement / data channel available / control room available



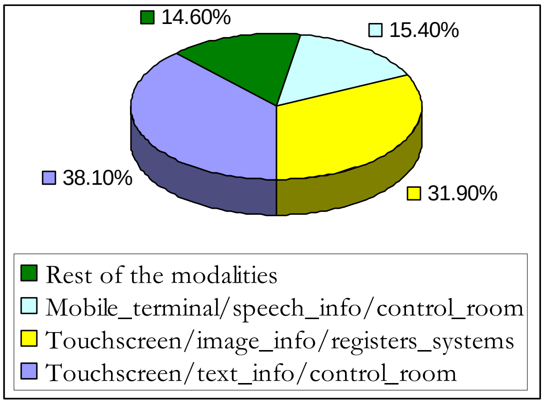
Final choice of item for all respondents (best three shown with the percentage):



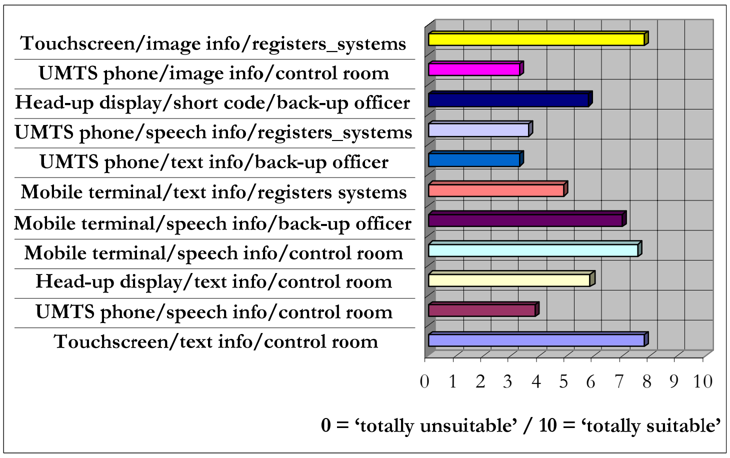
6) Driving / guidance / I-centric / route info / no data channel / control room available



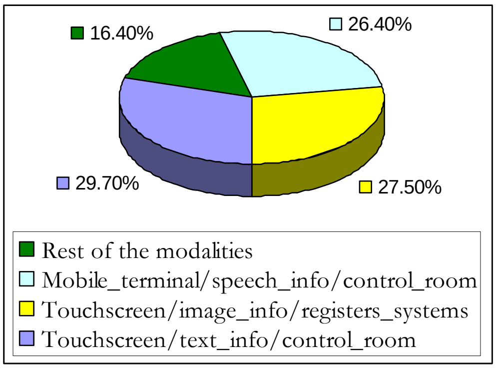
Final choice of item for all respondents (best three shown with the percentage):



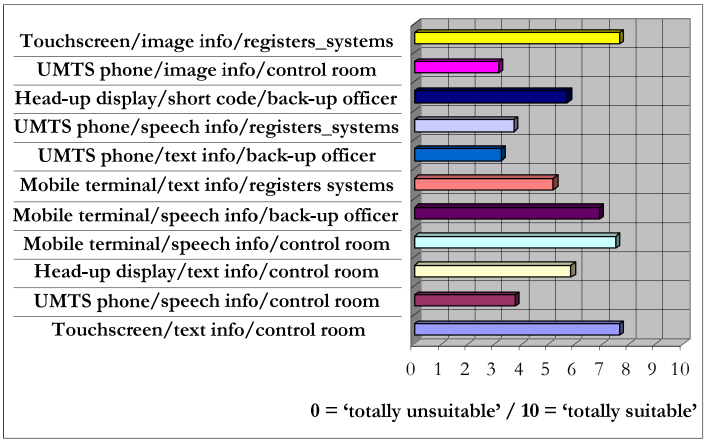
7) Driving / speed control / I-centric / registers info / no data channel / control room available



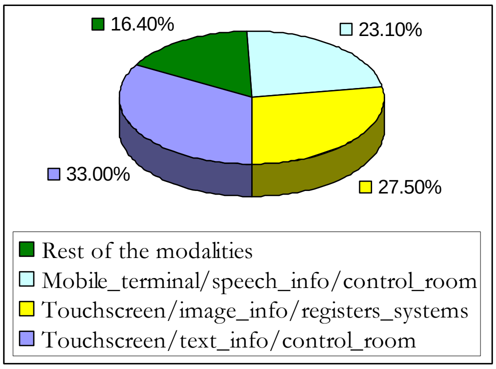
Final choice of item for all respondents (best three shown with the percentage):



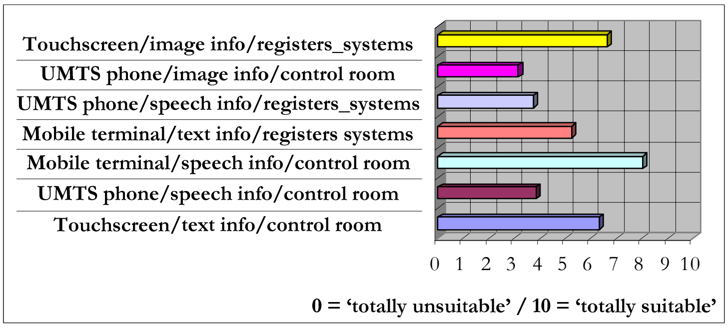
8) Not moving / speed control / we-centric / briefing info / data channel available / control room available



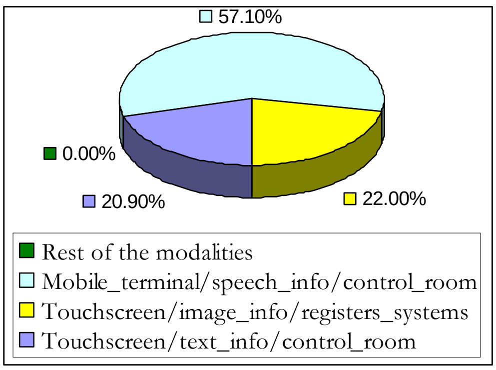
Final choice of item for all respondents (best three shown with the percentage):



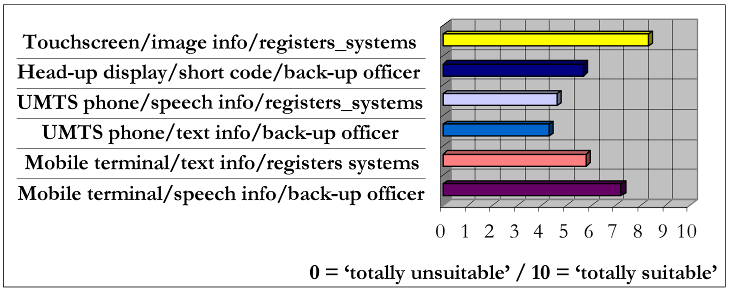
9) Driving / emergency aid / I-centric / give announcement / data channel available / control room available



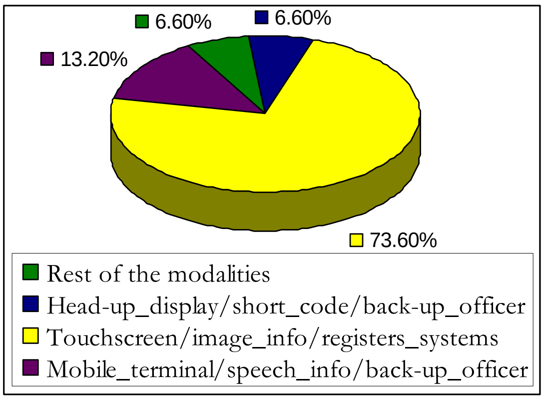
Final choice of item for all respondents (best three shown with the percentage):



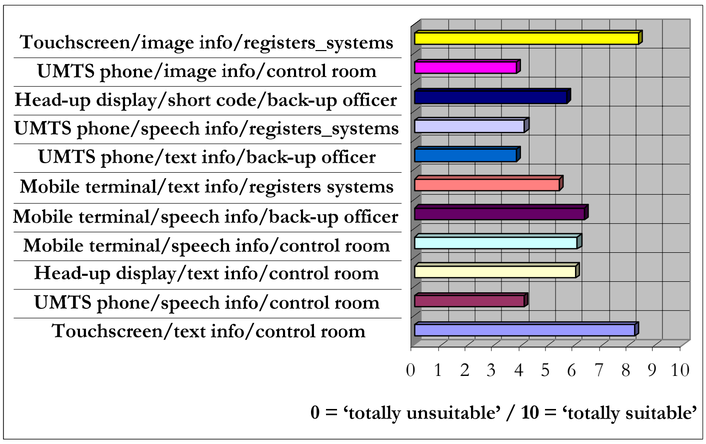
10) Not moving / guidance / I-centric / registers info / data channel available / control room not available



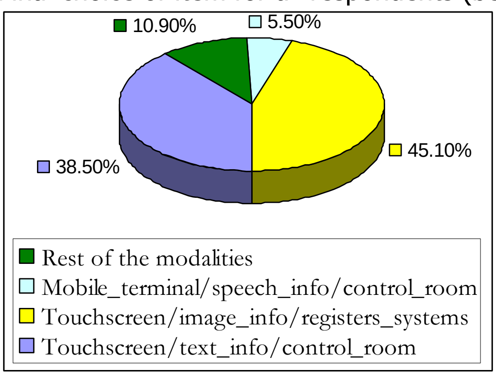
Final choice of item for all respondents (best three shown with the percentage):



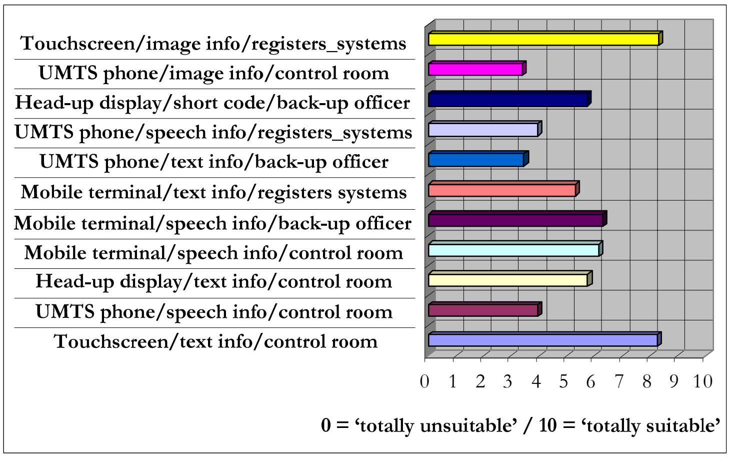
11) Not moving / speed control / I-centric / route info / data channel available / max. 5 minutes waiting for control room



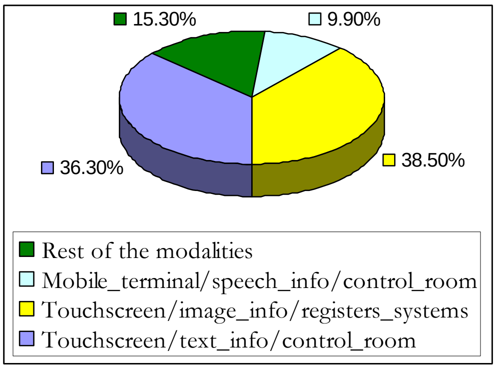
Final choice of item for all respondents (best three shown with the percentage):



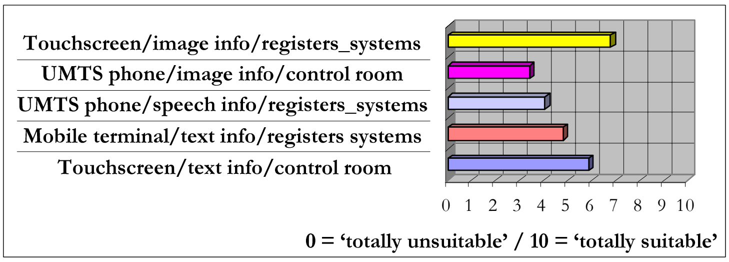
12) Driving / guidance / we-centric / briefing info / no data channel / max. 5 minutes waiting for control room



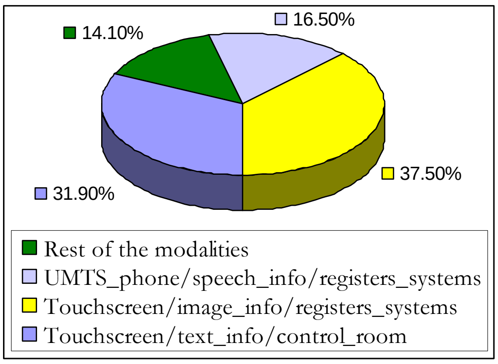
Final choice of item for all respondents (best three shown with the percentage)



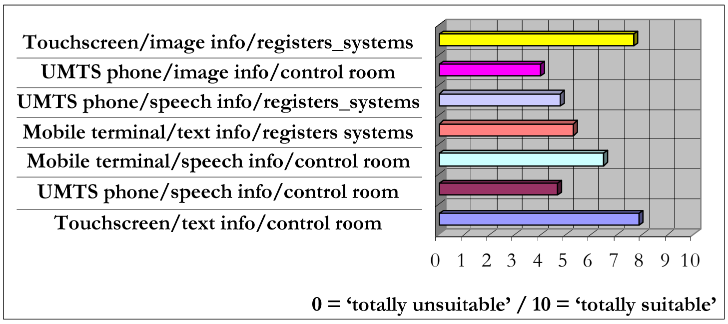
13) Driving / speed control / we-centric / give announcement / no data channel / control room not available



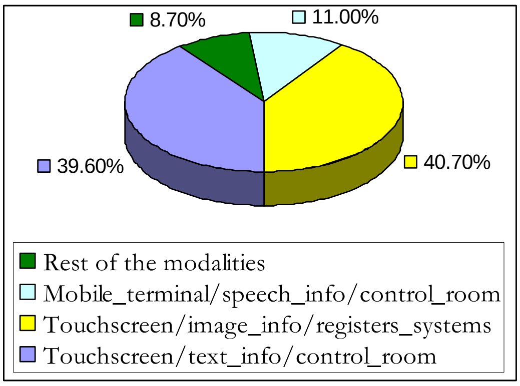
Final choice of item for all respondents (best three shown with the percentage)



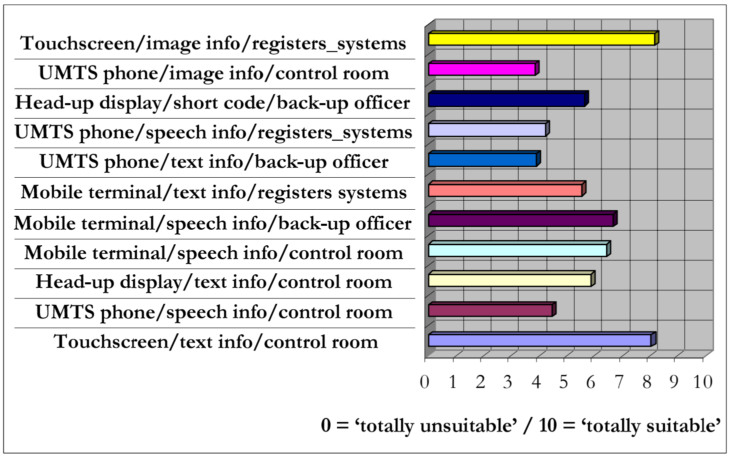
14) Not moving / speed control / I-centric / give announcement / no data channel / max. 5 minutes waiting for control room



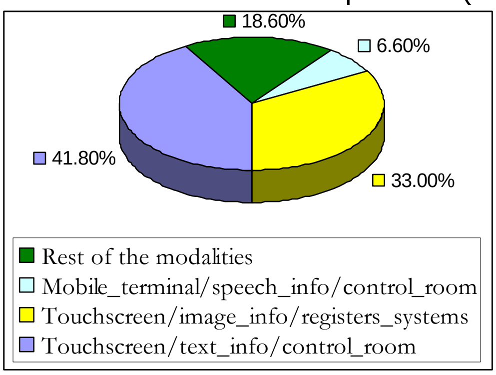
Final choice of item for all respondents (best three shown with the percentage):



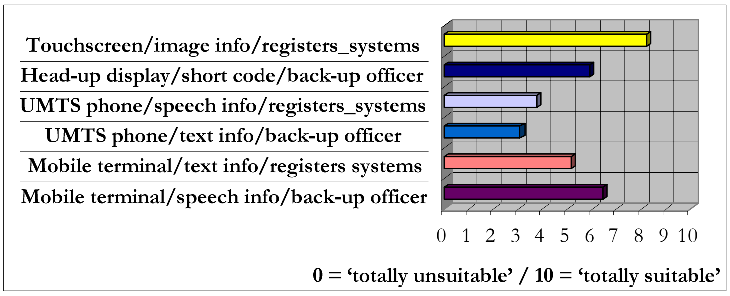
15) Driving / emergency aid / we-centric / registers info / data channel available / max. 5 minutes waiting for control room



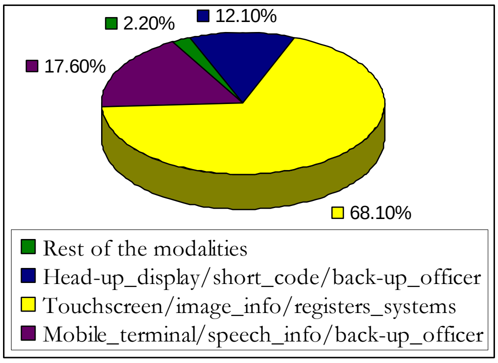
Final choice of item for all respondents (best three shown with the percentage)



16) Driving / speed control / we-centric / route info / data channel available / control room not available



Final choice of item for all respondents (best three shown with the percentage):



Appendix F) Conjoint / TAM research questionnaire example

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Beschrijving 1)

U bent bij uw motor en staat stil. U wordt opgeroepen te assisteren bij een noodsituatie. U opereert in groepsverband en communiceert onderling over een eigen groepskanaal. U heeft route-informatie nodig om de plaats van het incident/ongeluk te bereiken. De meldkamer en/of infodesk is direct beschikbaar voor informatie door middel van spraak.

Vraag 1 *
Is deze situatie herkenbaar voor u?

○ Ja
○ Nee

Vraag 2 *
Kunt u, gezien de beschreven situatie, voor elk alternatief aangeven op een schaal van 1 (volstrekt ongeschikt) tot 10 (bij uitstek geschikt) hoe u deze informatie wilt ontvangen? Graag achter ieder alternatief een cijfer invullen.

	1	2	3	4	5	6	7	8	9	10
Op een goed leesbaar beeldscherm, dat op het stuur gemonteerd is, krijgt u tekstuele informatie van de infodesk/meldkamer.	○	○	○	○	○	○	○	○	○	○
Via uw telefoon met een snelle UMTS verbinding krijgt u via spraak informatie van de infodesk/meldkamer.	○	○	○	○	○	○	○	○	○	○
Op het vizier in uw helm krijgt u een kort tekstbericht van de infodesk/meldkamer.	○	○	○	○	○	○	○	○	○	○
Via uw portofoon/mobilofoon krijgt u via spraak informatie van de infodesk/meldkamer.	○	○	○	○	○	○	○	○	○	○
Via uw portofoon/mobilofoon krijgt u via spraak informatie van de achterwacht.	○	○	○	○	○	○	○	○	○	○
Op uw portofoon/mobilofoon krijgt u tekstuele informatie die rechtstreeks afkomstig is uit “registers” of systemen.	○	○	○	○	○	○	○	○	○	○
Op het beeldscherm van uw telefoon met een snelle UMTS verbinding krijgt u tekstuele informatie van de achterwacht.	○	○	○	○	○	○	○	○	○	○
Via uw telefoon met een snelle UMTS verbinding krijgt u via spraak informatie die rechtstreeks afkomstig is uit “registers” of systemen.	○	○	○	○	○	○	○	○	○	○
Op het vizier in uw helm krijgt u door het gebruik van korte codes de informatie van de achterwacht te zien.	○	○	○	○	○	○	○	○	○	○
Op uw telefoon met een snelle UMTS verbinding krijgt u een afbeelding te zien met informatie van de infodesk/meldkamer.	○	○	○	○	○	○	○	○	○	○
Op een goed leesbaar beeldscherm, dat op het stuur gemonteerd is, krijgt u een afbeelding te zien met informatie die rechtstreeks afkomstig is uit “registers” of systemen.	○	○	○	○	○	○	○	○	○	○

Herhaling van beschrijving 1)

U bent bij uw motor en staat stil. U wordt opgeroepen te assisteren bij een noodsituatie. U opereert in groepsverband en communiceert onderling over een eigen groepskanaal. U heeft route-informatie nodig om de plaats van het incident/ongeluk te bereiken. De meldkamer en/of infodesk is direct beschikbaar voor informatie door middel van spraak.

Vraag 3 *
Als u uiteindelijk een van de getoonde mogelijkheden van informatievoorziening moet kiezen, welke zou dat zijn? (Uw keuze aanklikken)

○ Op een goed leesbaar beeldscherm, dat op het stuur gemonteerd is, krijgt u tekstuele informatie van de infodesk/meldkamer.
○ Via uw telefoon met een snelle UMTS verbinding krijgt u via spraak informatie van de infodesk/meldkamer.
○ Op het vizier in uw helm krijgt u een kort tekstbericht van de infodesk/meldkamer.
○ Via uw portofoon/mobilofoon krijgt u via spraak informatie van de infodesk/meldkamer.
○ Via uw portofoon/mobilofoon krijgt u via spraak informatie van de achterwacht.
○ Op uw portofoon/mobilofoon krijgt u tekstuele informatie rechtstreeks afkomstig uit “registers” of systemen.
○ Op het beeldscherm van uw telefoon met een snelle UMTS verbinding krijgt u tekstuele informatie van de achterwacht.
○ Via uw telefoon met een snelle UMTS verbinding krijgt u via spraak informatie die rechtstreeks afkomstig is uit “registers” of systemen.
○ Op het vizier in uw helm krijgt u door het gebruik van korte codes de informatie van de achterwacht te zien.
○ Op uw telefoon met een snelle UMTS verbinding krijgt u een afbeelding te zien met informatie van de infodesk/meldkamer.
○ Op een goed leesbaar beeldscherm, dat op het stuur gemonteerd is, krijgt u een afbeelding te zien met informatie die rechtstreeks afkomstig is uit “registers” of systemen.

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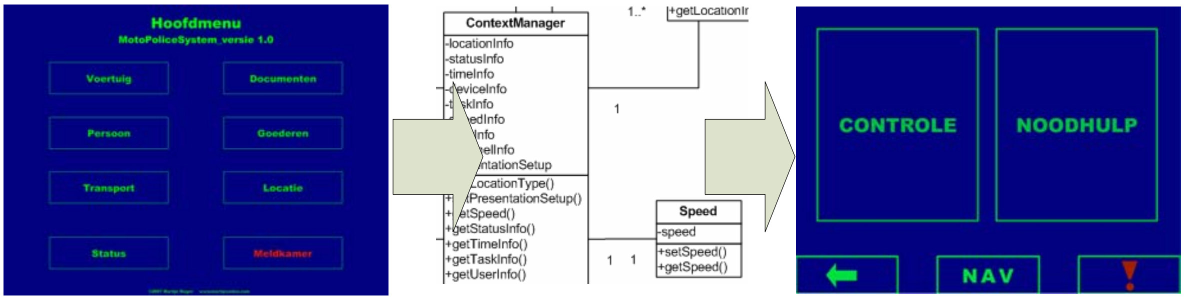
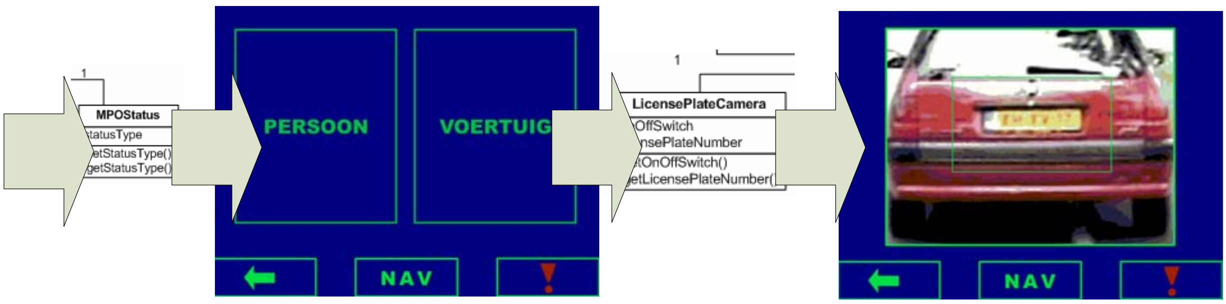
Appendix G) Scenario's explained in detail

License plate scenario

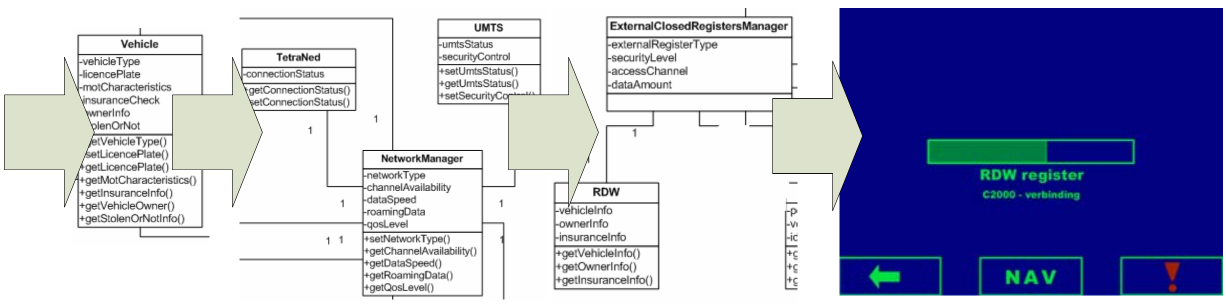
The MPO is standing still and has the main menu in front of him. The menu is based on P-Info and shows different information topics to be enquired. The MPO starts driving, thereby changing the setSpeed() operation which triggers the contextManager through an event to change the options



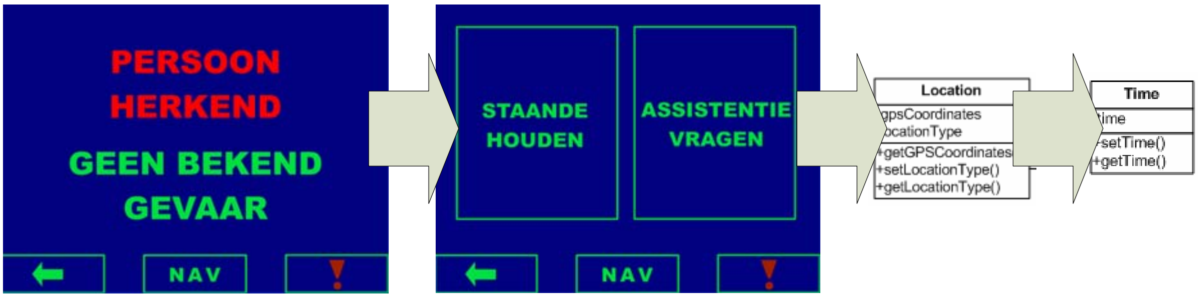
shown to the MPO. The MPO drives behind a car he wants to check. He presses the control (controle) button, which changes the menu in a new menu where he can enquire a vehicle or a person. At the same time the status of the MPO is set to "busy-control", thereby updating the status to the control room. After pressing the vehicle button the automatic license plate registration is started by executing the onOffSwitch() of the Camera through the DeviceManager on his motorcycle.



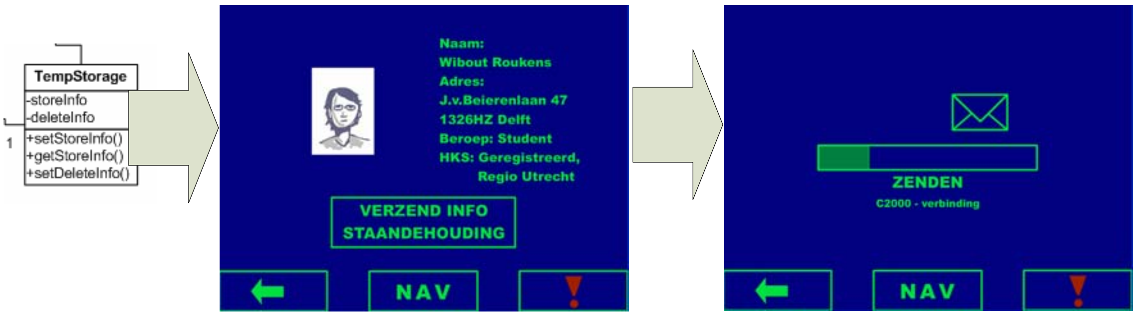
The system reads the license plate number and asks the MPO whether the license plate number corresponds with the real number on the car as a check. When pressing "yes", the system starts accessing the register storing data on all cars in the Netherlands (RDW). The system shows the download status and the current communication network which is chosen based on the specified QoS level. At the moment the system has checked the register it tells the MPO the car is in order. In the next menu the system asks the question whether to check the owner or not. The MPO presses the "yes" button. Now the system performs a similar task as in the previous step, but instead of executing the Vehicle class operations it performs the Person class operation getWantedOrNot(), thereby accessing the CVI and HKS registers. Due to the similarity with the above methodology no figures are shown.



After having received the data the system gives a warning in red letters stating that the person is signaled in the register. It immediately starts the getDangerLevel () operation to check whether known dangers are involved. The system shows the MPO the text: "no dangers are known". Now the MPO has to choose whether he asserts the person or asks for assistance. In this case the MPO decides to assert the person and pushes the assertion button. Pressing this button alerts the control room about the action, location and time with operations setStatusType(), getStatusType(), getLocation() and getTime().



After selecting the assertion button the MPO turns on the blue lights and siren, followed by the overtaking of the car to indicate he has to stop. Simultaneously, the system starts downloading more information on the person in the GBA register. While downloading the NetworkManager notices the C2000 signal is getting weak and switches to the UMTS network. The speed of downloading increases due to the higher available bandwidth of the network. At the moment all data has been downloaded the information is shown on the screen, combined with the reason for asserting the person and a picture if available. All data downloaded throughout the process is temporarily stored in the TempStorage class. When the person is stopped and colleagues arriving by car take over, the MPO finishes the process by pushing the "send info assertion" button. Having pressed the button, the system sends all information downloaded and the time and location as a package to the account at the bureau. Having completed the task, the setDeleteInfo() operation is executed to empty the storage. The main menu is presented to the MPO again.



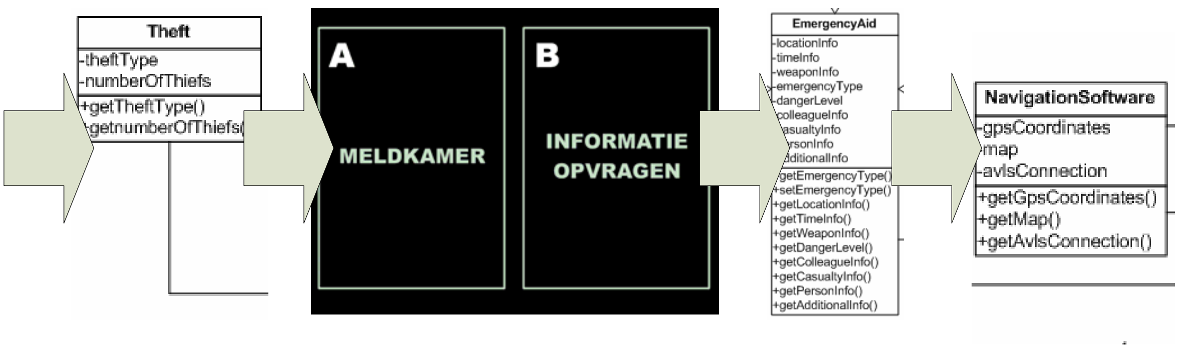
Differences between both mock-ups for the license plate scenario

The screenshots shown come from the touchscreen mock-up. Although the scenario and the presented information are similar for the head-up display mock-up, the interface and medium are slightly adjusted to the display and the use of speech recognition. In the head-up display mock-up "Alpha" and "Bravo" operate the left and right button respectively. A last important difference between the interfaces of both mock-ups is the entry of the license plate number. As explained and shown in figure X, the touchscreen mock-up uses a camera to detect the license plate number. For the head-up display mock-up the license plate number is entered using the speech recognition software. This is done to obtain more knowledge on the utility of speech recognition. To give an impression of the general differences in user interface the screenshots of the emergency aid scenarios are taken from the head-up display mock-up.

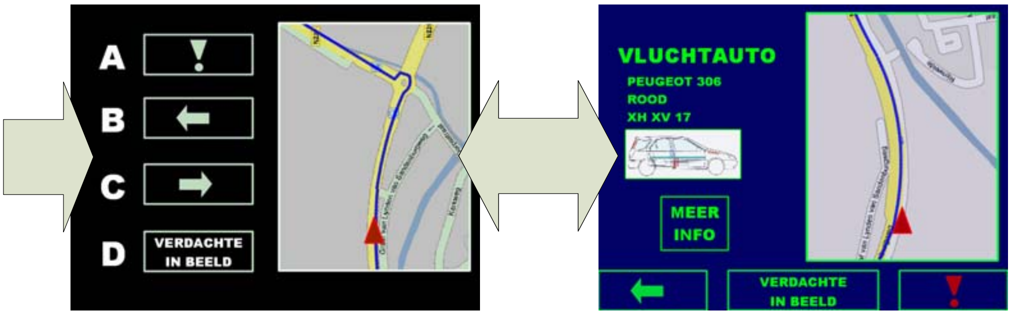
Emergency aid scenario

The MPO is standing still and has the main menu shown to her. Suddenly the MPO receives a message from the control room stating that an emergency aid is requested. The MPO chooses "accept" to notify the system the MPO is available and has received the request. At this moment the status of MPO is changed to "Busy-emergency" through the setStatusType() operation. In the following step the system executes the setChannel() and tells the MPO she is placed in a specific C2000 communication group by the control room. The system then starts the getEmergencyType() operation, asking for the type of emergency aid situation. Knowing the type of emergency is a theft, the Theft class operations are executed which result in the knowledge of a shoplifting situation with one suspect. This information is presented to the MPO so she knows what is happening. Now the MPO

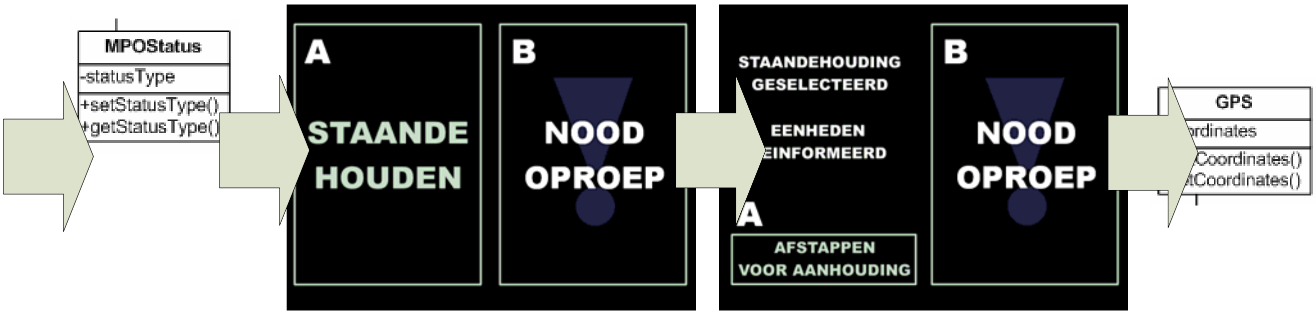
has to choose between calling the control room or requesting more information. The first option is chosen starting the getLocationInfo() operation from the EmergencyAid class. The location coordinates are send by the control, thereby calling upon the getGpsCoordinates() in the NavigationSoftware class. Now the navigation starts on the right and different options are shown on the left. At this moment the MPO starts driving according to the navigation shown in the display.



The upper option of the four options in the menu is to request a call with the control room. One option below is to go back and review the received information until now. When selecting the third option more information entered by the control room is presented to the MPO by executing the remaining operations of the EmergencyAid class shown above. The exact information depends on the available information entered by the control room. In this scenario executing the "more information" option gives information on the location, the getaway car, knowledge about the danger level and information on the suspect. An important notion needs to be made here about the difference between both mock-ups and the user interface. Testing the interface on both systems learned that they had to be different in order to be well used. The information in the head-up display mock-up is by speech through the speakers, whereas the information on the touchscreen is in the form of text. As a consequence the location of menu options is different. Their function is similar. The difference between both is clarified by adding the touchscreen version (with blue background).



At a certain moment the MPO passes by the car with the same license plate as presented to the MPO. The MPO chooses the "suspect in sight" option which changes the status of the MPO with the setStatusType() operation and the control room is notified of this action. The setCoordinates() operation is also executed which sends the location of the MPO to the control room as well. The MPO starts chasing the getaway car and is quickly behind it. As the suspect in sight option was chosen, the menu changes to two options. The MPO can either choose to assert the person by stopping the vehicle or contact the control room directly in case she feels the situation is too dangerous. She opts for the first and the system updates her status again, thereby notifying the control room of her actions. The blue lights and the siren are turned on. Having notified the driver of the vehicle, the MPO passes the car to take it to a place to stop. At all times, the MPO has a clear option to make an emergency call in case something goes wrong. The menu in her display also shows the option "get of for assertion". By selecting this option when getting off the motorcycle, the control room is notified about the MPO not being on the motorcycle.



The MPO checks if the descriptions of the suspect received earlier fit the driver and decides to arrest the person. When the person is arrested and colleagues arriving by car take over, the MPO finishes the process by pushing the "send info assertion" button. Having pressed the button, the system sends all information downloaded and the time and location as a package to the account at the bureau. Having completed the task, the setDeleteInfo() operation is executed to empty the storage. The main menu is presented to the MPO again.

Differences between both mock-ups for the emergency aid scenario

The most important difference between the head-up display mock-up and the touchscreen mock-up for the emergency aid scenario is described above. Other differences between both mock-ups are similar to the differences explained in the paragraph about the license plate scenario. The only remaining difference which requires further clarification is between the head-up display mock-up in the license plate scenario and the emergency aid scenario is. Where the menu of the first is controlled by just "Alpha" and "Bravo", the latter is controlled by "Alpha", "Bravo", "Charlie" and "Delta".

Appendix H) Questionnaire experimental research (Touchscreen version)

Algemene vragen

1. Wat is uw rang?

O agent
O hoofdagent
O brigadier
O inspecteur
O anders, namelijk...

2. Wat is uw hoofdtaak als motoragent?

....

3. Hoe lang werkt u al voor de politie? ....Jaren

4. In welk jaar bent u geboren? 19...........

5. Bent u een man of een vrouw?

O Man
O Vrouw

6. Bent u bekend met P-Info en/ of mobiel Blauw? (uw keuze aankruisen in het bolletje)

O Wel eens van gehoord
O Wel eens gezien
O Wel eens in mijn handen gehad
O Wel eens gebruikt
O Maak regelmatig gebruik van P-info en/of mobiel blauw

7. Heeft u ervaring met het gebruiken van een touchscreen op de motor?

O Ja
O Nee

8. Heeft u meegewerkt aan het internet onderzoek naar de informatievoorziening voor motoragenten in mei 2007?

O Ja
O Nee

Vragen over de huidige informatievoorziening van motoragenten

We willen U een aantal stellingen voorleggen over het gebruik van de huidige informatiesystemen van motoragenten. Wilt u per stelling aangeven of u het hier *zeer mee oneens* bent of *zeer mee eens* of *ergens daar tussen in:*

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Motoragenten maken gebruik van hun huidige informatiesystemen	☐	☐	☐	☐	☐	☐	☐
De huidige informatiesystemen maken het werk van motoragenten makkelijker	☐	☐	☐	☐	☐	☐	☐
De huidige informatiesystemen zijn gemakkelijk te gebruiken door motoragenten	☐	☐	☐	☐	☐	☐	☐
Motoragenten voeren hun taken sneller uit door het gebruik van de huidige informatiesystemen	☐	☐	☐	☐	☐	☐	☐
De informatie die motoragenten via hun huidige informatiesysteem krijgen, is de informatie die zij voor hun werk nodig hebben	☐	☐	☐	☐	☐	☐	☐
De verkregen hoeveelheid informatie past bij de taak van de motoragent	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om de informatie te ontvangen via het huidige informatiesysteem is niet te lang	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om het huidige informatiesysteem te bedienen is niet te lang	☐	☐	☐	☐	☐	☐	☐
Het bedienen van het huidige informatiesysteem heeft geen invloed op een veilige deelname aan het verkeer	☐	☐	☐	☐	☐	☐	☐
Het luisteren naar de informatie ontneemt niet teveel aandacht om veilig te blijven rijden	☐	☐	☐	☐	☐	☐	☐

Het huidige informatiesysteem voor motoragenten is de juist media voor:

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Informatie uitwisseling	☐	☐	☐	☐	☐	☐	☐
Het nemen van besluiten	☐	☐	☐	☐	☐	☐	☐

Wilt u in de vier onderstaande situaties aangeven of u het huidige informatiesysteem *zeker niet zou gebruiken* of *zeker wel zou gebruiken* of *ergens daar tussen in*:

	Zeker niet gebruiken	2	3	4	5	6	Zeker wel gebruiken
Stilstaan	☐	☐	☐	☐	☐	☐	☐
Rijden in constant veranderende verkeersomgeving (bijv. binnen de bebouwde kom)	☐	☐	☐	☐	☐	☐	☐
Rijden in stabiele verkeersomgeving (bijv. op de snelweg)	☐	☐	☐	☐	☐	☐	☐
Rijden voor "112" situaties	☐	☐	☐	☐	☐	☐	☐

Eerste indrukken van het touchscreen systeem

Kunt u hieronder kort aangeven wat er <u>positief</u> is aan het zojuist geprobeerde touchscreen systeem voor motoragenten:

Kunt u nu hieronder kort aangeven wat er <u>negatief</u> is aan het zojuist geprobeerde touchschreen systeem voor motoragenten:

Vragen over het touchscreen systeem in scenario "Kentekenbevraging"

We willen U een aantal stellingen voorleggen over het gebruik van het gebruikte touchscreen systeem voor moragenten, toegespitst op het kentekenbevraging scenario. Wilt u per stelling aangeven of u het hier *zeer mee oneens* bent of *zeer mee eens* of *ergens daar tussen in:*

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Motoragenten zullen touchscreen systemen zeker gebruiken	☐	☐	☐	☐	☐	☐	☐
Ik verwacht dat touchscreen systemen het werk van motoragenten makkelijker maakt	☐	☐	☐	☐	☐	☐	☐
Het touchscreen systeem is gemakkelijk te gebruiken door motoragenten	☐	☐	☐	☐	☐	☐	☐
Motoragenten voeren hun taken sneller uit door het gebruik van touchscreen systemen	☐	☐	☐	☐	☐	☐	☐
De informatie die motoragenten via een touchscreen kunnen krijgen, is de informatie die zij voor hun werk nodig hebben	☐	☐	☐	☐	☐	☐	☐
De getoonde hoeveelheid informatie past bij de taak van de motoragent	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om de informatie te ontvangen op het touchscreen is niet te lang	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om het touchscreen systeem te bedienen is niet te lang	☐	☐	☐	☐	☐	☐	☐
Het bedienen van het touchscreen systeem heeft geen invloed op een veilige deelname van de motoragent aan het verkeer	☐	☐	☐	☐	☐	☐	☐
Het lezen van informatie kost niet teveel tijd voor de motoragent om veilig te blijven rijden	☐	☐	☐	☐	☐	☐	☐

Het touchscreen systeem is de juist media voor:

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Informatie uitwisseling	☐	☐	☐	☐	☐	☐	☐
Het nemen van besluiten	☐	☐	☐	☐	☐	☐	☐

Wilt u in de vier onderstaande situaties aangeven of u het touchscreen systeem *zeker niet zou gebruiken* of *zeker wel zou gebruiken* of *ergens daar tussen in*:

	Zeker niet gebruiken	2	3	4	5	6	Zeker wel gebruiken
Stilstaan	☐	☐	☐	☐	☐	☐	☐
Rijden in constant veranderende verkeersomgeving (bijv. binnen de bebouwde kom)	☐	☐	☐	☐	☐	☐	☐
Rijden in stabiele verkeersomgeving (bijv. op de snelweg)	☐	☐	☐	☐	☐	☐	☐
Rijden voor "112" situaties	☐	☐	☐	☐	☐	☐	☐

Vragen over het touchscreen systeem in scenario "<u>Noodhulp oproep</u>"

We willen U een aantal stellingen voorleggen over het gebruik van het gebruikte touchscreen systeem voor moragenten, toegespitst het <u>noodhulp</u> scenario. Wilt u per stelling aangeven of u het hier *zeer mee oneens* bent of *zeer mee eens* of *ergens daar tussen in:*

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Motoragenten zullen touchscreen systemen zeker gebruiken	☐	☐	☐	☐	☐	☐	☐
Ik verwacht dat touchscreen systemen het werk van motoragenten makkelijker maakt	☐	☐	☐	☐	☐	☐	☐
Het touchscreen systeem is gemakkelijk te gebruiken door motoragenten	☐	☐	☐	☐	☐	☐	☐
Motoragenten voeren hun taken sneller uit door het gebruik van touchscreen systemen	☐	☐	☐	☐	☐	☐	☐
De informatie die motoragenten via een touchscreen kunnen krijgen, is de informatie die zij voor hun werk nodig hebben	☐	☐	☐	☐	☐	☐	☐
De getoonde hoeveelheid informatie past bij de taak van de motoragent	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om de informatie te ontvangen op het touchscreen is niet te lang	☐	☐	☐	☐	☐	☐	☐
De tijd die nodig is om het touchscreen systeem te bedienen is niet te lang	☐	☐	☐	☐	☐	☐	☐
Het bedienen van het touchscreen systeem heeft geen invloed op een veilige deelname van de motoragent aan het verkeer	☐	☐	☐	☐	☐	☐	☐
Het lezen van informatie kost niet teveel tijd voor de motoragent om veilig te blijven rijden	☐	☐	☐	☐	☐	☐	☐

Het touchscreen systeem is de juist media voor:

	Zeer mee oneens	2	3	4	5	6	Zeer mee eens
Informatie uitwisseling	☐	☐	☐	☐	☐	☐	☐
Het nemen van besluiten	☐	☐	☐	☐	☐	☐	☐

Heeft u nog op of aanmerkingen over het touchscreen systeem?

Heeft u nog op of aanmerkingen over het onderzoek?

In het kader van het onderzoek is het van belang dat u het zojuiste geteste systeem vandaag **niet** met uw collega's bespreekt. Dit zou invloed kunnen hebben op de resultaten.

Dank voor uw medewerking!

Appendix I) Validity threats of the experimental research

External validity threats

Interaction of selection and treatment
Determining the threat of the interaction of selection and treatment is done by asking the following question: "In which categories of persons can a cause-effect relationship be generalized?" (Campbell & Cook, 1979). The first important notion to be made is that little is known about the population making the generalization difficult. However, due to the specific aim of researching information provisioning for MPO's and only using MPO's as participants, the generalization is assumed to be correct. Focusing on more detailed categories inside the group of MPO's more conclusions can be made which further ground the generalization of the results.

Rao & Troshani (2007) claim gender and age moderate the adoption of mobile services in general. The internet research (with n = 91) showed a percentage of 3.3% of women in the sample, which was close to the 3.5% claimed over a known population. The sample of the research experiment shows a percentage of 4.7% of woman. This stays close to the known population percentage. The comparison of the age is done similarly and shows similar results as well for the internet sample (*M*=40, *SD*= 8.3, range= 35), as for the research experiment sample (*M*=41.3, *SD*= 8.3, range= 34). Though not included in the model of Rao & Troshani (2007), the rank of an MPO might influence the external validity as well. Here, the only comparison to be made is to review the sample of the internet research again. Of the latter, 1.1% was an Officer, 71.4% a Head-Officer, 24.2% a Sergeant and 3.3% an Inspector. From the experimental research sample 1.6% is an Officer, 63.5% a Head-Officer, 25.4% a Sergeant and 9.5% and Inspector. Again, the difference between the two data sets is minimal.

A last remark is made about the geographical distribution. Including enough police departments which are not all from the same region is important to achieve a national response from the experimental research and claim external validity. Primarily because different regions use different equipment and secondly due to differences that might exist in the work processes as explained in chapter 3. Figure 6.7 shows that not all regions from the Netherlands are included. It is not possible to claim if the final area covered is broad enough to reflect the opinion of MPO's on a national level. Executing a similar research in other areas must ground a national opinion.

Interaction of setting and treatment
This threat is answered by the question whether a causal relationship measured in the specific situation at the moment of testing can also be obtained in other situations (Campbell & Cook, 1979). The answer is bipartite. Firstly, an MPO works in many different circumstances and they are not all covered by the mock-ups. By using two scenarios an attempt is made to create the two most common situations task-wise. It is not possible to claim that these two scenarios can be generalized to all situations an MPO is in.

The second answer lies in the static nature of the test. The mock-ups try to simulate two tasks whereby the user has to use the system. But due to the static nature of the mock-ups, external influences like traffic, road changes, weather, noise and unpredictable behavior of suspects is not measured. Also, the effect of system usage on the driving characteristics (e.g. the balance when removing one hand from the handle-bar) can not be measured. Especially when focusing on safety issues, the dynamics of a real-life situation play a role. Measuring safety is almost impossible in a static environment. As Jagtman & Hale (2007) explains about current static system safety performance measures used in the US for navigation systems: "the system boundaries may be set too tight, as the dynamic circumstances under which the task under study has to be performed is not included. Not the task load, but these circumstances largely determine the possibility of performing the task safely". The problem Jagtman & Hale (2007) explains is also applicable to this research set-up. This means that the results on system safety are not directly usable in the implementation of a finished product. Further research by performing a pilot in a real-life situation is needed to more thoroughly test the influence on safety issues. We do include the results on safety issues from the experimental research as it gives a first impression which is a start-up for further research.

Interaction of history and treatment:
The last external validity threat can again be discussed on the basis of a question: "to which periods in the past and in the future can a particular causal relationship be generalized?" (Campbell & Cook, 1979). The experiment might be influenced by specific circumstances which happened at the moment of running the experiment. During the tests, no particular effects (e.g. higher stress rate of the MPO due to work related problems at that moment) were noticed by the author. The validity of the results in the future depends on two other matters not considered for this research. The first is when other fundamental developments in the field of information provisioning for MPO's arise, requiring a replication of the experiment. The second aspect is the learning effect of using the system multiple times. Both mock-ups are tested once per respondent. Running the experiment a few times might show different results. Due to time limitations this was not possible.

Construct validity threats

Mono-method bias
In order to explain mono-method bias, an example from Trochim (2006) is given: "with only a single version of self esteem measure, you can't provide much evidence that you're really measuring self esteem". The mono-method bias is a threat to this research due to the removal of indicator variables of the TAM/TMF constructs which is clarified in chapter 6. Given the high standard deviations given in table 6.5, this threat seems to have played a role in the measurement and should be taken into consideration when discussing the results of the research. On the positive side, during the completion of the questionnaires by the MPO's there was no sign of doubt. The only item that was seen as confusing to some was the first item in the pretest questionnaire. The MPO is asked to rate the following proposition: "*MPO's make use of their current information systems".*

Evaluation apprehension
Studies have shown that respondents are apprehensive about being evaluated by persons who are experts in personality adjustments of the assessment of human skills (Campbell & Cook, 1979). The latter might play a role in this research, as skills are required to use the mock-ups. However, as the author is not seen as an expert due to his student status, there is no reason to believe that the respondents were at any time apprehensive.

Experimenter expectancies
Using experimenters that know what is going to happen during the experiment can bias the data obtained (Campbell & Cook, 1979). The respondents of the experiment had some knowledge about the experiment although not to a high extend. They were informed that an information system prototype for MPO's was available to be tested, though without further clarification of the experiment. Moreover, the tested participants were asked not to discuss what they had tested with their colleagues during the day. It is difficult to judge whether the MPO's lived up to this request, but while explaining they understood the reason why indicating a level of engagement.

Interactions of different treatments
"This threat occurs if respondents experience more than one treatment, but is resolved by conducting separate analysis of the first and succeeding treatments which respondents received" (Campbell & Cook, 1979). As seen from the reliability chapter above, the solution proposed by Campbell & Cook (1979) is used here by measuring both scenarios independently. A learning effect between the scenarios is ruled out by switching the order of presenting the scenarios.

Restricted generalizability across constructs
This threat is meant to think about the negative consequences of the side effects of the treatment. It is impossible to measure all the constructs that the treatment has an effect on, but discussions with experts from the University and the MPO's themselves presented effects not thought of from the start. The most important effect is the safety of the MPO using the system. It is for that reason that items on safety were added to the total list of items created from the TAM/TMF model. Also, the main concerns of MPO's having experimented with the mock-ups were safety related. These concerns have been mentioned in chapter X and will be further discussed in the results chapter.

Internal validity threats

History
"History is a threat when an observed effect might be due to an event which takes place between the pretest and the posttest. The threat is controlled by insulating respondents from outside influences" (Campbell & Cook, 1979). The control measure explained is used throughout all the experiments as this was specifically asked for before starting with the experiment. Each department provided a calm location without interference.

Testing
The threat of testing arises when familiarity with the experiment is created. Due to the usage of two scenarios per mock-up there is a learning effect that is developed. By switching the order of the scenarios within the group the effect is balanced. Analysis of the learning effect showed no clear significant differences exist between the order of the scenario's which is strange (only two items showed a p-value < .05). There are two possible reasons for this occurrence. The first is that many MPO's compared answers of one scenario to the other. Even though the questions for each scenario are on different pages it is noticed by the author comparisons were made. The second reason lies in the scenario itself and might also influence the first reason just mentioned. The emergency aid scenario does present a situation which might look like an emergency aid scenario, but does not capture the dynamics of a real-life emergency aid scenario. Therefore, the difference between both scenarios might have been too small for MPO's to assess both situations differently from each other. This conclusion is highly important when discussing the results in the next chapter.

Instrumentation
Changes in measurement between the pretest and the posttest might be a threat to internal validity. Some discrepancy exists between the questions of the pretest and posttest as the items need to be changed according to the tested mock-up. Seen that this difference is small, the assumption is made that instrumentation is not seen as a threat. Another instrumentation problem arises because the two different scenarios are not measured in the pretest. The reason is that it would result in a longer questionnaire, and secondly would result in very different comparisons threatening internal validity even more. The pretest questions would need to be based on how the MPO interprets a license plate or emergency aid scenario of a real-life situation and not based on the scenario shown to the MPO during the experiment.

Statistical regression
"Statistical regression is a threat when an effect might be due to the respondents' being classified into experimental groups at, say, the pretest on the basis of pretest scores" (Campbell & Cook, 1979). Primarily by using the randomization method creating the groups, and secondly having used an ANCOVA analysis method which adjusts for the pretest scores, it is assumed this threat is removed when analyzing the data between the two experimental groups.

Selection
The selection threat is due to the effect of group differences. Although randomization is used to rule selection out, a short analysis is executed to check whether this is true. The check is based on the various background attributes. In the head-up display group (group 1) there is one woman out of 30, in the touchscreen group (group 2) there are two woman out of 33. In percentages the difference is small. The age difference is similar, as group one has an average of 40.7 years old and group 2 has an average of 41.9 years old. The difference in amount of years working for the police, differences are slightly larger than the age and gender difference. Of group 1 the average amount of years is 15.2 years, whereas group two has an average of 17.8 years. Because of the difference in experience, the effect on the results has been calculated. The groups are split into two based on the median of both groups together. Running the *t*-tests no p-values under 0.121 are calculated. The next selection check is the rank. Differences are shown, though small. Group 1 consists of 66.7% of Head-officers, 26.7% of Sergeants and 6.6% of Inspectors. Group 2 consists of 3% of Officers, 63.6% of Head-Officers, 24.2% of Sergeants and 9.1% of Inspectors. It is assumed the minimal difference in rank proportion of the data is not determinative. The last attribute being checked is the main task of the MPO. All participants are MPO's that officially perform both tasks used as a setting for the scenarios, but some are mostly focused on one task. The surveillance MPO's execute both traffic controls and emergency

aid tasks. Group one has 20 surveillance MPO's compared to 24 for group two. The amount of traffic MPO's is 5 for both groups. That leaves 5 emergency aid MPO's in group one and 4 emergency aid MPO's in group two. The main task performed by the MPO is seen as an influential attribute. Therefore a *t*-test is executed to measure the differences between the MPO's focused on traffic tasks and the MPO's focused on emergency aid tasks. Due to the low sample remaining no p-values show significant differences. When comparing the means of items 1 to 12 from both groups there is no clear difference. For some items the means are larger for group one whereas for other items the means are larger for the other group. The situation item 13, 14, 15 and 16 however show a large gap between the means and p-values close to the .05 level. The emergency aid MPO's rate the systems much higher in all four situations. The reason for this difference might come from the fact that emergency aid MPO's are used to drive in more difficult circumstances, giving them more confidence about using the system in all situations.

Mortality
This is a threat when respondents drop out during the experiment. Two MPO's were called away during the test. The data of both MPO's is not used for the research as it was incomplete.

Diffusion or imitation of treatments
"When various experimental groups can communicate with each other, respondents in one treatment group may learn the information intended for others" (Campbell & Cook, 1979). The removal of this threat has been discussed for the 'experimenter expectancies' threat of the construct validity.

Compensatory rivalry by respondents receiving less desirable treatments
"Here, the comparison group knows what the program group is getting and develops a competitive attitude with them" (Trochim, 2006). This origin of the threat (having knowledge about the comparison group experiment) is similar to the diffusion or imitation of treatments threat. The removal of this threat has been accounted for.

Appendix J) Data results per item of the experimental research

Question 1) MPO's will use system in the future

Testing difference between pre-test and post-tests:

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-.149	.882	-3.851	.000	-1.021	.307	-2.869	.004

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.951	.006	.334	.002

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-2.014	-2.203
Sig.	.044	.028

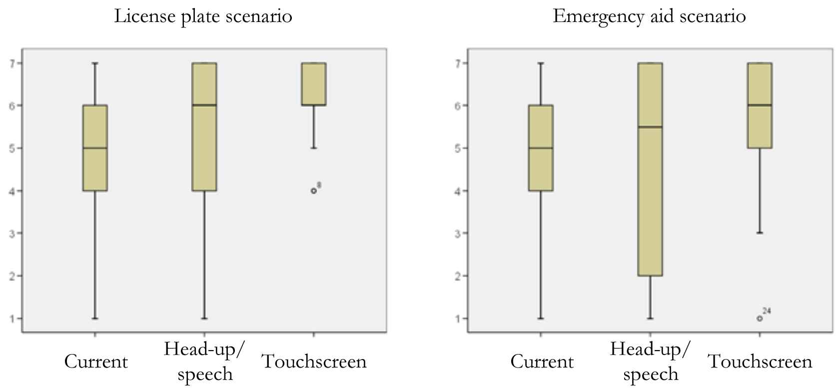
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15.433(a)	2	7.717	2.765	.071
Intercept	203.416	1	203.416	72.899	.000
v1Current_Info_System	.004	1	.004	.001	.972
HUD_OR_TOUCHSCREEN	15.123	1	15.123	5.420	.023

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	22.114(a)	2	11.057	3.301	.044
Intercept	198.584	1	198.584	59.289	.000
v1Current_Info_System	.947	1	.947	.283	.597
HUD_OR_TOUCHSCREEN	19.284	1	19.284	5.757	.020

Boxplots for question 1:



Question 2) System will make work of the MPO easier

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-.460	.646	-4.604	.000	-.320	.749	-3.738	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.767	.000	.727	.025

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-2.252	-1.820
Sig.	.024	.069

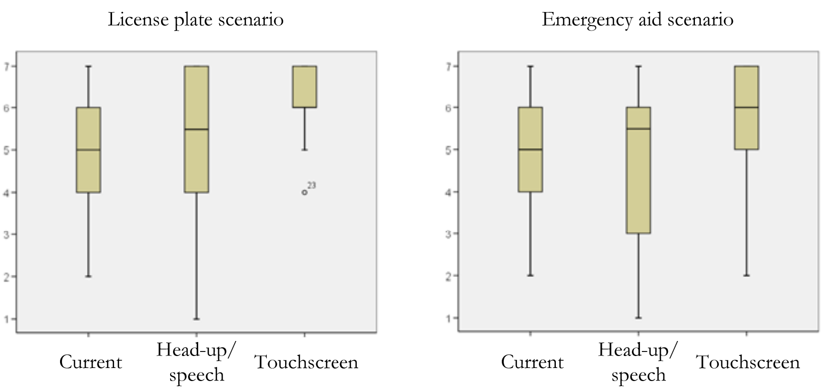
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	27.499	2	13.750	5.827	.005
Intercept	305.842	1	305.842	129.612	.000
v2Current_Info_System	8.901	1	8.901	3.772	.047
HUD_OR_TOUCHSCREEN	9.937	1	9.937	4.211	.045

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.397(a)	2	17.199	5.982	.004
Intercept	307.324	1	307.324	106.901	.000
v2Current_Info_System	16.721	1	16.721	5.816	.019
HUD_OR_TOUCHSCREEN	7.297	1	7.297	4.138	.046

Boxplots for question 2:



Question 3) System is easy to operate

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-1.428	.153	-4.824	.000	-1.797	.072	-4.487	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.155	.000	.065	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-2.907	-2.088
Sig.	.004	.040

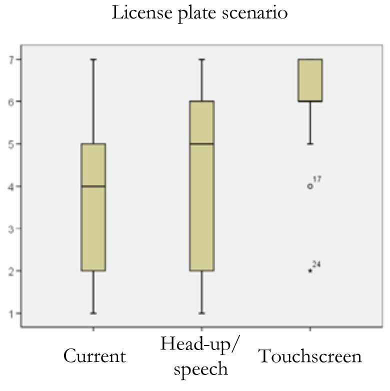
License plate scenario ANCOVA:

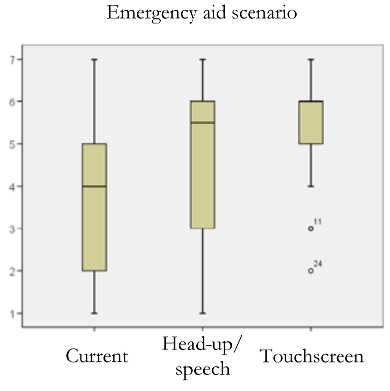
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	36.614(a)	2	18.307	6.487	.003
Intercept	342.339	1	342.339	121.309	.000
v3Current_Info_System	1.114	1	1.114	.395	.532
HUD_OR_TOUCHSCREEN	32.184	1	32.184	11.404	.001

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15.386(a)	2	7.693	2.477	.093
Intercept	343.241	1	343.241	110.528	.000
v3Current_Info_System	1.608	1	1.608	.518	.475
HUD_OR_TOUCHSCREEN	11.730	1	11.730	3.777	.037

Boxplots for question 3:





Question 4) System makes MPO's execute the tasks faster

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-2.504	.012	-4.464	.000	-2.663	.008	-3.927	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.017	.000	.006	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-1.988	-1.073
Sig.	.047	.283

License plate scenario ANCOVA:

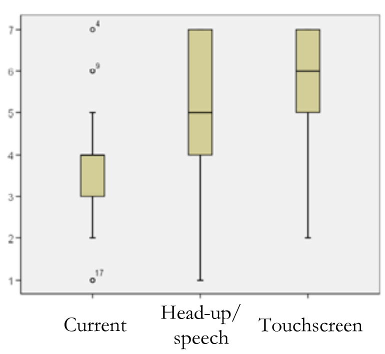
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	15.832(a)	2	7.916	3.010	.057
Intercept	323.417	1	323.417	122.958	.000
v4Current_Info_System	4.194	1	4.194	1.594	.212
HUD_OR_TOUCHSCREEN	9.959	1	9.959	3.786	.046

Emergency aid scenario ANCOVA:

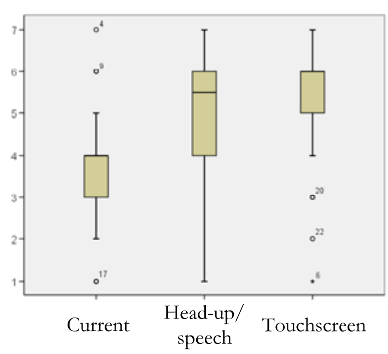
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.279(a)	2	1.140	.404	.670
Intercept	242.834	1	242.834	85.976	.000
v4Current_Info_System	.061	1	.061	.021	.884
HUD_OR_TOUCHSCREEN	2.108	1	2.108	.746	.391

Boxplots for question 4:

License plate scenario



Emergency aid scenario



Question 5) Information received through system is needed to execute the chosen task

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-3.399	.001	-4.283	.000	-3.310	.001	-4.099	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.000	.000	.000	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.024	-.201
Sig.	.980	.841

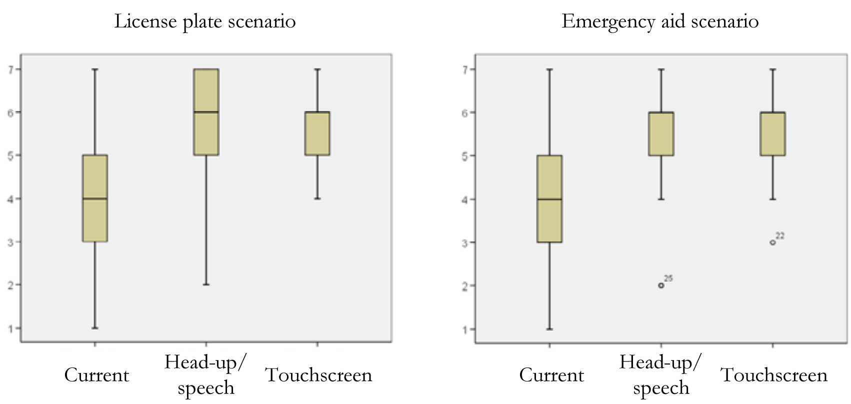
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.301(a)	2	.150	.146	.865
Intercept	240.614	1	240.614	232.790	.000
v5Current_Info_System	.259	1	.259	.251	.618
HUD_OR_TOUCHSCREEN	.041	1	.041	.039	.843

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.895(a)	2	1.448	1.194	.310
Intercept	201.400	1	201.400	166.091	.000
v5Current_Info_System	2.505	1	2.505	2.066	.156
HUD_OR_TOUCHSCREEN	.381	1	.381	.314	.577

Boxplot for question 5:



Question 6) Amount of information received on system fits the task

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-3.488	.000	-4.625	.000	-3.513	.000	-4.396	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.000	.000	.000	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.523	-.291
Sig.	.601	.841

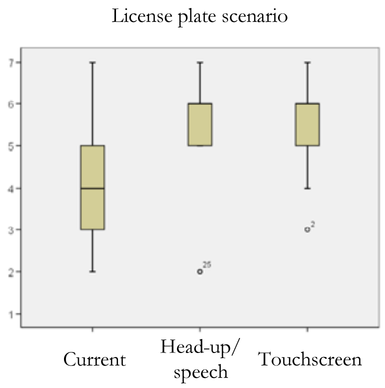
License plate scenario ANCOVA:

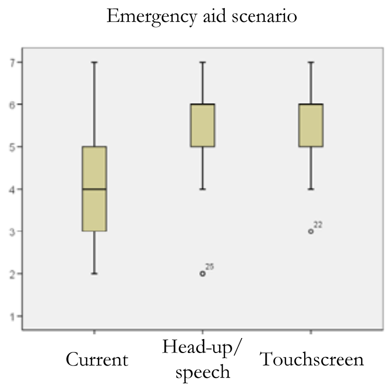
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.222(a)	2	1.111	.984	.380
Intercept	195.513	1	195.513	173.238	.000
v6Current_Info_System	1.494	1	1.494	1.324	.254
HUD_OR_TOUCHSCREEN	1.018	1	1.018	.902	.346

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.222(a)	2	2.611	2.187	.121
Intercept	162.244	1	162.244	135.892	.000
v6Current_Info_System	4.801	1	4.801	4.021	.049
HUD_OR_TOUCHSCREEN	.876	1	.876	.734	.395

Boxplots for question 6:





Question 7) Time needed to receive the information through system not too long

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-3.617	.000	-4.670	.000	-3.827	.000	-4.558	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.000	.000	.000	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-1.123	-1.049
Sig.	.262	.294

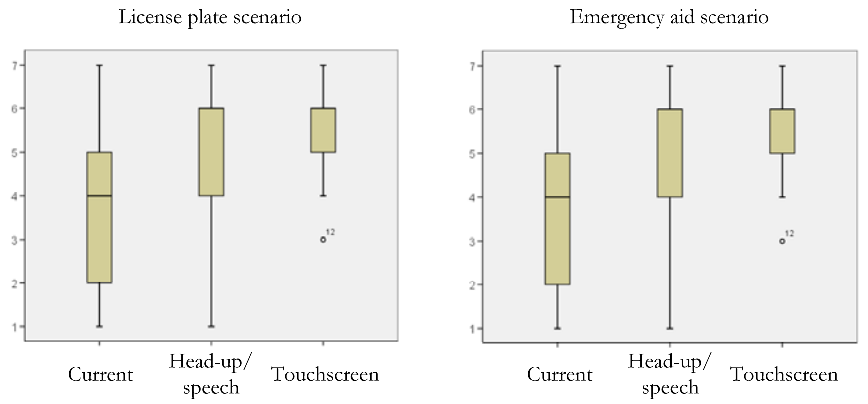
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.572(a)	2	3.286	2.078	.134
Intercept	267.771	1	267.771	169.374	.000
v7Current_Info_System	4.389	1	4.389	2.776	.101
HUD_OR_TOUCHSCREEN	2.955	1	2.955	1.869	.177

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.136(a)	2	2.568	1.600	.210
Intercept	273.549	1	273.549	170.449	.000
v7Current_Info_System	3.635	1	3.635	2.265	.138
HUD_OR_TOUCHSCREEN	2.091	1	2.091	1.303	.258

Boxplots for question 7:



Question 8) Time needed to operate the system is not too long

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-2.937	.003	-4.741	.000	-2.598	.009	-4.466	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.001	.000	.004	.000

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-1.978	-.869
Sig.	.048	.385

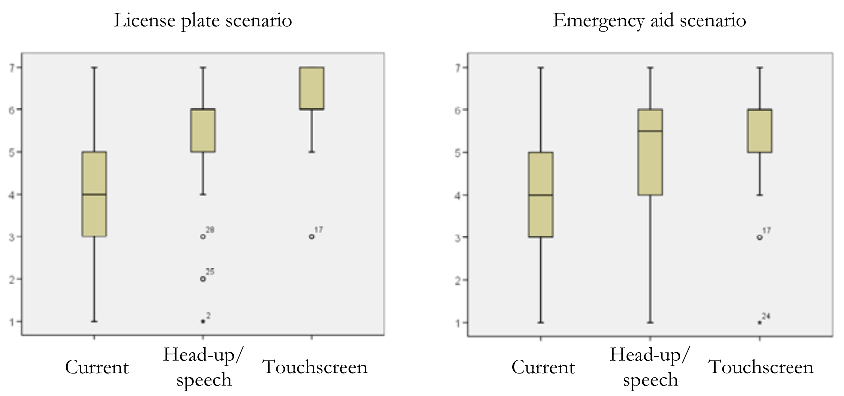
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.067(a)	2	7.033	3.713	.030
Intercept	238.111	1	238.111	125.711	.000
v8Current_Info_System	5.334	1	5.334	2.816	.043
HUD_OR_TOUCHSCREEN	10.408	1	10.408	5.495	.022

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.809(a)	2	4.404	1.853	.166
Intercept	210.186	1	210.186	88.425	.000
v8Current_Info_System	5.562	1	5.562	2.340	.131
HUD_OR_TOUCHSCREEN	4.363	1	4.363	1.835	.281

Boxplots for question 8:



Question 9) Operating the system does not influence the safety of the MPO in traffic

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-1.879	.060	-3.235	.001	-1.756	.079	-2.887	.004

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.074	.000	.087	.002

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.867	-.765
Sig.	.386	.444

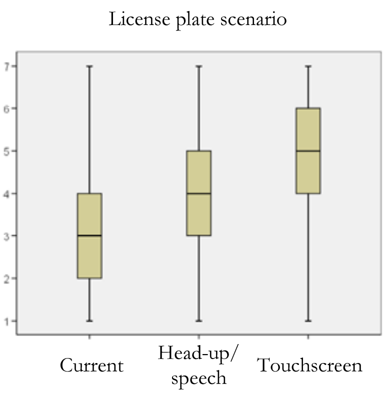
License plate scenario ANCOVA:

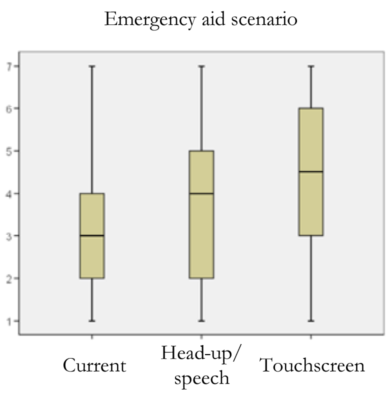
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.108(a)	2	3.554	1.172	.317
Intercept	283.577	1	283.577	93.551	.000
v9Current_Info_System	4.157	1	4.157	1.371	.246
HUD_OR_TOUCHSCREEN	4.206	1	4.206	1.388	.243

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.557(a)	2	4.278	1.356	.266
Intercept	290.372	1	290.372	91.997	.000
v9Current_Info_System	6.996	1	6.996	2.217	.142
HUD_OR_TOUCHSCREEN	2.879	1	2.879	.912	.343

Boxplots for question 9:





Question 10) Listening to / reading the information does not influence the safety of the MPO in traffic

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-1.992	.046	-.554	.580	-.683	.494	-.193	.847

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.041	.690	.270	.795

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-2.037	-1.193
Sig.	.043	.233

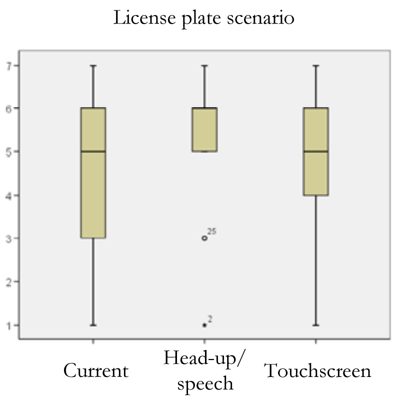
License plate scenario ANCOVA:

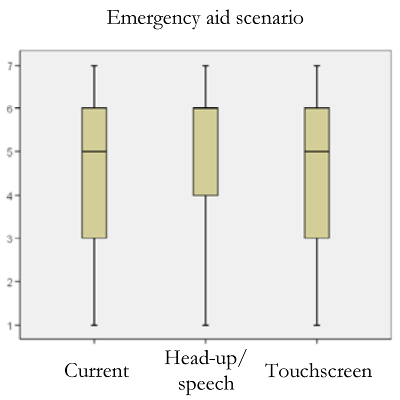
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.624(a)	2	5.812	2.596	.083
Intercept	120.087	1	120.087	53.645	.000
v10Current_Info_System	2.533	1	2.533	1.132	.292
HUD_OR_TOUCHSCREEN	8.183	1	8.183	3.656	.048

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.628(a)	2	4.814	1.856	.165
Intercept	101.774	1	101.774	39.234	.000
v10Current_Info_System	3.204	1	3.204	1.235	.271
HUD_OR_TOUCHSCREEN	5.590	1	5.590	2.155	.147

Boxplots for question 10:





Question 11) System is the right media for information exchange

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-2.117	.034	-4.379	.000	-1.973	.048	-4.086	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.037	.000	.043	.000

Testing differences between HUD post-test and Touchscreen post-test:
Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.956	-.322
Sig.	.339	.747

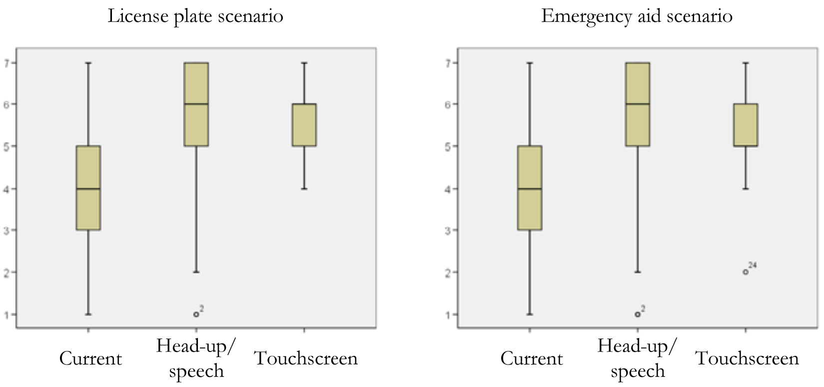
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.710(a)	2	1.855	.856	.430
Intercept	220.914	1	220.914	101.932	.000
v11Current_Info_System	.376	1	.376	.173	.679
HUD_OR_TOUCHSCREEN	3.629	1	3.629	1.675	.201

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.180(a)	2	1.090	.402	.671
Intercept	195.356	1	195.356	72.053	.000
v11Current_Info_System	1.432	1	1.432	.528	.470
HUD_OR_TOUCHSCREEN	1.126	1	1.126	.415	.522

Boxplots for question 11:



Question 12) System is the right media for decision-making

Wilcoxon Signed Rank test:

	License plate scenario				Emergency aid scenario			
	HUD		Touchscreen		HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.	Z-score	Sig.
Current system	-1.430	.153	-4.167	.000	-1.259	.208	-3.744	.000

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario		Emergency aid scenario	
	HUD	Touchscreen	HUD	Touchscreen
Current system	.185	.003	.187	.020

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.823	-.829
Sig.	.411	.407

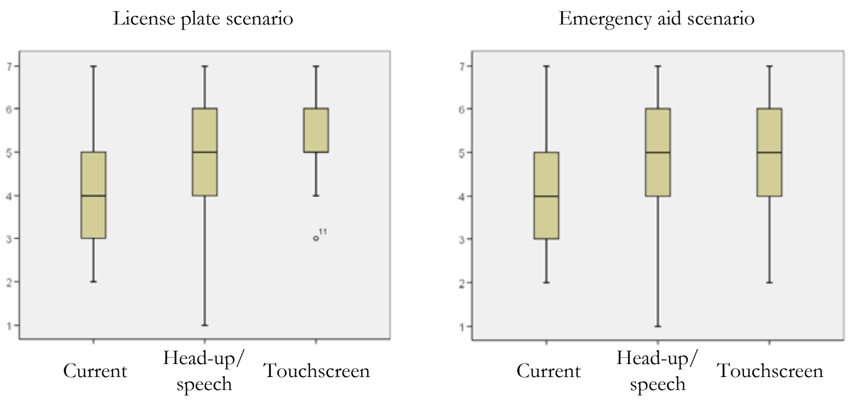
License plate scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.877(a)	2	.939	.512	.602
Intercept	151.747	1	151.747	82.726	.000
v12Current_Info_System	.256	1	.256	.139	.710
HUD_OR_TOUCHSCREEN	1.806	1	1.806	.985	.325

Emergency aid scenario ANCOVA:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.251(a)	2	.125	.057	.945
Intercept	148.533	1	148.533	67.142	.000
v12Current_Info_System	.160	1	.160	.072	.789
HUD_OR_TOUCHSCREEN	.135	1	.135	.061	.805

Boxplots for question 12:



Question 13) System usage when standing still

Wilcoxon Signed Rank test:

	HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.
Current system	-1.686	.092	-3.100	.002

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	HUD	Touchscreen
Current system	.053	.001

Testing differences between HUD post-test and Touchscreen post-test:

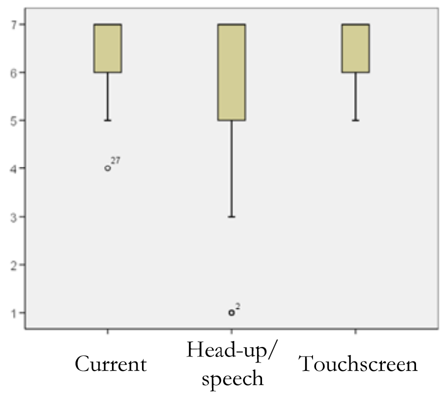
Wilcoxon Signed Rank Test:

Z-score	-2.606
Sig.	.009

ANCOVA results:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	19.568(a)	2	9.784	4.249	.019
Intercept	48.502	1	48.502	21.066	.000
v13Current_Info_System	.554	1	.554	.240	.626
HUD_OR_TOUCHSCREEN	19.530	1	19.530	8.482	.005

Boxplots for question 13:



Question 14) System usage in a constantly changing traffic environment

Wilcoxon Signed Rank test:

	HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.
Current system	-.382	.702	-1.914	.056

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	HUD	Touchscreen
Current system	.649	.037

Testing differences between HUD post-test and Touchscreen post-test:

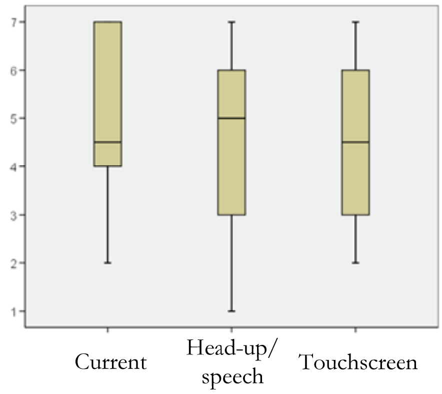
Wilcoxon Signed Rank Test:

Z-score	-1.098
Sig.	.272

ANCOVA results:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.791(b)	2	15.895	4.925	.010
Intercept	316.797	1	316.797	98.162	.000
v14Current_Info_System	31.789	1	31.789	9.850	.003
HUD_OR_TOUCHSCREEN	4.372	1	4.372	1.355	.249

Boxplots for question 14:



Question 15) System usage in a stable traffic environment

Wilcoxon Signed Rank test:

	HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.
Current system	-.184	.854	-3.102	.002

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	HUD	Touchscreen
Current system	.566	.002

Testing differences between HUD post-test and Touchscreen post-test:

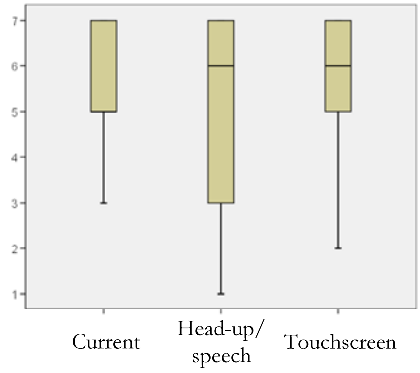
Wilcoxon Signed Rank Test:

Z-score	-.899
Sig.	.369

ANCOVA results:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16.811(b)	2	8.405	2.884	.064
Intercept	241.471	1	241.471	82.866	.000
v15Current_Info_System	11.872	1	11.872	4.074	.048
HUD_OR_TOUCHSCREEN	.801	1	.801	.275	.602

Boxplots for question 15:



Question 16) System usage in an emergency aid situation ("112")

Wilcoxon Signed Rank test:

	HUD		Touchscreen	
	Z-score	Sig.	Z-score	Sig.
Current system	-.043	.966	-2.910	.004

Paired samples test between pre-test ratings and post-test ratings (p-values are given):

	License plate scenario	
	HUD	Touchscreen
Current system	.919	.003

Testing differences between HUD post-test and Touchscreen post-test:

Wilcoxon Signed Rank Test:

	License plate	Emergency aid
Z-score	-.317	
Sig.	.751	

ANCOVA results:

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.082(a)	2	3.041	.704	.499
Intercept	349.118	1	349.118	80.818	.000
v16Current_Info_System	5.491	1	5.491	1.271	.264
HUD_OR_TOUCHSCREEN	.002	1	.002	.000	.985

Boxplots for question 16: