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Mobile Eye-phone – a study of relevance, effectiveness and user-perceived suitability

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Abstract

Videotelephony for blind people may sound as a contradiction in terms. However, when the service is based on two-way audio and one-way video from a blind or visually impaired person to a stationary service operator, a new and important communication service may have been born. This report describes the background to the service concept, two longitudinal studies of mobile Eye-phone use, five in-depth tests of mobile Eye-phone use with blind persons and supplementary tests with variations of QoS (Quality of Service). Requirements and considerations are discussed for the service, the terminal and the network and the report concludes that there is a real need for an Eye-phone service.

Contents

Executive summary

The mobile Eye-phone service concept is the use of remote inspection equipment by blind and visually impaired people in order to communicate with a sighted distant operator via a one-way video and two-way audio link. The operator can describe what the camera points at and help in reading what is written on a ticket, finding something lost or just describing the view.

In Norway there are about 90,000 totally blind or visually impaired people. A pre-project study has indicated that the potential user group of mobile Eye-phone would be about 9,000 people.

It was also identified that the service would be used to find the destination on a walking tour, help lost persons to navigate, guide in the use of public transportation, help browse and overview complicated scenes such as a lunch table, find a specific device like a ticket queuing machine as well as to aid reading all kinds of text.

These early data were used as input to more in-depth field studies that provided more details of the users' needs and derived requirements and considerations for the mobile Eye-phone service, the user terminal and the network.

This report describes the usage of specially developed test equipment with high quality video used on two trips, one work-related and one pleasure trip. A different participant took part in each trip. These studies showed how and in which situations the mobile Eye-phone could be used. The table below shows the classification of interaction pattern (Table 4).

Table 1 Classification of Eye-phone usage with examples

		Purpose of call		
		Verify	**Search**	**Observe**
Spontaneity of call	**Spontaneous**	*"Wasn't my room number 1012? I have to check."*	*"So now I have arrived here, but where is the exit?"*	*"How is my child enjoying herself?"*
	Planned	No example identified.	*"I've arrived as planned by bus, please direct me to the underground station"*	No example identified.

The trip-oriented field studies identified a high degree of spontaneity of calls that could not wait long before being served. This has implications on the organisation of the mobile Eye-phone service that should enable priority for spontaneous calls.

In addition, an in-depth study was performed of the five main usage situations identified in order to check out relevance, success rate and user satisfaction. The study involved 10 blind or severely visually impaired persons in addition to the service operator. In 98-99 % of approximately 150 tests, only two tests were not successfully completed. Both incompleted tasks were concerned with finding a lost item. A subjective rating of user satisfaction provided an overall mean score of 8 with 0 as the poorest and 9 as the maximum score of "extremely satisfied".

Two unique situations were identified from the in-depth study where there were the strongest demands on video quality. For these two situations the video quality was reduced until it was judged that those tasks could not be done with the same speed and accuracy. It was found that the audio quality should be at least the quality provided by GSM. For the video quality as judged at the operator's end, the exposure and focus should be correct with at least CIF (352x288 pixels) and at least 15 frames per second.

The map positioning of the user was expressed to be of great help for the operator in addition to other aids that could be extracted from the Internet (e.g. public transport timetables) for solving the task rapidly.

It is concluded that there is a need for such a service but that it can be problematic to find the terminal for those networks available during 2004. It is believed that within the next 1-5 years there will be terminals and networks that support the service.

1 Introduction

1.1 What is a Mobile Eye-phone?

Videotelephony for blind persons may sound as a contradiction. However, when the service is based on two-way audio and one-way video from a blind or visually impaired person to a service operator, a new and important communication service may have been born. With the help of persons who can see and act as guides, visually impaired persons could obtain information on what is present in their surroundings.

The "Eye-phone" concept is a complete system combining a videophone with a sighted service operator located in a service centre.

The videophone used by the visually impaired persons could either be a stationary or mobile device. This report is concerned with the mobile eye-phone and not a stationary eye-phone. A separate report concerning development of a stationary Eye-phone is available as (Lunde 2004).

The terminal for the visually impaired person could be a 3G terminal, such as the Nokia videophone, of which there are many candidates on the market (see Figure 1 left) or a wearable computer such as the VisiWear terminal (see Figure 1 right). The operator's terminal could either be a TV for video and a desktop PC for other information or only one (desktop) PC that also includes a video window. The operator service centre will be stationary in Mosjøen.

Figure 1 Left: Nokia's implementation as a mobile (video)phone. Right: VisiWear's implementation as a wearable computer

1.1.1 The test terminal

For the tests described in this report a specially designed wearable computer was used that provided a two-way audio-link and one-way video. The whole unit was attached to a belt that also had two bags for carrying the camera and the headphones when not in use. The wearable computer had a 600 MHz processor with Wireless Local Area network (WLAN) connection able to transmit CIF-information (Common Intermediate Format, 352x288 pixels) with a frame rate of 25 fps from the hand-held camera. The audio system had normal quality sound in the telephony frequency range of 300-3400 kHz. The appearance of the videophone when worn by a person is shown in

Figure 2 (left).

The service centre operator had a laptop with the screen displaying the video image from the test person. A second map window provided an additional option to determine the location of the Eye-phone user

Figure 2 (centre).

Because no network existed that could be used for the tests, the operator had to follow the mobile eye-phone user and test team in a peer-to-peer LAN set-up, typically up to 20-50 metres away. The operator was instructed not to reveal other information than he could see on his terminal. The operator's laptop was supported by shoulder straps at all times and a tripod if desired when stationary (Figure 2 right). A curtain-system ensured suitable legibility of the monitor in bright environments (Figure 3).

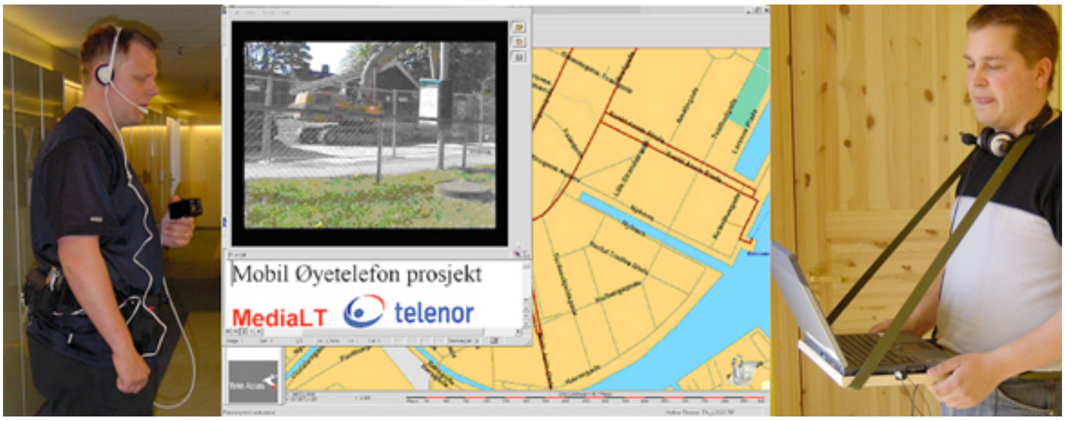

Figure 2 Left: Test person with his terminal, middle: Service centre operator's view of monitor, right: Service centre operator with his test terminal

Figure 3 The service centre operator with a curtain-system to protect against light and wet weather

1.2 New wireless and mobile networks

Jacobsen et al. (Jacobsen, 2002) have surveyed foreseeable future candidates for mobile networks and comprehensively included network fragments to full monolithic mobile networks. As mobile networks are access networks to the fixed global core network, the study concentrated on the mobile access network technologies. They divided the technologies into the following categories:

- *GSM* contains standard GSM, as well as high-speed circuit switched data (HSCSD), and the packet data extensions General Packet Radio Service (GPRS) and Enhanced Data for Global Evolution (EDGE).
- *UMTS* contains both Frequency Division Duplex (FDD) and Time Division Duplex (TDD), as well as the standard for asymmetric High-Speed Downlink Packet Access (HSDPA).
- *WLAN (Wireless Local Area Networks)* contains the two IEEE802.11 variants, a and b, as well as HiperLan/2. Also, the packet radio version of DECT (DPRS) is contained in this category.
- *Short range technologies* is the term used for Bluetooth, as well as Ultra-WideBand (UWB).
- *Broadcasting systems* are normally not associated with mobile communications. However, convergence between traditional mobile communications and broadcasting is a distinct possibility. The standards contained in this category are Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB).
- In *satellite systems*, only the Inmarsat BGAN is included. At the moment the prospect for the earlier planned low or medium orbit systems are not good, seemingly not having the capacity and QoS to defend the high complexity and cost.
- *Future wideband cellular* contains systems that up till now are only described conceptually, and that are relatively far into the future. The European *Mobile*

Broadband System (MBS) as well as *future Japanese cellular* are contained in this category.

Jacobsen et al. also identified important properties of each access network technology listed under the different categories as shown in Table 2.

Table 2 Network technology characterisation

		Typical user data rate (kbps)	Maximal user data rate (kbps)	Capacity (e-6* bit/s/m^2/ Hz)	Application support	Delay	Set-up time
GSM	GSM	14,4	14,4	1,15 (cell radius: 150m)	Voice, circuit switched	< 90 ms	<2,2 s
	HSCSD	43	57,6	1,15	Citcuit switched	Maximum 90 ms	<2,2 s
	GPRS	30	171,2	2,0	Packet switched	Best effort	N/A
	EDGE	128	474	6,0	Packet switched	<500 ms	N/A
UMTS	FDD	144	2000	5,7 (cell radius: 150 m)	Voice, packet switched	80 ms (radio)	
	TDD	384	2048	5,7 (cell radius 150 m)	Voice, packet switched	80 ms (radio)	
	HSDPA	1000	10000	26,3 (cell radius 150 m)	Packet switched		
WLAN	IEEE 802.11 B	2100	6000	ca. 1000 (cel radius 25 m)	Packet switched	10-50 ms	
	IEEE 802.11 A	4200	10500	1376 (cell radius: 25 m)	Packet switched		
	HIPERLAN/2	9100	28000	ca. 10000 (cell radius 25 m)	Packet switched, voice, video streaming	<5 ms	
	DECT (DPRS)	1000	2000	1019 (cell radius: 25 m)	Packet switched	50 ms	<50 ms
Short range technologies	UWB	50000	100000	0.00021			
	Bluetooth	64 (Voice) 700 (data)	1000	3185 (cell radius: 10 m)	Voice, packet switched		2 s
Broadcasting systems	DVB-T	10000 (shared)	31700	0.00017 (cell radius 50 km)	Broadcasting, (downlink only)	< 1 s	
	DAB	384 (shared)	1000		Broadcasting, (downlink only)	< 1 s	
Satellite systems	Inmarsat BGAN	64	144	ca. 1.5e-7 (cell radius 100 km)	Voice, packet		
Future wideband cellular	MBS	38000	136000	127 (cell radius 100 m)	Packet data	<500 ms	
	Japanese future cellular	20000	100000	72 (cell radius 100 m)	Packet data		

Those are the candidates that are most likely to be implemented within the next one to five years. The mobile networks like UMTS can have acceptable properties for Eye-phone and be available over large areas. The WLAN technologies like IEEE 802.A will support smaller areas with high enough bit-rate. The most likely scenario will be a combination of these two main groups of network technology. An Eye-phone user may then be handed over between networks with very different properties or QoS (Quality of Service) ranging from very acceptable to not at all acceptable for usage. The most promising candidates are UMTS as a base network with different WLAN technologies based in the IEEE 802-series.

Both Telenor and NetCom have committed themselves to a coverage of 80 % (for Telenor) and 98 % (for NetCom) for the UMTS network, and these networks will be implemented before the end of 2004. The user data rate will at least be 128 kbs.

Eye-phone users may therefore have mainly access to UMTS, but may be handed over to more suitable technologies at certain hotspots.

1.3 Previous Research & Development

The main published work of relevance to this area can be considered as:

- Research and development of information and communication technology for people with special needs (or "Design for All"), particularly the application of mobile videotelephony.
- Previous work on QoE (Quality of Experience) issues of mobile videotelephony and, in particular, its application for remote inspection.

Each of these areas is therefore reviewed below.

1.3.1 People with special needs and *e*Inclusion

A large proportion of previous and ongoing work on people with special needs and design for all has been performed in conjunction with sponsorship from the EC, particularly the Framework Programmes and the *e*Europe initiative. Most work has been in the area of services for elderly persons and persons disabled by deafness or physical handicaps (e.g., Clarke & Conjero, 2001). Recent work within the *e*Europe initiative has extended design for all to include children in addition to the elderly and persons with motor, cognitive or sensory impairment (Helmersen, 2003; Clarke et al., 2003).

Early work specifically on applications of videotelephony for people with special needs focused on elderly and mobility impaired persons (COST 219, 1995). Previous studies of deaf persons and visually impaired children using videotelephony on fixed networks (LAN, ISDN) have shown positive results (McEwan, 1996; Brooks, 1999). Videotelephony enables deaf people to communicate in the way that is most natural to them; i.e., visually through signing and/or lip reading. The application to visually impaired people has focused on providing real-time remote access to special teachers and visually-oriented computer-based training programmes for visually impaired children who would otherwise find it difficult to attend a specialised school (Moniz Pereira & Saragoça, 1998; Rocha, 1998).

Tests with mobile videotelephony have more recently applied to the needs of deaf people (Frowein et al., 2001). Frowein et al. used W-LAN equipment and NetMeeting (v2.1) for videoconferencing to examine sign language interpretation. They compared mediation between speech and sign language in a 'speech-to-sign relay' scenario and 'remote interpretation' scenario, in which a deaf signer and a hearing person are in one location and communicate with each other through a sign language interpreter at another location. A study of the opinions of eight deaf persons indicated that both scenarios were regarded as potentially useful by all, with the remote interpretation scenario appearing a little more favoured.

Frowein et al. (2001) examined the effect of transmission bandwidth (400 kbps, 128 kbps, 64 kbps) on the joint use of text and video communication and compared mobile videotelephony on a laptop with fixed videotelephony on a desktop PC. It was found that decreasing the bandwidth led to an increase in text usage as measured by the mean number of words written. Also, subjective ratings of the usefulness of a videophone for signing and lip reading indicated that mobile videotelephony starts to become an acceptable medium for signing at 128 kbps, although 25 % of the 16 deaf test participants still rated its usefulness as poor or very poor. This was also confirmed by the study of speech-to-sign translation, since six of the eight deaf participants reported that they could understand the sign language interpreter 'well' or 'very well' at 128 kbps and none of them rated their understanding as 'bad' or 'very bad'. For lip reading it was concluded that 400 kbps is required to achieve the same level of rating of subjective usefulness. Frowein et al. noted that these conclusions are dependent on the technology used in the experiment and are therefore regarded as provisional.

Ongoing work in the USA by Peifer et al. on the development of wearable computers for people with special needs has been reported by Lok (2004). A prototype for vision-impaired persons focuses on enhancing navigation. It consists of a pair of headphones and a wearable computer controlled by a handheld device; a shoulder strap on the bag housing the computer is outfitted with a GPS sensor, which works in conjunction with a head-tracking sensor on the headphones to track the wearer's location and direction. The computer plays beeps over the headphones, and the user moves toward the apparent source of the sound, thus following a pre-programmed route.

1.3.2 Remote inspection

A special application of videotelephony is the use of the remote image to see details of the remote environment rather than to simulate 'face-to-face' conversation. This special application is referred to as 'Remote inspection' (Hestnes et al., 1999). An illustration from the work of (Hestnes et al. 1999) is provided in Figure 4.

Figure 4 A remote inspection situation from road construction where the field worker gets assistance from an expert in his office

Experiments with mobile videotelephony have been simulated in laboratory situations for both ‘face-to-face’ and ‘remote inspection’ situations in order to assess the effects of changes in QoS (Quality of Service) parameters on user behaviour (O’Malley et al., 2003). One ‘face-to-face’ videotelephony experiment involved investigating the effects of different image sizes (3.5” and 29”) on task performance, communication processes and attitudes in a task involving negotiation (N = 48). The 3.5” screen was chosen as typical of screens on hand-held devices. Although differences for task outcomes and communicative processes were not statistically significant, the 3.5” screen had a significantly negative impact on measures of social presence. A second ‘face-to-face’ experiment investigated variations in resolution for a 3.5” screen using the same negotiation task (N = 86). In general there were no differences between CIF and QCIF resolutions for small screens, either in terms of task performance or communicative processes. The remote inspection experiment examined variations in packet loss and delay (N = 48). It was concluded that in general it seems as though delay does not affect performance of the remote inspection task used. There were some indications that packet loss has an effect but the sample was not large enough to determine this due to order effects.

Remote inspection has been examined through case studies in the offshore oil business and road construction industry in Norway (Hestnes et al., 2001). Ranked in order of importance the three main situation categories where the potential end-users stated that there is a real need for remote inspection are ‘Decision support’, ‘Guidance and demonstration’, and ‘Work planning’. These situations are identified as having a high perceived cost-benefit factor because problems can be solved faster with less travel and interruptions and because a remote expert can handle a greater number of sites. A key feature that distinguished the two main situation categories was the role of the participants in terms of the relative symmetry or asymmetry in expertise. Decision support, which is the most similar situation to Eye-phone, involves the communication of experts, whilst Guidance and demonstration involves communication between an expert and relative novice. It was found that still images could not support remote inspection, but may give additional help. Moving images such as video was essential. Furthermore, the critical nature of this video is not to provide classical “Talking Head” video as typically expected from videoconferencing, but “video-as-data” as defined by (Egido 1988). For the underlying network, it was found that the network QoS (Quality of Service) is the most important characteristic.

1.4 Background of the Eye-phone project

The Eye-phone project was initiated as a pre-project to study the feasibility of an Eye-phone service. This was followed up as a main project primarily for use of stationary systems. To this main project an extension was especially made to study the mobile Eye-phone.

Both the pre-project and the main project were organised as a consortium with partners such as MediaLT (project leader), Tandberg, itWork, eTerra, Norges Blindeforbund, Rikstrygdeverket and different departments of Telenor (Telenor R&D, Telenor Networks and Telenor Teleservice). The mobile Eye-phone project has been chaired by Telenor R&D with MediaLT and MapSolutions as the only contributors.

1.4.1 The pre-project

A pre-project was performed in 2001 to explore the need for an Eye-phone, implemented either as stationary videoconferencing equipment or a mobile system based on the concept of remote inspection. The pre-project was divided into the following activities:

- **Literature study** of any related work.
- **Demand analysis** where focus group studies were performed to identify unique needs that Eye-phone could fulfil and how an Eye-phone could be implemented.
- **Field test of equipment and service** using existing stationary videoconferencing systems. No mobile equipment was used.
- **Organisation of the service** in which established text telephony for deaf people was especially taken into account.

Based on the results from these activities (Lunde et al., 2001), a main project was started in January 2002.

1.4.2 The main project

The main project was a two-year project divided into the following activities:

- **Literature study** to look deeper into identified areas identified from the pre-project.
- **Field tests with stationary equipment** – with three sequential test-groups testing their needs and usage.
- **Evaluation of each test-group** with possible iterative corrections for subsequent tests.
- **Business model –** developing the Eye-phone service with respect to investments and running expenses.
- **Mobile Eye-phone** – performing a short evaluation and investigating equipment development.
- **Dissemination –** the spreading of information to target audiences including potential user groups, research conferences and publications.

1.4.3 The mobile Eye-phone extension

When the main project was initiated in the beginning of 2002, the project membership concluded that only very limited work could be performed in the mobile area because of limited commercial development of networks and terminals. Therefore only a short evaluation of feasibility was planned. This is the first study described in the current report (Section 3.1). As this first study produced such promising results additional funding was released for follow-up studies. A complete set of mobile Eye-phone studies therefore comprises this current report.

1.5 Methodology overview

This report summarises four main sequential empirical phases (Figure 5):

- *Focus group studies* (N = 19) were performed to **pre-test** the service concept and to identify initial user and technical requirements.
- *Longitudinal observations* (N = 2) were performed of the use of Eye-phone in one leisure-oriented and one work-oriented **trip**, whereby both planned and spontaneous real-world use of the Eye-phone could be studied.
- *In-depth user tests* (N = 10) of the Eye-phone were performed on five **important situations** identified from the focus group studies and longitudinal observations.

These studies provided experience-based subjective measures of Eye-phone relevance and satisfaction in addition to objective measure of Eye-phone effectiveness.

- Small scale *comparison tests* (N = 14) were performed on the **most demanding tasks** identified in the in-depth tests to examine the effect of reduced technical quality of the Eye-phone (resolution and frames-per-second) on these tasks and identify an acceptable quality level.

In addition to the two blind persons that participated in the longitudinal observation trips and the 10 blind participants in the in-depth user tests, a service centre operator participated to create the person-person pairing of each study. For the leisure-oriented trip and the five in-depth user tests this was the same service centre operator.

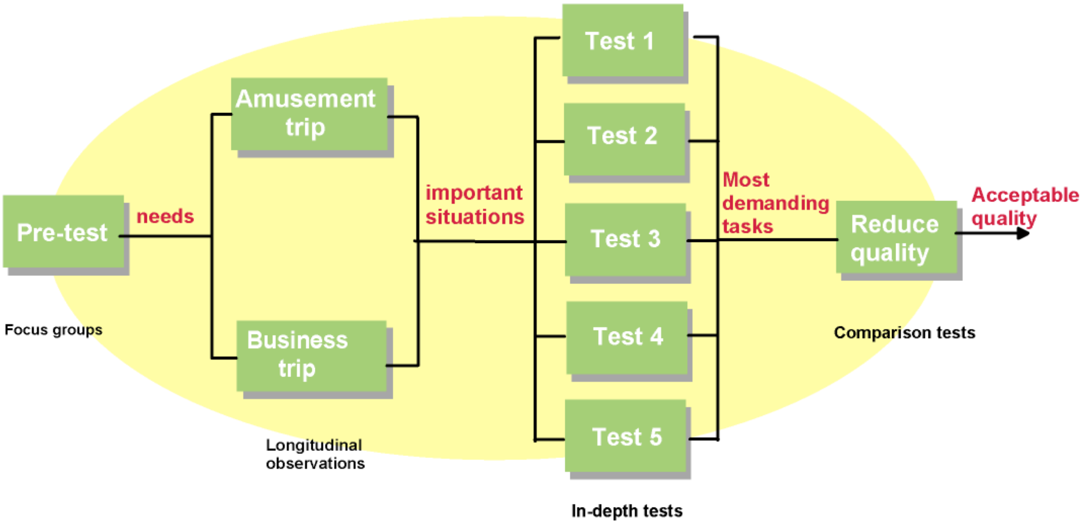

Figure 5 Summary of empirical phases

Results for each of these four phases are described in turn below, followed by a summary of main results and more general discussion and conclusions.

2 The pre-project – studies of service concept

The pre-study carried out by Lunde et al. (Lunde 2001) identified that within Norway there are about 90,000 blind or visually impaired people. Among them, there were about 9,000 that formed the main potential user group for the Eye-phone. The early results that were obtained regarding the needs of blind persons and preferences for types of terminals are summarised below.

2.1 The blind persons' needs

Two main categories of situations were identified for potential use of the service:

- Stationary situations,
- Mobile situations.

The main needs that an Eye-phone could support are listed below for each of these categories.

2.1.1 The use of stationary systems

The use of stationary systems would be typically at home and/or work for the following purposes:

- Mostly reading 'black text'
  - Find out what is in the post-box,
  - Recipes for making food, patterns for knitting and instruction manuals for kitchen devices,
  - Messages on the mobile phone, meter-reading on electric current meter and TeleText information on the TV (weather, news and programmes),
  - Parental checking of their children's homework, to ensure it is correct and to give responses,
  - Pin-codes for Internet banking where the calculator responds with a new code for every transaction.
- Inspect clothes for dirty spots.
- Parents that need to check their children for symptoms of diseases.
- Emergency situations such as the need for ambulance, police or fire services.

2.1.2 The use of mobile systems (everywhere indoor and outdoor)

The use of mobile systems was identified for potentially all locations both inside and outside the user's home. In addition to the above stationary situations, the pre-project identified:

- Browsing of information available to get an overview.
- 'Painting with words'
  - factual descriptions (e.g., of objects and products)

  - descriptions of food (e.g. a lunch table where a waiter informs that lunch is served – where, and what is it?)
  - inspiring prosaic descriptions (e.g., when coming to the destination of a mountain walk to 'see' the beauty of the landscape).
- Find where an object is – for example in a post office to find the ticket queuing machine, push the right button and find out when and where that number will be served.
- Find the destination on a walking tour, assure that the person is where they believe they are and get back on track when lost.
- To use public transportation and find bus stops, read the timetable and get on the correct vehicle and off at the right destination.
- Shopping – find clothes that fit, have the right size and colour.
- In restaurants – reading the menus.

2.2 Preferences for type of terminal

Based on the situations listed in Section 2.1, three different devices were identified and ranked in order of preference:

1. Automatic device with no service centre operator involved. This is a device that can be pointed towards the object of concern and upon the push of a button an automatic voice would name or describe the object (e.g. "It is Ronald", "The exit door is in this direction")
2. Mobile device with a remote operator (to be used everywhere).
3. Stationary device with a remote service centre operator (to be used at home or at work).

As the first preference for an automatic solution is currently impossible to implement, the project continued with a stationary solution (as described for the main project) and the mobile solution that is the focus of the current report.

3 Two longitudinal studies of real-world Eye-phone use

The two field trials involved an in-depth study of a blind person who undertook a significant activity with the Eye-phone that he would not otherwise perform without co-present human support.

Both field trials represented an observational study of 'a trip': For one blind person this represented a leisure-oriented trip and for the other blind person this represented a work-oriented trip.

Each trip is described in turn below.

3.1 An international leisure trip by ferry and train

When blind or visually impaired persons travel far, air travel is typically chosen as they are supported and guided by trained people all the way from the taxi station at the departing airport to the taxi station at the arriving airport. There are no such services with ferries or trains. International travel using both ferry and train was performed as a leisure-oriented trip using the Mobile Eye-phone.

3.1.1 The field-study participant and ambition

The test-person is 100 % blind and lost his sight when adult. He is very mobile and uses non-visual senses to walk along roads, climb stairs, etc. If people are around him, he asks them to describe, point or guide if necessary.

The test-person lives in Oslo and is the father of a daughter who prior to the study was soon to be seven years old. As a birthday present the test-person wanted to take her to the amusement park in Copenhagen (Figure 6). As this was to be 'his present', he did not want to use an accompanying sighted person. The test-person wanted to take the ferry one way and the train the other. Normally he would consider this to be too big a challenge and risk – what if they got lost, or if she get lost from him, or if she got hurt?

At the age of six years she can count to nine but cannot yet read or write and is not able to be a reliable guide. Therefore she was not in a position to offer many of the types of support expected during a trip.

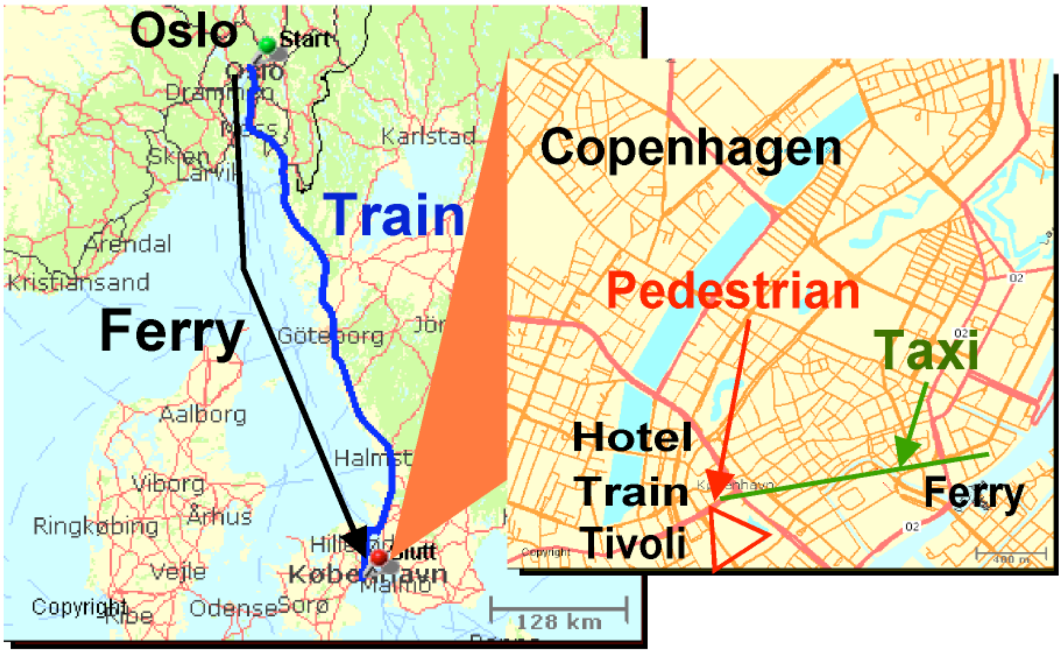

Figure 6 Location of Copenhagen relative to Oslo and detail of the Copenhagen area

3.1.2 Trip methodology

The data collection phase of the field study started at the ferry quay in Oslo at 15h00 on Monday 2nd June 2003 and ended at the central railway station in Oslo at 17h30 on Wednesday 4th June 2003.

The main design of the field study was to provide the test-person with the test version of the mobile Eye-phone (see Figure 2 left) and observe him throughout his trip whilst he freely travelled and enjoyed time with his daughter. Video recordings, photographs and interviews took place before, during and after the trip. A team of two researchers and two additional persons accompanied them:

- The main researcher/interviewer (who also operated a video camera and had responsibility to ask permission from relevant persons, such as on the ferry),
- Technical support person (also acting as photographer),
- Safety and quality officer (ensuring the daughter's safety, that the study was done with as little interference from the team as possible and also taking a video recording),
- The service centre operator.

The service centre operator was a skilled person who does this activity as his daily work, normally from a fixed office location in Mosjøen (in the North of Norway). In order to carry out a test with best quality video (25fps and 352x288 pixels) the service centre operator was not in a remote location for this trial as no network is available with the necessary bandwidth and quality for the whole trip. Although co-located with the test-person by being about 20 to 50 metres away, the service centre operator was instructed to only observe what the test-person was pointing at on a monitor as captured by the Eye-phone (Figure 2 left) and to only give information from what he could see on the monitor. The Safety and quality officer observed the service operator and checked that he only revealed information that would be expected if he was situated in the service centre.

The test-person provided the researchers with a sketchy plan of his travel from which a more detailed plan was worked out but not communicated back to him (Table 3).

The test-person wore a wearable computer designed for this study that provided a two-way audio-link and one-way video as described in chapter 1.1.1. The design was based on remote inspection equipment previously developed for use and tested by sighted field workers for communication with remote professionals (Hestnes et al. 2001).

Table 3 Detailed travel plan

Monday 2nd of June	Tuesday 3rd of June	Wednesday 4th of June
	0915: Arrival in Copenhagen	0630: Breakfast in the hotel and check out
	1000: Find a taxi for the hotel	0700: Walk to the central railway station
1500: Arrival at the ferry quay in Oslo	1030: Check-in at the hotel	0720: Find the right train, compartment and seat
Find the ferry, convert his order into a ticket, Go through customs, find the cabin, get installed	1100: Find the hotel room	0820: Departure from Copenhagen
1700: Ferry leaves Oslo	1200: Walk to the pedestrian street, eat, look, experience, shop	1230: Arrival in Gothenburg
Eat, take a swim in the pool, play in the children's playroom, shop in the tax-free shop		Change of train <== NB: Only 13 minutes
2200: Back to cabin, put daughter to bed		1243: Departure from Gothenburg
2300: Get a child watch, have a beer in the bar	1800: Walk to the amusement park, eat, have fun with daughter	1645: Arrival at Oslo central railway station
2400: Back to cabin to sleep	2200: Back to hotel to put daughter to bed	1700: Debrief

As it was vital to have equipment working, three different equipment solutions were made. It was necessary to plan where batteries could be charged and as the team had to make the study while they were moving, it was necessary to carry everything all the time.

3.1.3 Results

Key results of this case study are presented in two stages. First, the trip is described with focus given to when the Eye-phone was used. Second, an analysis of key elements is provided.

3.1.3.1 Description of a return trip from Oslo to Copenhagen

The key results are presented below according to the main different physical locations of the trip.

3.1.3.1.1 On the ferry

Observations started at the ferry quay two hours before ferry departure. From the ticket desk it was necessary to take stairs and walk along long corridors in order to get to the entrance of the ferry. This was done with a little help from the Eye-phone, in order to check that it was the correct ferry, identify the ticket desk and read the number of the cabin. The test-person used the Eye-phone in short periods. To arrive at the ferry, he mostly used his hearing to follow the others walking in the same direction. The test-person used the Eye-phone to navigate in the corridor to find the cabin door.

Once installed, he and his daughter went to the shops. They used the Eye-phone to check prices, have text on articles read out and to navigate. In the tax-free shop he used the Eye-phone to find the area for whisky and to search for a particular whisky to buy as a gift. The research team also checked for the right bottle and this turned out to be a difficult task for a sighted person. It was necessary to identify that there was a second, less obvious area of whiskeys. By use of the Eye-phone the test-person did not give up and successfully found the correct brand.

In the evening he chose not to use the Eye-phone for selecting food in a buffet and in stead went to a menu-served restaurant to have a rest from the tests. Normal activities went on till next morning with little use of the Eye-phone. At the arrival in Copenhagen, the test-person followed the people out with little use of the Eye-phone and arrived as intended at a taxi station.

3.1.3.1.2 In the hotel

For the test-person to find his room was the most difficult task at the hotel. The receptionist pointed to the lift and he used the Eye-phone when he came out of the lift as he was not sure on which floor he was and asked the operator if he could tell. For a distance of ten metres the operator could advise that there was only non-relevant information such as indicators for ‘lift up’ and ‘lift down’ and posters. They agreed to continue down the corridor to read at room doors. This ‘clean’ lift area design was judged by the research team to be difficult for sighted people also (Figure 7), but the test-person managed to assess and then find his room with the use of the Eye-phone.

Figure 7 A 'clean' hotel corridor with no information about floor level

On arrival at his room the electronic key card did not work and he called with the Eye-phone again. He was not sure he had remembered the right room number. He used the Eye-phone to check the folder in which the electronic key was delivered. He was helped to distinguish amongst various items (e.g. the key with no number on, a list of mini-bar prices, advertisements for pay-TV) to find the receipt that gave the correct room number.

3.1.3.1.3 In streets and pedestrian areas

The test-person asked the hotel receptionist for directions to the main pedestrian shopping street, the amusement park and the central railway station. As he was able to remember the directions he found his way without using the Eye-phone.

In the pedestrian shopping street he used the Eye-phone to look for particular types of shops, to check prices and sometimes to navigate within shops. These were short moments of use; for example when he made a connection, asked for the price and disconnected.

He also decided to use an automatic cash dispenser (mini-bank) for the first time outside Norway (Figure 8). He needed help from someone he could trust. He used the Eye-phone rather than ask a passing stranger. The sun was shining from a clear sky causing reflections on the mini-bank's screen so it was difficult for the operator to see the text on the screen. By trying different camera angles the text became readable. A mini-bank time-out function caused some stress that made it more difficult to proceed as fast as needed. On the third attempt he succeeded.

Figure 8 The use of a mini-bank

3.1.3.1.4 At the amusement park

In the amusement park he was mainly led by his daughter, who would run from the roller coaster to the jumping castles and to other attractions with her father hand-in-hand. Except for two occasions, he managed without the Eye-phone. He used it once for looking around to get a description of what was to visit. The second time he used it was to look at his daughter in a jumping castle and listen to the operator describing how much she enjoyed being there.

3.1.3.1.5 On the train

Find the train at a big railway station was not very easy. The test-person used the Eye-phone most of the time to pass from the entrance all the way to the platform. In the big hall, with many posters, logos, advertisements, etc., it was difficult for the operator to find the right information. This was also a problem for sighted persons. The test-person started to search for an information display for all trains but gave that up. Then he searched for the entrances to the platforms. At the entrances he pointed around with the camera and found monitors. He showed each monitor until finding the one for his train. When the train arrived, the operator could easily recognise a carriage number on display at each carriage entrance. In the train, the test-person had a problem remembering his seat number and used the Eye-phone by showing the service operator his ticket. He also used it to find the right seat, especially as the seating number sequence was not as straightforward as he expected (Figure 9). Also sighted travellers had problems understanding the numbering scheme.

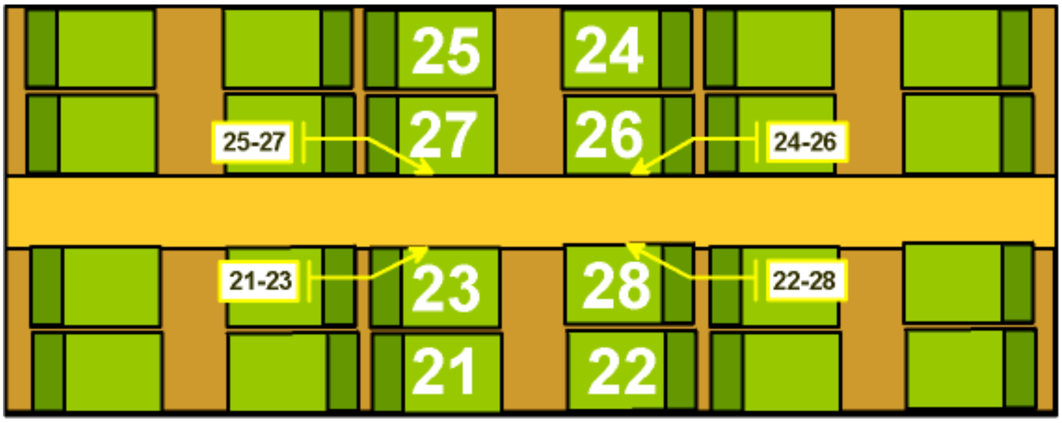

Figure 9 The seat numbering in the train was not as straightforward as expected

It was known in advance that it would be necessary to change trains in Gothenburg. At the Malmø station, after 1/5 of the trip to Gothenburg, the train stopped and it was announced that only the last three carriages would continue. The test-person did not know his carriage position, but because he had a ticket for Gothenburg with a seat number, he remained sitting confident that his carriage would continue. However, that was wrong and he would have been left behind with no other train that day to bring him home. The sighted research team were also confused and had not noticed in which part of the train they were. After a team member realised the problem, the team intervened and brought the two persons to the last three carriages. At this point it was discovered by a sighted member that the external number LCD display of the new carriage was now updated to the ticket number.

3.1.3.2 Analysis

The use of Eye-phone for the trip on the ferry, in the hotel and in the shopping street all went well. The amusement park was a situation where there was very little use of Eye-phone but what use there was, went well. In the railway station and in the train all use of Eye-phone went well. Over this trial period the Eye-phone was used 15 times on the first day, 10 times on day two and eight times on day three. The success rate of achieving the aim of an Eye-phone call was 100 % and the test-person was able to keep to the plan with all the items in Table 3.

Although he did not use the Eye-phone in the Malmø railway station incident, this was a kind of problem that was not recognised to be a problem for Eye-phone, as it could also be a problem for a sighted person. In this case, use of the Eye-phone gave confidence to use a mode of transport in a way that would not have been otherwise attempted, but the railway system was not reliable enough to fully support his trust.

The majority of calls lasted less than five minutes. A few calls took 5-10 minutes and the longest call of approximately 10 minutes was in the ferry duty-free shop when the test-person had to identify a second area for whisky when searching for a particular brand. The second longest call was at an unfamiliar mini-bank and this terminal presented a challenge for obtaining a good image from a screen with reflections and time-out mechanisms.

He reported that the Eye-phone was most useful for quick calls (e.g. search for room number, then disconnect), reading small amounts of text (e.g. cabin number, seat number on train), navigation help (e.g. find exits, train platforms) and "on-the fly" questions (with his ideal procedure being: "connect; 'what is this?', 'OK', disconnect").

There appeared to be three main situations of Eye-phone use:

- To verify information or objects when found (after finding something either independently or with Eye-phone help)
- To search for information or objects
- To observe a person, situation or environment.

Sometimes the test-person used the Eye-phone in a planned and sometimes in a spontaneous way. This led to a classification of Eye-phone use on the basis of Purpose of the call and the level of Spontaneity of call as illustrated in Table 4. As can be seen in Table 4, for this case study not all possible types of use from the derived classification were observed.

Table 4 Classification of Eye-phone usage with examples for a leisure trip

		Purpose of call		
		Verify	**Search**	**Observe**
Spontaneity of call	**Spontaneous**	*"Wasn't my room number 1012? I have to check"*	*"So now I have arrived here, but where is the exit?"*	*"How is my child enjoying herself?"*
	Planned	No example identified	*"When I arrive in the tax-free shop I will search for that whisky"*	No example identified

The Eye-phone was not used for short walks in streets, when a sighted person (his daughter) was able to lead and when walking in predictable queues.

The service centre operator reported that every task initiated was solved properly. He was able to cope with an image from a camera that was held in all positions (including upside down) and did not need to ask the test-person to rotate the camera. Though the map system with the positioning system of the blind was not used, he felt it had a high potential.

3.2 A work trip involving use of underground train

To complement the leisure-oriented trip using international ferry and train a second observational study was performed that involved more local urban travel by underground train and walking. The motivation for this trip was a typical working day travel to the premises of a client.

3.2.1 The field-study participant and ambition

This test-person was 100 % blind and approximately 45 years of age. He lost his sight when he was young. He is a self-employed piano tuner living 50 km north of Oslo. This requires travelling to the location of each piano to be tuned, which can be time-consuming and expensive in travel costs. This test-person prefers not to be dependent on expensive taxis to take him directly to a work location, for example, as he should remain price-competitive with sighted piano tuners.

His aim was to have the Eye-phone assist him to be able to use public transport and especially the underground train in Oslo to arrive at a customer location in an urban area of Oslo.

Although he uses certain bus routes, he normally does not use the Oslo metro.

3.2.2 Trip methodology

The case study methodology was essentially observation and interview based in a similar way to the Copenhagen leisure trip (Section 3.1.2).

Three pre-meetings with interviews were done to find out what kind of trip he would like to try out, where it should be and a try out of the Eye-phone. The data collection phase of the field study started at the centre of Oslo after the study participant had already travelled from his home alone, using his ordinary well-known bus (approximately a one hour bus trip).

The trip was done during normal working hours between 0810 in the morning till 1130.

The test team met him outside the University of Oslo and from there the study began with the trip to the address where the piano was to be tuned (Figure 10).

This trip is approximately 15 km including a 1 km walk.

The trip involved:

- Walking to an underground station,
- Finding the ticket desk and buying a ticket,
- Taking the underground train from Nationaltheatret to Røa,
- Leaving the destination station and walking through busy shopping streets,
- Finding the client's building in an urban residential area of apartment blocks,
- Finding the right doorbell where there were 50 to select from.

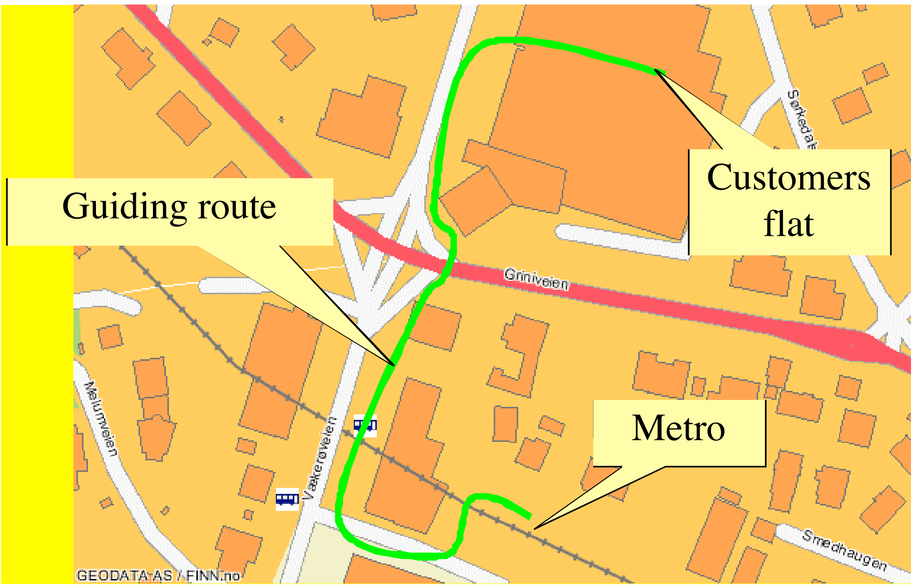

Figure 10 Route from the underground railway station to the location of the piano-tuner's customer location

A team of two researchers accompanied him:

- The main researcher/interviewer (who also operated a video camera and was responsible for asking permission from relevant persons, such as in the underground railway station),

- Technical support person (also acting as the service centre operator).

Unlike the case study of the Copenhagen trip, the role of the service centre operator was taken by a researcher (who had been present during the Copenhagen trip) rather than a professional operator.

The same equipment was used as in the Copenhagen trip (described in Section 1.1.1 and 3.1.2).

3.2.3 Results

Key results of this case study are presented in two stages. First, the trip is described with focus given to when the Eye-phone was used. Second, an analysis of key elements is provided.

3.2.3.1 Description of a work trip to tune a piano

The key results are presented below according to the main different physical locations of the trip.

3.2.3.1.1 Starting off on an urban street

The test-person carried by hand a bag of piano tuning equipment (weighing about 10 kg). He normally carries this bag in his left hand and has his white stick in his right hand. When wearing the Eye-phone, he required a free hand for the camera. He took the camera in his right hand at the expense of using his stick although he reported feeling insecure without his stick. The camera does not show what is just in front of the feet if it is pointed straight ahead in a normal way. Because the test-person was afraid of obstacles at feet-level, he suggested that there should be an extra camera for the feet.

Figure 11 The test-person used the Eye-phone in his right hand and the bag in the left hand

He commented early that "Things are going too slowly" although he suggested that efficiency could be enhanced by some training in using the Eye-phone for a while.

The researchers considered him to be 'over-using' the Eye-phone when he could have been more efficiently using his stick 'off-line' with connection to the service centre for new instructions.

The test-person was successfully guided to the underground railway station. He bought a ticket at a ticket office and continued further down to the platform, using the Eye-phone all of the time. He found the right train and entered, all the time using the Eye-phone with continuous communication with the operator.

3.2.3.1.2 On the underground train

Very few stations were announced on the loudspeaker. However, the test participant knew most of them previously when he took the underground to a station called Huseby. At Røa, he correctly left the train. He had never been at this station before.

At the destination platform he was anxious to know whether the platform would be level with the train floor. He was concerned that he could fall down because he did not use his stick which would have saved him from this, and the operator had problems with an exact distance. On arrival it turned out that the platform was level with the train.

3.2.3.1.3 From underground station through busy shopping streets

From the platform he walked up a long staircase to the exit, out into busy streets, along a road with no pavement and along a shopping street where goods were put out on the pavement as well as lighted torches, as is the tradition. All the time, he was guided by the operator with instructions like: “Turn slightly to the right”, “Be aware of an obstacle on your right hand side” and “Point the camera a little more upwards”. The test-person dealt with everything successfully other than one shopping display stand that he walked into without injury. Although the operator could see the obstacle, he estimated it to be further away.

3.2.3.1.4 Arriving at an urban residential district

Upon arrival at the neighbourhood of his destination the researchers continued to observe that the test-person was using the Eye-phone effectively[1] but inefficiently[2] because of over-use of Eye-phone and under-use of his traditional stick.

On the researchers’ suggestion, he tried to use both stick and camera in one hand, but this was not accepted because he needed the stick in one hand and the camera in the other. As a solution to this would be to use a backpack rather than a hand-held bag for the piano tuning equipment, a researcher carried the bag from this point on. The test-person reported that he now felt much safer and progress was observed to be much faster when Eye-phone was used in conjunction with the stick.

The operator occasionally had difficulty in estimating and stating the correct distance to an object of relevance (e.g. a potential obstacle). He tended to estimate objects as closer than in reality, which confused the test-person.

His customer location was an apartment in a complex of apartment buildings. To find the precise destination was judged not straightforward for a sighted person. It was necessary to find the entrance “205B” when number 205 and 205A was relatively straightforward. Number 207 was more difficult because it was in a tunnel. This tunnel led to a rear courtyard where number 205B was situated. However, the correct entrance was found.

This entrance had an array of about 50 doorbells with a number for each apartment and a list adjacent to this displaying the names of the tenants with the associated doorbell number. The Eye-phone was used successfully to find the right doorbell.

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[1] *Effectively: Human Factors term applied for current purposes to the success rate of responses to the test-person’s requests.*

[2] *Efficiently: Human Factors term applied for current purposes to the speed and number of actions by which a request is solved.*

3.2.3.1.5 At the work destination

On arrival at the destination apartment, the test-person did not need the Eye-phone as was stated in the pre-trip interviews.

3.2.3.2 Analysis

On the travel from the pick-up place to the customer's location, all use of Eye-phone was effective. Except for the situation when the test-person walked into a shopping stand on the pavement (Section 3.2.3.1.3), the success rate of achieving the aim of the Eye-phone call was 100 %.

It is possible to categorise the uses of Eye-phone within the same classification scheme as used in the earlier case study trip to Copenhagen with a different participant (Table 4). Examples are shown in Table 5. However, the use of Eye-phone by the two different case study participants was very different when it came to walking. Whereas the work-trip participant used the Eye-phone almost continuously to be guided along streets, the leisure trip test-person made intermittent calls with the majority of calls lasting typically less than 5 minutes. The first participant did not use the Eye-phone much as a walking aid.

Table 5 Classification of Eye-phone usage with examples for a work-trip to a customer

		Purpose of call		
		Verify	**Search**	**Observe**
Spontaneity of call	**Spontaneous**	*"This train stop should be Røa, shouldn't it?"*	*"Which is my client's doorbell in this list of 50?"*	*"Is the station platform the same level as the train floor?"*
	Planned	No example identified	*"I've arrived as planned by bus, please direct me to the underground station"*	No example identified

The business test-person concluded from this first experience with Eye-phone that the use of Eye-phone in addition to a stick provides more speed and a higher feeling of security. He reported that he was satisfied with the guidance that was offered and would use the Eye-phone again for this type of trip if it became a real service.

The service centre operator reported that the camera did not have a wide enough visual angle to enable satisfactory guidance when the stick was not used. Therefore users of Eye-phone should be encouraged to find a mode whereby both camera and stick can be used when needed.

3.3 Conclusions

The Eye-phone was used by both case study participants to 'verify', 'search' or 'observe'. However, there was a different type of usage in terms of a preference for "on the fly" quick calls by one of the participants and more continuous support by the other participant.

Whenever the two test-persons decided to use the Eye-phone, the call achieved its aim.

There appears to be three main situations when the Eye-phone was used:

- To verify information or objects when found (after finding something either independently or with Eye-phone help)
- To search for information or objects
- To observe a person, situation or environment.

These situations can be further classified on the basis of whether the call is ‘planned’ or ‘spontaneous’.

On the basis of both case studies with an Eye-phone it appears that where sighted people would not experience any major problem in interacting with their environment, the Eye-phone worked well. Calls with the service operator took longer in situations when sighted people would also experience problems (e.g. poor hotel lift exit design, poor shop display) or can expect to experience initial problems (e.g. first time use of an automatic cash dispenser) but were still successful.

From the blind participant’s perspective, the two test-participants reported that they would use the Eye-phone if it became a real service. They would make such trips again without the reassuring presence of a following research team or a sighted person.

Two technical developments that could enhance the use of Eye-phone are:

- Better map support for pedestrians, including identification of entrances and shortest walking route.
- For the longer-term, 3D video could be considered to improve the difficulties that the work-trip operator had in estimating and communicating distances to objects.

4 In-depth user tests of five selected situations

The aims of the in-depth user tests were to:

- Examine user satisfaction and task effectiveness when using Eye-phone for the key situations identified by potential users in the pre-project interviews and confirmed by the longitudinal observational case studies.
- Identify particularly demanding tasks within the situations for tests of reduced technical quality in the comparison tests (Section 5).

4.1 Description of situations

The five most relevant situations that were identified from potential blind users of Eye-phone are summarised below (Table 6). In Table 6 each situation is classified on the basis of the main types of tasks that were expected to take place in that situation, using the classification scheme devised after the longitudinal case studies (Table 5).

Table 6 Five situations tested

#	*Name*	*Description*	*Classification*
1	Mini-bank	Withdraw money from a cash-dispenser	**Search** & Verify
2	Shopping	Select food item(s) within a single shop	**Verify**, Search and Observe
3	At a bus stop	Identify correct bus as it arrives at a bus stop	**Search,** Verify & Observe
4	Finding something lost on the ground	Retrieve a dropped item	**Search** & Verify
5	Being lost	Walk to a familiar or safe location	**Search** & Observe

Enough flexibility was given to the situations so that their relevance was maximised for each participant. First the test-person was asked if the task was relevant for them – did they lose items on the ground from time to time? If so, the participant could choose, if they wanted, a typical item that they typically lose on the ground and they could decide what food item they would be purchasing from the shop.

The situation ‘Being lost’ was implemented by asking the participants to start in a previously unknown part of Oslo.

The user-tests did not have ‘Observe’ as the main type of task (bold in the table), but some of the tasks involved Observe task, for example “On the bus” involving observing the environment in order to decide when to spot the bus coming. In addition, the Verify and Search tasks associated with the relevant situations.

4.2 Test methodology

A test session with each participant involved the use of Eye-phone for each of the five situations in sequence (i.e. repeated measures design). The Majorstua- and Bislett-area of

Oslo was selected because it offered good facilities for each test situation in close proximity (Figure 13), including fall-back options (e.g. wet weather). A typical test session took from two to four hours.

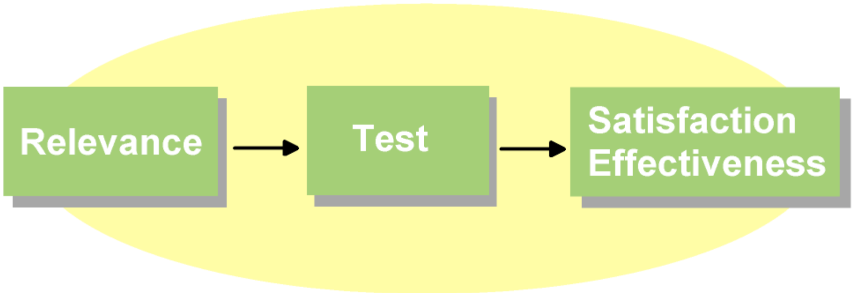

Figure 12 The most relevant tasks identified for the Eye-phone were tested for effectiveness and user-rated satisfaction

As inferential statistics were not planned for this small sample size and because much importance was given to adapting during each test session with the relevance of the test situations for the participants, a randomised or exactly counter-balanced order of test situations was not conducted. All tests result in the measure of task effectiveness and user satisfaction (Figure 12).

However, there was variation in the order of situations. Table 7 presents the order for each participant.

Table 7 Order of test situations for each participant

	Situation				
Participant #	Mini-bank	Shopping	Bus stop	Lost item on ground	Being lost
#1	1	4	3	2	5
#2	1	4	3	2	5
#3	3	5	2	4	1
#4	2	5	4	3	1
#5	2	4	5	3	1
#6	2	5	4	3	1
#7	2	4	5	3	1
#8	2	4	5	3	1
#9	2	5	4	3	1
#10	2	4	3	5	1

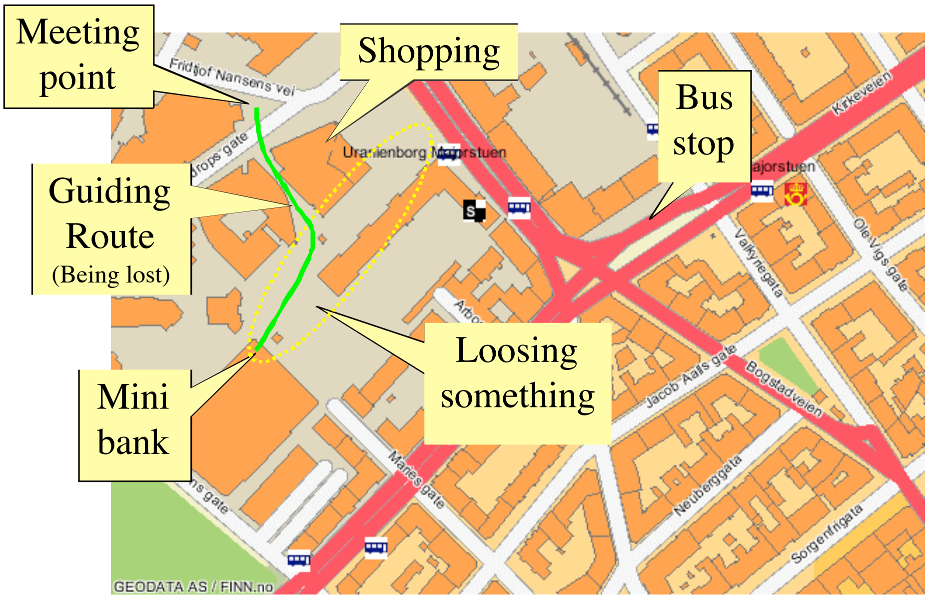

Figure 13 Locations of the sequential test positions

All the tests were done with the same service operator, the same person who was operator for the observation study trip to Copenhagen (Section 3.1): A skilled person who does this activity as his daily work, normally from a fixed office location in Mosjøen (in the North of Norway). In order to carry out a test with best quality video (25 fps and 352x288 pixels) the service centre operator was not in a remote location for this trial, as no network was available with the necessary bandwidth and quality for all tests. As for the longitudinal observational case studies, the operator was typically 20 to 50 metres away from the test participant and was instructed to only observe what the test-person was pointing at on a monitor as captured by the Eye-phone and to only give information from what he could see on the monitor.

The same equipment was used for the test participant and service operator as described in Section 3.1.2 and illustrated in Figure 2.

A semi-structured pre- and post-situation interview of each test participant took place. The pre-situation interview asked if the task to be performed was relevant to them. The post-situation interview asked participants to say whether or not they were satisfied with the use of Eye-phone for a given situation by giving a number on a scale from 0 (not at all satisfied) to 9 (extremely satisfied).

A measure of Eye-phone effectiveness was obtained for each situation on the basis of whether or not the situation objectively was achieved.

A measure of user efficiency has not been computed as all tests represented first-time use of the Eye-phone and also because greater importance was given to context relevance to a participant than strict task control. However, subsequent analysis of the video and audio recordings would allow this.

4.3 Test participants

Five male and five female participants took part in the tests as Eye-phone users. The average age of the test participants was 44 years (standard deviation = 14). Of the ten participants, eight were totally blind. The remaining two were severely visually impaired to the extent that only strong light/items with strong contrast could be seen.

Eight of the ten participants owned a guide dog, although only five of these owners brought their dog during the test. Therefore five test participants were accompanied by a guide dog and five were unaccompanied.

4.4 Results and conclusions

4.4.1 Relevance of Eye-phone situations

For five situations rated by ten persons there were a total of 50 questions of relevance. Of this total, only two of 50 situation/participant mappings (4 %) were answered as not relevant. There was one person who considered the **Mini-bank** situation to be irrelevant to them (apparently as they did not have or believe in use of bank cards) and another person who stated that **Being lost** was not relevant to them.

Nine of the ten participants expressed that use of a **Mini-bank** would be relevant to them, if they could gain access to use and despite their current inability to use a mini-bank (without human support).

4.4.2 Eye-phone effectiveness

Four of the five situations achieved 100% successful completion. These were the **Mini-bank**, **Bus stop**, **Shopping** and **Finding an unknown place (Being lost)**. The only situation for which Eye-phone was sometimes found ineffective was **Finding something lost on the ground -** on two occasions (20 %) the researcher terminated the test as over six minutes had elapsed and it seemed unlikely that a successful outcome would soon occur.

Table 8 Cross-tabulation of Eye-phone effectiveness for each situation

	Eye-phone effectiveness		
Situation	**Task completed**	**Task not completed**	**N**
Mini-bank	10	0	10
Item lost	8	2	10
Bus stop	10	0	10
Shopping	10	0	10
Being lost/finding unknown place	10	0	10

Only two of the ten participants had ever used a mini-bank and both of these previous users had used a mini-bank once or twice with the help of sighted persons. All participants were able to successfully withdraw the intended amount of money from the **Mini-bank**. Eight participants succeeded on the first attempt and two participants succeeded on the second attempt.

Although guide dog owners were not asked directly if they thought that an Eye-phone could replace a guide dog, two participants who were guide dog owners volunteered the opinion that an Eye-phone could replace a guide dog. One person qualified this for persons who have only a moderate need of a guide dog.

4.4.3 User satisfaction with Eye-phone

On a 10-point scale where "9" represents "extremely satisfied with use of the Eye-phone" the mean rating across all five situations was 8.

The highest rated situations were the **Bus stop**, **Shopping** and **Being lost**, which each obtained a rating of 8. The **Mini-bank** received a rating of 7 and **Item lost** received a rating of 6 (Table 9).

The lowest rated situation of **Item lost** (rating = 6) also had the greatest variation in ratings (Standard Deviation = 3), with ratings ranging between 0 and 9.

Table 9 Cross-tabulation of user satisfaction rating of each situation (10-point rating scale where 9 = "extremely satisified")

	Eye-phone satisfaction		
Situation	**Mean**	**Standard deviation**	**N**
Mini-bank	7	1.9	10
Item lost	6	3.0	10
Bus stop	8	0.4	10
Shopping	8	1.5	10
Being lost/finding unknown place	8	1.0	10

4.4.4 Conclusions

Overall, all of the five situations tested were judged as relevant by the test participants. Eye-phone had very high effectiveness as measured by successful task completion (100 % in four situations) and was rated very highly in terms of satisfaction (mean overall rating = 8). The lowest rated situation was where Eye-phone was the least effective, but this situation still obtained a mean satisfaction score of 6 (out of 9) and an 80 % (8/10) success rate.

The Mini-bank situation was the situation where all participants were naïve to mini-bank use. Even the two participants who had been introduced to a mini-bank by a sighted person did not use a mini-bank to regularly withdraw cash. A mini-bank is a rather complex device that presents multiple options where the wrong task-path may be taken in error and where 'time-out' functions exist. Despite this, eight of the participants withdrew the correct amount of money on the first attempt and the remaining two participants succeeded on only the second attempt. This indicates a high level of efficiency of Eye-phone use.

Two persons volunteered the belief that Eye-phone could replace a guide dog. It is possible that even more participants would have indicated this if they had been asked directly.

From these user tests it was decided that the most demanding situation for tests of technical quality reduction on task completion was the Shopping situation. Although Finding something lost on the ground was the least effective situation for Eye-phone, the Shopping situation was considered the most demanding for quality as it typically provided the double challenge of finding an item amongst a set and then reading product label information. The Shopping situation was therefore used in the subsequent tests of technical quality reduction as described in the next Section.

5 Tests of technical quality reduction

In both the longitudinal tests (Chapter 3) and in-depth tests (Chapter 4) high quality video was used in order to explore as many situations as possible where a future service may be of high utility to visually impaired persons. Some situations of mobile Eye-phone use may not be feasible if the technical quality of the service is reduced. Therefore follow-up tests to the in-depth tests of Chapter 4 were performed in which technical quality was reduced to identify the minimum acceptable quality level for the situations studied.

5.1 General approach

5.1.1 Selection of situation of use

During the in-depth tests the service centre operator was asked to identify special fragment situations where the demand on the technology was high or highest. The most demanding task for the service operator was assessed to be in the shop situation because he had to find the right area of food while the test persons where walking (movement demand) and to read small text on an article or a label. It was also necessary to be able to identify the most relevant search item while studying a part of it; i.e. reading one word selected from an entire line of text. In particular, the operator had to be able to read text on shelves and identify product groups to check if the user was getting to the correct destination.

Given these requirements two key areas were identified for testing:

- Where there is a high demand on space resolution,
- Were there is a high demand on movement.

5.1.2 Quality levels

These requirements relate respectively to demands placed on the terminal equipment, in terms of space resolution of the screen, and the network, in terms of video frames per second.

The test equipment enabled a range of modes of quality level for both space resolution and video frames per second (fps):

- For space resolution three quality levels were tested:
  - CIF (Common Intermediate Format with 352x288 pixels)
  - QCIF (Quarter CIF with 176x144 pixels)
  - SQCIF (Sub QCIF with 117x83 pixels)
- For transmitting movements four levels of frame rate were used:
  - 2-3 fps
  - 5-6 fps
  - 10-15 fps
  - 25 fps.

The 'space resolution' and 'movement' tests are described in turn below.

5.1.3 Equipment

The same equipment was used as employed in all other studies described in the current report.

The camera was a high quality analogue camera with good auto-iris and auto-focus. The auto-iris handled all light conditions for all of the in-depth tests of Chapter 4 with acceptable brightness. There were in-door situations around the mini-bank with limited light and out-door situations in morning/dawn before sunrise with almost night conditions. Still-picture cameras that are available on the market for GSM phones do not have such a huge dynamic iris area. We assume that will be the same for handheld mobile video cameras for next generation of mobile systems.

The camera also had an auto-focus that made the picture sharp without noticeable delay. It was able to focus from infinity down to a 2 cm distance between an object and the surface of the lens. Most cameras, if they have this great dynamic area, have at least a switch for normal and macro focus distances.

The camera also had a zoom function that could be controlled by the operator, but this function was not used in the tests.

5.1.4 Research design

The shopping situation was used for the tests. It was beyond the scope of the investigation to perform controlled experiments to identify thresholds according to sample statistics. These are tests based on a single user-service operator pairing and subjective measures of ability and acceptability of reading.

For tests of this nature it is inappropriate to consider either space resolution or frame rate in isolation of the other. Therefore tests were performed with each resolution-frame rate pairing and results are presented as a cross-tabulation of these two variables.

5.1.5 Participants

A blind person did not participate in these tests. Since there was a repetition of the user-interactions that had the strongest demands on the video, it was important to redo them just as have been done when judged as the most demanding interactions. The project therefore found it better to use a sighted person who has seen these interactions rather than trying to redo the test.

At the operator’s site, the real operator judged what he saw on his screen.

5.2 Screen space resolution test

5.2.1 Procedure

The camera was held in front of a 10x6 cm price tag with 10-point Arial text. The camera user and service centre PC user communicated to interactively vary the position of the camera relative to the object.

A view of the operator's monitor during the test is shown as Figure 14.

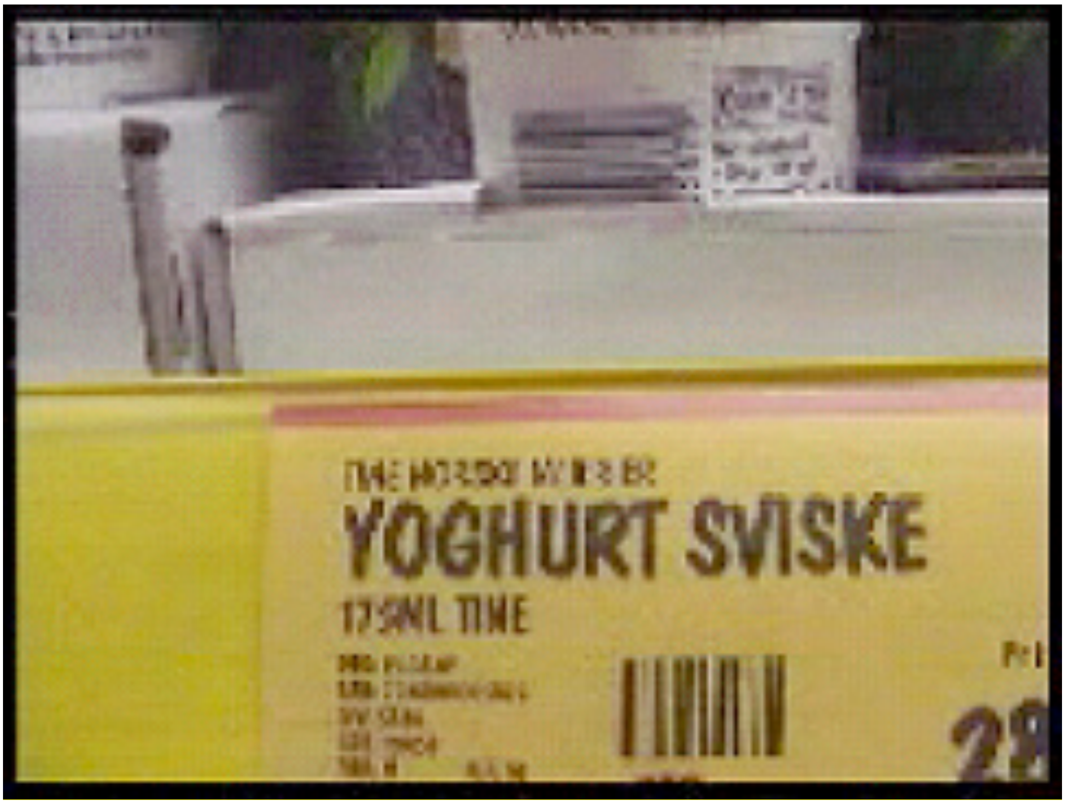

Figure 14 View of the operator's monitor when performing the space resolution test with QCIF and 25fps with camera 2 cm away

5.2.2 Results

Results for the acceptability of space resolution for price-tag reading are summarised in Table 10.

To be judged acceptable the text needed to be read with the whole price tag visible. In such a situation the image covered 2/3 of the screen.

When the camera was held closer to see if is was possible to read each word covering the full screen it was judged to be a non-optimal reading strategy for a user and movement was found to reduce legibility.

Table 10 Acceptability for space resolution

		Number of frames pr second			
		2-3fps	**5-6fps**	**10-15fps**	**25fsp**
Space resolution	**SQCIF**	Unreadable	Unreadable	Readable on full screen one word	Readable on full screen one word
	QCIF	Unreadable	Sometimes readable	Readable on full screen one word	Readable on full screen one word
	CIF	Sometimes readable	Acceptable	Acceptable	Acceptable

5.2.3 Conclusion

For the situation studied it is possible to recommend that at least CIF with 5 fps is used for adequate space resolution.

5.3 Movement test

5.3.1 Procedure

The user walked with a speed of 0.5 m/s along shop display rows with the camera pointing in waking direction. The operator was required to identify which product categories were being passed on both sides of the shopping aisle (i.e. categories such as milk, juice, soup, coffee, tea).

A view of the operator's monitor during the test is shown as Figure 15.

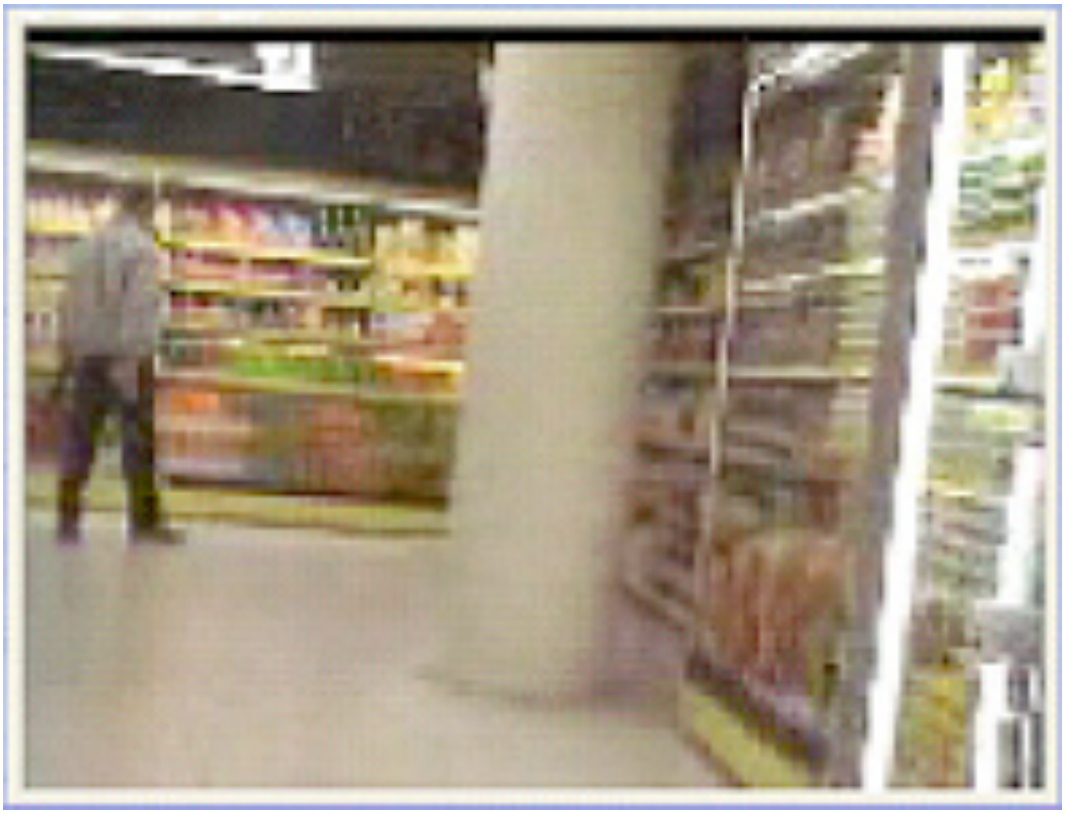

Figure 15 View of the operator's monitor when performing the movement test with QCIF 25 fp

5.3.2 Results

Results for the acceptability of frame rate for price-tag reading are summarised in Table 11.

To be judged acceptable the mobile Eye-phone needed to provide at least CIF resolution with 10 fps for movement.

Table 11 Acceptability for movement

		Number of frames pr second			
		2-3fps	5-6fps	10-15fps	25fsp
Space resolu-tions	SQCIF	Unreadable	Unreadable	Unreadable	Unreadable
	QCIF	Unreadable	Unreadable	Sometimes readable	Sometimes readable
	CIF	Unreadable	Sometimes readable	Acceptable	Acceptable

5.3.3 Conclusion

For the situation studied at least CIF with 10 fps is necessary for communication involving movement.

5.4 Discussion & recommendation on technical quality

The table of results for the two series of tests use colour to distinguish the results found for certain quality levels (Table 10 for space resolution tests and Table 11 for movement tests). Yellow cells are those quality levels that are considered to be acceptable *only if* the user is patient, steady and makes close-ups. By applying the results obtained from the in-depth user tests (Chapter 4) it is concluded that these areas *cannot be used* because five of the ten test users expressed that the amount of time required for being patient, steady and making close-ups is unacceptable.

Although the results are based on qualitative judgements by one person, they are considered to have high validity because this person was the experienced professional service centre operator who also participated in the two-day observational study of the leisure trip to Copenhagen and the 50 in-depth tests. Also, the tests were very focused on the most challenging situations for video quality that this operator had identified from his previous experience. However, further work with a larger sample size is recommended in order to test replicability of these results.

It is therefore recommended that the operator should receive at least CIF and 10 fps quality information for the video window. This advice is based on the use of a good camera with good auto-iris and auto-focus with macro-capability.

6 Main results

The following main results are identified.

The results of this section are presented in addition to the results provided separately for each of the four empirical phases described in:

- Section 2 (The pre-project – studies of service concept)
- Section 3 (Two longitudinal studies of real-world Eye-phone use)
- Section 4 (In-depth user tests of five selected situations)
- Section 5 (Tests of technical quality reduction).

6.1 The situations were relevant, achieved effectively with high satisfaction

The longitudinal case studies examined leisure and work trip activities that were offered by the case study participants as highly relevant to them. The in-depth user tests and technical quality tests examined tasks that were judged as relevant by the test participants.

For both the case studies and the in-depth user tests the Eye-phone was close to 100 % effective from the user perspective. All tasks initiated for the Eye-phone during the two case studies were done and 98-99 % of the tasks tested in the in-depth tests were successfully completed.

A verbal rating scale of user satisfaction included in the in-depth tests provided an overall mean score of 8 with 9 as the maximum score of “extremely satisfied”.

6.2 Almost all tests were achieved by the operator

Every test was solved effectively other than 1/5 of the tasks for two participants in the in-depth study (for the situation “lost something on the ground”).

6.3 CIF 10-15 fps is the minimum recommended quality

Lower technical quality (space resolutions with QCIF and SQCIF) can sometimes be effective for navigation activity (e.g. obtaining an overview while moving). But CIF is needed for a situation that requires reading more than just a word in a sentence.

QCIF requires being close to the image in question for detail, necessitating that the user pans the camera more to pass information to the operator. This is not favourable. In the in-depth user tests, half of participants complained if too many adjustments of camera position were required for a task.

Lower technical quality was observed to require more time and cause more user and operator irritation, with less user satisfaction.

These results imply the need for a 100-200 kbs transmission rate for video with the best codecs available.

6.4 Asymmetric equipment is required

Equipment arriving on the market is 'symmetrical' in that cameras on handheld terminals communicate with the same category of terminals with small screens. On these terminals the space resolution is typically QCIF or lower. There is no reason to transmit higher quality for display on such a terminal. Indeed, an experimental comparison of videoconferencing for face-to-face negotiation Hestnes et al. (Hestnes 2003) have found no significant difference in either task outcome or communicative process between CIF and QCIF quality on small mobile 3.5" monitors.

When the communication is asymmetric as for the Eye-phone with one-way transmission of video from a mobile terminal to a desktop terminal with 19" monitor, there appears to be higher demands placed on the mobile terminal.

Remote inspection terminals are advertised which will soon be available on the market. They are based on wearable computer technology (such as VisiWear www.visiwear.com) and can be candidates for Eye-phone applications. The problem is that these terminals have been advertised for one year with a promise that they would soon be available. The project would like to see and test them to see if they are suitable for the Eye-phone.

6.5 GPS is considered a good service element

GPS was simulated in the tests to demonstrate the ability for the operator to identify the location of the Eye-phone user. This functionality was believed to be a good aid by both the operator and the user.

6.6 The user interface was identified as helpful

The user interface for visually impaired persons was minimised to a hand-held 'pointing' camera and one 'hotline' call button. All test participants reported that the user interface was simple and helpful.

The service operator expressed a high degree of satisfaction with the layout of the service centre screen (Figure 16). This screen gave access to the position of the test-person (in a map application), access to all Internet information (e.g. address of a business or person to visit, events) in addition to the video information transmitted (by the visually impaired person's camera). Internet access can provide the operator with additional and unplanned information that may assist in a particular situation (e.g. bus timetable).

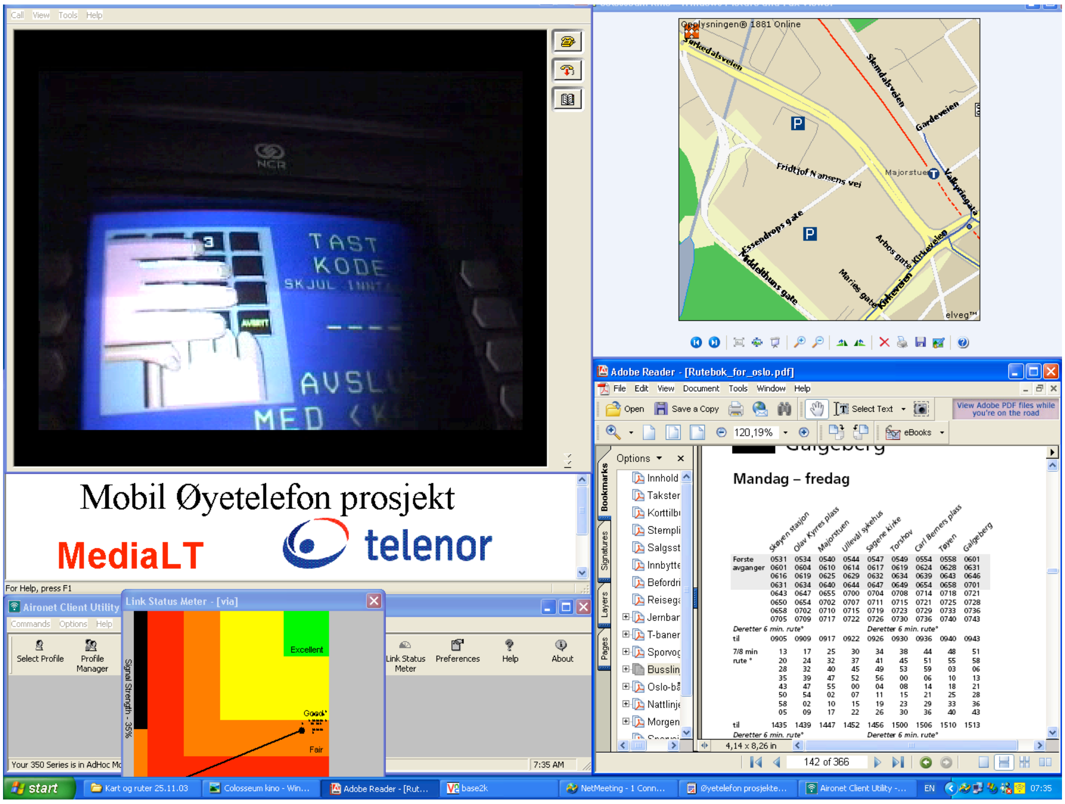

Figure 16 A possible operator user interface providing video, map, timetables and access to other Internet information

6.7 Site-maps require further development

Current map information is road transport oriented rather than pedestrian oriented. The typical users are in vehicles moving along roads in traffic lanes. Map information is used for route planners, navigation and to identify POI (Points of Interest), but only for those travelling in the traffic lane. Information that supports these applications is maximum speed on the road, width, one-way or two-way driving pattern and entrances to the motorway.

No known systematic collection of pedestrian information is currently available. Pedestrian areas are not registered and route planners cannot be used to cross a motorway.

In the future slower moving road users such as bicycle users and pedestrians should also be supported.

7 Discussion and conclusions

In addition to the main results, a number of points arisen for discussion and conclusions are drawn for service design considerations.

7.1 Strong requirement for 'Observe' tasks

The value of blind and visually impaired users being able to observe a person, situation or environment has been highlighted as extremely important.

For example, during his trip to Copenhagen the test-person emphasised that one of the most important aspects of Eye-phone use was the ability to have described to him how much his daughter was enjoying herself in the amusement park. A participant in the in-depth user tests suggested that a particular good use of Eye-phone would be the ability to "walk in a shopping street and browse into shop windows".

7.2 Eye-phone can encourage new risks

Enabling blind persons to move about and interact more freely places them at the risk of 'everyday' poor design of constructed environments and services (such as inconsistent operation of the train service in the Copenhagen trip). It can be argued that more initiatives to enable vulnerable persons to interact with their environment and services should be met with better quality design and operation of constructed environments and services.

In addition, once in a situation for which dependence is placed on the Eye-phone the users may become vulnerable if the device fails to work. However, similar situations can happen today too. For example, one of the test participants explained how some years previously (before the availability of mobile telephones) he was walking home from a party in the night when he got lost. No one was available to ask for help at this time of night and he did not want to disturb people in their sleep. He therefore continued walking until the morning when he met up with a person distributing newspapers.

With the development of an Eye-phone service it will be necessary to make users aware of what can happen if the system breaks, batteries get discharged or no coverage is detectable.

7.3 Eye-phone can be preferable to a guide dog or an accompanying person

The Copenhagen leisure trip illustrates a situation where the presence of an accompanying sighted person is fundamentally inconsistent with the purpose of the activity for the blind person (the trip was to be *his* birthday present to *his* daughter). The work trip to tune a piano illustrates a situation where too much use of a taxi service or the presence of an accompanying person is not feasible due to the realities and economics of operating a business.

During the in-depth user tests three participants chose to make comparisons between Eye-phone and the use of a guide dog. Two participants who owned a guide dog commented that Eye-phone could replace a guide dog. One participant argued that the Eye-phone is particularly good for walking short distances (e.g. from a bus to a taxi). The other participant argued that Eye-phone would be better for situations where it is difficult to use a guide dog or even be with another person (e.g. a shopping centre). A third participant who was not a current guide dog user also expressed that the Eye-phone could substitute a guide dog when there is only moderate need for a dog.

7.4 Long term usage may change the results

Except for one field test over a duration of 3 days, the tests were based on relatively short-term usage within one day. Also, the visually impaired participants had no previous experience with this application. From the main project investigation of stationary Eye-phone use (see chapter 1.4.2), it has been recognised that a change in usage and usefulness can occur over time and when the commercial aspects are taken into account. In particular, it can be expected that tasks will be achieved even more efficiently and the user will be even more aware of the tasks with which the Eye-phone really can help. Most participants in the in-depth tests commented that their ratings of satisfactions and their efficiency would increase even higher after a little more time to get experienced with the system. The chosen business model will also place implications on use, particularly depending on the extend to which users themselves will be required to to pay for the service.

7.5 Design considerations

Design considerations are divided into three perspectives:

- Design considerations to the service (section 7.5.1),
- Design considerations for the terminal (section 7.5.2),
- Design considerations to the network (section 7.5.3).

7.5.1 Design considerations to the service

The following considerations for the Eye-phone service have been identified from an analysis of suitable situations for Eye-phone.

Have operators available for prioritised calls – from a service centre operator perspective, there is a clear requirement for service availability at unpredictable times for spontaneous calls. An efficient economical solution should be searched where operators do not just wait for calls. In the mobile situation, this is more important than for the stationary Eye-phone (the stationary Eye-phone is not treated in this report).

Be prepared for demanding calls – current feedback is positive but it can be seen that service centre operators can be placed in demanding situations, such as interacting with clients when they are stressed, in emergency situations or users who have experienced accidents.

Give advice on mode of use – there is a need to judge when to be directive and encourage Eye-phone users to help themselves. In particular some participants appeared to become over focused on the use of the Eye-phone, using it for long periods when navigating and walking. As a result they stopped using usual methods and especially their stick. Therefore the operator may need to adopt a directive style such as “Continue walking straight ahead and then call me again if you want when you reach the shop”. It is possible that this behaviour would reduce quickly upon gaining experience of using the Eye-phone.

‘Observer’ should be trained – the value of Observe activity (e.g. Section 7.1) places requirements on the operator to be able to observe and describe people, situations and environments in a prosaic, interesting and powerful way. Differences must be expected, both in people’s ability to perform this task and Eye-phone users’ expectancies for types of descriptions.

Be economic with words, give only relevant information – providing the correct type and amount of information will be a skill influenced by appropriate experience and training. For example, several in-depth test participants stated that the Eye-phone is "easy to use with good guidance" and commented on the role of the operator in making them comfortable. A participant commented that part of the skill of helping to walk and navigate is not to give too much information. Another suggested that walking navigation could involve instructions to change direction by ways of angle degrees, as using 'right a bit' instructions tended to result in over-reactions and the need for repeated corrections. In the work-trip study using a non-experienced operator the operator occasionally had difficulty in estimating and stating the correct distance to an object of relevance (e.g. a potential obstacle).

Use only skilled operators – related to the previous two points, the operators should attend training before being exposed to real users. The training material should include frequently met situations such as guiding and demonstrating the use of mini-banks, how to correctly obtain information from the Internet, such as timetables for public transportation that have possible changes.

Confidentiality – there is a requirement to consider thoroughly how confidential information need not be exposed to the operator (e.g. in a mini-bank situation the camera might not be pointed at the keyboard when typing the PIN-code). There should be the correct professional attitude to confidential information. Appropriate material should be developed to assist training and the provision of well-thought answers that can be received by the users themselves.

Good terminology for positioning of camera – it is easy to provide 'too much' guidance (e.g. "Turn slightly to the right") and some advice can also be ambiguous (e.g. "turn the object around").

7.5.2 Design considerations for the terminal

Good enough audio quality – Audio quality should be better than or as good as GSM quality. Audio is the main medium - if the audio fails, it is hopeless to continue with only video. The audio should be easy to attend, also in noisy environments. GSM quality seems to be good enough for this purpose.

Good video quality – video should at least be received with CIF quality with 10 fps. It should be considered that the mobile Eye-phone will be used at home and at work for the situations identified (Section 2.1). From the stationary tests, not less than 4CIF (i.e. providing double the number of pixels than CIF in both x- and y-directions) has been recognised as video quality for reading mail.

Automatic mobile terminal – consider the terminal as a one-button terminal; i.e. the user presses the button and it connects to the service centre. This implies that the camera function should have automatic tuning of focus and iris.

Camera must be suitable – the camera should not be too big or heavy for pointing in the directions required. The camera may be a separate unit that is connected to the terminal cordlessly or via a cable.

Consider a zoom-function controlled by the operator – sometimes the object is too far away, such as a label behind a fruit counter or on the other side of a busy road. A zoom-function should be considered in spite of the disadvantages that there will be a stronger demand on the user to manage to hold the camera still and also that the operator may more easily lose context. A zoom function could be combined with a pan and tilt function.

Consider a video rotation function for the operator – the test-persons often hold the camera with the wrong rotation to display the image correctly. The operator may benefit from the ability to rotate (i.e. n*90º). However, this might lead to a loss of context.

Provide robustness – in inhospitable environments the terminal may be exposed to rain. Likewise the terminal may be dropped or bumped into walls and other hard objects. It is therefore necessary to consider a waterproof and shockproof terminal.

Provide predictable reliability - users can cope with equipment that stops functioning if they are aware of it. What is critical is that users know both when and why there can be equipment failure. For example, a warning of a low battery level gives predictable reliability.

Long enough battery life – a high quality codec will imply a high workload on the terminal processor that drains the batteries. It is therefore necessary to consider the terminal specification for battery life in inspection mode.

7.5.3 Design considerations to the network

Consider network coverage – the network should be reachable everywhere. None of the existing or upcoming networks can meet this requirement today. If the right terminal is chosen, 144 kbps can be used (which is supported by UMTS in 2004). There may also be hotspots where there are much higher bit-rates.

The network should not introduce characteristics that hinder person-to-person communication - currently there are many characteristics that cause concern. For example, too long delays, too much noise or distortion and dropouts will not be tolerated and will hinder the introduction of these services. Video may be delayed much longer than audio due to asynchrony. The effects on human communication need to be understood and taken into the consideration. Related work in this area is already described as Guidelines (Hestnes et al. 2003; ETSI, 2003).

8 Further work

Further work on Mobile Eye-phone should include more emphasis on Observe tasks in addition to Search and Verify tasks and also conduct more tests over a longer time to avoid only first-time use of the system.

As the tests of different quality levels were not based on sample statistics the results for this area should be considered provisional until larger-scale study in this area is conducted.

Telenor's strategic interest in developing mobile communication markets in Central and Eastern Europe coincides with the entry of many Central and Eastern European countries within the European Community during 2004. Mobility and *e*Inclusion are important elements of required work within the European Communities funding regimes for collaborative projects. Therefore a collaborative project with subvention from the EC may be a particular opportunity for further work, which addresses a large user group of blind persons across Europe.

From 1 May 2004 The EU is being expanded to 25 member states and 450 million people. Telenor has international operations in several of the member states eligible for EU funding of collaborative R&D, standardisation and demonstrator projects (Table 12).

Table 12 Current and future planned EU membership ***(countries in bold text represent areas of current Telenor international operations)***

Current EU member	Membership in 2004	Membership in 2007	To be elected
Austria	Cyprus	Bulgaria	Turkey
Belgium	**Czech Republic**	Romania	
Denmark	Estonia		
Finland	**Hungary**		
France	Latvia		
Germany	Lithuania		
Greece	Malta		
Ireland	Poland		
Italy	**Slovakia**		
Luxembourg	Slovenia		
Netherlands			
Portugal			
Spain			
Sweden			
UK			

There are two main EU funding programmes within which a Mobile Eye-phone collaborative project can currently be envisaged:

- 6th Framework Programme - the 6th Framework Programme of the EC is expected to issue its 3rd Call for proposals mid-2004. Neither an exact date nor a work programme has yet been published. *e*Incusion was a major theme of the 2nd Call for proposals which is now closed. Suitable action lines within the new work programme for the 3rd Call should be assessed for the appropriateness of their R&D objectives in relation to Eye-phone. Within the context of the Information Society Technologies priority of the 6th Framework Research Programme, the Strategic Objectives of "2.3.1.3- Broadband For All", "2.3.1.4-Mobile and Wireless Systems Beyond 3G" and "2.3.1.8-Networked Audiovisual Systems", of the current version of the IST Work Programme 2003-2004 are of particular relevance. EC consultation is beginning to review these subject areas, as described in the existing IST WorkProgramme 2003-4, to consider whether any changes to the text are appropriate for the WorkProgramme 2005-6, which will become the basis for future Calls For Proposals.
- *e*Europe programme - the *e*Europe 2002 Action Plan is to be succeeded by the *e*Europe 2005 Action Plan to focus on plans for widespread broadband networks throughout the EU by 2005 and the development of Internet Protocol IPv6. The main objectives of the Action Plan include the modernisation of public services and giving everyone the opportunity to participate in the global information society. Under the *e*Europe 2002 Action Plan many projects on people with special needs were achieved through the collaboration of ETSI Technical Committee Human Factors and the creation of STFs (Special Task Forces) for the production of ETSI technical reports, guides or standards. Therefore opportunities for collaborative work in this area should also be relevant and assessed in due course.

Significance for Telenor

There is a great need to understand user groups of Telenor. One user group is visually impaired people. This report indicates that there is a real need for blind and visually impaired people to use new services like mobile videoconferencing if the QoS is good enough.

It has been good for a telecom operator to be associated with the inclusion of users with special needs (or '*e*Inclusion', Design-for-All). In addition, usage of technology by people with special needs can shape the user interface for people without significant disabilities. One result was that blind people can use the Eye-phone successfully also where there is poor usability design. In our tests we found that Eye-phone was used successfully with extra time in situations where even sighted persons experience difficulty navigating or finding an item.

The public relations-effect of supporting disabled people such as the visual impaired is significant. The project has already been on NRK1 TV twice seen by 1.5 million viewers. There has also been coverage on TV2 and more public relations are planned.

The mobile Eye-phone is intended to extend the use of the Telenor Teleservice Text telephony service. This is a service for deaf people. Eye-phone gives new momentum to this service by bringing in a new user group. The potential user group is estimated at 9,000 users out of a total of 90,000 visually impaired people in Norway.

Also outside Norway, there can be expected to be a similar need for mobile Eye-phone in countries where Telenor Mobile operates. The project will study this more carefully in the summer of 2004 when the new calls for EU's 6^{th} framework programme are announced.

References

The reference list is divided into relevant topics for mobile Eye-phone. Not everyone has a reference in the text, but all of them are recognised as relevant to the chosen perspectives, which are:

- CSCW (Computer Supported Cooperative work),
- Einclusion,
- Eye-phone,
- QoE (Quality of Experience or User based Quality of Service),
- Mobile networks,
- Remote inspection,
- Videoconferencing,
- User-oriented Guidelines.

CSCW (Computer Supported Cooperative work)

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