PLACEMEMO – SUPPORTING MOBILE ARTICULATION IN A VAST WORKING AREA THROUGH POSITION BASED INFORMATION

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ABSTRACT

The purpose of our research is to evaluate and redesign a position based information system. We report on ethnographic fieldwork about road inspection, i.e. management of large trunk roads. Road inspectors travel to identify defects and disturbances and then handle the problems or delegate the work. The current information system (ProData) allows position-based reporting with the principal purpose of rationalizing paperwork. We argue that the visible interruptions in the work show that the system functionality doesn't fit with the specifics of their mobile work. Our findings inform the body of research on mobile position based information systems. First, the designers of ProData have focused on the use of position-based information in an organizational setting, whereas the researchers focus on support for individual activities like reminder tools. Mobile work often demands that both these perspectives be addressed. Secondly, we argue that both the researchers and the ProData designers have to pay attention to the practical details of mobile activities and local collaboration. We recommend development of PlaceMemo, a communication system supporting the making and sharing of position based voice messages. This system will support the user in individual as well as collaborative articulation of contingent situations.

1. INTRODUCTION

This paper is based on field studies among road inspectors conducted during the year 2000 in Stockholm. The purpose of the empirical work was to increase the knowledge of the conditions in mobile work as well as to evaluate current technical support, and to identify services and applications that could be used to develop the work at the maintenance contractor. We are particularly interested in systems where the information contains geographical position (hereafter called position-based information). Road inspection includes identification of defects in the road infrastructure as well as other forms of disturbances in traffic, and the handling of these problems. It is a collaborative activity drawing on the skills of the inspectors to make contingent interpretations of objects as defects when conducting their work. However, collaboration and sharing of information is hampered by the almost isolated position of the road inspectors in their vehicles. First, their ability to collaborate is reduced by the distance to other colleagues. Secondly, they are restricted by the mobile work situation, as they are almost constantly on the move. In this situation, infrastructure maintenance could be supported by mobile IT, which would open the organization for new forms of collaboration and sharing of information. The ability to localize objects would be facilitated. The information associated with these objects would be easier to recall, and the sharing of information would be viable.

Our fieldwork also concerns a growing body of research focusing on position-based information systems. These systems are often designed with the general aim of augmenting reality (AR), i.e. to provide users with an enriched experience of real world actions. This research focuses on technical issues such as methods of tagging objects, or places, with digital information [Dey & Abowd, 2000, Ljungstrand, et al, 2000, Marmasse & Schmandt, 2000, Rekimoto & Ayatsuka, 2000]. We claim that exploring specific social practices could potentially benefit these systems, and inform technical research on the demands and problems as seen from the users' perspectives. It is imaginable that AR could be useful in collaborative settings. Our case, where the roads are the workplace seems to be promising since it is widely dispersed and crowded with objects, and the distance between colleagues and objects hampers collaborative activities. The paper concludes by making design recommendations for the *PlaceMemo* prototype. The prototype is intended to complement the existing system (*ProData*) in supporting informal interpretation sharing of possible defects. But it will also act as a tool handling individual reminders.

2. RELATED WORK

Our understanding of road inspection draws on previous experiences from research in the field of computer supported cooperative work (CSCW). Here, work is understood as a local and contingent activity. This implies that all activities performed by humans include a level of *articulatio*n, i.e. they do not follow a predetermined schedule, and the activities could be described as situated [Schmidt & Simone, 1996, Suchman, 1987, Mantovani, 1996]. Further, even though the articulation work sometimes only involves a single individual, it often also includes collaboration and sharing of information. But collaboration seldom follows easily predicted and routinized paths. Participants often have their own ways of working and solving problems, and the decisions are connected to a particular situation that makes it hard to reuse knowledge in new contexts. There can also be reluctance to share personal skills with other people since one's individual advantages will be lost [Grudin, 1994]. These are problems that the participants have to overcome to enable collaboration. Thus, the following aspects of work must be included when designing support for collaborative work from the perspective of CSCW research [Grudin, 1994, Schmidt & Simone, 1996] i.e. support for articulation work; support for sharing information; supporting the group while still supporting the individual tasks.

A distinction can be drawn between this approach and a more traditional path when designing information technology for organization work. The latter approach focuses on automation of organizational work. It works if the activity is carried out by routine or as if according to a stable plan. The former approach focuses on support of the articulation work. If the task is complex and characterized by constant deviations from what is to be expected, automation will not work, as you constantly have to take new situations into consideration [Schmidt & Simone, 1996].

Recent studies of occupational groups, working with infrastructure management, have a common denominator in their interest in the consequences on organizations of mobile work conditions in combination with a *widely distributed working area*. Examples of occupational groups studied are process engineers [Bertelsen & Bødker, 2001], bus drivers [Juhlin & Vesterlind, 2001] and service technicians [Orr, 1996, Wiberg, 2001]. At a glance, the tasks performed by the process engineers [Bertelsen & Bødker, 2001] could be seen as individual, but their actions affect the running of the plant, and therefore also their colleagues. To facilitate their work there is a need to share information, but not in the sense of universal access to everything, everywhere. The information cannot be separated from specific action, which in turn is tied to specific places. Accordingly they characterize the environment as a common information space, and the importance of being on location to take the correct actions. The other studies describing bus drivers [Juhlin & Vesterlind, 2001] and service technicians [Orr, 1996, Wiberg, 2001] reveal certain similarities with the process engineers. A slight difference could be observed in the fact that they perform their work in a broader setting, and coordinate certain activities while being mobile. Taken together these studies have increased our knowledge of mobility and collaborative work. But up to now they have mostly considered occupations where people move from one stationary workplace activity to another.

The road inspectors, as well as road users in general, are even more affected by mobility. They engage in thoroughly mobile activities, i.e. they drive trucks, at the same time as they conduct collaborative work in a wide area. The *ProData* system in use is based upon position-based information, which correlates with the interest in AR research of tagging the physical world with digital information. A number of applications based on the availability of positioning have been suggested in the AR research such as comMotion [Marmasse & Schmandt, 2000] and CybreMinder [Dey & Abowd, 2000]. The comMotion-system is supposed to be used in a geographically extensive area since the positioning is based on GPS. Translating the coordinates into defined places, such as “home”, “work”, etc, has solved the complexity of understanding the figures of longitude and latitude. The main feature of the system is its location-learning agent. Once a location has been defined, a to-do list is associated with it, either by voice or text. The system also provides the possibility to subscribe to different information services [Marmasse & Schmandt, 2000]. The CybreMinder-system permits the user to create reminders, which could be triggered by more complex conditions, including e.g. relative time, other users' availability or status on the stock market [Dey & Abowd, 2000]. Current attention is also raised towards generic problems of organizing this kind of information [Persson, et al, 2001]. It is for example conceivable that the electronic spaces would be overfull with information.

3. METHOD

There is a growing recognition that a detailed understanding of users' practices is essential in determining the requirements of new technologies. As such ethnography, or ethnographically influenced fieldwork, is increasingly being linked with technology development process.

Ethnography was originally developed within the area of anthropology and sociology as a method to gain insight into the cultural practices of societies [Prus, 1996]. When used in the area of systems development, the technique could be seen as a way of gaining insight and understanding into everyday practices [Hughes, et al, 1992]. The fast growing body of ethnographic research and its popularity in CSCW is explained by the need to account for problems with the use of information systems, as well as new demands to understand social interaction when designing mobile information technology [Heath & Luff, 2000]. It is central to ethnography to see users' activities as taking place within a socially organized sphere [Hughes, et al, 1994]. Due to the familiarity of their everyday situations, many important activities are taken for granted by those who perform them. Consequently it is not sufficient to simply ask people about their practices. Furthermore, people generally find it difficult to articulate their knowledge, to describe their way of performing tasks [Hughes, et al, 1992]. Therefore, in addition to interviews, ethnography relies on observation. In systems design several various ethnographic approaches are used. The research presented in this paper constitutes an introductory phase in the project and will be followed by development of new prototypes and evaluation, a process described and applied by Ljungberg et al [1998].

We participated in the inspector's work by following them in their daily tours of inspection in the region ‘Stockholm North’. There are three different local offices, and at each one of them there are one or two road inspectors. Additionally there is a staff of ten to twenty persons at each local office, with several occupational groups represented. Five different inspectors, belonging to the three different local offices, have been studied during a period of ten working days. We observed their work when sitting in the drivers' cabin. We followed them out of the car when tasks were performed outside, and also during three morning-meetings at the office. We took extensive field notes, which were transcribed immediately after returning from the inspection tours. The transcriptions were analyzed, and a set of themes was identified. A few themes and a representative sequence are presented in this paper.

4. SETTING

The inspector spends most of his working day alone inside the cabin of the truck. It is his responsibility to care for some of the main roads north of Stockholm. He must identify and deal with objects and defects that could disturb traffic. These tasks are all regulated in a contract with the orderer. An inspection tour lasts around seven hours and takes him 150 to 250 kilometers. The inspector patrols the road-network according to a predetermined schedule. The frequency of the inspections on each road type is determined by traffic flow and road size. Main roads in the region are inspected every other day. Minor roads are inspected with less frequency.

A major part of the inspector's time is spent seated in the cabin of the truck, where most of the information technology is attached. He is surrounded with a large palette of technological equipment, including an FM-radio; communication radio (UHF); a Psion handheld computer; and a mobile phone equipped with a separate microphone and a hands free speaker.

The *ProData*-system, consisting of a mobile computer (Psion Workabout) connected to GPS-receiver, is the main tool for gathering information during inspection. The contractor develops the system together with a consultant company specializing in geographical information systems. The system was initially introduced as early as 1998, and the functionality has continuously evolved. The GPS-receiver automatically logs the position during the inspection. All defects reported by the inspector are coded and linked to the correct geographic location. The codes are based on contract with the orderer, and they are described in a document placed in each vehicle. The codes belong to nine main categories, each of them containing a minimum of five sub-categories of possible defects. In addition, the system allows the users to write their own textual input. The defects should be reported, according to the work manual, irrespective of whether they are repaired or not. The log created by *ProData* will then verify that the roads have been properly inspected. Mobile phones are used to inform colleagues about local contingencies and to delegate tasks. It is also necessary to communicate with colleagues to stay updated on the status of the road network and to share joint information regarding their tasks. There are also elements of interaction with people outside their organization e.g. the police and/or the Traffic Information Central (TIC). Finally, the FM-radio is a source for local traffic information.

5. ANALYSIS

In everyday work, the inspectors conduct several activities. Basically, the work consists of three different tasks, which are identifiable in the following example. The inspector sees a fox lying dead on the roadway while driving on his daily inspection tour. He *identifies* it as a defect. He halts the vehicle immediately behind the object of interest, since the truck will then protect him from the surrounding traffic when he is out on the road. Before stepping out of the truck he *reports* the defect. In this case he fill in the forms provided in the *ProData*-system. He uses a combination of a predefined defect code, which is documented in the manual present in the vehicle, and his own textual input. The positioning system (GPS) forces him to be at the spot of interest when the report is done. Otherwise the automatically generated position-data will differ from the position of the defect, and the report will be incorrect. Finally he leaves the cabin of the truck to *deal with* the defect, i.e. remove the dead animal from the road. Thus the fundamentals of road inspection include identification, reporting and repair.

5.1 Identification as on-going interpretative work

On many occasions neither the identification, nor the appropriate description when reporting, are as evident as in the previous example. On the contrary, it often takes the skill of the inspector based on the ability to interpret contingent situations and conduct successful collaborations, to make the appropriate judgment of how to apply the manual in a specific situation. It can for example be difficult to decide if the defect is physically located in their area of responsibility. Some road signs could either be illegal or have a temporary permit. Missing signs could be awkward to identify without genuine local knowledge. Some of the objects, in the loosely defined working area, are gradually becoming defects, while other defects occur instantaneously.

In the following case, the inspector is faced with the problem of deciding if an object (a car) should be understood as a defect or just part of normal road use. We are driving on a motorway north of Stockholm, and the inspector discovers a red Mazda parked by the roadside.

> Inspector: I have not seen it before, so I will report it. If it's still here on Wednesday I'll do it. The owner may have gone to the gas station, but it looked quite nice. Perhaps it will be gone by then. It wasn't rusty. It's troublesome that we cannot remove the abandoned cars. The police have to contact the owner as long as it isn't placed dangerously for the other road users, and the police seldom make this decision.

The inspector is weary about the interpretation of the car. He is clear about the object as newly arrived there. Thus, it has not been reported earlier on. But as soon as he decides to report the object, he postpones the activity until he receives more information. If he waits two days, and the car is still there, it is more probable that it really is a defect, i.e. an abandoned car. In this situation, he interprets the condition of the car to get an indication of its status. If it is rusty it is more likely that it is abandoned. New cars are seldom left alongside highways according to this way of reasoning. Thus, the case-by-case identification of defects demands interpretative skills of the inspector. In some occasions he also has to consider information given by his colleagues. They could tell him if the object has been accorded the status of a normal object rather than a defect.

5.2 Postponing reporting and repair

In most cases inspection is not a three step sequential activity. Even in cases when identification is made, it normally leads to neither reporting nor repair. Instead these activities are postponed for different reasons such as poor working conditions or difficulties stopping the vehicle due to the current traffic situation. Reporting very seldom occurs if they do not engage in repair or delegation, i.e. if they stop the truck in the vicinity of the defect. The vehicles in the surroundings limit the possibilities to make an immediate stop, because of the risk of being hit from behind. In a number of situations, the possibility of immediately taking care of identified defects could be limited, because of the need for certain equipment, or tools. These situations are characterized by a need to remind oneself to bring the required equipment on a later occasion. In the following example, the inspector stops the truck on the highway, since he caught sight of a gap in the road safety fence:

> Inspector: That gate is open. I do not have a padlock with me. I suppose I have to write it down. [He writes on a Post-it note] "1000 m north Måby traffic interchange junction, road safety fence gate unlocked."

He uses a steel wire to temporary close the gate. He will come back at a later moment and close the gate with a padlock. When repair work needs to be planned they use paper notes as reminders to access earlier reported data. He makes a note of the position of the defect as a reminder of when to plan for stopping the truck. The need to write notes is an indication that they have problems remembering the details of the defects.

5.3 Insufficient reminders

The widespread working area plays an important role in the complexity of handling individual jobs as well as collaborative reminders. In many cases objects have been identified as defects, but without the possibility to take care of them immediately. The repair will be postponed to a later time. In the best case a reminder, consisting of a paper note will be created, otherwise they try to memorize the task. The problem of recalling the task when approaching the location, or being at the correct location, is obvious in the following examples. While preparing the vehicle for the daily inspection tour, a colleague tells the inspector to take care of a cable in front of a traffic light. He is told of the geographical location, and that the defective cable should be visible. He promises to take care of it since he will pass this area. But by the end of the day he has done nothing to handle the problem. The rich environment makes it troublesome to memorize the specific position, while the focus is on driving the vehicle and continuously searching for other possible defects. The following example will show the importance of the physical object as a reminder. When passing an underground passageway in the vicinity of the exit to Rotebro, the inspector was reminded of an earlier discussion with a colleague. The discussion concerned broken windows in the underground passageway. He made an immediate call with his mobile phone, to remind his colleague to take care of the defect. Most often the physical object acts as a trigger when recalling a task that has to be taken care of. In most of the cases, it is already too late, since he has already passed the object of interest. In many cases they use Post-it notes to handle the reminders, or even try to memorize the details. It is obvious that these instruments to handle reminders are characterized by a loss of stringency and precision.

5.4 Resources for delegation

The paper notes also give inspectors the possibility to hand information over to colleagues when they meet in person. This might occur at the office but could also happen on the road. The information could also be useful when discussing with a colleague on the mobile phone. Then the Post-it note reminds him with details of what to discuss, such as in the following example. The previously observed Mazda is still there when we reach the same place later the same day. This time, the inspector stops his vehicle in order to file a report. Still, he is not absolutely certain what to do. Is it enough just to report the object into his computer or should he engage in delegation?

> Inspector: The car is still left by the roadside. It is probably stolen.
>
> Researcher: Are you having problems with finding the correct code?
>
> Inspector: No. But I am writing some more details “Mazda 626 LLF657”. There is a certain code to use ‘abandoned cars’. That one is really good. In the same way I can use the code ‘dropped load’. But there is a problem since I can’t retrieve what I have reported. For example this car, if I change my mind and decide to call the police I can’t retrieve the registration number if I haven’t written it on a Post-it note. I don’t know what to do.

He is not satisfied with the *ProData* system in this situation. It doesn’t support the delegation of work tasks, i.e. in this case when the police have to be informed. The neglected support for delegation also affects the possibility to share the responsibility for a specific road setting.

5.5 Barriers for collaboration

The problem lies in the difficulties in retrieving earlier reported data. It is impossible to access data on the handheld computer. Occasionally this causes data to be reported twice, i.e. both on a file on the computer and on a Post-it note. The problems are apparent in the following example. An inspector, working temporarily during the holiday months, hesitates in reporting major defects. He believes that, in most cases they are already reported. Reporting it once again would only cause problems. He tells me that he usually writes the defect on a piece of paper, and checks with the computer at the office, before he files it into the computer. He will report minor defects, e.g. dead animals, since he takes immediate care of them. In many cases they will report without checking back at the office. When the same defect is reported on several occasions, the quality of the database will decrease. An attempt to avoid this problem is letting the inspectors have their “own” roads, which they inspect. This will probably increase the possibilities for them to be aware of their earlier interpretations and formal reports, but occasionally this is problematic when sharing working tasks, e.g. sharing roads.

6. DISCUSSION

The work of the inspectors consists of several tasks, which are contingent and characterized by constant deviations from what is to be expected. There are obvious elements of hesitation when applying the organizational rules for identification of defects, as well as appropriate actions to take (as formulated in their work manual). The distinction between knowing the rules and applying them is huge. The character of the work is influenced by the following conditions, in line with the understanding in CSCW-research: interpretation of defects demands on-going work; the vast working area requires engagement with positioning; a mobile context constrains the inspectors.

First, the identification of defects can be understood as *on-going articulation work*, as in the case of the red Mazda. The red car does not tell the inspector by itself that it is abandoned. The road inspector has to articulate it, which demands prolonged engagement, as a defect, instead of a random parked car. Secondly, it is clear that the road inspector has to attend to the specifics of working in a vast area. Most importantly, this is visible in the way they work to handle location and positioning of objects. The difficulties in finding the defects is apparent in the way they attend to position when they formulate their Post-it notes. They have to carefully *define the position* of the identified defect. However they often forget to take care of the defect, since they forget the task while performing the inspection of the area. Thirdly, the *mobile character* of the work constrains their activities. The mobility of other road users decreases their freedom of action and the system can't be used while driving. Thus reporting and repairing is normally postponed to an indefinite future. Stopping the vehicle is often very difficult and time consuming. Therefore, they try to remember the defect and its location when they pass by. But it is not easy to remember all the details. And memorization tends to individualize the performance of work task and it becomes difficult to share the inspection of a road section, or information on its condition. Sooner or later they have to stop at the site of the defect.

The orderer is engaged in designing support for infrastructure management such as *ProData*. Still several observed interruptions occurred. The driver has to be at the same geographical place as the defect to make a comprehensive report. He also has to stop the vehicle, since it is impossible to report while driving. He has to punch several keys on a keyboard as well as read the manual to find the appropriate code. Therefore he often refrains from filing a report.

As a consequence, the organization of the work tends towards individualization. The inspectors try to identify and repair as an individual task as much as possible and keep all their knowledge in their heads. This leads to a situation where the databases consist almost only of identified defects that have already been taken care of, and where the possibility to use *ProData* to plan future work and delegation is practically non-existent. The sharing of knowledge on the road network is at a minimum in a situation where the orderer and the contractors of inspection, as well as traffic information centers are in demand of even more exhaustive information to conduct their work properly. If a report is filed into the system, the inspectors lose all access to the information. It follows that it is difficult to see if the defect is already reported. There is still a need to save information about the defect for a later moment. In these cases the inspectors write Post-it notes to support their memory. However, Post-it notes are not sufficient for their work. The good thing with these notes is that you can hand them over to someone when you meet, and you can use them to prepare a future inspection tour. It is also possible to easily describe the situation in the road inspectors own terms with due sensitivity for the situation. The bad thing is that they cannot drive and write at the same time. They are also difficult to distribute, and lack the qualities of a universal positioning system like GPS. Furthermore, they do not help in planning a stop during an on-going inspection tour. Mobile phones suffer from similar problems since they demand that the driver either stop at the location of the problem to get enough time to get in contact and account for the situation, or depend on a Post-it note if the call is made from somewhere else.

To sum up, the fieldwork supports an understanding of road inspection as individual, and/or collaborative, articulation of the identification of defects as well as the decisions on what to do next. Further, we recognize that driving is the main task of inspection, which limits the inspector's freedom of action, and concentration. *ProData* is designed to move the stationary worksite to another stationary place, which is the place of the defect. But the inspectors are doing a truly mobile job, since they are almost constantly on the move. It is not a case of movement between different work places, because the continuous movement could be understood as the work itself. Thus there are a number of design-requirements in *ProData*, to support the inspectors that taken together severely restrain their activities.

7. DESIGN IMPLICATIONS

The need to stop the vehicle in order to either communicate or report is probably the most important factor hampering road inspection. Thus, designing a system that makes these activities easy to perform while being mobile could increase the number of reports and communication, and thus strengthen the possibilities for articulation of these activities. The organization would receive better knowledge of the identified defects and could plan their work in another way, e.g. new forms of job sharing and job rotation. A simplified method of reporting would probably lead to an increased amount of reports on defects, which have not yet been taken care of. The prototype is based on a Pocket PC platform in order to become a truly mobile device, which not necessarily needs to be mounted in the vehicle. Further it will be connected to a GPS-receiver to enable the retrieval of coordinates, and GPRS to enable communication.

7.1 PlaceMemo – voice-memos associated to physical locations

We recommend a system, which demands less of the user in terms of activities on the spot of the incident or defect, since the inspector is occupied with many activities, such as driving the car. Still it is essential to save the position of the problem that should be handled. The interaction with the computer should be limited while driving the truck. We believe that there is a possibility to create reminders in the form of voice recordings while driving, which are associated with certain geographical positions. Thus, when a defect is identified the inspector pushes a button (on the steering wheel) coupled to the computer. The precise position will be registered by the GPS-receiver, a short signal will notify the inspector that the position is saved, and the voice message is being recorded. He starts by speaking his message, and as soon as he is finished he pushes the button a second time to stop the recording. The use of audio does not restrict the memos, as do the predefined defect-codes, instead it enables him to record the voice-memo in any form. The memos could contain something similar to what they now are writing on the Post-it notes. We have decided to name this service or application *PlaceMemo*.

7.2 Supporting several work tasks

ProData is built to support the preparation of administrative documents, which are essential to account for what has been done. This focus leaves out support for inspection as an on-going activity, which also explains the limited usage of the system. This mistaken approach is common in the design of information systems, according to Grudin [1994]. *PlaceMemo* has the possibility to become a more integrated tool for inspection work. To fit with current practice, i.e. the articulation work, it is essential that the system should handle different forms of information, that is both situated and contingent ways of representing defects as well as the filing of data according to the formal organizational requirements. Voice-recordings are easier to do and less restricted in terms of vocabulary than the coding scheme.

7.3 Supporting individual work

The system should support planning of individual work with an easy way to retrieve the *PlaceMemos*. Here we suggest different methods to trigger the reminders, for example the coupling to location, time or route. During the inspection tours the reminders should have the role of informing the inspector, to give him a reasonable chance to prepare a stop in time, which is especially important when the roads are crowded with vehicles. The individual road inspector should have the possibility to decide, according to his preferences, the conditions of how, and when, the *PlaceMemos* will be presented. In many cases, the inspector needs to prepare for the inspection tour, by bringing certain equipment. Before leaving the office, he will have the possibility to retrieve a list of all recorded memos, and choose the ones he wants to listen through.

7.4 Support easy reporting

To achieve a higher number of reports in *ProData*, the *PlaceMemo*-system should act as supporting tool in the formal reporting procedure, seeing that it will be saved to a better occasion than driving on the motorway. The inspector could e.g. listen through and code the voice messages during a break, i.e. he will import *PlaceMemo*-data into the *ProData*-system. It could be done in the computer in the vehicle, but also between the *PlaceMemo*-system and the central *ProData* database, by the use of GPRS. The position data is the principal information, but the voice message could also be reused. The ideal solution would be one single system allowing the user to report with formal defect-codes and/or voice-memos. In the case of designing a prototype, the level of integration will be looser.

7.5 Support for delegation

Delegation could be performed at more suitable occasions with *PlaceMemos*. The recorded information could be a support when calling a colleague, as a starting point to discuss delegation of a task. Apart from listening to the *PlaceMemos* before initiating the conversation, the use of GPRS would facilitate sharing of voice messages among colleagues, and accordingly each particular inspector would not be so strongly tied to his assigned roads. The *PlaceMemo*-system will be integrated with an e-mail client, enabling the inspector to share the specific voice messages with a chosen colleague. The audio file will automatically be attached to the e-mail.

8. CONCLUSION AND FUTURE WORK

Similar concepts have been developed around the theme of position-based messages, but with the purpose of being multi-purpose tools, demanding too much from the user in the computer-human interaction, in a mobile context. The functionality and the user interface in these systems are heavily influenced from a stationary setting, with the screen as a main source for textual in- and output. The specific activities studied in this case demand a stronger focus on interaction while being on the move. The main objective with the proposed design implications is not only to handle reminders. The information stored in the intended system should support interaction with specific colleagues. Earlier research has instead focused on design for public broadcast, which is based on central storage of data. The design implications presented suggest a redesign of the current system, to integrate informal actions into the formal reporting tool. We focus on the support of manual work, integrating loosely coupled methods of recalling, delegating, and informing about actual contingencies. The road inspectors will have the possibility to provide an augmentation of the physical environment, by recording *PlaceMemos* and making them retrievable for other people, i.e. colleagues, present in the physical environment. The system does not force the messages to fit into a predefined shape; the limitation lies in the form of voice-messages connected to geographical positions. These positions will be in the form of GPS-coordinates, thus the messages are easy to access, since all vehicles are bound to the roads even if their working place is widely geographically dispersed.

A prototype is currently under construction, and will be brought back to the original setting of the inspectors to be evaluated. The evaluation is planned to take place during 2002. Discussions are held with the company developing the formal system (*ProData*), regarding the functionality of importing *PlaceMemo*-data into the formal system.

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REFERENCES

Bertelsen, O. W. & Bødker, S. (2001). Cooperation in massively distributed information spaces. In *Proceedings of ECSCW.* Kluwer.

Dey, K. A. & Abowd, G. D. A. (2000). CybreMinder: A Context-Aware System for Supporting Reminders. In *Proceedings of the 2nd International Symposium on Handheld and Ubiquitous Computing* (HUC) Bristol, UK.

Grudin, J. (1994). Groupware and social dynamics: Eight challenges for developers. In *Communications of the ACM.* (pp. 92-105). Vol 37, No 1, January 1994.

Heath, C. & Luff, P. (2000). *Technology in Action*. 280p. Cambridge University Press, Cambridge.

Hughes, J., Randall, D. & Shapiro, D. (1992). Faltering from ethnography to Design. In *Proceedings of CSCW92* (pp. 115-122). ACM Press, New York.

Hughes, J., King, V., Rodden, T. & Andersen, H. (1994). Moving out from the Control Room: Ethnography in System Design. In R. Furuta & C. Neuwirth (Eds.), *Proceedings of CSCW'94* (pp. 429-439). ACM Press, New York.

Juhlin, O. & Vesterlind, D. (2001). Supporting Bus Driver Collaboration: New Services for Public Transport Management. In *Proceedings of 8th ITS World Congress*, Sydney, Australia.

Ljungberg, F., Dahlbom, B., Fagrell, H. Bergquvist, M. & Ljungstrand, P. (1998). Innovation of New IT Use: Combining Approaches and Perspectives in R&D Projects. In *Proceedings of PDC ´98,* Chatfield, R. Kuhn, S. & Muller, M. (Eds), Palo Alto, CA, USA, CPSR.

Ljungstrand, P., Redström, J. & Holmquist, L. E. (2000). WebStickers: Using Physical Tokens to Access, Manage and Share Bookmarks to the Web. In *Proceedings of DARE'2000*. ACM Press, New York.

Mantovani, G. (1996). *New Communication Environments – From everyday to virtual.* Taylor & Francis Ltd, London.

Marmasse, N. & Schmandt, C. (2000). Location-aware information delivery with comMotion. In *Proceedings of HUC'2000*, Bristol, UK.

Orr, J. (1996). *Talking About Machines.* Ithaca, NY: ILR Press.

Persson. P., Espinoza, F. & Cacciatore, E. (2001). GeoNotes: Social Enhancements of Physical Space. In *Proceedings of CHI'2001.* ACM Press, New York.

Prus, Robert, Symbolic Interaction and Ethnographic Research-Intersubjectivity and the Study of Human Lived Experience, (Albany, State University of New York Press, 1996)

Rekimoto, J. & Ayatsuka, Y. (2000). CyberCode: Designing Augmented Reality Environments with Visual Tags. In *Proceedings of DARE'2000*. ACM Press, New York.

Schmidt, K. & Simone, C. (1996). Coordination mechanisms: Towards a conceptual foundation of CSCW systems design. In *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, vol. 5, no. 2-3, 1996, (pp. 155-200).

Suchman, L. (1987). *Plans and situated actions: The problem of human-machine communication*, Cambridge University Press, Cambridge.

Wiberg, M. & Ljungberg, F. (1999) Exploring the vision of anytime, anywhere in the context of mobile work, In *Knowledge Management and Virtual Organizations*, edited by Yogesh Malhotra, The BizTech Network.

Wiberg, M. (2001). *In between Mobile Meetings: Exploring seamless ongoing interaction support for mobile CSCW.* (Ph. D. thesis), Umeå University, Dept. of Informatics, Sweden.