

Dealing with Mobility: Understanding access anytime, anywhere

MARK PERRY[†], KENTON O'HARA[^], ABIGAIL SELLEN[‡], BARRY BROWN[‡] AND RICHARD HARPER[∞]

[†]*Dept. of Information Systems & Computing, Brunel University, UK*

[^]*The Appliance Studio, Bristol, UK*

[‡]*Hewlett-Packard Laboratories, Bristol, UK*

[∞]*Digital Worlds Research Centre, Surrey University, UK*

ABSTRACT

The rapid and accelerating move towards the adoption and use of mobile technologies has increasingly provided people and organisations with the ability to work away from the office and on the move. The new ways of working afforded by these technologies are often characterised in terms of access to information and people 'anytime, anywhere'. This paper presents a study of mobile workers that highlights different facets of *access* to remote people and information, and different facets of *anytime, anywhere*. Four key factors in mobile work are identified from the study: the role of planning, working in 'dead time', accessing remote technological and informational resources, and monitoring the activities of remote colleagues. By reflecting on these issues, we can better understand the role of technology and artefact use in mobile work and identify the opportunities for the development of appropriate technological solutions to support mobile workers.

KEYWORDS

Mobile technology, mobile workers, mobile communication, awareness, distributed collaboration, diary study, interviews, information access, anytime, anywhere.

MOBILE WORK, MOBILE TECHNOLOGY

The rapid and accelerating move towards the adoption and use of mobile technologies has provided people and organisations with the ability to work in novel and previously unanticipated ways. Such developments are at both the level of emerging technological infrastructures for connectivity (e.g. WAP, Bluetooth, Sun's Jini, and HP's JetSend, location pinpointing technologies, 3G and GPRS) and mobile information appliances such as mobile phones, personal digital assistants (PDAs), and laptop computers. These have the potential of provoking even more radical changes in work practices and encourage an even greater level of mobile work and distributed collaboration.

Mobile work differs in many interesting ways from desk work. It can also present the business traveller with a unique set of difficulties. When people work in an office, they have greater familiarity and certainty about the environment and resources (i.e. technologies, information, documents and people) available to hand. People in offices know where technologies such as the photocopier and the fax machine are and that their personal equipment is set up appropriately for their work environment. They structure the information and documents around them to suit their needs and they know who to ask for particular kinds of information. Such familiarity with their environment affords them greater freedom over the way they organise their work. Of course, systems break down and technology can go awry, but in general, when people work at their office desks, they know how to go about fixing their problems, and finding what they need to perform the job at hand.

Contrast this resource-rich view of office work with the difficulties encountered by a mobile worker on a business trip who may experience a range of different contexts both in transit and at their final destination. Such contexts (e.g. clients' offices, hotel rooms, airports and vehicles such as trains, aircraft and cars) are likely to be more unfamiliar to the mobile worker in terms of factors such as available technology and communication infrastructures, available workspace and noise levels (Lamming *et al.*, 2000). In addition, they do not have the access to colleagues or knowledge of who to seek to get support. The greater unpredictability - or *heterogeneity* (Kristofferson and Ljungberg, 1999) - of the contextual constraints within which mobile work must take place means that they have less control over the configuration of their environment and therefore the way that they manage their work.

In light of the particular difficulties encountered by mobile workers, one of the major premises of mobile technologies is to remove the bindings between a fixed space and a person's information and communication resources. By supporting access to these resources wherever they go, the argument is that uncertainty associated with the contextual constraints encountered while mobile is removed. This is intended to give back control to the mobile worker over when and where they can do their work. As a rhetorical device for the promotion and selling of mobile technologies, the "access, anytime, anywhere" construct serves an important function. However, in terms of understanding technology use in mobile work and informing design through this

understanding, such a construct may not be quite so useful since it misrepresents the reality of the difficulties faced by mobile workers. Indeed, as other authors have argued (e.g. Churchill and Wakeford, 2001), this and other rhetorical devices used in the mobile technology industry “contribute to a common discourse of mobility” from which narratives of use are drawn. These narratives embody a set of simplistic assumptions about the nature of mobile work. In the absence of a real understanding of what constitutes mobile work, these narratives are the only fallback in justifying and shaping design decisions.

As Luff and Heath (1998) have shown, misunderstanding the nature of mobile work can be problematic and can lead to technologies being used in unexpected ways. For example, they describe a situation in which a mobile device was introduced onto a building site to replace a paper allocation sheet used to record the amount of time that workers were spending on particular aspects of the job. The system was supposed to provide a mobile resource for the foremen as they wandered round the site to help them monitor problems as they were encountered and to support in situ discussions with other people on the site. What happened in actual use, however, differed from the intent of the designers. Instead of being used as a communication tool in support of the mobility of the foreman around the site, it was primarily used as a data documentation device. That is not to say that it failed as a useful tool, but merely that it was not useful for its intended support of mobile work practice. This occurred because the device actually impeded certain important features of the collaborative work practices of the foremen and the other workers when out on the site. For example, with the existing paper-based version of the allocation sheets, there would be a brief hand-over of documents and a simultaneous discussion about the problems on site. During these discussions, the paper documents would be dynamically positioned to render them “accessible” to the participants as the needs of the conversation dictated. With the new electronic mobile system, the characteristics of the device, such as its size, shape and screen intensity made it difficult for such subtle shifts of “accessibility” of information between collaborating participants. In practice, then, the system actually hindered mobile collaboration rather than supported it.

In response to some of these issues, what we set out to do in this paper is contribute to a deeper clarification of the rhetorical underpinnings of mobile work. In particular, rather than treating the three concepts of *access*, *anytime*, *anywhere* as monolithic terms, we intend to argue that each of these terms is multifaceted in meaning with each facet having different implications for the way in which we think about mobile work and the technologies designed to support it.

As an illustration, one simply has to look at one of the primary purposes of mobility itself. That is, one of the main reasons for being mobile is to have face-to-face interactions with others (e.g. Bellotti and Bly, 1996; Lamming *et al* 2000; Henning and Bragen, 1994). It is well established that face-to-face access to colleagues is different and usually much richer than remote collaboration through technology. There are thus different kinds of access to other people and one needs to look carefully at whether new technologies can deliver the necessary support for the task at hand. Similarly, if we look at access to documents and information, again, different kinds of tasks require different kinds of access. For example, the kind of access required to be able to exchange a document as an email attachment is different from the level of access necessary to allow editing of the document. In the first instance one does not really require visual access to the contents of the document but merely access to the digital information that encodes the document such that these bits can be emailed onwards¹. In the editing instance, one requires visual access to a modifiable document.

To illustrate the notion of “anywhere” in the same way, we can see that accessing or transporting documents between a desktop computer in an office and a laptop in a hotel room constitutes a different level of spatial granularity than the “anywhere” associated with Luff and Heath’s (1998) micromobility of documents and artefacts (the small shifts in position and orientation configurations of artefacts in response to the ongoing demands of a particular task). The granularity differences in spatial shifts in these two examples demands a different set of affordances from the information embodiments used to support them. So the laptop is able to receive a document anywhere that a network connection can be established with the computer back at the office. But once the document is received, the laptop cannot be spatially reoriented at the micro level, for example during a face to face interaction, in the kind of ways that a paper embodiment of the same document would allow (e.g. Luff, Heath, and Greatbatch, 1992; Harper and Sellen, 1995). This notion of “anywhere” also assumes a geometric notion of space, in which all places are assumed to be functionally equivalent. We can also look at the social facets of “anywhere” and consider spaces in terms of the different properties and social norms governing the kinds of activities that can take place there. For example, the kind of mobile phone conversation one can have in a public place surrounded by others is different from the kind of conversation could have in a different place with no one else around (cf. Churchill and Wakeford, 2001). In this instance, anywhere access is *possible*, but may not be *acceptable*.

Finally, as an illustration of the notion of “anytime” let us consider the task of writing a document on a laptop while needing to reference some information from a source document. The level of time granularity associated with a quick glance access of information from a paper document located adjacent to the laptop is very different from the time granularity associated with getting exactly the same information by pulling the document over the Internet. The different embodiments of the information in these two instances offer very different values and properties in terms of the way they can be drawn upon as a resource for the

¹ It is recognised that one might want visual access to the document for the purposes of confirming that the correct document is being attached and sent. For the purposes of this illustration, this is not important and so is not included.

ongoing activities. To ignore these different facets is to ignore the very features of the competitive artefact ecology within which new mobile devices must operate. As with notions of space assumed in the rhetoric of “anywhere”, the notion of “anytime” often assumes a linear notion of time. This is as opposed to the facet of “anytime” characterised by the social norms and properties of time that affect information access and communication behaviours. For example, many people might consider it inappropriate to make a phone call about work-related issues outside a mutually agreed understanding of “work time”.

In this paper then, we present a user study of mobile workers on business travel in order to further unpack what it means to be mobile and to work in different places at different times. We hope to learn from observation of how they currently use the resources they have to hand to think systematically about what they might need in the future. For example, we hope to be in a better position to answer important emerging design questions such as how and why should wireless communications be incorporated into mobile devices (such as PDAs)? What new data services might be useful to access via mobile phones? What document handling facilities should be incorporated into mobile devices? In addition to informing new design directions for mobile technologies, it is also about developing an understanding into the rationalities of use of existing artefacts in real world practice from which we can begin to infer how emerging technologies will compete for use in the ecology of existing communication and information artefacts.

PREVIOUS RESEARCH

Much of the research on mobility has dealt with technology issues such as limited battery life, unreliable network connections, varying channel coding, volatile access points, risk of data loss, portability and location discovery (Wiberg and Ljungberg, 1999). However, as a number of authors have commented, user centred research of collaborative mobile work is now beginning to emerge as an important field in its own right (e.g. Luff and Heath, 1998; Bergqvist *et al*, 1999). There is now a growing number of studies of mobility in collaboration offering observations and findings about the actualities of mobile work. Some of the findings can be recast to inform our particular concerns about “access, anytime, anywhere” and form the foundations on which observations from our own study of mobile work can build.

In one of the earlier studies of its kind in the area, Whittaker *et al.* (1994) carried out an in-depth shadowing study of 2 mobile professionals. One of them was primarily mobile within the local office environment, the other was mobile both within the local office, but also remotely (within the local metropolitan area). The primary focus of their work was on the informal communication activities of these people rather than mobility *per se*, but they also looked at the role mobility served in enabling access to colleagues for these interactions. This occurred through the chance encounters with colleagues that mobility facilitated such as bumping into someone while roaming, as well as more planned visits to the offices of others. This extent of this mobility away from the desktop led to difficulties in being able to access colleagues successfully (two thirds of attempted phone calls failed because the other person was not at their desk). The study also highlighted how different spatial locations varied in terms of the perceived intrusiveness associated with them. For example, in “on the move” serendipitous informal interactions, the caller is not interrupting the recipient in the same way as when calling on them at their office. The subtly different social properties of these spaces influence the duration of the collaborative activities.

Local mobility (defined as within easy walking distance of their office space, walking between rooms or buildings at a local site) is further examined in an ethnographic field study of a distributed design team by Bellotti and Bly (1996). The particular theme of the study was how this local mobility was important in supporting communication and awareness activities highlighting the importance of collocating with a colleague to get a richer level of access than would be possible using telecommunication from the desktop. The mobility also gave a certain level of access to colleagues that provided people with awareness of what was going on elsewhere in the workplace. However, one negative consequence of this local mobility was that, as in the Whittaker study, telephone access by remote colleagues was made more difficult.

Awareness and communication are also discussed in Luff and Heath’s mobility studies (1998). One example they discuss comes from their observations of staff and management at the London Underground. In this case, many of the information and communication resources that were required for them to perform their work were located in the Ops room. When a member of staff was mobile and away from this room, they were unable to access the ongoing changes taking place in it: they no longer had continuous visual and auditory access to colleagues and information such as inadvertently overhearing activities in conversations and phone calls. The access to this information was ongoing and unplanned when in the Ops room - one cannot predict the time when a particular piece of eavesdropping will become an important resource for a particular work activity. The form of access that many mobile technologies (such as mobile phones) provide is not equivalent to the access allowed by *being* in the Ops room, since this kind of remote access must be deliberately initiated.

As we have discussed earlier, Luff and Heath’s (1998) paper talks not just about the mobility of people but also the mobility of artefacts (micromobility) and the way they are ongoingly configured within collaborative activity. By articulating examples of these different configurational needs, they point to some of the different facets of “access”, “anytime” and “anywhere” that we are addressing in this paper. In particular they discuss how the properties of different forms of representations of the same information impact on micromobility. For example, when talking about the role of documents in mobile conversations (cf. Whittaker *et al.*, 1994) they point to the ecological flexibility of paper in this role compared with conventional computer systems

or even laptops which are regarded as “cumbersome and rigid” in terms of how they can be used during conversation.

The role of documents and access to documents in mobile work is further developed in a series of studies by Eldridge et al, (2000) and Lamming, *et al.* (2000). These studies examined situations involving mobility both within the local area and beyond the metropolitan area using a variety of quantitative and qualitative approaches to data collection. These studies are important in characterising some of the particular features and problems of mobile work such as the unfamiliar nature of the environments in which people often find themselves, the unanticipated nature of document activities, the difficulties in “accessing” remote documents and the frequency of face-to-face interactions in which paper documents play a key role (cf Luff and Heath, 1998). The findings from these studies are used to inform the design of a new system called Satchel. The Satchel system allows document tokens to be carried round on a mobile device. When these tokens are instantiated, for example by beaming them to another device (e.g. a Satchel enabled printer), the actual document is pulled across the Internet to the recipient device. Some of the design features of the Satchel system are clearly based on the need to think about different facets of information access. For example, they talk about the need to beam a document token to a printer to create access to the document appropriate for face-to-face interaction. This they regard as different to the type of access necessary simply to beam a document token to another mobile device.

With regard to unpacking the concepts of *anytime* and *anywhere* in the Satchel papers, there is less discussion but there is an important point to be raised here. Many of the features of the Satchel system are dependent on place and time being defined by the presence of Satchel enabled devices. This is not a criticism of Satchel *per se*, whose value has been demonstrated through extensive field trials (e.g. Lamming *et al.*, 2000), but is intended as a vehicle for illustrating the different features of different places - defined by the technological ecology of that space. These issues perhaps become more apparent if we consider some findings from O’Hara et al (2001) regarding the relationships between the mobile phone conversations of mobile professionals and their document activities. For example, one participant from the study was driving his car and received a phone call regarding some information on a spreadsheet on the caller’s PC in the office. While the caller was able to give a certain level of “access” to the information by verbally describing it to the driver, the driver really needed visual access to the document to truly engage in the conversation. The point here is that while a mobile technology could allow access to the necessary document by having it transmitted to the mobile phone in the car, this would not be suitable for the situation at hand. Additional technology would be necessary to allow the appropriate level of visual access to the document contents. In this particular situation, the characteristics of the place (the car) were such that this additional technology was not available - therefore “access” here was not possible. Similarly, if we consider the particular time when the person received the phone call, the ongoing activity of driving meant that visual inspection of a document would be dangerous anyway.

Lack of awareness of recipient activities and features of time and place which impact on type of access possibilities can lead to disruptions in what Churchill and Wakeford (2001) call the ‘reciprocity’ and ‘rhythm’ of collaborative interactions between mobile workers and colleagues. Reliable rhythms, they argue, are necessary to establish for ongoing collaboration to work effectively. The breakdown in the reliability caused by the particular difficulties of mobile work and technological problems they observed can lead to the subsequent abandonment of particular communication and collaboration media for mobile workers. In relation to these issues, their fieldwork also points to the problems caused by the functional asymmetries between devices that purport to allow access anytime, anywhere. For example, they talk about access asymmetries between emails sent from a desktop machine to a mobile device. The mobile device was restricted in terms of its ability to view attachments as well as its ability to have access to the embedded hyperlink URLs. Sender expectations were such that the email had been read with all the same levels of access available at the desktop. This not being the case there were mismatches in rhythm expectations leading to problems in ongoing collaborative activity.

A core component of mobile work is travelling. Wiberg and Ljungberg’s (1999) ethnographic study of mobile telecommunication engineers in Sweden examined how the work they did was dependent on both time and place. Their results show that travelling could not easily be avoided because of the places that they had to visit physically, such as telephone poles, network routers, locations where new cables needed to be drawn, as well as customers’ homes and non-mobile customers. The timeframe that the work had to be conducted in was also often not negotiable, as, for example, customer service had to be dealt with within 24 hours or rebooting parts of the telephone network had to be done at night. Another important finding from the study was the problem of knowledge sharing amongst the technicians. Since they worked alone in their cars most of the day, they faced a very real problem of finding out about ongoing developments in other projects. The authors conclude that the practical limitations of the structure of their work made it impossible for the mobile service engineers to conduct knowledge sharing “anytime, anywhere”. Whether this is the case for other types of mobile workers is debatable, but an examination of these issues is long overdue if we are to design really effective mobile technologies.

What we see in these studies is a move toward examining the nature of mobile work. However, this research area is still not populated with a large enough corpus of information to undertake any kind of theory building. The area is further complicated by the increasing adoption of new technologies and organisational work practices. Nevertheless, understanding the nature of the problems that mobile workers face and their artful use of the resources that they have access to *can* provide a rich resource to designers in scoping the design space that they will need to work within. The purpose of the current study is therefore to further understand the nature of mobile work by looking at mobile workers’ activities carried out before, during and after business travel.

Within this study of mobile workers *in situ*, we focus on how these workers manage information through documents and through mobile communication technology.

METHOD

From previous work, such as segmentation studies of mobile professionals (e.g. Ablondi & Elliott, 1993) it is evident there is great diversity in the nature of the work that mobile workers do, their modes of travel, and their document and technology use. We therefore felt it important to recruit a sample of mobile workers that were representative of these differences. To do this, 17 mobile workers from the UK were chosen from a range of different professions. Participants were pre-screened to represent different levels of mobility in terms of typical duration of business trips (overnight, day), distance travelled (e.g. within local area, national, international), type of transport (e.g. plane, train, car) and the extent to which they worked collaboratively. Professions included a variety of management personnel from a range of industries, sales staff, consultants, medical workers, civil servants, and the media. For a summary of the participants, their roles, resources and patterns of mobility, see Table 1.

We were particularly keen to represent frequent air travellers to destinations outside the UK as well as regular road or train travellers moving within the local area and other parts of the country. For this reason, we did not examine working from home (as a form of mobile work). All participants bar three worked in different organisations. The relatively small number of participants selected meant that we could afford to explore the rich details of their activities, using interviews in which they were able to show us the resources that they had described and sometimes even demonstrate their use. The study was not designed to provide a complete survey of mobile behaviour but rather was intended to be interpretive, rather than statistical. Thus we will not discuss statistics or frequency data here, but will examine use-practices and situated activities.

In order to collect rich and detailed information about the interviewees and their work practices, we felt it was important to gather many different kinds of situated data, and to gain our understanding, as far as possible, from observation and interviews in the actual work settings of these individuals. This would involve gathering a comprehensive set of data covering the full range of communication and document activities that these mobile workers were engaged in. Interviews alone will not suffice, as people are necessarily selective in what they describe or think is important to discuss. The solution to this involved using a combination of diary techniques, interviews, and analysis of the artefacts (technologies and documents) used during specific business trips. This grounded the study in real activities and provided a means of unearthing the detailed contextual backdrop of the participants' information and communication activities.

We decided the best way to gather grounded data was to plan our interviews around actual business trips, both before and after these trips. In this way, we hoped to gain a longer term understanding of what happened during travel – from the kinds of preparations made prior to travel, to the minutiae of what actually took place over the whole travel episode. This helped to give a deeper understanding of the context surrounding the mobile workers' activities. Each participant was therefore interviewed twice. To aid the contextual nature of the interview and to support the interpretation of the data, where possible, interviews were conducted in the participants' usual (static, i.e. non-mobile) workspaces; these were located in and around London and Bristol over three months in mid 1999. Approximately 43 hours of interviews was conducted in all; these were tape-recorded and later transcribed. Where appropriate, artefacts were also photographed. A follow-up study was conducted between November 2000 and Feb 2001 to see how patterns of activity had changed in the meantime; this examined another five mobile workers from the same profile in terms of their mobility. This involved a single one and a half hour interview following a business trip (similar to the second interview of the primary study). No major differences were noted in their behaviour and use of technology other than in their increased use of text messaging for personal reasons, most usually for co-ordinating meeting locations and for playful messages. Their data is not included in this report as it did not involve the full interview schedule, and as such they are not directly comparable, although it is interesting to note that after one and a half years, very little has changed in the activity patterns of mobile workers.

A first interview prior to the trip helped to inform us about the context surrounding the mobile workers' activities - why they travelled and what preparations they were making for the trip, who they would be seeing and what they would be taking with them. This was conducted as close as possible prior to the departure date for the next upcoming business trip, in the majority of cases, 2 working days or less before the trip (cancelled trips making up the remainder). The interview was around an hour long, and its purpose was to build up a general background about the nature of the participant's work and their home life. We explicitly asked questions regarding their position and responsibilities in the workplace, who they worked with and the nature and frequency of this collaboration; we then asked for descriptions of 'typical' days, so that we were aware of the difference between their office and travel based activities. We asked further information about the frequency and type of typical travel that they undertook. So that we could understand their information, communicational and technological requirements, we asked about their family and social networks, existing technology infrastructure at home and office and the availability of, and technologies used whilst they were mobile. The participants were then asked questions specifically relating to the upcoming business trip. This included the purpose of the trip, the duration of the trip, where they were going and whom they were expecting to meet. In terms of information and communications activities, we enquired about the kinds of information they were expecting to pick up over the travel episode, the preparations that they would have to perform before travelling, such as planning presentations (e.g. photocopying, MS PowerPoint slide creation), preparing documents to take with them (and why). Finally, we enquired what technologies they would be taking with them (and why). At the end of the interview, the participants were asked to bring any materials (e.g. emails, paper,

and electronic documents) generated or collected while away to the second interview.

A second interview was carried out as soon as possible after the trip (again, for the majority of interviewees, within 2 days of returning) and was based around the schedule of events that had taken place on the trip in terms of their information use and communications activities. This lasted about an hour and a half on average. In this respect, our approach allowed us to ground the study in real activities and to use the trip diaries and existing artefacts to unearth the detailed context of their document and communication. We began the interviews by focusing on an overview of what had happened during the whole trip. The participants were then asked to identify a typical day in the trip to unpack in more detail. This ‘typical’ day was determined in concert with the interviewee: this allowed the participant themselves to highlight the *everyday* nature of their work, rather than the interviewers picking unusual episodes. A schedule was then constructed of this whole day from waking to sleeping, framed in terms of their travel, informational and communications related activities.

The participants brought material that they had generated or collected during the trip to this interview and these were discussed in relation to their activities, goals and motivations. They were asked what they planned to do with these artefacts after returning. This formed the basis for discussing the use and purpose of these artefacts (with respect to their activities, goals and motivations). To support the data collection and its subsequent analysis, during the interviews, a document and communications inventory was taken. The document inventory involved the compilation of a list of the information used by the participant prior to their travel episode, during the diary day, and during the rest of the trip. (e.g. text, document, scribble, sound, scene), how it was acquired or produced, and how it was (or was expected to be) used. For example, this included activities such as reading it, distributing it to another person, storing it for later use, and so on. The communications inventory recorded the communication episodes (for example, phone calls, email, and fax use fax) during the diary day, the purpose and nature of this communication, and subsequent use of information from the communication. The inventories collected in these interviews allowed us to investigate the extent to which documents were used in conjunction with communication episodes in the analysis. In a final set of questions, the participants were asked if they had experienced any particular problems in relation to their document-related and communication activities while travelling – these too were recorded in an inventory.

FINDINGS

Unsurprisingly, there was great diversity in the nature of mobile working by the 17 people in this study and in the ways in which they appropriated the tools they had to hand to accomplish their work. Even the notion of ‘mobile work’ itself was diverse. The participants in this study were mobile in many different ways, echoing the findings of Dahlbom and Ljungberg (1998). They worked at multiple (but stationary) locations, they walked around a central location, they travelled between locations, worked in hotel rooms, worked on moving vehicles, and worked in remote meeting rooms. Participants described their activities involving some or all of these types of “mobile” work, with each having its own particularities, constraints and sets of resources.

Rather than consider each of these kinds of work in turn, we sought to try to identify any common themes or features of behaviour that bound them together. Here we found four sets of key findings about the way in which mobile technologies (both “high tech” devices such as mobile phones, and “low tech” artefacts such as paper) were used by mobile workers to maximise flexibility in their ways of working and access to information while on the move. These issues can be summarised as follows:

- Σ Preparing for a trip and planning for the unpredictable (“planful opportunism”)
- Σ How mobile workers effectively made use of “dead time”
- Σ Use of the mobile phone as a “device proxy”
- Σ Use of technologies for remote awareness monitoring

These four topics explore key notions of resource and task flexibility, how mobile workers make effective use of their time, how they maintain awareness about remote activities, and how they are able to access remote information and devices. While other authors have discussed some of these findings in some form or another, what we attempt to do here is to explore the issues surrounding them. We demonstrate *how* these activities are used in supporting the performance of mobile work and the ways in which they are interdependent and intertwined both with and within other activities. We will consider each key finding in turn in the sections that follow.

Planning Opportunistic Access to Information

As we have indicated, one of the characteristic difficulties of mobile work is that there is less predictability and more restricted access to information and artefacts in the environments encountered. One of the important features of mobile workers then concerns the ways in which they deal with this through planning activities prior to the trip to make sure that they can use the information when and where it is required. One may interpret this as appearing somewhat paradoxical in the sense that planning can be argued to be ill-suited to unpredictable circumstances. However, this would be to overload our use of the word planning. Rather, what we mean is that in order to be able to flexibly adapt to the situation, mobile workers had to be prepared to generate workarounds through *ad hoc* activities developed in concert with the resources that they were able to co-opt at the time. When people know that they are going to encounter situations in which they cannot know exactly what is required of them, they can plan for this by collecting together and carrying particular technologies, documents and resources. We call this ‘*planful opportunism*’,

in contrast to ‘opportunistic planning’ (Hayes Roth and Hayes Roth, 1979) in which people make plans ‘on the hoof’ reacting to circumstances as they are experienced.

This planning activity centred on making sure that documents and information would be available in the appropriate form when and where they would be needed. Much of the trip planning behaviour centred on participants collecting together paper documents in a project, or trip, file. Files on particular topics (for example, client records) were printed out, photocopied or collected from filing cabinets. Having them in paper form allowed them to be collated together in a common format to be taken on a journey and then their contents selected from and configured as the situation at the remote site developed. In a quote from one of the participants, there is a clear requirement to take paper documentation for use in different situations:

“So there’s about a dozen folders in plastic wallets on my desk and I’ll probably be taking about three of them in their current form and probably another one which has sort of components of two or three of those other wallets. So I’m going over with information in my hand...”

The reasons for gathering together paper into a single format file was that paper has important characteristics (e.g. Harper and Sellen, 1995) that make it useful for opportunistic appropriation by the mobile worker in a range of circumstances both predictable and unpredictable. The planned activity and context of use was important in decisions of where, when and how the information was going to be used. For example, in mobile meeting situations, small amounts of paper were portable enough to be taken to the meeting, immediately viewable for *ad hoc* reference and referral as required. This permitted them to distribute the documents among others for use there and then², and afforded a high level of micromobility (Luff and Heath, 1998) within the meeting space that made it a useful conversational resource. Likewise, paper was frequently used for *ad hoc* reading activities, as illustrated by the number of participants who printed documents out or carried paper documents specifically to read if they experienced any spare time and had to work in places where they could not do other types of work (because of a lack of resources). The use of paper was ecologically flexible and thus by choosing it as a medium, the participants knew that it could be accessed in contexts where other technologies would be awkward to use. This ecological flexibility meant that carrying paper was perceived as a reliable option. Paper use was not hindered by the complications of technology infrastructure incompatibility or breakdown, and as such it was sometimes carried as a backup of electronic documents.

Planful opportunism was also seen with digital technologies with some particularly elaborate strategies being employed to ensure that access to the information in different places and different times would be in the appropriate forms for use. As the following extract from a project manager in an e-business department illustrates, these combined media strategies also highlight the kinds of perceived potential breakdowns in the access to and use of information by the mobile worker:

“...I’ll be sending out the slide set which will drive the meeting next Thursday. My feeling is that I’ll have good access to cc mail once I’m over there but I may not access to the other information that is on the shared drive.... I’ll be moving round from one desk to another and that my experience is that I can’t actually log on as myself over in another county because it messes up all the NT settings on the other person’s PC so the best I can do is log on to my cc mail on their PC.... I’ve asked if I can have a lap-top during the week just so that if I do need to any work in the evenings and I have that capability.... What I’ll do is I’ll probably [take] a diskette over with me too with the most important documents and just so that I know that I’ve actually got the information, the electronic information with me. Particularly the slide set you know, the most important documents, I’ll probably take both in paper form and electronically because my design session I’ll want to be using the electronic version rather than the paper version.... I’ve e-mailed myself with all my bookmarks so that if I need to get hold of a URL during the week and I can’t remember was it on e-mail or did I stumble across it or whatever then I can go into just one e-mail message knowing that the attached file contains all my bookmarks.... I even e-mail myself at home as well so that if I need to do any work in the evening then I’ve got the right documents there, electronically sent to me....”

What this example shows is that the level of uncertainty associated with mobile work and the different forms in which information is both delivered and carried to make it accessible in the right form, in the range of places where it will be used, for a range of different tasks. This participant was unsure as to whether he could take a laptop, was unsure about whether there would be sufficient email reliability both in the hotel room and the office he was visiting. What was interesting was that having the ability to send information electronically did not exclude the need to take it on paper.

One of the subjects commented that the laptop and mobile phone provided him with the ability to access unanticipated documents either from the hard drive or via mobile phone connectivity and thereby reduced the need for some of the pre-planning activities. This is indeed an important potential benefit of the mobile technologies and illustrates an interesting relationship between the need for pre-planning and the flexibility provided by mobile technologies. However, what was additionally interesting about this was that in reality, the participant also carried various paper documents, some of which were available electronically on his laptop,

² ‘Permitted’ in the sense that no common technological infrastructure was assumed for exchange, although conversely, they were also restricted because multiple copies might be required for *ad hoc* distribution, in which case paper can be less flexible than electronic documents.

should he have needed them. This also applied to a number of the other participants with laptops. There were various reasons given for this: for example, the possibility that these paper documents would be used as an impromptu conversational resource in meeting situations, or for reading whilst travelling. The point here is that if a document was needed for a discussion it would be to hand in paper form, and paper was regarded as being more appropriate to the context of this unanticipated use.

Planning behaviour, then, was not simply about what documents were needed but also in what form they were needed to allow appropriate access on the trip. Laptops for example did not support the same type of impromptu document access as paper for various reasons despite the fact that in theory they offered the potential flexibility to open unanticipated documents from the hard disk or over a network connection. First, laptops were not generally regarded as ‘casual use or carry devices’³. Impromptu information retrieval via connected laptops was hindered by the fact that laptops themselves were subject to planning decisions about whether or not to be taken. While approximately 70% of the participants had a laptop that they could take with them, only about half of these actually took them on the trips we studied (most of these cases involved an overnight stay). Furthermore, taking a laptop on a trip did not necessarily imply that it would then be subsequently taken into meetings. What is important about this is that this form of laptop carrying behaviour conflicts with its potential use to support *unanticipated* document and communication needs.

Working in Dead Time

While it was possible to talk about the purposes of business trips, the nature of work undertaken during these trips was highly varied. The work carried out cannot be usefully characterised simply in terms of the specific work purposes of the trip, such as the need to meet face to face with a client to discuss something. To do so would be to ignore the large amounts of time outside the scheduled activities of a trip characterising much of business travel. This time was described by participants as “dead” time, “travel” time, “spare” time or “wasted” time. The common factor was that this time occurred between tasks and between meetings, usually in which the participants had little control over the resources they had to hand. Work in this ‘dead time’ would take place in a variety of locations (e.g. cars, trains, buses, aeroplanes, hotel rooms, airports and office buildings), each placing a range of different constraints on the information artefacts that could be used and the kind of work that could therefore be done. Examples of this included time spent in transit, or waiting for travel, such as in airport lounges or railway stations. Where the participants knew that they would have periods of dead time to fill, they would often plan ahead to make good use of it:

“On a completely dead day like I had on Wednesday, I can check some Voice mail, check some e-mail but otherwise have an uninterrupted, quiet day in my hotel room. I can just focus. I spent a lot of time sorting loads of notes in my bag. Sorting it in to stuff I could file. This was stuff I had taken away with me. Before I left I knew the Wednesday was going to be clear so my briefcase was full of all these notes I had accumulated and never prioritised the time in order to rationalise them and get them sorted.”

In addition, many of the business trips described by the study participants were characterised by multiple meetings or activities that were scheduled to exploit the fact of being in a particular location or within the vicinity (saving time, money and effort). The accounts manager for the brewery, for example, had a management meeting one day, and decided to stay overnight rather than return home because she had a training meeting next day in the same part of the country. This need for her to stay overnight created a period of dead time in the evening. Likewise, many of the overseas trips were characterised by multiple meetings spread over several days (to take advantage of having travelled that distance) with long periods of time between meetings.

The need to work in dead time was recognised as being increasingly important for those engaged in mobile work to help manage the build-up of tasks that occurs while they are mobile. If the workers wait until they return to complete these tasks, they will have a heavy backlog of work to catch up with. Working in dead time allows them to distribute some of this build-up of workload over the time spent away from the office:

“It’s convenience, to keep on top of it, because if you don’t, it will be full and be completely out of control by the time you come back... Travelling is just part of the job as opposed to a rare event. I’m travelling 2 or 3 times a month so it’s part of the job. Staying in touch is important, both from a management of the workload perspective, to make sure there’s not this enormous pile, and secondly to be in touch if there is anything that comes up that needs a quick response.”

From a design perspective, being explicit about how dead time is used is important because it appears to be a key element of mobile work with its own distinct characteristics. For example, it is very different from the kinds of activities and contexts in which the more scheduled, face-to-face activities occur during business travel. This can have implications for understanding the different levels of information access that are required or possible in particular situations and places where the mobile worker finds they have some dead time. For example, for those participants who spent time in cars, the only real work that was possible was based around the use of the mobile phone, hands-free or otherwise. Access to information and documents in these instances is

³ The level of casualness varied among participants. One of the subjects, for example, who had a laptop and a mobile phone, downloaded his email at the airport while waiting for his flight.

not limited just by technology but by the limitations of human information processing (cognitive loading, attention, memory, etc.) and the physical inability to read and process document-related information while driving.

The exact form that dead time takes for mobile workers can be difficult to characterise because of the range of circumstances under which it occurs. There is a huge variety for example in the different time scales involved with certain types of dead time. For example, the time period of a break in a meeting is different from the time spent in a hotel room, and the utilisation of time in a particular situation requires a particular resource and technology set. Taking advantage of short time periods between meetings or during meeting breaks was conducive to doing work such as making a phone call or checking voice mail on the mobile phone. Here we found that activities were rarely organised according to priority or urgency. Rather, work was organised according to the context where dead time was experienced and the resources available to hand, such as mobile technologies and artefacts, the work being 'fitted in' as, and when, it could be done. The ecological flexibility of a technology was therefore an important part of this type of activity, the mobile phone and paper being particularly useful in supporting this kind of work in giving access to a variety of resources. As one of the participants discussed in their use of the mobile phone to access voicemail:

"It's more accessible because you can do it from far more places geographically than you can e-mail - car, airport lounges, home, as opposed to which e-mail needs to be in the office most of the time. It's also quicker both to connect and to listen to and to respond to."

When time permitted, a few of the participants who used laptops would also use them during this dead time for checking their email or, very occasionally, creating new documents. As the following example illustrates, a participant took advantage of the fact that there was a delay with his flight that provided him with an appropriate length of time to engage in some 'email activity'. What is interesting to this discussion is the way that this was done: he had utilised a period of dead time in the hotel room to access his email, downloading it to his laptop - but not reading it. This allowed him the flexibility to exploit the delay time at the airport by providing immediate access to read and write responses to these emails.

"Called to see if I could get hold of my wife to say hello, wasn't there, left a message on voice mail and then headed off to LA and sure enough the flight was delayed so sat in the airport and worked and got through some of those e-mails that had been piling up that I hadn't been able to get to....Just basically took my laptop out."

Other types of dead time were less constrained by time availability and more by the environment, in terms of physical and network resource availability. For example, dead time on the plane was often utilised by participants to read paper documents. This was partly because of the ease of use of paper (as noted above), but also because many of the participants liked to use (and planned for) this uninterrupted time for a certain type of quiet, reflective reading and annotation. In addition, the constraints on the space available can impact on the type of work that can be done to make use of this time and therefore the level of document access that was required. For one of the participants, the work that he would do with a laptop would generally require access to other documents to view and refer to them while manipulating an electronic document on the laptop. The fact that he could not use his laptop and simultaneously access documents from his briefcase meant that he had to restrict this work in dead time to reading paper documents:

"I read a few things on the plane. I don't use laptop on plane. In the back of the plane there is not enough room to use a laptop and have access to your briefcase."

The notion of dead time is a problematic one and is difficult to pin down. We have made use of it because it is analytically useful, but also because it was a frequently used category by the participants themselves. What makes it hard to define is its fragility: mobile workers actually make use of this time, so it is not strictly unusable in terms of the actions that can be conducted within it. Rather, when they expect to spend a period of time out of communications or without the full set of resources to do the work that they would ordinarily have, the participants made use of devices and preparation strategies to (at least partially) revive this time. In practice, however, we found dead time was rarely used as efficiently as it could be. Here then lies a challenge for developers: to design devices and services to allow mobile workers to make full use of dead time taking into account the diversity of environments in which it occurs and the paucity of resources often available.

Phone as a Device Proxy

One of the main uncertainties that emerged in the mobile work we studied was when and where people would have access to technologies and documents necessary to do particular aspects of their work (for example, a fax machine or an email connection). As it happened, helping to deal with or work around these uncertainties turned out to be a key value of the mobile phone. The flexibility of the mobile phone (in terms of where it could be used and its use in problem solving discussions) allowed participants to be able to access equipment and documents back home or at another location *by proxy*. For example, one of the participants was in his car where he had an hour of dead time available. He therefore made a phone call to a customer using his mobile about some equipment for he was trying to sell. While he was able to give them enough overview information to get them interested, the customer wanted full written details to peruse before they would commit to buying. Here, the phone call was not sufficient in itself

to make the sale because the customer needed time to look through the details more closely and in his own time. There was therefore a need to support the verbal communication with some form of paper-based visual information to meet the customer's needs. The solution to this was to fax this information to the customer in support of the phone call. However, the participant did not have access to a fax in the car and nor did he have access to the information in a document at hand. He therefore made a call on his mobile phone to his office requesting that they find the necessary document and fax the full details to the customer.

This example is interesting because the participant did not have access (in the sense of being able to forward the information on to the client) to the information necessary to complete the demands of the phone call. Predicting the need for taking the document was not possible because of the ad hoc nature of the phone call during what was otherwise dead time in the car. As such, not only was the technology not available to send the fax but neither was the document. So while a mobile faxing device could have been useful in situations like these, this must be interpreted within the context that the mobile worker will often not have the information they want to be able to compose the fax.

Other examples of the use of the phone as a device proxy include it being used to dictate letters and to access and respond to emails:

"... I could ring up the office normally and speak to my secretary, she does shorthand and she can type it as quick as I can say over my mobile 'phone, you know, letter to so and so, really urgent, must go out, dear Mr so and so reference our conversation, I have pleasure in quoting you for this blah, blah, blah, that's the price Linda, you know, and she'll end and whatever It, and I'll say nip in my drawer and get the technical information, get it in the post this afternoon, he's really chasing it. You know, that sort of thing happens but I can do that on the 'phone. I can do most things verbally."

In another instance, one participant had phoned his office when he was unable to connect remotely to get someone there to log into his email account and read aloud any emails that he had received. He then dictated his replies over the phone and they typed this up and sent it off as an email. However, although the telephone can act as a device proxy, it is not always the ideal task for the job:

"...I mean I use a mobile telephone probably because I haven't got a mobile fax, it would be nicer for me because I find myself ringing up one person in the office and I might ring him up ten minutes later to say I'd forgotten something so if I could sort of you know during the day jot down everything I had to tell one person in the office and send off a fax then you've also got the written record and so it's safer."

Whilst it may not be the perfect tool, the phone allows the mobile worker to achieve their important goals without having to place a high degree of effort in locating or carrying around specialised information or communication appliances with them. In this respect, the mobile phone provides a workaround to help reconstitute some of the resources normally available to the office worker in a flexible manner as and when the needs arise, by allowing their operation from a remote location, if not by directly operating them remotely. The mobile workers therefore do not need to carry their offices with them, but do carry the means by which they can access (at least a degree of) their functionality.

Remote Awareness Monitoring and Access to Colleagues

Maintaining informal awareness of what is going on in the office and building a sense of community are important features of work. Evidence of this is seen in the workplace design literature (e.g. Tanis and Duffy, 1999) and in studies of informal communication (Heath and Luff, 1991; Whittaker *et al.* 1994). In the office, information that may or may not be useful to the worker is picked up incidentally throughout the course of a normal work day, through, for example, bumping into people in the corridor or being interrupted by someone needing to speak to you.

One of the problems faced by mobile workers away from the office is how to maintain this informal awareness of what is going on back in the office and also how to maintain a sense of community at work. Mobile technologies can potentially help to support these aspects of work. In the study we saw some evidence of this. For those who took laptops on business travel, these workers were able to maintain some sense of connectivity with the workplace through email. However, email activity was typically performed at the end of the day in a hotel room, when there was time to download it, and when network access was available.

Use of the laptop (and thus access to email) was also much more infrequent than that of the mobile phone. For many of the study participants, the inability to access email anytime and thus maintain a connection to their offices was partially ameliorated by using their mobile telephones to 'touch base', and keep 'up-to-date' with developments at work whilst away. They found it useful to phone the office "just in case" anything urgent arose so that they could monitor developments. They also used the mobile telephone to keep abreast of general contextual issues that could impact on their understanding of situations and therefore, on their job. This was important not just for dealing with issues whilst away, but also to help with the catch-up period on returning to the office.

In practice, obtaining this information was not always a matter of urgency, and it was performed at convenient points during the day to support their awareness of what was going on at the periphery of their current tasks. The kind of information they required

was not something that could be easily specified and was not predictable in terms of what they needed it for and when. Such demands were met by the synchronicity of the phone communication - adding to the value and consequent ubiquity of mobile phone use within the mobile worker community. These types of phone calls also tended to have an element of social banter associated with them that helped to maintain the social connection at work while away from the office:

“We’ve always had a habit keeping ourselves, keeping one another up to date as the day goes on...if he’s down in London I would say you know OK we’ve had a brilliant day or we’ve had a bad day you know we’ve just got a habit of doing that...sometimes it’s just social banter you know: he’d say he had a good day, he had a bad day that type of thing, and by the way I bumped into so and so, do you remember him you know we saw his project a year ago when it crashed, you know ooh wasn’t it good you know just that type of thing. He rang me a couple of times just to say yes that order he had expected to come off had happened or it hasn’t.”

In terms of being called, as opposed to calling out, the mobile phone also worked as a personal locator – a continuous contact point for communications that was equally important in keeping the mobile worker informed of general information or unpredictably important information as it arose throughout the day.

DISCUSSION

Whilst we have focused on mobile work as a phenomenon in its own right, we do not argue that it is the mobility, per se, that motivates much of what mobile workers do. Rather, the evidence suggests that much of what determines their activities can be explained in terms of the limited resources they often have available to accomplish their work, as well as the ways in which these resources change depending on the context of their work. Taking this as a starting point, we can begin to see how activities are related to the different settings that mobile work occurs in – when travelling, in meetings, between offices, and so on. We can also begin to see how the uncertainty about what resources will be available, and what contexts mobile workers will find themselves in, determines their activities.

For example, some of the strategies we saw our mobile workers engage in centred on ways of ensuring flexibility and adaptability in their work practices, such as planful opportunism and the use of versatile artefacts such as paper and mobile phones. The need to support this flexibility is why the notion of *access, anytime, anywhere* has become such an important mantra in the development of mobile technologies. When thinking about design issues in relation to mobile technologies, however, the terms are too abstract to be useful as a resource for guiding design as they stand. To be truly useful it is necessary to use empirical findings (such as those presented in this paper) to unpack exactly what these terms mean.

Information “access” is not simply about having the capability to pull the appropriate document across a network. From the perspective of the mobile worker, the notion of access needs to be extended to include *how* the document is used and whether it is in the appropriate form to be viewed and interacted with. As an illustrative example, connected laptops allow “access” to documents in that they allow the mobile worker to pull documents over a network. However, for certain tasks, such as reading and understanding long documents, the laptop may be an inappropriate medium. In this sense, access to the document is inappropriate in that it fails to support the same kinds of interaction or “getting to grips” with a document that can be achieved with paper (O’Hara and Sellen, 1997). This issue of restricted access starts to become even more important when considering the emergence of PDA and phone-based data and document access facilities using the Internet that offer immediate, but even more constrained viewing facilities than a laptop. There will be situations where these handheld devices are fine for the purpose of exchanging documents with other handheld appliances, but without appropriate devices to support viewing (such as a display or a printer), they offer limited access for practical use. The point here is not to criticise the utility of these devices, for they clearly offer the mobile worker increased informational access and flexibility, but to illustrate where they may not offer the idealised level of “access anytime, anywhere” initially promised.

In terms of “anytime” access there are also important distinctions from the users’ perspective that are highlighted by findings from the study. Consider for example, when a mobile worker is in a meeting and needs a document as an object to refer to in a conversation. The moment of need for that document is only short lived, creating a small window of time within which access is appropriate. In these circumstances, the time costs of accessing the document over a network for example would be of the wrong order of magnitude necessary for the demands of the social situation. So while from a technological perspective it is possible to access the document anytime, from the perspective of the mobile worker there are practical limitations on this. Further examples of distinctive notions of “anytime” can be seen in some of the communication practices found in the data. Mobile workers were able to use small amounts of time between meetings to make phone calls or access voicemail and respond accordingly. Compare this to the email communication while mobile, which was typically checked and responded at the end of the day, due in part, to time and effort costs. From the perspective of the mobile user, both of these mobile communication technologies operate at different orders of magnitude of time. That is, use of a mobile phone was possible during smaller units of time – it could therefore be used whenever a small unit of time was available. The activity of downloading and checking email with a laptop however, would take up longer units of time. Therefore as an activity, it could typically only be carried out when such larger units of time was available – which was obviously less frequent. As a consequence of operating at these different orders of time magnitude, these different communication devices provide different values to their users.

The understanding of ‘time’ in the term ‘anytime’ can be further complicated by what Jauréguiberry (2000) has described as ‘simultaneity’: the superimposition of activities on top of one another, so that multiple activities can be performed at the *same* time. This can be seen in the simple example of someone both performing the activity of driving and also using the mobile telephone to communicate with a distant other; this would not have been possible prior to the introduction of a mobile, single-hand-use telephone. Here, “One is not substituting one activity for another, or dealing with a task more quickly” (ibid. p. 257), and this complicates the rather simplistic notion of being able to work *anytime*. This layering of work on top of other work and intertwined with that other work (driving to a meeting and simultaneously arranging its location) means that technology designs based around the one dimensional notion of *anytime* will not be focused on the very work that the designers are attempting to support.

Whilst time and place are in many ways inextricably linked, it is nevertheless useful to unpack the notion of “anyplace” in itself. Places can be described at many levels of granularity that are each important from the perspective of portable technologies and artefacts. For example, sometimes laptops were transported from city to city but not necessarily carried from meeting to meeting at the same place. Likewise, large briefcases full of client files were easily transported from city to city in a car but it would be inappropriate to take them all into a meeting. The physical form factors of these objects do not facilitate “casual” carrying. This prevents them being ubiquitously available to the mobile worker anywhere, so that their use is limited in unexpected circumstances. Further, within a meeting room there are finer levels of granularity with regards to place in terms of how documents and artefacts are moved around in support of conversation (cf. Luff and Heath’s (1998) notion of micro-mobility).

There are other findings in the data that illustrate additional distinctions between place for the mobile worker in relation to infrastructure issues. Consider, for example, one of the study participants who sent files to both personal and work email addresses because each was easier to access from either a hotel or their office respectively. Firewalls complicated the methods of access to email outside the office that was being visited, increasing the potential for access difficulties from the hotel. The personal email address therefore provided the easiest solution for accessing the information from the hotel for this participant.

These distinctions in the meanings of these terms have particular importance when we consider that mobile work is not just about the primary purpose of the trip (e.g. a meeting) but also the related dead time activities. The depiction of dead time in the findings points to different forms of access that are required by the mobile worker and which occur over a variety of times and places. A range of resources and strategies are used by the mobile worker to achieve different types of information access according to the constraints of where they are and time availability. Understanding the values of new and emerging technologies is partly dependent on understanding how they are co-opted by mobile workers during dead time. For example, understanding the different levels of access to a document for a particular dead time activity can explain why that document is taken on a trip in a particular medium or gathered on a trip in a particular medium. A mobile worker may choose to gather a document from a meeting in paper form so that it can be read and contemplated during the time spent on the journey home. Alternatively an electronic copy may be gathered to allow manipulation of the document in the hotel room for later use in a trip report or presentation.

Perhaps one of the perhaps most interesting findings of the study is how mobile workers use other remote co-workers to access information and devices. Work becomes explicitly collaborative as the mobile worker attempts to co-ordinate events in their local environment with remotely accessed resources. Talk is central to the mobile work described, and the telephone is the key technology that supports this. Data enabled mobile devices and miniaturised desktop technologies may not by themselves create more effective mobile workers. Unlike the futuristic expectations of a ‘road warrior’ carrying a range of technologies around with them, we see a leaner individual, more adaptable to the changing circumstances that they encounter, and using their skills at manipulating the environment and collaborating with others to carry out their work. As we have seen in this study, mobile workers frequently make use of the flexibility built into the technology to do things that they were not explicitly designed for. Perhaps, as designers, we should be designing tools that can be co-opted flexibly to meet the unexpected contingencies of mobile work. This ‘designing for unexpected use’ is not a novel idea (Robinson, 1993), but in a development environment in which targeted mobile device functionality is accelerating, we need to reconsider the benefits that such technologies bring to the work.

In terms of direct implications for the design of technology, this study has the potential to inform the development of a number of possible avenues. The technologies that would have supported the behaviour of several of the mobile workers that we interviewed would have:

- ∑ Been lightweight, highly flexible technologies, rather than highly specific, integrated systems. Technologies that could be adapted to use in a variety of situations would have been more useful than highly complex and powerful but single use devices. There is a clear demand by the participants for tailorability in the information and device sets that they carry around with them, chosen to match the requirements and particularities of the travel episode;
- ∑ Allowed more effective planning of activities or flexible allocation of resources. Technologies such as shared group calendars that could be accessed and updated remotely would have been useful in that it would have allowed them to co-ordinate their availability when mobile with other people from their organisation;
- ∑ Supported the effective use of dead time to plan for the upcoming mobile activities and to catch up with non-mobile-

related work. An important issue in respect of dead time is that it often takes place (although not always) in short periods of time snatched when available, making a requirement for 'instant on' type devices that do not require lengthy boot-up times. Much dead time is also only available when the mobile workers are engaged in other activities conducted at the same time (e.g. driving), and the cognitive and physical demands need to be minimised: the use of voice (for information access and data entry) in these environments would be particularly useful because of low demands on the user's visual attention;

- Σ Allowed the location, use of and access to locally available resources (e.g. through Bluetooth). This might involve a system through which local technologies could be 'captured' by a mobile telephone or mobile data device, to print, scan, and otherwise access or make available information from a remote source (perhaps paid for through the use of some kind of micro-payment); and
- Σ Allowed the monitoring of remote activities more easily, perhaps through the use of radio, or reduced bandwidth mobile voice over IP ('VoIPoMo'), carrying sounds from the office or relevant announcements (over GPRS or another 3G system; see also Mynatt, *et al.*'s [1998] "Audio aura"), or the use of subscriptions to text-based office information (see for example, Fitzpatrick *et al.*'s Elvin [1999]), broadcast over WAP, or SMS / text messaging.

The data show a demand for immediate and easily accessible information, and there are obvious links here with the high bandwidth, 'always on' technologies of GPRS (General Packet Radio Service), and 3G (3rd Generation) data telecommunications technology. However, much of the material that the participants required was already available to them (albeit non-optimally for their task and requiring some effort to access and transform it into a useful form) through social networking and the use of the telephone. How much users, or businesses, would pay to access additional information on top of what they were already able to access is, of course another question, but the additional utility that they would have benefited from having them is also questionable. In many cases, the workarounds that the participants employed when they needed information appeared to be acceptable to them in the performance of their work, with minimal weight and size overheads, and at the same time flexible enough to be useful in a range of different situations.

CONCLUSION

Whilst there are some more obvious solutions for the design of technology, the point of this discussion has not been to advocate particular design implications for particular devices. Rather the aim is to encourage reflection about work and technology from the perspective of what kinds of resources mobile workers need access to, and how those needs change depending on where they are, the time they have available, and what they are doing. For example, looking at these different issues can help us understand why paper continues to play such a key role in mobile work in terms of the type of access it supports across a wide range of timescales and places, but also where some of its drawbacks lie in terms of access across distance. Similarly, it can help understand what has made the mobile phone so important in terms of different levels of time and place and its ability to mimic different levels of access by proxy. Understanding the kinds of access the mobile phone does not support, such as visualising information can help inform judgements about the potential range of new data and document services emerging. It can also help us think about what might be required of a wider ecology of technology appliances to support these documents and data services, such as ubiquitous displays and printer technology for viewing information provided by these document and data services.

In addition to this analysis, the paper also highlights the *mechanisms* by which the mobile workers organise their actions, both as individuals and to co-ordinate their activities with others. In many ways, it is not simply interesting to note that various artefacts played into different activities, but it is especially useful to know *how* they were used in the organisation of their work. In particular, we can see both the mobile aspects of the work, and how the 'everyday' or non-mobile aspects of people's work intrude into the mobile component of their work. The two appear indivisible, and technology that only supports the mobile component of mobile work will not support a large component of its users needs.

In this paper we have illustrated some of the unique characteristics of mobile work in terms of the unpredictability and uncertainties associated with it. A key feature of mobile work lies in the strategies that are used to create the necessary flexibility and adaptability to operate within the context of the uncertainties that mobile workers face. Understanding these strategies and their underlying motivations is dependent on more than simply saying they want access to information anytime anywhere. What we hope to have shown is that only by unpacking these terms more systematically from the perspective of the user can we begin to understand the role of certain key technologies and artefacts in mobile work and where potential opportunities may exist for new mobile technologies and services.

ACKNOWLEDGMENTS

The authors would like to thank the study participants for generously giving their time and effort in this study. We would also like to thank Francis Djabri and Lauren Peacock for their help in conducting the second set of follow-up interviews, and Jackie Brodie in reviewing the manuscript.

REFERENCES

- Ablondi W.F. & Elliott T.R. (1993) *Mobile professional segmentation study*. BIS Strategic Decisions.
- Bellotti, V. & Bly, S. (1996) Walking away from the desktop computer: distributed collaboration and mobility in a product design team. In *CSCW 96: Proceedings of the Conference on Computer-Supported Cooperative Work*, September 17-20, Boston, Mass.: ACM Press. p. 209-218.
- Bergqvist, J., Dahlberg, P., Ljungberg, F. and Kristoffersen, S. (1999) Moving out of the Meeting Room: Exploring support for mobile meetings. In *CSCW'99: Proceedings of the Conference on Computer Supported Cooperative Work*, 12-16 September 1999, Copenhagen, Denmark, p. 81-98, New York: ACM Press.
- Churchill, E. F. and Wakeford, N. (2001) Framing Mobile Collaboration and Mobile Technologies. In Brown, B., Green, N., and Harper, R. (Eds) *Wireless world: social and interactional implications of wireless technology*. Springer Verlag.
- Dahlbom, B. and Ljungberg, F. (1998). Mobile Informatics. *Scandinavian Journal of Information Systems*, vol 10 (1,2), p. 227-234.
- Eldridge, N. Lamming, M, Flynn, M. Jones, C. Pendlebury, D. (2000) Studies of Mobile Document Work and Their Contributions to the Satchel Project. In *Personal Technologies, Special Issue on HCI and Mobile Devices*, 4 (2&3), p. 102-112.
- Fitzpatrick, G., Mansfield, T., Kaplan, S., Arnold, D., Phelps, T. and Segal, B. (1999) Augmenting the everyday world with Elvin. In *Proceedings of the 6th European Conference on Computer Supported Cooperative Work*. Eds. Bødker, Kyng and Schmidt. 12-16 September, Copenhagen, Denmark, p. 431-450. Kluwer: Netherlands.
- Hayes-Roth, B. and Hayes-Roth, F. (1979) A Cognitive Model of Planning. *Cognitive Science*, **3**, 275-310.
- Harper, R. and Sellen, A. (1995) Collaborative Tools and Practicalities of Professional Work at the International Monetary Fund. In *Proceedings of CHI '95 Conference on Human Factors in Computing Systems, Vancouver*, p. 122-129. New York: ACM Press.
- Heath, C. & Luff, P. (1991) Collaborative activity and technological design: task coordination in London Underground control rooms. In *Proceedings of the 2nd European Conference on Computer Supported Cooperative Work*, September 25-27, Amsterdam, The Netherlands, p. 65-80. Eds. Bannon, Robinson & Schmidt. Kluwer: Netherlands.
- Henning, J. and Bragen, M. (1994) *Mobile Professionals in Focus*. BIS Strategic Decisions, Norwell, MA.
- Jauréguiberry, F. (2000) Mobile telecommunications and the management of time. *Social Science Information (Information sur les Sciences Sociales)*, 39 (2), 255-268.
- Kristoffersen, S. and F. Ljungberg. (1999) Making Place to Make IT Work: Empirical Explorations of HCI for Mobile CSCW. In *GROUP'99: Proceedings of the international ACM SIGGROUP conference on supporting group work*, November 14-17, Phoenix, AZ, p., 276-285. New York: ACM Press.
- Lamming, M., Eldridge, M., Flynn, M., Jones, C., & Pendlebury, D. (2000) Satchel: Providing access to any document, any time, anywhere. *ACM Transactions on Computer-Human Interaction*, 7(3), Special Issues entitled "Beyond the Workstation: Human Interaction with mobile Systems, p. 322 – 352.
- Luff, P., Heath, C. and Greatbatch, D. (1992) Tasks in Interaction: Paper and Screen based documentation in collaborative activity. In *Proceedings of CSCW '92 '98: Conference on Computer-Supported Cooperative Work*, Toronto, Canada, p. 163-170. New York: ACM Press.
- Luff, P., Heath, C. (1998) Mobility in Collaboration. In *Proceedings of CSCW '98: Conference on Computer-Supported Cooperative Work*. ACM Press, 305-314.
- Mynatt, E.D., Back, M., Want, R., Baer, M. and Ellis, J.B. (1998) Designing audio aura. In *Proceedings of CHI '98 Conference on Human Factors in Computing Systems*, Los Angeles, CA: ACM Press, p. 566-573.
- O'Hara, K., Perry, M., Sellen, A.J. and Brown, B.A.T. (2001) Exploring the relationship between mobile phone and document use during business travel. In Brown, B., Green, N., Harper, R. (Eds) *Wireless World: social and interactional implications of wireless technology*. Springer Verlag.
- O'Hara, K. and Sellen, A.J. (1997). A Comparison of Reading Paper and On-line Documents. In *Proceedings of CHI '97, Conference on Human Factors in Computing Systems*, Atlanta, GA, p. 335-342. New York: ACM Press.

Robinson, M. (1993) Design for unanticipated use..... *Proceedings of the third European Conference on Computer-Supported Cooperative Work*. Eds, De Michaelis, Simone & Schmidt. September 13-17, Milan, Italy, p. 187-202. Kluwer: Netherlands.

Sellen, A. and Harper, R. (1997) Paper as an analytic resource for the design of new technologies. *CHI'97: Proceedings of the Conference on Human Factors in Computing Systems*, 131-137. New York: ACM Press.

Tanis, J. and Duffy, F. (1999) A Vision of the New Workplace revisited. In *Site Selection, September , 1999*.

Whittaker, S., Frohlich, D. and Daly-Jones, O. (1994) Informal workplace communication: What is it like and how might we support it? In *Proceedings of CHI 94: Conference on Human Factors In Computing Systems*. New York: ACM Press, 131-137.

Wiberg, M. and F. Ljungberg (1999) Exploring the vision of anytime, anywhere in the context of mobile work. In *Knowledge Management and Virtual Organizations*, ed. Yogesh Malhotra. Idea Group Publishing.