Mobile Communication for People with Disabilities and Older People: New Opportunities for Autonomous Life

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Abstract. The fast diffusion of mobile telephony is opening a vast diversity of new opportunities for people with different levels of physical restrictions, these due to disability or ageing. For this people mobile technology not only allows ubiquity for communications but also anytime access to some services that are vital for their security and autonomy. Together with the numerous advantages, remote services can also mean important social and ethical risks for this group of users making indispensable that these risks are detected, analysed and avoided. Therefore, this paper analyses the novelties that mobile technology has introduced into the lives of users with disabilities and older people, points out some dangers and challenges arising from the use of these technologies and revises some future applications of the present mobile technologies.

1. INTRODUCTION

It is unnecessary to mention the enormous social change that the development of mobile telephony has supposed for many people. The possibility of establishing communications from anywhere and at anytime, without the need of being linked to a fix telephone, opened a great variety of new possibilities for personal communication, information and also for employment. This is even truer for the people that have limitations in their movements. Motor disabled people and many older people have seen enhanced the possibilities of carrying out an independent life, just if they can carry and use a mobile telephone.
This paper analyses the diverse uses of mobile telephony to urge the incorporation of disabled and older people in the design process from the initial stages and the use of the "design for all" approach. This is made from the conviction that the mentioned possibilities will become real only if the needs of disabled and older people are taken into account in the design of both equipment and services provided through mobile communication networks.

2. SCENARIOS

In this section, some situations in which the mobile telecom user might be found will be described. These basic scenarios will eventually expand into more complex ones according to the abilities of the users or the particular details of the situation. The analysis of these scenarios will allow us to show the needs, procedures of use, barriers, etc., that people with disabilities and older people can find when they use these services.

2.1. Voice Call Scenario

This scenario is related to the most frequent use of mobile communications. The user just wants to communicate by voice with somebody. This is, apparently, a very simple situation but when it is more deeply analysed, it can be found that certain people in specific environments can experiment serious difficulties.

In this scenario the user has to locate the phone, to hold it, to somehow dial the number, to be able to talk and hear during the conversation, to hang it up and, probably, to place the phone somewhere. Due to their difficulty to perform one or more of these tasks some users hardly fit in this scenario. Even if the generic problems are not very different from those experienced over fixed networks[1], some new features are available and new services can be used. For instance, in the case of deaf users, no standard equipment or service will help in this scenario, as direct voice input is not possible. Thus, manual or automatic voice-to-text relay services are required[2].

Hard of hearing users also experience important problems when using GSM mobile phones or DECT wireless terminals [Hansen 96]. These are due to the interference between the phone RF transmissions and the hearing aids. These effects can be minimised if they are considered in the design phase of both the phone and the hearing aid.

But, deaf users are not the only ones which have access problems in the simple phone call scenario. As a further example, the case of users with severe mobility restrictions can be considered. These users

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[1] Good revisions of these topics can be found in [Roe 95], [von Tetzchner 91].

[2] Manual relay centres are well known and has been available in most developed countries for some years. Usually, over wired phone lines the deaf user will use a special text telephone. On mobile networks short messages (such as the SMS [see http://www.gsm.org/technology/sms.html] available in the GSM networks) could be used to support this type of text communication but this possibility is usually limited by:

Terminals: Each message has to be sent separately indicating the destination number. Incoming messages have to be read using specific commands and no reordering mechanism is provided.

Operator Billing Policies: Operator usually charge on a "by message" basis. This can make text telephony over SMS very expensive.

It is important to consider that these limitations are not essential to the SMS messaging system and adequate terminals and operator policies can easily solve them. As an example of these facts even higher level protocols like WAP [WAP98] can be built on top of SMS. While this type of implementations become more popular there are currently several mobile text telephones (based on Nokia communicator and similar devices) which either use the same protocols over the mobile phone voice channel, or transmit the text as data using the standard data protocols and relay on a gateway to convert them to the ordinary text phone protocols.

The impossibility of listening (and talking in the case of mute-deaf users) to the intended conversation is the biggest problem experimented by deaf users when accessing a mobile voice network. There is a secondary problem related to messages such as "the terminal is not available at this moment…", "the number you dialled is not assigned", etc. These messages are usually sent only by voice thus making them *non-existent* to deaf users. Several operators are currently trying to solve these problems (e.g. BT with its virtual text network). The solution looks simple in mobile networks were text-messaging functions are readily available and the entire voice message can be easily duplicated with text messages. In the real world things are not so simple because voice messages can originate in many different places in the network.

make up one of the groups for which mobile phone can be, in principle, more beneficial. For those users whose only way to move around is an electric wheelchair most of the devices required for everyday living must be installed in the chair. For them a mobile phone can be the most natural element to communicate with their friends or relatives or to contact emergency services in case of need. In this case, the biggest problem is not the conversation itself, but the possibility of starting and ending it. Most of these users have very limited control over their hands, which makes impossible picking up the terminal, holding it and dialling in the common way. Thus, if a terminal is to be used in this situation some new requirements that imply complete hands free operation must be considered. These are:

- External microphone and speaker connections should be available.
- It should be possible to pick the phone for an incoming call without using the hands.
- It should be possible to place a call without using the hands.

Those requirements are not only valid for the wheelchair user scenario but they are also good for the car driver scenario. This is probably the reason why the two first requirements are met by most currently available terminals. The third one is technically more complex and some solutions which are valid for the wheelchair scenario may not be adequate for the car driver and vice versa[3]. If the terminal is fully controllable by voice commands it can be used easily and comfortably[4] in both scenarios. Current generation terminals may include embedded voice diallers but, to the authors' best knowledge, none of them can be fully controllable by voice. As voice recognition technology becomes better and the processors embedded in the terminals become more powerful this type of control will probably become very common.

Most current mobile terminals include an interface connector that, usually, permits an external device[5] to have full control over almost every phone function. If this is the case, the best solution is probably to have a single device acting as user interface for all other devices resident in the wheelchair. This is the main idea behind wheelchair buses like M3S and DX[6]. To our best knowledge interfaces to connect mobile terminals to these buses are not currently available. Unluckily, in most cases, the terminal interface is not publicly documented and this restricts the number of devices that can implement this solution. Several terminals supporting the infrared-based IRDA standard are already in the market. Currently Bluetooth[7] is also emerging as an open standard for communicating with mobile devices including terminals, PDAs and notebooks. Probably the situation will improve when the use of these standards becomes commonplace.

Blind users can also have some access problems when using mobile phones for voice communication. These problems are, however greatly reduced in comparison to those which appear when using public access terminals. Mobile terminals, being personal devices, can be known very well by the person who uses and carries them. Thus, locating the terminal is an easy task and placing and handling the calls has no greater difficulty either. The main access problem in this case is using the keyboard but if this has a

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[3] For instance, when a driver wants to place a call she or he can stop, perform the call and, when the conversation has started, continue driving. Many of us will probably not even stop although this is neither legal nor recommended. In the case of the wheelchair user this solution is, obviously, not acceptable.

[4] Supposing the voice recognition system performs adequately which is not true in most currently available voice diallers

[5] Usually a PC with a PCcard interface.

[6] see http://www.dynamicmobility.co.nz and http://www.tno.nl/instit/tpd/m3s

[7] See http://www.bluetooth.com

standard layout, keys can be distinguished well from the background and a single raised dot on the number 5 key, most blind users will feel comfortable with their mobile phone. A difficulty, experimented by many blind users (and other users to a smaller degree), is the one associated to changing the batteries and charging them. These difficulties are greatly reduced if the needs of these users are considered in the terminal design phase.

Another large user group that has problems with mobile terminals are older users. Many terminals are difficult to use and, thus, many users feel they will not be able to handle them. Good design practice reduces these problems significantly. The situation in this case, probably due to the market significance of this user group, has clearly improved in the last years. Currently terminals with large displays, that keep most common functions easy to use, are quite common[8] but there is still great room for improvements.

People with severe confusion problems could also benefit largely from mobile communications but, in this case, the user interface must be kept much simpler than in all the cases above. The system must probably decide with little user participation whom to call. This situation will be explained in greater detail in the "I am lost" scenario below.

2.2. Message available scenario

In this scenario the user is informed that a message is available in the voice mailbox. Not all operators perform in the same way when messages are available. Basically all of them[9] will send the associated terminal a text notification indicating the presence of the message. Some operators will later make an automatic voice call to the user informing her or him that some messages are available and giving instructions on how to listen them[10].

Each of these techniques denies access to some users, but if both of them are available the situation improves:

- For deaf users the messages should be kept as regular text mail and the short message notification method is obviously adequate.
- Hard of hearing users can listen to messages if they can handle regular voice conversations but, will generally prefer to be notified by text messages although, it is not uncommon that they would like both types of notifications.
- Blind users should obviously be notified by voice.
- For mobility restricted users, the main problem is usually to select among the different options given to them by the mailbox management system. In this case it is important not to place too short[11] limitations in the time the users can take to select a command. It is preferable if these parameters can be modified on a user by user basis.
- Older users usually don't like text messages and prefer voice notification. For these users it is important to keep the options in the mailbox management system as simple as possible. As indicated

[8] Badly designed terminals with many buttons, small letter displays, and complicated operating procedures are still very common also.

[9] Except in the case of analogical networks, that may not be able to send text messages.

[10] If a terminal can read text messages using text to speech it can generate the voice notifications without operator intervention. See the Text message scenario for a more detailed discussion on this topic.

[11] Users with important mobility limitations must be taken into account in the definition of what "too short" means.

above, the best solutions can only be implemented if the way in which the operator handles the mailboxes can be adapted to the specific user needs.

- In the case of users who experiment large confusion problems voice mail is probably not a good idea independently of its implementation.

2.3. Text message scenarios.

Text messaging in mobile networks has become increasingly popular in the last years[12]. But text messages have their own accessibility problems. These problems are very well known because they are just a variation of the computer access problems that were common before the multimedia era.

It is interesting to note that some ideas originally developed for users with strong mobility restrictions like *word prediction* [Garay 97] and *reduced keyboard disambiguation* [Lesher 98] have come to the mainstream market through their application in mobile telephony. The size requirement of an ordinary mobile phone rules out standard QWERTY keyboards for text input and, thus, the standard 9 or 12 keyed keyboard must be used for this propose. When this is done all users are in the same situation that disabled people and must employ techniques that users with little control over their mobility have been using for years. These means that all the approaches invented to reduce the number of keystrokes required to write a word have become important to the public in general[13]. This process will be beneficial for disabled users in the long run as it will make word prediction and disambiguation techniques improve.

For mobility restricted users the main problem with messages is being able to write them. Even if the terminal incorporates a word predictor it will not be usable by most users with important mobility restrictions directly. For this propose it is essential that the terminal can be controlled externally from a device that can easily be commanded by the user. This was already mentioned in the "voice call" scenario.

Blind users have two different problems. First, they must be able to read the messages. Considering that these messages are usually very short[14] text-to-speech conversion is the best alternative for retrieving them. Text-to-speech is a mature technology[15] but to the authors best knowledge is not available in current terminals. No doubt that future terminals will be able to read text messages.

The second problem is more difficult and more interesting, as it differs from the standard computer access problem. With ordinary computer keyboards blind users don't have great difficulties for inputting text. As it has been mentioned above the ordinary keyboard is almost ruled out for mobile designs and word prediction and reduced keyboard disambiguation methods are becoming commonplace. With this type of input devices blind users experiment much greater difficulties than with keyboards with unambiguous mapping. This is due to the fact that with word prediction the user must be ready to see

[12] A good revision of the motivations for this and the ideas that operators may follow to encourage text message use is available in http://www.gsm.org/technology/sms_03.html

[13] As an example of this, the Tegic T9 algorithm is based on ideas that have been known in the Assistive Technology community for years [see http://www.tegic.com]. We are not questioning in any way the originality of the specific details of the Tegic patent (U.S. Patent No. 5,818,437).

[14] In some cases like GSM SMS the protocol imposes a very short maximum length, while in other short length messages are imposed by usage.

[15] Several good TTS engines are available, e.g. from Lernout&Haupie, see http://www.lhsystems.com

the different suggested alternatives and choose among them. As an example in a common implementation of the T9 algorithm if the user likes the first alternative s/he will just hit the "spacebar" once after inputting the word, if the second alternative is desired the spacebar must be hit twice, etc. Other actions are necessary to input a word that is not included in the dictionary. Thus we have a problem, How can this be implemented in a way that is natural for a blind user? A simple solution could be to stick to QWERTY keyboards or at least to unambiguous keyboard mappings[16].

In principle, *voice recognition* is an attractive alternative for composing messages. In this case the situation is much more complex than when we talk simply about voice controlled terminals, this is due to the fact that we are not dealing with command recognition but we have to be able to recognise dictated text. The technology for this purpose, although currently available, is still not fully reliable and its processing requirements are above those available in mobile terminals. This situation will probably change in the near future.

2.4. "I need help" scenario

Many times a user may need some kind of assistance. We are not including in this scenario some cases in which the user safety may be in risk. The situations where the user is lost, or the user experiments health problems, are dealt in specific scenarios. The "I need help" situation is reserved for those cases where the user needs information about the network operation, phone numbers, etc. That is, the cases where the user needs generic help[17] and also the cases where the user wants to contact a standard emergency service[18]. For users with no significant disabilities this aspects are well covered in most networks as they provide specific numbers for network help, generic help and emergency. Even for these users there is an important problem when roaming as different networks use different numbers for these services. Sometimes these numbers can be used from any terminal, at least in the operator country whilst, in other cases, they can only be used within the specific network. This situation is annoying when help is needed and especially in the case of older people. A good solution could be to provide specific keys: a relatively large button in the terminal to ask for help in emergency situations and a smaller one to ask for network and generic help.

Another generic problem is related to multilinguality as many people, and specifically many older people, will like to be answered in their own language when they need help.

Deaf people have an important problem with most help services' numbers since, currently, any access to there must be done by voice. This means that any deaf user has to ask for help using the same relay centres used for standard voice call communications. This situation is not very logical as, usually, the help centre operator will process most of the calls searching the required information using a computer terminal. This same terminal could easily be used to handle the user requests received as text. Some operators provide limited text message based help facilities but these should be extended to handle all the functions available by voice and should become commonplace.

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[16] Some terminals like e.g. the Ericsson T10S, reduce the number of keystrokes by using multiple key selection. In this way the unambiguous keyboard is preserved. Of course this implementation requires great manual dexterity thus making thing difficult for other type of users.

[17] Like in asking for a taxi, making an hotel reservation, changing a flight, etc.

[18] Like the "112" emergency service in Europe.

2.5. "I am lost" scenario

When the user is lost and needs assistance, mobile telecommunication devices can be of great help. All cellular networks provide mechanisms that permit the course localisation of the terminal. In some situations, e.g. when the user wants to know by which road is she driving, this information could be sufficient but for most common situations this is not the case. GPS satellite based positioning system provides world wide absolute positioning within about 100 m[19]. This can be improved even further by using differential GPS where a fixed land based station broadcasts GPS corrections for a limited geographical area. In many developed countries some commercial radio stations transmit these corrections using RDS in the standard FM band. With DGPS the errors are related with the distance to the reference station but they are within 10 m in most situations. Currently some mobile terminals embedding GPS receivers are already available and some operators are starting to offer this type of services. Other solutions for localisation are also possible.

In principle, everyone could benefit by being able to ask for help in finding a specific route or, being able to ask for a taxi in the street without having to explain the pick up location. Of course the same arguments hold for calling and ambulance, the fire station or the police. Users who experiment some confusion, including many old users, could find these functions especially attractive if they could be used in very simple ways. The user interface for this type of device must be studied very carefully if they are to be useful.

2.6. “I don’t feel well” scenarios.

This scenario is closely related to those described in 2.5 and 2.4. If the user is able to dial the help numbers[20] and to handle a conversation the services outlined in the preceding scenarios are sufficient. Even if the user was only able to push a button, help could be brought to the right place if localisation functions are available in the terminal and the network. But, What kind of help should be brought? How to handle the worst situations where the user is not even capable of pushing the emergency button? To provide an integral emergency service, these questions have to be answered. This type of service is especially useful for older and disabled people living alone.

To answer the above questions some health-monitoring device must be worn by the user. This devices could, in principle, analyse health parameters like heart rate, breathing rate, blood pressure, etc. and trigger and alarm to the emergency service when and emergency situation is detected and the user is not able to do so. The mobile terminal would send the health parameter information together with the user position thus making possible to bring the right kind of assistance to the right place very quickly. The success of these systems depends greatly on:

- The possibility of designing non-invasive sensors which are comfortable and aesthetically acceptable by the users.

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[19] On May 1st 2000 US President Clinton announced that the intentional degradation of GPS signal would be discontinued. This will make Differential GPS useless as the accuracy with ordinary GPS will be as good as with any differential correction.

[20] Or press the specific emergency button.

- Giving the user full control over what type of monitoring s/he wants, and the possibility of cancelling it without triggering any alarm.

3. MOBILE COMMUNICATION IN THE LIVES OF PEOPLE WITH DISABILITIES AND OLDER PEOPLE

From the analysis of these scenarios that compile many experiences of real use, some ideas about the impact of mobile communication systems on the disabled an older peoples lives can be extracted.
What disabled users expect from mobile communications is not very different from what the generic user expects from these services: mostly, fully reliable personal communications and services to improve, as much as possible, safety and quality of life. Where are the differences? Mainly in the greater user dependence on this services and in the specific interface requirements. In most cases, if all user needs are considered in the design phase, equipment and services will be usable by most people. The requirements that mobile communication systems for disabled and older people should met can be classified under the following categories:

- Personal communication: One of the most important needs of people with restricted movement is personal communication. People with severe motor restrictions can experiment serious difficulties to use wired telephones. These difficulties are mainly due to the need of reaching its position in a limited period of time to be able receive a call, and the frequent inadequate location that can make wired telephones hard to use. Thus, for these users mobile technology enhances their chances of personal communication avoiding the previous restrictions to some places and some times in the day.
- Security: Older and motor disabled people experiment restrictions that can led them to potentially risky situations that increase when they try to carry on an independent way of life. Situations of illness, home accidents, and so on, require a quick communication channel to obtain urgent help.
- Social integration. Access to education and labour market: In the last years wired telephones have granted access to formation and job opportunities through *telematic* services, such as tele-working or tele-education. These services have contributed to social inclusion and autonomy of many users with disabilities. But, in very isolated regions, where standard telephones are not available, mobile telephones are the only way to reach services that contribute to socialisation. Even if the access to these services does not need structural modifications, the prices charged to people using them should especially be considered and subsided, to promote their social integration and to avoid the discrimination of people living in these disfavoured regions.
- Autonomy: As it has been mentioned in the previous paragraphs, the combination of personal communication, security and access to integrative services gives to people with disabilities and older people more opportunities to carry out an independent way of life.

The accessibility to mobile telephony is also conditioned by the ergonomic limitations of the handsets. Sometimes, mobile handsets are very difficult to handle and include an enormous number of functions, very seldom used, that makes the operation very complicated[21].

Many of these user requirements can be fulfilled if the needs of all the possible users are taken into account when a new service or device is planned. The patching of standard devices to adapt them to the special needs of determined users is being substituted by a new design philosophy that tries to consider the requirements of all the possible users. This design philosophy is usually called *design for all* and has proved to be very valuable not only to include more people in the use of the designed equipment, but also to enormously enhance its usability for everyone. Devices designed for all are easier to handle, learn, understand and use for all the users.

Nevertheless, it is very important to consider that sectors of the population that are not able to use the systems *designed for all* will possibly remain. So, it is essential that products and services are designed in such a way that, when necessary, they are open to possible adaptation for specific user needs. Moreover, for those users that cannot use these adaptations, specific services and equipment should be provided.

4. RISKS OF MOBILE COMMUNICATION FOR PEOPLE WITH DISABILITIES AND OLDER PEOPLE

The provision of services through mobile telephony can also led to social and ethical risks for users with disabilities and older people[22]. Some of them have been envisaged in the mentioned scenarios. Let us summarise the most critical of them.

- Social isolation: The provision of personal communication and security help through mobile systems is frequently accompanied by a reduction of direct human relations with relatives, friends and care personnel. For this reason some users may feel that the technology they are provided impedes the human relations they previously had and, consequently, they reject this technology.
- Lost of personal autonomy: Some services that monitor the health status or the location of the user for their security, may also incur in invasion of their capacity of taking decisions.
- Lost of privacy: The tendency to establish communication in open places (an increasingly frequent habit that many users do not even realise) makes private communications being heard by estranges. In many cases, users with disability can not chose the place where they use this service. Moreover, older users may not be conscious about the openness of their communications.
- Economical barriers Even if mobile services were fully accessible, there is still another important barrier: the economical one. Many of the special requirements that users with disabilities and older people have using mobile telecommunications imply slower communication and longer use, resulting in higher prices for the same service.

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[21] *Number storing, redialing, credit card management, call waiting, call forwarding, autoanswering, number screening, and on and on are constantly being squeezed onto the real estate of a thin appliance that fits in the palm of your hand, making it virtually impossible to use. Not only do I not want all those features; I don't want to dial the telephone at all. Why can't telephone designers understand that none of us want to dial telephones? We want to reach people on the telephone!* [Negroponte 95].

[22] Interesting studies about ethic and social problems for disabled and older users can be found in: [Colon 93], [Taipale 95] and [Takkar 90]

In the same fashion that potentially contaminant industries are asked for an study of possible environmental impact, the introduction of new *telematic* services and mobile equipment should include a deep study of the social and ethical impact over the users with disability and older people. This study should clearly point out the critical aspects that have to be avoided, and also describe the compensatory dispositions that have to be taken to avoid negative effects over their lives [Abascal 97].

5. COMPETENCE, TECHNOLOGY ACCEPTABILITY AND USER NEEDS

People trying to introduce technological advancements to help disabled and older citizens have to overcome some extended clichés: the lack of ability of the hypothetical users to handle complex devices, and also their acceptability[23].

The last one is frequently formulated as: "older people reject technology". Nevertheless, there is no evidence that older people dislike the use of novel technology in a larger measure than other people do (except, of course, very young people that are usually enthusiastic about technology). Rejection is frequently due to the low quality of the interface, automatic teller machines being a paradigmatic example. Moreover, some studies show that adequately trained older people are in general able to use technology[24]. The origin of this cliché can be found in the fact that technological aids have frequently been introduced without a deep study of user needs, an adequate training period, a good support service and, in many cases, substituting human care. These conditions lead to a certain failure and, consequently, the rejection.

The other frequent cliché is formulated: "technological devices are too difficult to be used by disabled and older people". Many experiences show just the opposite: designers who have had contacts with disabled and older people are surprised of the rapid adaptation and the level of efficiency that these users are able to reach in short time when the device adequately fulfils their needs. If the user-system interface is appropriately designed, there is not reason for a misuse of the device. Moreover bad designs are difficult to be used, not only by disabled and older people, but also by every one[25].

Another possible cause of the misfit, and therefore rejection of *telematic* help systems, can be a deficient evaluation of user needs. Frequently the emergence of new technological advancements move engineers to imagine hypothetical benefits for disabled and/or older people if these technologies were applied to solve presumed user needs. These assumptions, when they are not based on in-depth studies about users interests, needs, wishes, likes, etc. lead to misconceptions that produce systems not suited for the target user group and hence they are rejected. Only serious studies about user needs[26] can result in systems that satisfy the true user needs and will therefore have the possibility of being accepted by them.

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[23] See C. Rott "Elderly people and new technology: Psychological issues of competence and assistance" in (Tapiovaara 95)

[24] "Attitudes and Acceptance" by S. Bjørneby et al. (Tetzchner 91), refutes the myth of the technological incompetence and disinterest of older and disabled people to use technology from experiments carried out in England, Portugal and Norway.

[25] "Thus badly designed systems handicap all users." [Thimbleby 95]

[26] Such as the one mentioned by S. Collins et al. in "Telecommunications Needs as Expressed by Elderly People and People with Disabilities" (Tetzchner 91)

6. GUIDELINES FOR THE DESIGN OF MOBILE TELECOMMUNICATION SYSTEMS FOR USERS WITH DISABILITIES AND OLDER PEOPLE

The design of mobile telephone terminals should improve very much to be fully accessible for people with disabilities and older people[27]. There are many useful guidelines that can help in the design of *telematic* services and equipment [Brant 95] [Gill/Shipley 99].
As an example, a booklet published by the RNIB[28] on behalf COST 219 bis[29] offers clear guidelines to improve the usability of mobile handsets[30] [Gill 99]. These guidelines give useful advice about key issues, such as ergonomics of the handset, including the visual display and keyboard, the need of on-line audio help, volume control, wireless connection to other devices via infrared port, and so on.
We must insist in the idea that all the enhancements in the accessibility of mobile telephone handsets are also useful for people without disabilities. Moreover, frequently people make use of the mobile phones under some conditions that put them in similar situation to disabled users. For instance, a user of mobile telephone in the car, thus, without the possibility to look at the display, has the same requirements for the mobile terminal than a blind user.

7. MOBILE COMMUNICATIONS FUTURE: COMBINATION OF TECHNOLOGIES

The impressive influence of mobile telephony on disabled and older people lives will be multiplied by the use of combined technologies. Let us show some of the most challenging possibilities in this area.

7.1. Mobile text telephony

Digital telephones can transmit coded characters. If the telephone handset has any type of textual keyboard, the typed characters can be shown in the receptor's display. A difference with the fax communication, this textual communication is interactive, giving the interlocutors the possibility of dialoguing.
In some countries, text telephony is frequently used by deaf people for personal communications [Gjøderum 99]. When a text telephone is used, it is necessary that at the other end there is either another text-telephone, or a relay service that acts as a translator for not deaf people. Other possibilities of communication, using voice-to-text and text-to-voice translation are under research, due to the difficulty presented by speaker-independent continuos discourse speech recognition with telephony voice quality.
The mobile text telephone can not only fulfil the needs of communication of deaf people. It can also help deaf people having understanding difficulties to obtain help from special services. In this way, they can use their mobile text telephone to make consultations on line, ask for clarification, etc.
Usually text telephone includes alphanumeric keyboards, containing a large number of keys. But recently, some studies have been carried out about the use of the classic telephone keypad for text

[27] "A telephone handset is probably the most redesigned and overdesigned appliance on earth, yet remains utterly unsatisfactory. Cellular telephones make VCRs pale with their unusable interface." [Negroponte 95].
[28] See http://www.rnib.org.uk/
[29] See http://www.stakes.fi/cot219.htm, lhttp://www.stakes.fi/cot219.html
[30] See http://www.stakes.fi/cost219/mobiletelephone.htm

transmission, and how to cope with the ambiguity generated by the fact that the number of key is smaller than the set of characters [Kushler 98], [Lesher 98].

7.2. Mobile telephones as light terminals to Access to Internet

Even if nowadays Internet is not widely used by disabled and older people, it is expected than in the near future this use will increase greatly. Accessibility to www is increasing rapidly[31]. And some www pages will be of great help for disabled people. For instance, to download information in a format which is more readable for them (transport, timetables...). This information is unforeseeably needed: it is not possible to previously know when and where it will be consulted. For this reason mobile terminals will become very valuable for ubiquitous access to Internet.

The palmtop computers that include mobile phones and the mobile phones that include accessibility to Internet, already in the market, are far from guaranteeing the accessibility to people with disabilities. The web accessibility guidelines issued by TRACE Center[32] specify the characteristics that a mobile terminal has to have to be fully accessible to Internet for every one.

An important aspect is that when accessing the Internet using a current generation mobile terminal (GSM or CMDA) the user is immediately restricted to limited display capabilities and very reduced bandwidth[33]. This means that most of the material present in Internet pages has to be transformed to adapt it to the capabilities of the user. This situation is absolutely parallel to the situation of many disabled users accessing the Internet using their standard terminals. In this way, everyone is carried to a disabling situation by the mobile telecom environment. This has very important consequences as any initiative that tries to bring internet access to regular mobile terminals will also automatically easy internet access for disabled users. The Wireless Access Protocol[34] (WAP) and its associated Wireless Markup Language (WML) are very strongly typed, in the sense that every specific type of media embedded in the pages must have and associated type and alternative representation when possible. A great effort is being made to provide WAP gateways for standard HTML pages. This can, at least in principle, improve the access to the Internet in general for disabled users.

With the emerging Bluetooth standard, a user will be able to use her/his mobile phone controlling it from any other device including not only PDAs and notebooks but also Assistive Technology devices such as communicators and wheelchair controllers. In these last case a bridge will be used to connect it to the chair standard bus. As this standard, which is based in a 2.4 GHz RF connection supports wireless networks with a 10m range[35] it can also be used for connection to fixed networks while the user is at home or at the office.

7.3. Mobile telephones and GPS. Tele-guidance

[31] Find information about the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3) in http://.w3.org./wai/
[32] See http://trace.wisc.edu./world/web
[33] This situation will change in the so called 3G mobiles, e.g. UMTS.
[34] The Wireless Application Protocol Architecture Specification, from Wireless Application Protocol Forum, Ltd, 1998, is available at http://www.wapforum.org/
[35] Can be extended to 100 m.

GPS technology permits the localisation[36] of the receiver with increasing accuracy, that using complex methods can reach to the metres. Currently, as a result of the European TIDE More project, Benefon is offering a GSM terminal with embedded GPS receivers. This type of systems will probably become more widespread in the future as being able to cope with the "I am lost" scenario depends basically on them. This type of systems are also essential if we are to provide health care support for users away from their home.

As applications for mobile phone terminals with localisation capabilities in many areas are potentially very large, the success of these systems is easy to predict[37]. The real benefits for disabled and older users will depend to a great extend on their needs being considered during the design phase and, to a very great extend, on the possibility of controlling these systems from other devices using an open protocol.

8. Conclusions

Mobile communications technology has a great potential to change the lives of disabled and older people. The industry is starting to take in account this collective as a potential market, mainly due to three reasons: the rising proportion of disabled and especially older people in occidental societies, the possibility of governmental subsidised prices for people with disabilities and, the potential introduction of some of these devices into the main-stream market. But the advantages offered to disabled and older people can only be useful if the design is made taking into account their real needs and requirements.

The benefits that users with disabilities and older people can obtain from mobile access to some services are accompanied by some risks that have to be evaluated and avoided. In this way, the authors propose the inclusion of an *ethical and social impact study* in every project related to mobile equipment and remote services for disabled and older users, in which possible dangers are pointed out and compensatory actions are described.

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[36] Several other alternatives are available for mobile phone localisation. In the US localisation capabilities will be mandatory in all mobile terminals in the near future.

[37] For instance, the Finish telecommunication operator “Keski Suomen Puhelin” provides orientation services through a server for localisation of users of a specific model of GSM. (http://ultra10.almamedia.fi)

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