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USER-CENTERED DEVELOPMENT OF VIDEO TELEPHONY FOR SERVICING MAINLY OLDER USERS: REVIEW AND EVALUATION OF AN APPROACH APPLIED FOR 10 YEARS

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Abstract: *A research and development (R&D) approach has been applied to video telephony (VT) in northern Finland since 1994 by broad consortia. The focus has been on the considerable involvement of ergonomics within the engineering and implementation of VT. This multidisciplinary participatory ergonomic R&D approach (PERDA) is described briefly, in general and through two cases. The user-centeredness should be discernible in this sociotechnical systemic entity. A consortium—comprising mainly manufacturers, individual and organizational users of technological products, and R&D organizations—serves as a natural context for product development. VT has been considered to have much potential for enhancing (multimedia) interaction and effective multimodal communication, thereby facilitating many activities of everyday life and work. An assessment of the VT system, called HomeHelper, involved older citizens, as clients or customers, and the staff of social, health, and other services.*

Keywords: *ergonomics, older users (of technological products), participation, research and development, usability, user-centered design, video telephone.*

INTRODUCTION

A participatory ergonomic research and development (R&D) approach, PERDA, with an emphasis on user-centered technology and usability, has been applied to video telephony (VT) and its applications in northern Finland, and has been facilitated by consortia of research partners. The PERDA projects have been managed by the University of Oulu, usually

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in cooperation with the University of Lapland. A multidisciplinary academic research group, consisting of ergonomists, computer and software engineers, industrial designers, psychologists, physicians, nurses, and anthropologists, has been operating various R&D consortia together with a number of hardware, software, and service companies, as well as public sector partners. The principal idea of PERDA (Väyrynen, Tornberg & Kirvesoja, 1999) and the academic core of the PERDA consortia have remained the same for 10 years. The stakeholders (company partners and nonuniversity organizations) of the consortia have varied, at least slightly case by case, during the period of PERDA operation. Stakeholder organizations, including the National Technology Agency of Finland, have been funding the PERDA projects. The users of the technological products under research, both individuals (end users) and organizations (service providers), have held special participatory roles within PERDA (Väyrynen, Kautto, & Kirvesoja, 1998).

The following information and communication technology (ICT) products or systems, especially VT, have been studied and developed by these consortia since 1994. A total of 11 case projects have been conducted, dealing with

- telephones, telephone services, mobile phones (multimedia, though primarily voice-only), video telephone, various concepts for diverse industries, and other needs
- video telephone with a touch-screen and a user-friendly user interface (UI), called the HomeHelper
- robotics-style aids for a "smart" home, supporting other ICT products and applications.

The emphasis of the work of these consortia in the last decade has been implementing the concept of ergonomics within the concept and design phases of technology research. Generally, ergonomics introduces a user perspective to design (Pheasant, 1988, 1996). First, *ergonomics* encompasses the empirical physical, cognitive, and psychosocial knowledge of the characteristics of human beings and their activities and experiences. This conventional knowledge of the capacities and limitations of the human being as a user is necessary, but not sufficient. We also must know and understand the needs of users related to their working and living environments and contexts. According to the literature (Hendrick & Kleiner, 2002; Langford & McDonagh, 2003; Wilson, 1995) and our experience, user participation has often had a key role when success has been achieved.

In addition, the field of gerontechnology has played a major role in the research work of the consortia. Gerontechnology was originally introduced in the early 1990s, and is now relatively well-known in all industrialized countries (Bouma, 1994; Fozard, 1994; Harrington & Harrington, 2000). In addition to the design of special products, *gerontechnology* refers to basic and applied research that deals with the interaction between older people and their technological environment. Throughout history, humans have utilized various tools (technologies) to be able to work and live better. Such empowerment by products can be one of the benefits of (geron)technology for the independence and welfare of older citizens. In our cases, instead of gerontechnology, the approach had aimed to guarantee "geronusability" of products (Väyrynen, 2002). This means that often just the UI designed especially for older users is enough to meet the need, instead of designing the whole technological product for older users.

Quite naturally, the traditional textbooks on human factors engineering present guidelines for designing for older users. One example is the list by Sanders & McCormick (1998, p. 77) for designing information processing tasks and ICT products like VTs:

- Strengthen signals—make them louder, brighter, and so forth—for older people

- Design controls and displays so that irrelevant details do not act as distractions
- Maintain a high level of compatibility[1]
- Reduce time-sharing demands
- Provide more time between signals and responses to them or, ideally, let the user set the pace for her/himself
- Allow enough time and practice for initial learning.

The aims of this paper are two-fold: (a) to describe our approach (PERDA) in general, but especially through two practical cases, as well as the main background in the literature; and (b) to evaluate our approach, with some recommendations drawn from the advantages (pros) and disadvantages (cons) of the approach. The evaluation will be based on the entire set of consortia projects from the past decade; this evaluation process will be detailed later in this paper. However, two case studies are provided that highlight the wide participation of individuals and organizations that play a key role.

The first case presented deals with a pilot project for provisioning social, health care, religious, and banking services to older people through a prototype VT device. The second case focuses on the pilot project for a comprehensive technology and service system for older citizens (trials of the VT "pre-product" known as HomeHelper).

PERDA APPROACH IN THE CONTEXT OF THE CONSORTIA

PERDA, as a design approach, is user-centered, which means that the concept of ergonomics and the basic ergonomic system model (depicted in Figure 1a) are key starting points (Pheasant, 1988). The user-centered design of products has many relations to the concept of user-driven products, as opposed to technology-driven products (Ulrich & Eppinger, 2004). Many tools for user-centered design and participatory product development, characteristic of PERDA, are presented by Langford and McDonagh (2003) and Wilson (1995).

However, PERDA also emphasizes the complete contextual system, as shown in Figure 1b. This highlights the importance of the additional components within the basic user-product-task system.

The product development, or tailoring tasks, within PERDA are carried out following the procedure of the 3 + 3 model (Figure 2). This procedure supports the ordinary company-level design and development through research-style activities.

Finally, the consortium of each PERDA project provides empirical material for the user studies and usability studies, with the individual users and organizational users within the consortium piloting the prototypes, pre-products, and products developed. The technology companies use these data to utilize the concepts of new products.

PERDA always starts from the needs and characteristics of individual users, which in our cases consisted of clients/customers and the employees who use these products to carry out the desired tasks, that is, daily living and work activities. In brief, the objective of ergonomics is to achieve, within the interactive system, the best possible match between the product and its users in the context of the tasks (see Figure 1a; Pheasant, 1988, 1996). Furthermore, it recognizes that the interaction between the product and the user takes place in a larger context, which can be described as a balanced (living or work activity) system (Figure 1b).

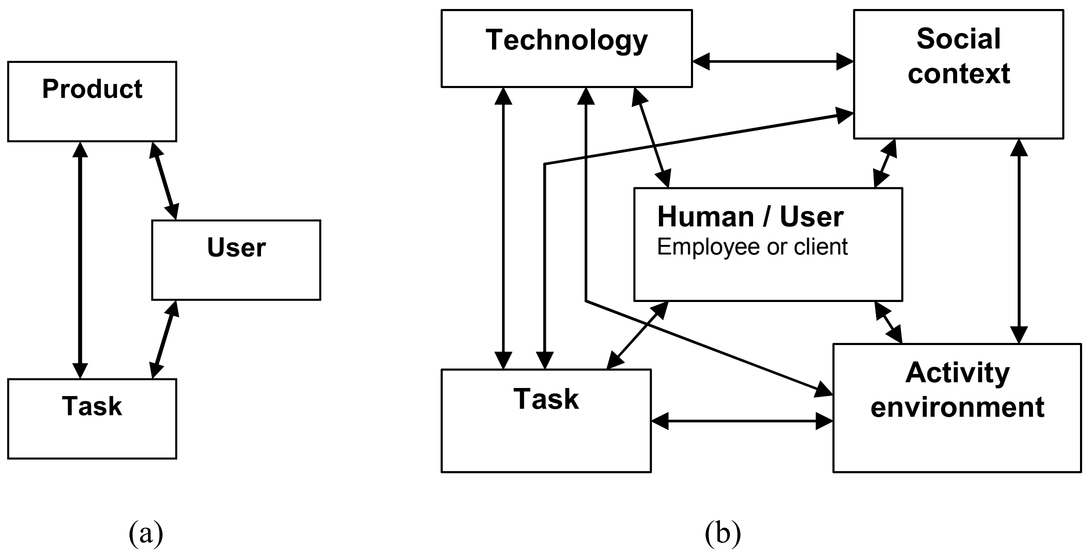

Figure 1. The basic ergonomic system (a) is a user-product-task system (Pheasant, 1996). The extended ergonomic system (b) is an applied modification of the balance model of a work system (based on Carayon & Smith, 2000; Smith & Carayon, 1995; Smith & Sainfort, 1989).

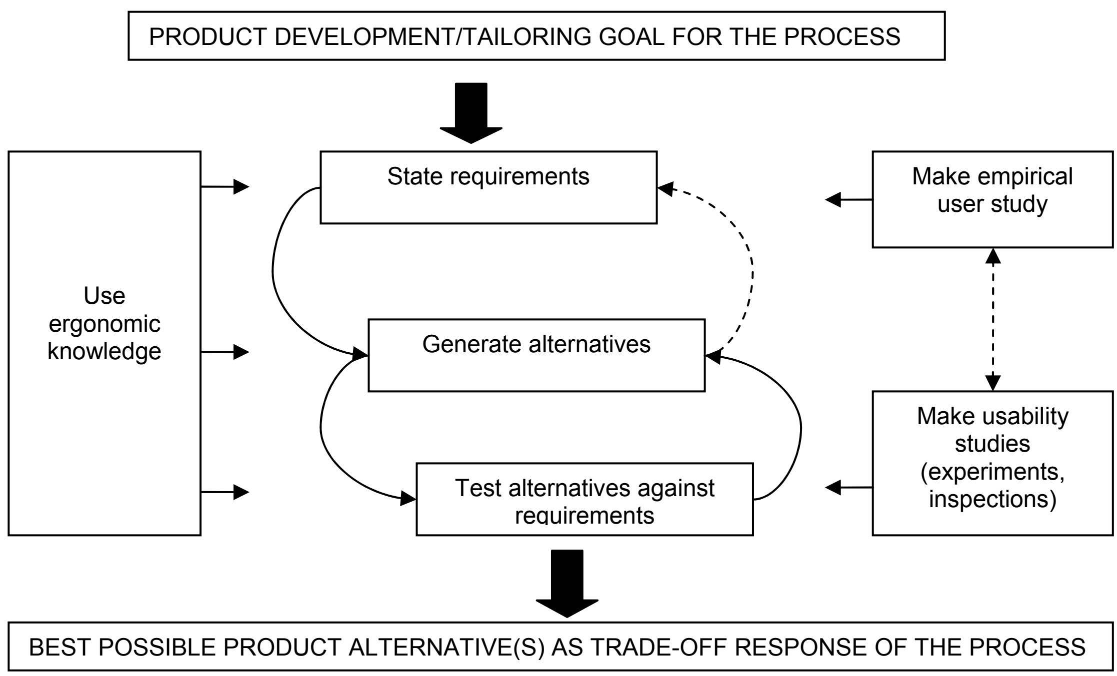

Figure 2. This 3+3 model, in which the three-phase design process is supported by ergonomic knowledge and methods, is an essential part of the PERDA (Väyrynen et al., 1998; Väyrynen, et al., 1999). The rationalistic design is carried out in the processes shown in the center of the figure. The dotted arrows illustrate concurrent engineering potential as well the feedback channel (Tornberg & Väyrynen, 1999). The model is an embedded part of a stakeholder cluster that provides both product needs and possibilities to realize products utilizing technology (Väyrynen et al., 1998).

The role of older users and that of employee users providing services to older users have been characteristic of PERDA because our projects have had close links to the field of gerontechnology.

User-centered design should be an essential part of the contemporary R&D activities within a company. An appropriate amount of relevant knowledge and a robust procedure are needed to create usable, that is user-friendly and useful (Stanton & Barber, 1996), products for markets. The PERDA aims to be compatible for use in industrial enterprises, too.

To facilitate this compatibility, we surveyed technology companies in our consortia to determine the importance of various key product properties (Väyrynen, Törmänen, & Autio, 2002). We asked them about six elements that we thought were essential attributes from the end-users' perspective. The question was, "Presuming that these 6 features comprise a total of 100% of a product, which share would you allocate to each of the features a through f?" The percentage results are listed beside by the attributes and are based on the answers (*N* = 32) received from the technology companies:

a) Number of functions (8%)
b) Price (16%)
c) Industrial design (11%)
d) Technical functionality (19%)
e) Usability (23%)
f) Reliability (23%)

These results are useful to show the importance of usability from the company's perspective. It is clear from these results that the emphasis on usability is not just an academic research perspective.

According to our experiences, usability can be characterized in terms of nine key product attributes (Väyrynen et al., 2002): (a) easy to learn to use[2], (b) effective and efficient when used for tasks[3], (c) easy-to-memorize usage procedures, (d) easy to avoid errors, (e) good physical features of the user interfaces, (f) physically and mechanically compatible with human anthropometric and biomechanical characteristics (e.g., industrial design, mechanical dimensions, mass, center of gravity of the product), (g) easy to avoid health and safety risks (h) easy to implement in the context of use, and (i) able to provide a feeling of high subjective preference (e.g., acceptable appearance and services, pleasant use experience).

Because of the importance of a balanced combination of design features to meet both the physical and cognitive characteristics of humans will remain or probably increase in the future, we found it necessary to add more physical attributes to the often purely cognitive-oriented concept of software or ICT usability (e.g., Faulkner, 1998; Nielsen, 1993; Shneiderman, 1998). Changes in technology appear to support this conclusion, because (a) software UIs are increasingly being embedded in traditional products, such as machines and daily service systems, and (b) mobile ICT is becoming more popular as compared to stationary PC-style workstations.

Our own user-centered design process model, which is an essential part of PERDA, includes three elements: ergonomic knowledge, a user study (Tang, 1991; Wiklund, 1995), and a usability study (Figure 2). These three approaches are combined with the three "purely" technological phases of traditional and rational design. This 3 + 3 model (Figure 2) has been utilized in our R&D projects along with an experimental and participatory emphasis and traditional expert-oriented evaluation.

Within the 3 + 3 model and the PERDA, each combination of technological and UI solutions composes a product alternative that possesses a certain total “goodness” when compared to the multiple criteria of requirements (Pahl & Beitz, 1988; Väyrynen, Kirvesoja, Kangas, & Tornberg, 1999/2000). In other words, these product combinations comprise the best trade-off responses in fulfilling the 3 + 3 process shown in Figure 2.

The following details and comments are aimed at characterizing PERDA further. The definition of the user profile is an important part of a user study, as is the task analysis to define needs (e.g., What will the user/operator actually do with the application/product/system in development?). Observation, inquiries, interviews, and the focus group technique are used to collect empirical field data (Wiklund, 1995). An effective user study is an important basic tool for preventing a mismatch between the product and user requirements and, hence, for promoting final usability.

Usability studies help elaborate the design alternatives, or concepts, initially identified through requirement specifications based on the user studies. Usability studies are an indispensable part of the ergonomic approach: They are used to identify, observe, and measure the interaction between the user and the product in assessing usability. Measuring the interaction between the users and the products is the fundamental principle that underpins all ergonomics (McClelland, 1995). A user trial—the most common type of usability study—is an experimental investigation in which a group of users interact with a version or versions of the product under controlled conditions (Pheasant, 1988, 1996).

A cooperative usability study, where the designer and the user together analyze the product in the different phases of the iteration process, is a promising new alternative (see Figure 3a). Generally, user and usability studies help in discovering costly design errors soon after they have been made, and facilitate the implementation of new technologies. In addition, a user-centered, participatory approach like PERDA makes the users feel that decisions are being made not only for, but also with, them. Resistance to or disappointment in new products, such as tools, can be prevented or alleviated. Participation optimally takes place at both the organizational and the individual levels (Wilson, 1995). Thus, for instance, both top-down and bottom-up approaches (Deschamps & Nayak, 1995) can be utilized.

Descriptive studies yield useful information on general human characteristics, abilities, and limitations, as well as the users and usage of various products. As far as usage, needs, and conditions of use are concerned, various studies and documents are available for user studies. One method that has proved useful is the focus group (Langford & McDonagh, 2003; see Figure 3b). To be effective, the expert guiding the focus group must present all of the users’ requirement specifications drawn from various data sources. One possibility to achieve this is through the use of a multicriteria, often hierarchic, weighted structure in presenting a product’s key features, among them usability and safety requirements based on ergonomics. These would represent the criteria that form the overall goodness of the product (see Table 1).

In the strategy of contemporary companies, managing innovations is a key to productivity and growth (Kaplan & Norton, 2004). A culture of creativity and innovation is promoted. To promote creativity in participatory procedures, our PERDA study teams have used various techniques in recent projects, especially brainstorming and the OPERA method, which is a special form of brainstorming with multiple phases (Mikkonen, Väyrynen, Ikonen, & Heikkilä, 2002). Based on our prior experience and the literature, we also have developed a new method, known as the user game, for identifying user needs. This game and story-assisted user study integrates a focus group, a group interview, and observation into one flexible and

(a) (b)

Figure 3. The design process—specifically the user studies and the usability studies within PERDA—can be characterized by frequent, direct contact with the people who are potential users of new products. One new form of interaction with people is to have the researcher/designer and an older end user cooperatively go through the design alternatives (a). Image (b) shows a focus group consisting of representatives of service staff and researchers involved in a demonstration with prospective users regarding how the technology meets their needs (Kirvesoja, Sinisammal, Väyrynen, & Tornberg, 1999). In this particular situation, the service provider used the VT to provide medical training on diabetes. This focus group also followed the nurse's lecture and assessed how the information and process was being grasped by the elderly participants. Both (a) and (b) are linked to the first phases of conceptualizing and prototyping the VT system called HomeHelper. The VT set in (a) was a late-stage prototype of HomeHelper whereas in image (b) a TV set was used as VT monitor. The use of a TV set was typical of the VT process in our first case presented here.

Table 1. Multicriteria Requirements Assessment Model for Video Telephony (VT) Devices.

Criterion definition	**Proportion (%) representing the weighting factors, that is, the relative importance of each criterion**
VIDEO	
Seeing (bidirectional)	20
Showing (bidirectional)	12
AUDIO	
Hearing (bidirectional)	15
Speaking (bidirectional)	10
CONTROL	
UI software	10
Input devices	15
CONFIGURATION	
Postural effects	4
Physical features	10
Appearance	4
Sum of the weights	100

Note: The weights of each of the nine criteria as a share of the total overall "goodness" of VT can be defined empirically or as opinions of experts. The latter was the source of these criteria and weights. (Pahl & Beitz, 1988; Väyrynen et al., 1999/2000; Väyrynen & Pulli, 2000).

quick method that can be used to gather information from a relatively large group of users (see Figure 4; Härö, 2003; Tamminen, Riekki, & Väyrynen, 2001). To our knowledge, no such method for identifying the needs of older people has been suggested earlier.

In this method, the older people play a board game and tell stories under the guidance of one or preferably two researchers. The aim of the user game is to give the participating older subjects (aged 65+) a feeling of experiencing a situation by visualizing environments with a map and photos. This feeling helps them to remember details of the situation, which, in turn, helps them and the researcher to identify real needs in the first phase of research, that is, during the user study, as well as to invent solutions to meet those uncovered needs in the second phase, that is, during alternative solution generation.

Experimentation with alternative products, prototypes, or early concepts mainly includes usability tests. The test trials may be field experiments (Figures 5 and 6) or laboratory simulations (Figure 7). Requirements specifications (e.g., Table 1) and checklists help experts make heuristic usability evaluations using inspection methods, for example by utilizing literature guidelines and the designer's expertise and experience (Nielsen, 1993).

Figure 4. The so-called user game enhances data collection during a user study by providing topic triggers for recollection and/or description of activities. This image shows the first phase of the game being played in which an older player explained how she performs a typical daily activity (Härö, 2003; Tamminen et al., 2001).

Figure 5. In this field trial of video telephony, an older client in her home was showing to a physician at a health care center, via the VT service, the condition of her ankle (Kirvesoja, Sinisammal et al., 1999). A TV set was used as a VT monitor during this case.

Figure 6. Some user trials with touch-screen-operated video telephones were carried out at an older individual's home. This technology allowed the client to make video calls to her friends, relatives, or service providers.

Figure 7. Industrial designers from the University of Lapland experimented with concepts and UI features of videophones by constructing a realistic wooden mock-up.

PERDA CASES

Within our ergonomic and gerontechnological framework, several ICT applications (devices, systems, software, services, content) have been under special consideration. Many products, technologies, and systems have been developed, described, and assessed in detail. Table 2 shows the basic features of our 11 cases.

Table 2. The Primary VT and Closely Related Case Projects by the PERDA Consortia.

Technology (product & service)	Research foci: User versus Product / Activity / Task / Work / Process	Figure number	References
A) Telemaintenance of technological production systems in industry	Remote working support, telepresence, information transfer, shared expertise		Väyrynen & Mielonen, 1994
B) Telemedicine: VT remote psychiatric consultation	Sparsely populated areas, long distances, communicating effectively without traveling, feeling of being face-to-face in communication		Oikarinen, 1998
C) Industrial machinery maintenance tasks using VT	Providing special expertise to remote industrial sites via on-line video communication		Kautto, Väyrynen, & Kirvesoja, 1997; Kautto et al., 1998
D) VT as a tool to provide home services for the elderly (started in 1995)	Health, banking, and religious services, some pilots via ISDN video communication, UI design	3 b, 5	Kirvesoja, Sinisammal, et al., 1999, (see Case One)
E) Concurrent engineering-type activities in manufacturing via VT	Product developers and designers communicate with remote prototype manufacturing		Tornberg & Väyrynen, 1999
F) Telephone services, mobile phone services (mainly voice)	Voice interface, hearing and speaking, cognitive factors		Pirinen et al., 1997; Mikkonen et al., 2002
G) Multimedia home aid communication (mmHACS) via VT to provide diverse services and contacts	Sensing, cognitive processes, manual control / UI, especially audiovisual displays & input, touch screen	3 a, 6, 7	Ikonen, Väyrynen, Tornberg, & Prykäri, 2002; Riekki, Röning, Väyrynen, & Tornberg, 2000

H) Video telephones in telemedicine,	Implementation and usability issues, cognitive, physical, social, organizational factors, patients and personnel as users	8	Kirvesoja, Oikarinen et al., 1999; Väyrynen et al., 1999; Väyrynen & Pulli, 2000; Väyrynen, Törmänen, Tornberg, & Prykäri, 2001
I) (Ge)robotics	Cognitive processes, sensing, UI, safety, compatibility with the home, remote control via VT, telepresence		Riekki et al., 2000
J) Wheel walker with ICT support (ÄLLI)	Mechatronics, embedded ICT, physical and cognitive UI, outdoor application, navigation, VT	4, 9	Tamminen et al., 2001
K) Video telephones in a municipality and location-based services for providing diverse services	UI, usability evaluation methods, user experience, new services, field conditions	10, 11	Röning, Alakärppä, Väyrynen, & Watzke, 2005; Alakärppä, Röning, & Väyrynen, 2005; Rusanen, 2004; Väyrynen, Röning, & Alakärppä, 2005 (see Case Two)

In all of the cases studied through our research consortia, a fairly large number of end users and managers of utilizing organizations were involved. Both private companies and public sector partners were involved as suppliers of various services. Both service sector employees and clients/customers (e.g., physicians and senior citizens) were actual users. Indirectly, however, the managers and the organizations as a whole were often involved especially as far as the implementation of new tool is concerned (Figure 8). End user applications were most often aimed at indoor use but the cases comprised mobile product facilitating outdoor use as well. The latter ones were not only mobile phone-based (see Mikkonen et al., 2002) but the cases included one with a wheel walker basis for embedded ICT (Figure 9).

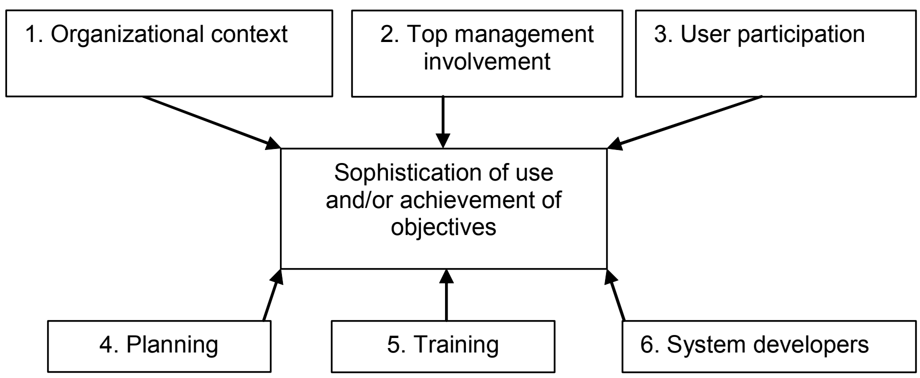

Figure 8. In addition to concrete product models used in the study, abstract operational models were used, for example, to demonstrate a successful approach to implementing technology into a user organization (based on Majchrzak et al., 1987). This model was utilized when new telemedicine technology was introduced into the Central Hospital of Lapland and in the entire Lapland Hospital District (Kirvesoja, Oikarinen, et al., 1999).

Figure 9. Mobility aids for older people were equipped with a multimedia terminal, making positioning-based outdoor navigation support possible. The project developed products and services to support the independent coping of older citizens. The ÄLLI project (Table 2, Technology J) concentrated on walking aids, user interfaces, and service concepts.

Case One: Piloting Services via Video Telephony

This case involves several pilot VT studies, conducted from 1995 to 1997 (Kirvesoja, Sinisammal, Väyrynen, & Tornberg, 1999). These studies had their roots in some aspects presented within the literature, in the global and local progress of telecommunication, and in some earlier experiments (Väyrynen & Mielonen, 1994). VT services may be a more cost-effective form of care than either institutional care or domiciliary visiting services (Gott, 1995), and this has been one of the most important reasons for providing services via VT to elderly and disabled inhabitants in industrialized countries. In Finland, the first experiments of this nature were started in the late 1980s (Perälä, 1993).

A European evaluation of the pilot video telephony-based services for elderly and disabled people reported that older users liked the video telephone service and wanted more of it (Research and Technology Development in Advanced Communications Technologies in Europe [RACE], 1993). The service providers were also satisfied with the pilot test.

Field Studies

For the field studies, the consortium involved primarily local partners. Videra Ltd., a manufacturer of VTs, provided the technology, and researchers from the University of Oulu carried out the trials and other experiments. The purpose of this field experiment was to acquire practical experience on the applicability of VTs in providing social, health care, religious, and banking services (Table 3). The public sector partners in the project were a city and a municipality. Personnel of a local church quite briefly tested the VT system in view of developing the conventional practices of spiritual and pastoral care. A bank cooperated in a brief experimental use of VT for banking transactions. A VT system was also used to transmit sign language messages. In addition, service providers participated with researchers in several focus groups concerning the potential for and the development needs of VT (see Figure 3b).

Table 3. Participating Organizations in Case One.

Organization	Personnel	Clients
City of Oulu:		
Home Care Service of Southern Oulu	28	1,379
Interpreters' Center in the City of Oulu Handicapped Service Unit	4	137
City Service Center	10	735
Runola Home for the Deaf	30	56
Oulu Association of Evangelic Lutheran Parishes	210	100,000
Municipality of Tyrnävä:		
Home Care Service	14	124
Lepola Rental and Service Flats for the Elderly	4	58
OKO Bank, Tyrnävä	7	3,200
Tyrnävä Health Care Center	20	4,200

Each organization took part in the trials with a small sample of personnel and clients.

Elderly participants, home care workers, and other service providers were either interviewed or they filled out a questionnaire based on the interview questions to gather background data and opinions on the VTs. After the trials the people involved filled out a second questionnaire. By gathering opinions both before and after the experimental trials, we could reveal the influence of experiences. Deaf participants in a different phase of the study were asked their opinions only after the trials.

An experimental field setup was used at various service flats for the elderly in Oulu and Tyrnävä (Table 3). The home care staff operated the VT system and the elderly subjects communicated usually as groups of a few members with the different service providers. Researchers gave instructions to both the staff participants and elderly participants and observed the trials. A total of 22 elderly subjects participated, involving an equal number of males and females. Their mean age was 72.5 years. The experiments included remote appointments with physicians, a dental hygienist's presentation of oral hygiene, a presentation by home care service workers regarding themselves and their work, a presentation by social workers' regarding available services, and a public health nurse's lecture on diabetes (cf., Figure 3b). In addition, one patient held a more thorough VT consultation with a physician concerning the treatment of leg ulcers (see Figure 5). For bigger groups, demonstrative trials with VT and descriptions of potential use scenarios were carried out as far as banking and religious services were concerned.

In another field setup, 20 deaf or hearing-impaired subjects, most of them middle-aged or older, tested the video telephone, usually as groups of a few members. Several realistic situations were simulated and several activities, services, and instruction-giving settings were tested. Various sign language discussions by deaf subjects via VT and the provision of spiritual and pastoral care to deaf subjects by church workers were carried out more systematically.

On the provider side of the experiments, a total of 40 representatives of various professions were involved. The most frequent occupations represented in this phase of the experiments were home care workers ($n = 20$), nurses ($n = 4$), and physicians ($n = 3$).

Results

In the field experiment, the VT contacts regarding health care and social issues between the staff and the elderly subjects were notably active. The subjects asked a number of specific questions concerning their health. However, when leg ulcers, rashes, scabs, and bruises were evaluated over the VT, it turned out that the two-dimensional view was inadequate. Illumination and correct reproduction of colors also appeared to be of notable importance. Because the experimental connection with the bank was brief and the timing was not good, it was not possible to elicit the elderly persons' experiences with banking. So too was the specific feedback regarding the religious services limited because of the brevity of the trial.

Before the experiment, 64% of the elderly subjects believed that the use of VTs would increase in the future, while the corresponding percentage after the experiment was 75%. Before the experiment, only 18% of the elderly considered the VT to be easy to use, while 50% gave such an assessment after the experiment. The best benefits of the VT system assessed by the elderly were the visual contact and the possibility of establishing a connection easily and quickly. It was further pointed out that VT greatly facilitated the lives of persons with limited mobility, and VT contacts were even compared to in-person visiting and thus considered a means to alleviate loneliness. Practically the only perceived drawback was the high price of the VT set.

Only 55% of the deaf subjects, who were users of sign language, were able to read or write Finnish. But, after the trial, 90% of these participants believed that VTs will become an increasingly common tool for the deaf. Only two subjects (10%) had previous experiences with VT. However, 65% considered the VT to be useful in their daily activities, and 85% evaluated its use as easy or relatively easy. Sign language conversation over a VT was thought to be moderately successful by 55% of the subjects, and nobody found it difficult.

Eighty-eight percent of the various service providers were female. Their mean age was 37.7 years. No previous experience with VTs was reported by 95% of them. The majority of respondents found the VT a practical, useful, and even a moderately good tool (Table 4). As many as 70% of the service providers said that the VT met their expectations the first time they used it, and 25% said they met no difficulties concerning the use of the VT system. However, some had difficulties in using the mouse and focusing the image. The twitching of the image was considered unpleasant, and system management was difficult whenever there were problems. Ease of use was considered the most important characteristic by 40% of these service providers. Visual contact ranked second, followed by the ease of establishing the connection, a clear image, and simple operation. The greatest potential of the system was considered to be the decreased need to transport elderly people and the consequent savings in cost and time, as well as the improved living conditions of the elderly subjects and the working conditions of the home care workers. The VT was also considered a useful tool in home nursing as well as in remote medicine, consultation, and negotiations via remote medical service. In the banking business, services of which were only briefly trialed and discussed during these field studies, the major uses of VTs were seen to be in information service, negotiations, marketing, and product presentations.

Table 4. Overall Evaluations by Service Providers of the VT system.

very poor		OVERALL RATING					very good			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**no opinion**	**mean**
0	0	0	0	3	10	17	**53**	17	0	**7.4**
unnecessary		OVERALL NEED					necessary			
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**no opinion**	**mean**
0	0	0	0	9	6	14	**40**	28	3	**8.1**

Note: $N = 40$; the data are provided in percentages, based on responses to a 9-point scale.

Discussion

According to this experiment, VT is likely to be most beneficial in contacts for the home nursing and home care staff as well as the health care center personnel. Physicians, public health nurses, and clinical nurses are clearly better able to evaluate an elderly client's health status and need for an office visit over a VT than over a conventional telephone. This will help to decrease the number of unnecessary visits.

A VT system would allow deaf persons to communicate in their native language. Increased use of such systems would notably increase their capacity to communicate with service providers and other deaf people, and even relatives, with sign language. Many of the deaf have inadequate reading and writing skills in the majority language and are therefore unable to benefit from a text telephone. Sign language interpreters could similarly use the VT as a handy tool.

VT also seems applicable in at least some banking business. The need for absolute confidentiality continues to be a problem, however. It is still necessary to solve the problems of reliable client identification and the transmission of electronic signatures over a VT connection. But preliminary negotiations for a loan, for instance, are easy to carry out, provided the client turns up in person to sign the papers. VT systems might facilitate personal banking by people with limited mobility. Investment counseling and some other services are also easy to provide over a VT system.

Case Two: Services Brought Home via an Internet VT System

The second case presented here is the most recently completed case, and deals with technology and services aimed at older users in a municipality context. Thus, it is comparable with Case One discussed above, which was a large and sufficiently long-lasting study of VT. Improvements in the technology include, in particular, the HomeHelper UI, the displays, and the capacity and speed of the network. A requirement model of VT that describes a combination of multiple criteria for good product (see Table 1) has been an important tool for assessing progress in the details and overall goodness of different versions. Case One had already provided many ideas and needs to be developed, as did the many subsequent iterations. The ICT infrastructure and acceptance of ICT by people have been developing as well over the past decade.

The principal objective of this most recent project (see item K in Table 2) was to improve the daily functions of people of older ages and to promote well-being and safety through the possibilities of new technology (see Röning, Alakärppä, Väyrynen, & Watzke, 2005; Rusanen, 2004). So the focus was not only on VT; other ICT possibilities were screened as well. The project emphasized usability, interaction, enjoyment, and a positive experience with use, and it sought answers to three questions:

(a) What services made possible by ICT can support the elderly in living at home?
(b) What kinds of services can be smoothly integrated into a VT system?
(c) What is the usability of the services via VT developed?

Field Studies

A quite sophisticated VT system, called the HomeHelper, was tested in the form of a "pre-product," that is, a late-stage prototype, followed by long-lasting utilization of the procedure of Figure 2. Services that older users need were discussed and evaluated with the personnel of various service providers in the municipality of Ristijärvi, Finland.

During the starting phase of the project, the older users' needs—an important part of the user study—were collected and arranged in a table based on their estimated importance. Rating system for importance involved assigning points according to the following criteria:

1 point:

- the need is mentioned only by one source
- the need has not been considered very important by those who raised it

2 points:

- the conclusion of the need's importance by a researcher or an expert group
- most of the service providers or older people consider the need to be important

3 points:

- need was very frequently stated by the older people.

The needs for different services that arose from this weighting process were ranked in the following order: Safety, leisure, shopping, health care, memory aid and information, transportation, navigation in unknown places, and banking services. These needs, then, were considered priorities.

Based on both the discussions and ranking, three remote services were chosen for the trials: (a) a health care center (health care professionals assessing and discussing the health status of the elderly), (b) a local church (the elderly viewing a religious service transmitted to their residences), and (c) shopping (the subjects' choosing and buying retail products from shops using a video connection).

Trials were carried out in two test locales, the municipality of Ristijärvi, Finland, and Vancouver, Canada. The technical test setup of the system is shown in Figure 10. The Canadian results have been reported only partially, and mainly in the Finnish language (Rusanen, 2004). Detailed reporting will be provided later, but principally the results of the Canadian study are in line with those of the Finnish study. Therefore, this article will address only the results of the Finnish study site.

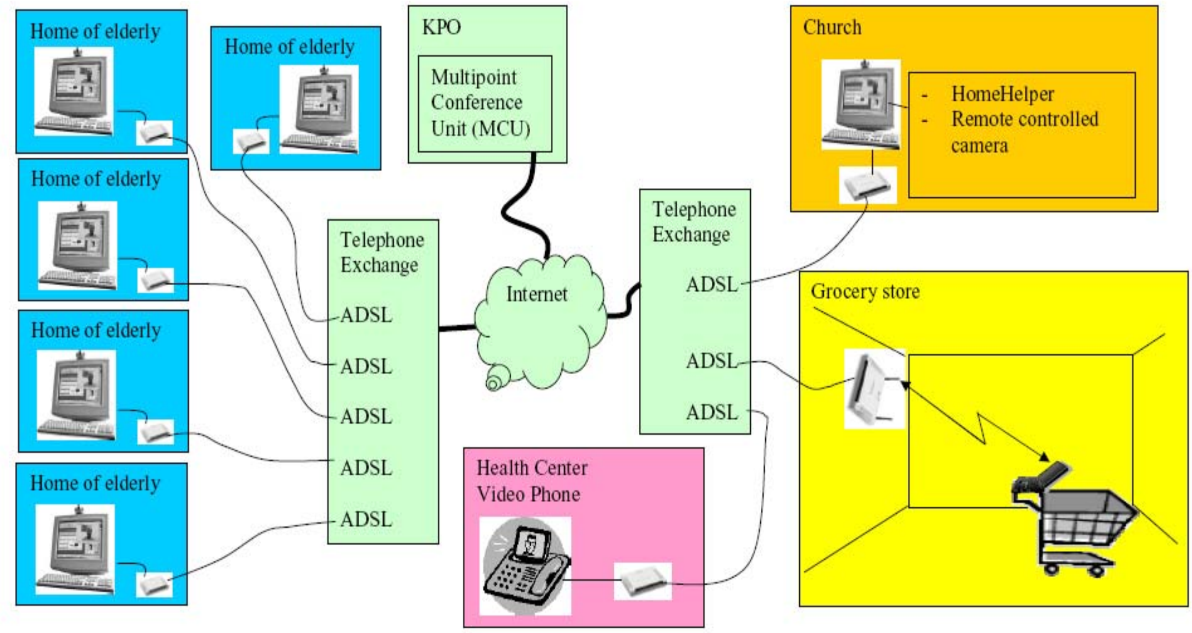

Figure 10. This illustrates the test setup in Case Two, Ristijärvi, Finland. The HomeHelper VT devices, as part of an integrated system, were used in homes (left) and the HomeHelper VT and other VT technologies were located at service providers.

Ristijärvi is a small Finnish rural municipality in the Kainuu region, with a sparse ($N <$ 2,000), quickly "graying" population and long distances to a relatively small variety of services. Available services consist mainly of public health and social services.

A group of older adults from Ristijärvi were introduced to a set of broadband wireless daily living communications technologies that compose the HomeHelper (HH) VT, a system of which there were three kinds of home devices (Figure 11). The main goal of the usability study was to gather input from older adults regarding the usability, relevance, and potential of such a system in terms of their daily needs. Ideally, this system of technology would provide improvements in the quality of life of the seniors, especially those who are frail or isolated.

The service provider users group consisted of the personnel of (a) public health services in the municipality's health care center, (b) a local majority religious congregation, and (c) a local grocery store. The personnel collaborated with the researchers to establish suitable service provisions for the trials of the HH system carried out in field conditions, both at the service providers' locations and in the homes of the older customers.

The case involved two independent studies. The first involved test trials in which older users (N = 5, 3 males, 2 females; mean age 66.4) had an individual on-line connection providing each of the three services (health care access, religious liturgy, and on-line shopping). The second study comprised focus group discussions with eight seniors other than those involved in the HH system trials. They were tasked with evaluating the process of peer tutoring, and of assessing three concept variations of VT sets (see Figure 11) that were potential alternatives to the HH for providing a system of daily living services for older users.

Figure 11. Various monitors, including TVs, and other components of the VT system were studied throughout the duration of the VT cases. Most recently (Case Two), the HomeHelper terminal device concepts, most of them at the "pre-products" stage, were tested. From the left: a special videophone set, a tablet PC, and a desktop PC.

The main foci in the trials were

(a) to observe and record the users' first impressions of the services and the HH devices,
(b) to evaluate the instructions that were written by researchers to facilitate independent operation of the HH,
(c) to observe how often the users came to situations in which they could not independently operate the HH,
(d) to evaluate the acceptability of the HH as a technological product,
(e) to study how often and what kinds of errors were met during operation of the system for service provision,
(f) to determine if it was possible for the users to use the HH system in a time-efficient manner, which particularly concerned the usability of HH UI, and
(g) to ask the users to rate the HH system and services on a semantic differential scale as far as usefulness, general ease of use, and feeling of use.

The focus group study concentrated on the opinions of the feasibility of the HH system. Various devices were viewed, researchers described the devices and scenarios in which they could be used, and the opinions and ideas of the older persons were sought regarding the potential use situations. Some of the subjects acted as peer tutors and instructed the rest of the subjects on the use of the HH system. The members (N = 8) of the instruction group then ranked the HH devices based on their experienced opinion regarding the total goodness and usability of each device.

Results

While the data from this case are extensive (see Rusanen, 2004), only a portion of the results can be included in this paper. The usefulness of the possibility to carry out the grocery shopping via VT scored 4.0 on a semantic differential scale (1 = *really useless*, 5 = *very useful*). The corresponding score the seniors gave for being able to shop without feeling pressured or hurried unpleasantly was 4.4. When debriefed, the users reported finding the HH shopping experience pleasant, natural, and genuine. The respondents declared that the usefulness and practical value of HH e-shopping would increase as their personal health declined. They also recommended this service for younger users with musculoskeletal disabilities.

The usefulness of health services was scored 4.2 on the same semantic differential scale described above. The score was the same when asked, "How did you find discussing your own health issues via the HH?" All the users felt secure and confident in discussing intimate health issues by utilizing the remote HH. Additionally, pharmacy services were suggested as having positive potential in further trials.

The local church service was generally less appreciated via the video telephone compared to the other two test activities (usefulness score = 3.4), even though the pleasantness of participating from home was scored 4.4. The respondents reported the HH-based church service from their congregation seemed too much like watching a generic service on TV. Furthermore, according to these elderly participants, the feelings of one's own congregation and own church could not be experienced when using remote teletechnology, such as the HH.

The general ease of use for the system was scored 5.0; operating the touch screen, 4.8; navigating between levels on the UI, 4.8; and making video calls, 4.6. However, the important technical features in video telephony—the quality of picture and voice—were scored 2.8 and 3.0, respectively. Thus, the weakest aspect of the HH concept was the technical level of the displays, that is, the screens and loudspeakers. Of utmost importance from the overall results, nevertheless, is that the older users were satisfied, on the whole, with the service concepts developed for the HH system. And in principle, they found the HH to be both easy to use and a useful device.

During the focus group discussion, the following aspects of the lives of older people were emphasized: health care, bank services, commuting, living alone, and the role of computers. The HH system was thought to be able to positively affect all the above areas. However, the principal positive attitude toward adoption of the HH system also included many preconditions, for instance, provision of proper and diverse services, costs, ease of use, and overcoming a phobia toward computers and HH as well. Yet, many positive social consequences, such as more frequent contacts with family members, privacy, and security, were acknowledged. The last two issues were of the least concern by the older subjects when the future possibilities of HH system were discussed.

The group of eight seniors tasked with assessing the three options for HH devices provided their feedback after using the products to inform other seniors about their use. They ranked the HH devices in the following order of preference: a special videophone set, a tablet PC, and a desktop PC (see Figure 11).

Discussion

This study, although modest in scope, proved to be a successful pilot project in determining the user-friendliness of the further developed HH VT system. Further larger-scale testing is now in order, with higher demands on the verification of the reliability of trials and validation of measured results.

Due to the small size of the sample of subjects, however, the scientific significance of the project is limited. Therefore, we feel the sample size of seniors that are exposed to this type of technology must be enlarged. In addition, a great variability of needs exist within the aging population, even within a single culture/country. Thus, to properly investigate the potential of such a technology in seniors' daily lives, we would recommend a much larger applied field study, for example, where a number of HH prototypes are set up in public settings, such as senior centers, churches, or dining halls of seniors' housing complexes. These obviously would be useful for making it possible for seniors to get acquainted with VT system, in general, and with some of the accompanying services and other end-user devices. Many of the services via VT, though, are relevant only under conditions with privacy.

A second area of research we feel would be beneficial to the HH development is a more detailed study regarding the adoption of such technology by senior citizens. As we have seen with other research, the adoption of new products by older users is restrained by the importance of their rituals (Ikonen, Väyrynen, Tornberg, & Prykäri, 2002). The challenge of encouraging seniors to embrace new technology can apply to the HH system. The HH system would need to be perceived as useful for and used by all aged persons, so as to remove the stigma of aging and frailty. Related to this line of research, we feel one of the best ways to alter the negative or stigmatizing perception of a device intended for seniors is to engage family members (and caregivers) in the training and adoption process. One could imagine a set of usability studies with the HH system that would require sons, daughters, and spouses to be active participants in the study, for example, each member of the family would agree to use the HH for his/her own chosen daily living activities. We hypothesize that having the whole family involved would lead to greater adoption by the older adults.

EVALUATION OF THE PERDA APPROACH

The Methods of Evaluation

The method of evaluation comprises mainly the principles and practices that utilize balance sheets, a SWOT analysis, a force field analysis (Langford & McDonagh, 2003), a PDCA or Deming cycle (Hutchison, 1997; Logothetis, 1992) of improvements, and, of course, benchmarking (Hutchison, 1997; Logothetis, 1992) as well as other well-known tools of quality management, especially TQM (total quality management; Hutchison, 1997; Logothetis, 1992). Balance sheets are composed of a list of pros and cons. A SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis often helps when a general evaluation has to be made and illustrated. A force field analysis helps identify the factors that are helping or hindering the achievement of a desirable outcome. The relative strengths of the forces are usually marked either as scores or as arrows with different lengths.

A PDCA cycle represents the continuous notion of process improvement that starts with a planning (P) process. This is followed by a limited trial, represented by the do phase (D). After limited deployment, the process is evaluated using a check (C). This indicates whether the process needs modification before full deployment, the act (A) cycle. An evaluation of one's own process performance against benchmarked (good) practices or other comparative information or data is nowadays very common in any organization.

Outcomes of the Evaluation

The first method of evaluation used in assessing the PERDA research and the actual research projects was a balance sheet of the pros and cons, the positive outcomes and the problems or negative outcomes, of each case within the decade-long period of research. Table 5 provides one pro and one con from each of the research projects detailed in Table 2.

Table 5. Principal Balance Sheet for Case Projects by the PERDA Consortia.

Technology (product &service)	Pro	Con
A) Telemaintenance of technological production systems in industry	Promising start in a university laboratory	Only principal trials without a specific immediate future plan
B) Telemedicine: VT remote psychiatric consultation	First evidence that VT technology works in real tasks (meetings) to overcome long distances	Only training and consultations among professionals without involving patients (clients)
C) Industrial machinery maintenance tasks using VT	Portable field device with some efforts to tailor the user interface	Interest of maintenance companies limited mainly due to network and other technological problems
D) VT as a tool to provide home services for the elderly	Positive participatory experiences at the municipality level with some public and private remote services	Problems with the ISDN network limited possibilities to extend and continue trials
E) Concurrent engineering-type activities in manufacturing via VT	Virtual office concept, made possible by VT, supported concurrent engineering within the design and prototyping departments of a manufacturing company	Too little emphasis was placed on the quality of the terminals (cameras, microphones, monitors, loudspeakers)
F) Telephone services, mobile phone services (mainly voice)	A quite challenging tailoring of the UI needed for older users was realized	Shopping and other services were not ready to be utilized by voice-controlled automatic phone ordering system
G) Multimedia home aid communication (mmHACS) via VT to provide diverse services and contacts	VT as a unique prototype called HomeHelper with a "very easy" touch-screen-only UI could be iteratively constructed	Success with the VT terminal could not be supported by a service provider or network
H) Video telephones in telemedicine	Large-scale implementation of telemedicine (e.g., video-consulting) by a large user organization was first modeled and then realized	User-centered optimization and tailoring of technology was limited due to the purchasing policy of the organization
I) (Ge)robotics	Vision of possible synergies of a VT connection via the Internet and helping telemanipulation with remotely controlled mobile robots	Robots were seen by some individuals and organizations as "enemies" of direct human services, care, and contacts
J) Wheel walker with ICT support (ÄLLI)	A specially designed wheel walker was outfitted with ICT facilities (own UI with VT, mobile [video]phone, navigator, personal digital assistant [PDA])	Ownership of idea and utilization of a "mechatronic" product prototype caused confusion between ICT and mechanical company partners within the consortium
K) Video telephones in a municipality and location-based services for providing diverse services	The creation of an integrated, user-friendly VT system known as the HomeHelper that provided accessibility to a broadband Internet network, fixed or WLAN (Wireless Local Area Network), and a variety of public and commercial services proved to be beneficial and could now in principle be implemented by individuals and organizations within society	Big questions remain: Is the ICT infrastructure capable to meet the system's needs? and Who will pay for VT products and services (individuals or society)?

Only one pro and con is provided per case: This table corresponds to the information found on Table 2.

Many factors—some helping, some hindering—have affected the 10-year research and development of the use of VT for older users. The most important factors are illustrated in Figure 12 as force arrows pushing in opposite directions. Naturally, the helping forces need to be strengthened to make it possible for us to achieve the target of "where we want to be" through PERDA, and the hindering forces tempered. This way we could close the now existing gap between the current state and the desired end-state.

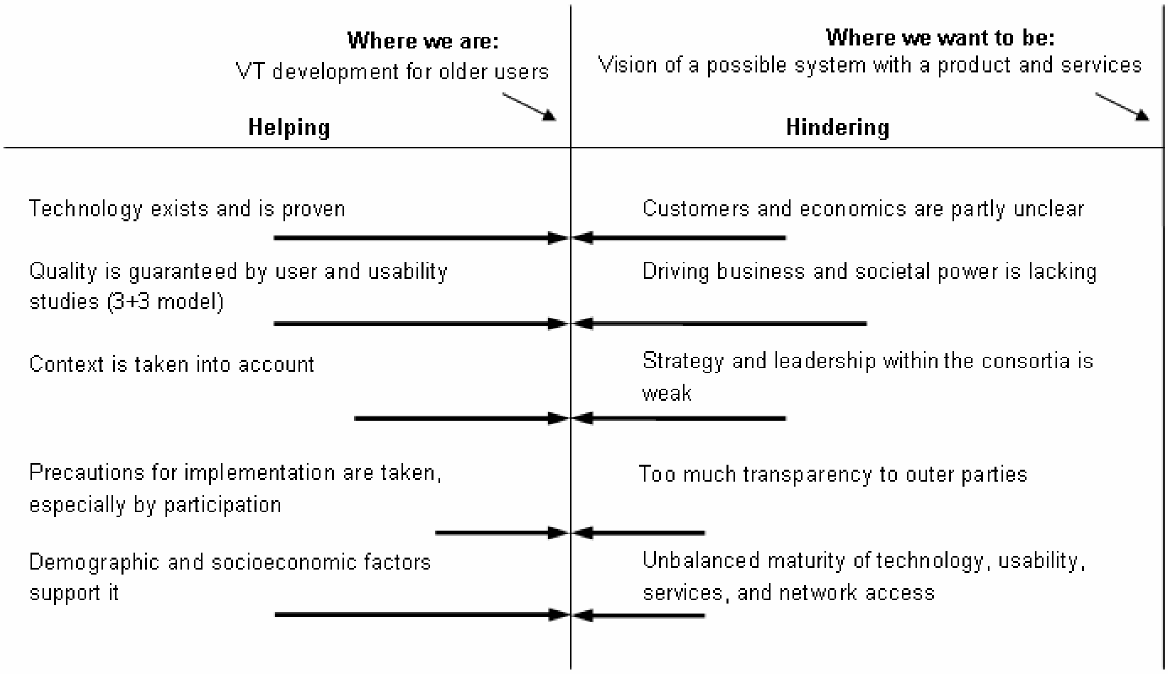

Figure 12. This force field analysis shows the main factors identified by the authors that helped or hindered achievement of the goals in the VT R&D approach. The arrows on the left represent the forces helping while the arrows on the right represent the forces hindering the process of reaching the target of "Where we want to be." To reach our goal, we have to enhance the helping factors while simultaneously diminishing the hindering ones, thereby moving from "Where we are" towards the target.

PERDA was evaluated by the researchers applying it. A short self-audit was made by use of the SWOT method (Figure 13). In this application of a SWOT, the strengths and weaknesses were based on past experiences and the current situation, while the opportunities and threats dealt with future views. Compared to the force field analysis of Figure 12, the SWOT was able to equip us with more refined analysis categories. The SWOT shows the complexity of the VT R&D field. The needs and possibilities, time and resources, and individuals and contexts make the playing field more demanding.

Part of our idealistic 10-year mission that motivated these developments was to empower older people by means of (geron)technology. Some ICT solutions, including VT, are being applied currently at the regional and municipal level. Telemedicine is the clearest example (Kirvesoja, Oikarinen et al., 1999; Oikarinen, 1998). However, many technical applications

Strengths	**Weaknesses**
• Multidisciplinary • Cooperation with a research consortium • Know-how about the field (context) • Voice of end users is heard • Small and medium-sized companies able to participate • Public and private sector developing new services together • Dissemination of user-centered design to participating companies • Wide communication and interaction	• No holistic system under development, just sets of devices/services • Lack of wide cooperation with other research groups in Finland • Laborious, time-consuming approach • Transparency to outside parties • Links to quality management within organizations too weak • Verification and validation reviews were not clear enough • Weak links to economic assessment
Opportunities	**Threats**
• More important and bigger organizations could participate • Significant cumulative know-how and competence for wider systems with diversity of services • Generation of new enterprises based on gerontechnology and ICT • Increasing positive attitudes toward changes and implementation of new technology • Methodological experiences with older users can be generalized to all users • Optimal compatibility with other parts of the whole ICT and service infrastructure	• Some of the stakeholder organizations grow tired of development projects • Shrinking of the number of parties in the consortium • Lack of competence of junior researchers • Decreasing creativity and/or the ability to spawn innovations • Not enough ability to increase cost-effectiveness and added value for user organizations • Lack of balance between social and business interests • Lack of achieving a market-ready VT system

Figure 13. This SWOT analysis diagram provides one assessment of the individual and organizational user-centered product development process for the VT via the PERDA.

tend to remain at the level of laboratory prototypes or small-scale field demonstrators, for example the ones aimed primarily at residential use. Therefore, more synergic efforts should be focused on the ability to start large-scale trials, and to find out which ideas are most feasible in regard to the potential benefits for older people and society. It should also be borne in mind that some of the research innovations in technology have been integrated into real-life applications in embedded or diffused ways, such as hidden in subassemblies rather than as separate products, as they were during our R&D projects.

Still, we can conclude that concrete benefits have surfaced from the PERDA. In particular, users are keen on participating in R&D processes, UIs can be radically improved, and the implementation of VT technology into organizations and daily life takes more time than anticipated by R&D personnel and technology companies.

When viewed strictly as academic projects, we believe our PERDA processes with the diversity of cases have been successful. Nevertheless, room for improvement certainly exists. Ways of enhancing the practical possibilities of our PERDA system could include the following four lessons:

- more emphasis on idea generation and the cross-checking of needs versus technological possibilities before building a consortium (cf., Ulrich & Eppinger, 2004);

- macro-ergonomics (Hendrick & Kleiner, 2002) might give a new boost to the general level, and contextual design (Beyer & Holtzblatt, 1999) at a specific level, to achieve a closer contact with stakeholders in field conditions;
- more emphasis on the role of top management in involving companies in the consortia. Although the experts within companies see the important value of product usability (Väyrynen et al., 2002), top management often prefers the attitude of "wait and see" for market demands; and
- allow time (perhaps 4 to 5 years) for the effects of new strategic lines in innovation processes to come to fruition (Kaplan & Norton, 2004).

Regarding the ideal PDCA cycle of development (Hutchison, 1997), we found that in most of our PERDA cases only the Plan and Do aspects could be carried out. Some cases implemented the Check step, but the Act element was lacking almost completely. As far as PERDA is concerned, the most practical developments dealt generally with the PDCA cycle in that it always started by designing (Plan), followed by the phases (Do) in the laboratory or by small-scale field trials; the Act phase on a large scale could not be done. So, the fifth lesson we've learned for future R&D is that the full PDCA process must be used when aiming for a practical new innovation in real life.

The sixth lesson learned concerns dealing with the design process and project reviews (International Organization for Standardization [ISO], 2002) by the management of PERDA consortium participants: More validation efforts have to be made, not only verification, and the review phase of R&D should be carried out quite carefully. *Verification* refers to comparing the design output with the design input, whereas *validation* refers to a comparing of the product/service with the users' needs (ISO, 2002). Quality management (Logothetis, 1992) practices and standards (ISO, 2002) emphasize verification and validation as parts of a successful R&D process.

The seventh lesson is linked to innovations and markets. Kaplan and Norton (2004), for example, conclude that sustaining a competitive advantage requires organizations to continually innovate to create new products, services, and processes. Successful innovation drives customer acquisition and growth, margin enhancement, and customer loyalty. Accordingly, managing innovation includes four important processes:

(a) identifying opportunities for new products and services
(b) managing the research and development portfolio
(c) designing and developing the new products and services
(d) bringing the new products and services to market.

The PERDA and the consortia could take care of the first three processes fairly well, but the fourth one was a clear problem.

As the next step, our own experiences encourage us to emphasize the following points as far as our 3 + 3 model within PERDA is concerned (cf., Figure. 2):

1. For stating requirements
    - Make a thorough user study, particularly getting acquainted with the literature and other more practical documents; and meet directly with the target users in assessing the tasks, context, and conditions, particularly concentrating on the user profile, needs, and wishes.

- Identify the key issues of the future marketing and implementation phases in a given product's life-span.
- Emphasize the quality of the requirements specification (goal setting), and collect or utilize guidelines and so-called "main headings," that is, a list of principal requirement areas (Pahl & Beitz, 1988) regarding the older users' characteristics, needs, and preferences.
- Build a multicriteria model of requirements (Kirvesoja, 2001; Väyrynen et al., 1999/2000).

2. For generating alternatives
   - Utilize multidisciplinary groups of experts and consult both a variety of professionals related to the product idea and the older users directly.
   - Communicate new concepts creatively and in a participatory manner to iteratively customize the concepts according to ideas and feedback.
3. For testing alternatives
   - Remember the best guidelines for heuristic inspection of usability.
   - Compare alternatives by using, for instance, a multicriteria requirements model (see Table 1).

GENERAL DISCUSSION AND CONCLUSIONS

Based on our experiences over the past decade, and highlighted in the two cases presented in this paper, we can conclude that it might be more appropriate to focus on tailoring products (e.g., through customized UI characteristics perceived as desired usability attributes) for older users rather than on customized technology in general (Väyrynen, 2002). It seems to us that often what is needed is not a totally new technology but rather gerontailoring for geronusability of current products. This involves the customization of current products for older users or utilizing the knowledge and/or test results to help older customers make better choices.

Our research underscores that we should emphasize the following features even more:

- The designers should be viewed as partners of the user or the user organization (Majchrzak et al., 1987).
- Designers should know and utilize a larger variety of experimental approaches.
- All participants representing various stakeholder groups should enhance mutual communication, for example, the concept communication (Ulrich & Eppinger, 2004), as we did in our product creation process (Mikkonen et al., 2002).
- Individual and organizational users should be linked to the design process early and through long-lasting actions to promote the implementation of the products (Eason, 1998; Kirvesoja, Oikarinen et al., 1999; Wilson, 1995).
- The outward appearance of the products or technologies under development need to be appealing to older adults (Alakärppä, 2002; Alakärppä & Kovanen, 2002).
- The entire design community should adopt the five key features of design for usability (Shackel, 1986): (a) user-centered, (b) participative, (c) experimental, (d) iterative, and (e) user-supportive. These features are also beneficial for successful implementation.

Recently the design processes have become easier to manage by the R&D personnel because the newest European and international design standards quite rightly emphasize both individual and organizational user-centered design aspects (see European Committee for Standardization [CEN], 1995, 2000; CEN & ISO, 2003a, 2003b, 2004; International Electrotechnical Commission [IEC], 2004; ISO 1998, 1999; ISO & IEC, 2001).

In addition, one possibility for modeling user-centered design is to integrate it under the holistic umbrella of quality. A standard jointly published by the ISO and IEC (2001) deals with a concept of quality in use, including attributes such as effectiveness, productivity, safety, and satisfaction with software products. Contemporary textbooks on ergonomics clearly see the importance of design standards, product and system development, usability, and the implementation phase (Bridger, 2003; Dul, deVries, Verschoof, Eveleens, & Feitzer, 2004). Since Shackel (1986) linked usability and ergonomics, the development of user-centered design has taken giant leaps. Contemporary ergonomics has proven to be an important discipline and practice, particularly regarding successful technological development and change for older users. Both top-down and bottom-up approaches (Deschamps & Nayak, 1995) should be utilized, the former being linked more to organizational participation and the latter to end user participation. Both approaches are emphasized in PERDA.

The question about the appearance of the technologies is essential from the user's point of view, and in particular how those using the technologies will be assessed through the eyes of others. The user of these devices should be perceived as a full, equal member of the community at large, and all products that compensate for disability should be seen as unexceptional products. These specialized products should be seen simply as other consumer products, such as glasses, clothes, and household electronics, which are affected by fashion.

To sum up, products are at their best when they are able to provide added value for all three stakeholders: the manufacturing enterprises; the utilizing organizations, such as the state, municipality, or country, or the service-providing company; and last, but not least, the individual people as workers, citizens, and customers (a win-win-win situation).

The increasing goal of wellness in industrialized societies creates the needs—and provides the resources—for new, tailored products and other technological solutions for older people to help them manage better at home (and at work). To meet these demands, an obvious must is to promote a special user-centered and participatory design to effectively utilize technological progress as a contributory factor to welfare and empowerment. Emphasis on ergonomics and human factors has been shown to be a solution to the challenges of developing or tailoring useful and user-friendly technologies. This emphasis has, according to our experiences, been linked with a decision to set up a cluster of stakeholders to back up R&D projects. In particular, we recommend that a systematic approach of knowing, respecting, and involving older users should be applied. One applicable model is our ergonomic PERDA, with an emphasis on experimental usability engineering within the context of ICT engineering and industrial design.

Obviously our consortia have been quite good at engineering and ergonomics, but for many reasons we have had problems with the commercialization of the products tested. Quality expert Juran (1995) lists several activities that a technology company must conduct to in order to build volume production. Of Juran's recommendations, our group is lacking, for example, "examination of market and economic feasibility" (p. 230). Pahl and Beitz (1988) recommend that designers have close contacts with their sales department.

VT can bring added value to work and life. For example, people can see things and other people remotely, and not only at stationary terminals but also with mobile devices. However, "market trials, especially those in which VT is used in residential settings, are necessary to better understand how it will be used. Although VT will initially be deployed for and applied to interpersonal communication, it will probably soon be used for video information and entertainment services, ranging from catalog shopping to adult-oriented services" (Kraut & Fish, 1997, p. 559). We in northern Finland will continue in the R&D of VT technologies within the PERDA, perhaps utilizing even more multidisciplinary research groups, empiricism, and, especially, enhanced business connections.

For people in the Nordic region—like for many other people living in sparsely populated areas—ICT applications like VT are of special importance. In general, as far as supporting general development in European and corresponding societies, VT is a system able to boost the creation of innovative service markets. Convergence and compatibility of various technologies and fixed or mobile networks offer more and more possibilities for VT to penetrate the public use and the social benefit. At the same time, the knowledge and skills of user-centered design need to be continuously developed.

ENDNOTES

1. Sanders & McCormick (1998) describe compatibility and time-sharing as follows: "The concept of compatibility implies a process of information transformation, or recoding. It is postulated that the greater the degree of compatibility, the less recoding must be done to process the information" (p. 58), and "When people are required to do more than one task at the same time, performance on at least one of the tasks often declines. This type of situation is also referred to as time-sharing" (p. 72).

2. Attributes a and h are related to the organization/other people (Kirvesoja, Oikarinen, et al., 1999; Majchrzak, Chang, Barfield, Eberts, & Salvendy, 1987) in addition to being related to individual users, while all other attributes relate only to an individual user.

3. In attribute b, *effective* refers to the number of tasks and work that can be done (outer productivity), while *efficient* means that a person is able to take care of his/her role when using a product for tasks easily and healthily enough, and without becoming overloaded or outspending his/her resources (see International Organization for Standardization [ISO], 1998).

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