Chapter 2
Living Safely and Actively in and Around the Home: Four Applied Examples from Avatars and Ambient Cubes to Active Walkers

Martin Biallas, Edith Birrer, Daniel Bolliger, Andreas Rumsch, Rolf Kistler, Alexander Klapproth and Aliaksei Andrushevich

Abstract Assistive technology may support people in staying longer independent and improving the quality of life inside and outside of their homes. However, bringing all necessary aspects together to finally bring a product successfully to the market is challenging, as many researchers in the field have experienced over the last years. It means to tackle the technical issues arising, very closely study the potential customers getting to know their needs, their barriers of acceptance and knowing how to creating value for them and to eventually market, sell and ship the final product to them. We believe that only a joint effort of an interdisciplinary team involving technology, human sciences and business partners will have a chance of success. The following pages document four successful and promising AAL projects and their teams, results and experiences on the way to get there.

Keyword Design thinking · User-centred design · Assistant · Dementia · Informal carers · Active Walker

---

The original version of this book was revised: Chapter 2 has been updated with the co-author "Aliaksei Andrushevich". The erratum to this chapter is available at 10.1007/978-3-319-42890-1_12

M. Biallas · E. Birrer · D. Bolliger · A. Rumsch · R. Kistler (✉) · A. Klapproth · A. Andrushevich
Engineering and Architecture (CH), iHomeLab,
Lucerne University of Applied Sciences and Arts, Luzern, Switzerland
e-mail: rolf.kistler@hslu.ch

A. Andrushevich
e-mail: aliaksei.andrushevich@hslu.ch

I. Kollak (ed.), *Safe at Home with Assistive Technology*,
DOI 10.1007/978-3-319-42890-1_2

2.1 Introduction

Inventing assistive technology (AT) and services that let people stay at home longer and maintain their independence and individual quality of life is a meaningful but challenging task. For various reasons, it was a long, rocky road to get the first products to the people in need. In Europe, AT started about a decade ago with a range of innovative sensor and web technologies. It was a technically driven endeavour mainly initiated by engineers and computer scientists at the dawn of the emerging Internet of Things. Aside from the fact that these technological solutions were not really ready to be implemented as real-life active and assistive living (AAL) products at that time, one of the main issues with these first projects was lack of in-depth knowledge about the real needs of the end users: elderly people themselves and their informal and formal carers.

Having identified the reasons for poor acceptance of early solutions, project teams became more interdisciplinary, involving end-user organisations, psychologists, gerontologists, usability experts, designers and others in a more user-centred, end-user-driven development process. As the technology became more stable and sound, the results of the projects, though still at prototype stage, gained more visibility and acceptance because the people who would use the technology were involved from the beginning and solutions were tested with them in realistic field trials. However, assistive solutions didn't really break through, although they were promoted as having a great future in a huge emerging market. It soon became clear in the community that even a technologically sound solution for which there is demand among the intended target group won't work if the business model and value generated around it do not guarantee sustainable commercial success.

In many respects, this was one of the most challenging tasks for developers of AAL solutions. It meant involving other stakeholders from different sectors such as health care providers, the high-tech industry, private service providers and distributors (for example telcos), public authorities, and national and local governments across Europe, which is very diverse. They all matter and need to put their weight behind rising start-ups to help them bringing these innovations to the market. In particular, incorporating innovative products—or rather classes of products—that provide new but necessary service models into the existing care environments and processes, has proven challenging.

Despite all the challenges AAL product developers face, we still believe—some of us as informal carers ourselves—that there is a need, a market and a way to bring these solutions to people. However, this will require a joint effort by all disciplines covering technology, human sciences and business. This article documents four successful and promising AAL projects that go in this direction, reporting on their teams, results and experiences.

2.2 DALIA—Assistant for Daily Life Activities at Home

iHomeLab—Lucerne University of Applied Sciences and Arts, exthex GmbH, Virtual Assistant bv, TP Vision Belgium, Graz University of Technology, Upper Austria University of Applied Sciences—Institute of Applied Health and Social

Sciences, Volkshilfe Steiermark—gemeinnützige Bertriebs GmbH, terzStiftung, Woonzorg—en dientencentrum 't Dijkhuis, Stëftung Hëllef Doheem

2.2.1 Overview and Aims

At some point in life, an older person may need help to manage the daily activities and his or her personal health at home. In most cases, relatives do the biggest share of the caring. But the new situation causes substantial changes in the lives of the people involved and brings many limitations and personal burdens. Our solution, DALIA, is designed to solve that problem. We have developed a new integrated support system designed to help both older adults as primary end users and their informal carers as secondary users. The solution connects them and also provides them with easy access to formal care and medical services.

There are two main challenges connected with entering the AAL market. The first is user acceptance of AAL applications and their usability. Many older people are either not used to technical devices or physically unable to operate them without help. DALIA uses a virtual personal assistant with a human appearance that supports speech interaction to hide this technical complexity. The assistant is accompanied by simple user interfaces that look the same across different platforms. The second challenge is that AAL solutions tend to focus on a single area (for example, fall detection) and use specialised devices (for example, wristbands). If broader care is needed, this can lead to multiple systems being installed. Aside from the high costs, nobody really wants several different systems at home. DALIA is designed to run on consumer devices found in many contemporary homes already. It seamlessly integrates different service modules in a single application that can run on those devices. In this respect DALIA can provide a cost-effective, holistic and personalised solution for older people and those involved in their care.

DALIA is an essential step towards efficient care support that is economically accessible for everyone.

2.2.2 Implementation

DALIA provides an integrated, individually tailored home system, based on a virtual personal assistant, that supports and empowers older adults to live independently at home and care for themselves for as long as possible. It allows informal carers, formal care providers and medical services to connect with the people they care for and provides them with new and powerful collaboration features.

DALIA relies on current technology and integrates existing consumer devices (smartphone, tablet and TV) to provide a wide range of AAL modules that support older people in their daily life in a single application. The primary users or their informal carers can activate the modules that suit and help them and deactivate modules they won't use. Modules include:

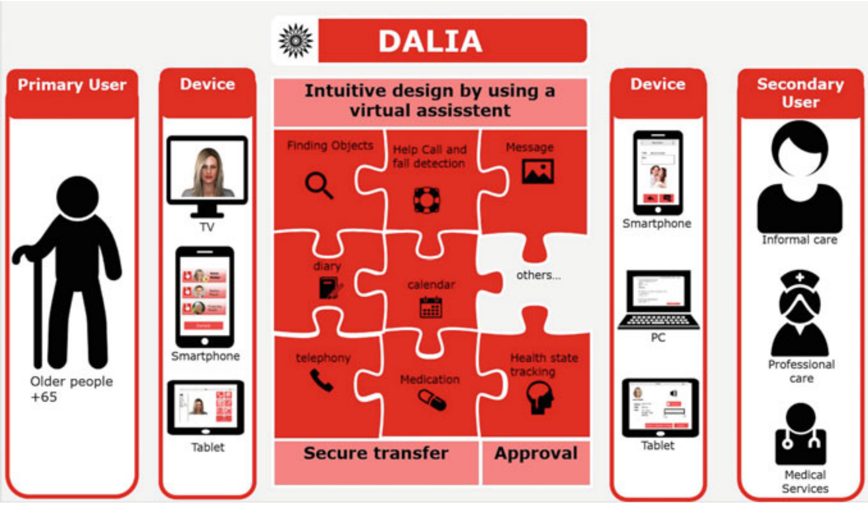

Fig. 2.1 Dalia system overview. *Source* DALIA consortium

- *collaboration* (video calls, sending messages)—enables easy exchange with family and friends, thereby supporting participation in social life
- *calendar*—used as a shared planning aid for appointments (for example, doctor's appointments) and generates automatic reminders
- *diary*—used to support an active lifestyle, document important events and preserve memories
- *emergency call and fall detection*—triggers an emergency call in situations where help is needed (either manually or by using a fall detection algorithm)
- *medication*—supports the administration of medication, e.g. medication reminders, errand lists for medication that has run out and security features such as warnings about maximum doses a day.
- *toolbox*—integrates a collection of easy-to-use tools to support daily life (for example, finding lost things)
- *state of health tracking*—includes assessment of current state of health and motivation to perform physical or mental tasks guided by the virtual personal assistant.

The user interface integrates a virtual personal assistant of human appearance that simplifies interaction with the system and allows interaction using natural speech (through speech recognition and text-to-speech).

By including interfaces for informal carers, DALIA allows them to stay in touch with their loved ones and care for them remotely, even if they do not live together. The easy-to-use interface provides the same look and feel across all devices (Fig. 2.1).

To build trust in the system and protect user privacy, DALIA integrates state-of-the-art encryption. Directed approval by the older adult allows other users to connect to DALIA. If the older adult has given them permission to access data, carers (informal carers and formal care and medical services) may provide support remotely, for example by adding appointments and reminders, managing medication or simply making a video call to have a chat. In turn, older adults can share their day-to-day experiences with carers through photos and messages, letting them take part in their life. If they want, older adults can give permission for automated, high-level notifications to be sent to carers in specific cases (for example, medication intake not confirmed).

- *DALIA* is an integrated but modular solution that is individually customisable to the needs of the individual.
- *DALIA* provides an interactive virtual personal assistant that knows its users and cares for them. It talks and understands natural speech so that all functionality can be easily accessed through its speech control interface, especially on the TV, tablet and laptop.
- The *DALIA* consortium involves real end users and care organisations that have already shown a great deal of interest in the solution. Additionally, the consortium has a powerful network of business partners with an interest in the solution and plans to sell it.
- No sensitive data is shared via cloud services outside *DALIA*. Proxy re-encryption is implemented, where the data host is only forwarding data and has no direct access to sensitive data. Sharing of data has to be explicitly approved by the primary end user for each module and each informal and formal carer.

2.2.3 Evaluation and Feedback

End users (older adults, informal carers and formal carers) were involved throughout the project in a multi-stage approach.

- The first step was the end-user elicitation phase. The elicitation plan used a step-by-step approach to optimise the data collection process.
- The second step was to formulate specifications for different use cases in three requirement workshops together with formal carers.
- In the third step focus groups were introduced: These groups of end users gave feedback on use cases, screens and designs. The aim was to collect information

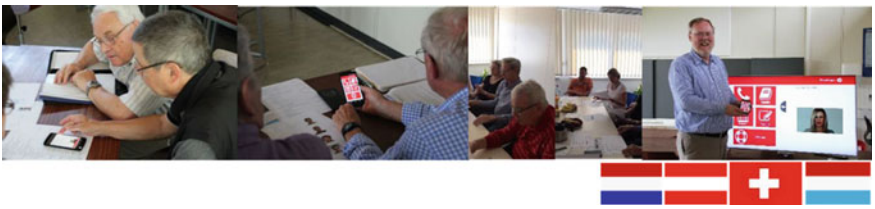

Fig. 2.2 End user involvement in four countries

and find out if there were any obvious flaws in the requirements and design as early as possible before and during implementation. The procedure was iterated on a two-monthly basis, each time adding a new module (five focus groups held).

- The fourth step involved lab testing. These tests were designed to continuously evaluate DALIA's software. The aim was to test finished sections with end users during the implementation phase to improve the software while developing it further (five lab test sessions held).
- The last stage consisted of a series of field tests, where the finished prototype was tested in a realistic environment by each user for 3 weeks (Fig. 2.2).

2.2.4 Conclusion and Lessons Learnt

The *DALIA* project can be seen as a real success. At the end of the project a fully functional and evaluated prototype was available that served as a basis for commercial product development. One business partner—a start-up formed to develop the product further—planned to launch it within 2 years of the project closing with the support of additional consortium members.

Three factors contributed to the success of *DALIA* during set-up and execution:

- *Co-creation*: include all stakeholders in co-creation workshops with a focus on the end users as soon as possible and really listen to them. Have a good mixture between push (innovative new aspects you want to include in the system) and pull (features requested by end users). Prioritise requests clearly and bundle them into several, iterative, testable, well balanced system prototypes.
- *Architecture*: do not build everything from scratch. Where applicable use proven frameworks (such as Google services) that are stable and can be adapted to the specific needs of the project. This approach allows progress within these frameworks to be used in the project for free. Concentrate on the specific features of your project (encryption, adaptability) and differentiate yourself there. Design a KISS (Keep It Simple but Smart) system with lean and clear interfaces between the different modules and development responsibilities. There is not just one type of end user who will use your solution. Users have multiple needs, and these will change over time. Therefore, make sure the architecture supports a solution that is modular and can be customised. Furthermore, allow the solution to be configured remotely and provide help with appropriate data protection.
- *Collaboration*: ensure easy and frequent communication among all partners. This is essential for distributed project work. Regular online meetings and a clear task list facilitate information flow. When the project starts up, it is important that all the people involved meet face-to-face for a kick-off workshop and do some team-building activity. Then, during the project, agile development will allow fast prototyping with repeated feedback loops involving all

stakeholders. This helps to keep the project on track and minimise risk and deviation from the project goals.

As with every project, there were also some lessons learnt that may help to improve current and future projects:

- Start as soon as possible with working prototypes. Show and discuss them with all stakeholders very early in the process. Improve the prototypes iteratively and evaluate them, continuously involving all stakeholders.
- Involve the distribution partners at an early stage. Do not focus on end users only. The benefit (for the potential distribution partner) of being able to integrate the services easily into their existing business work flow is very important. Therefore do not just develop a lean end-user interface. Make integration, manageability and maintenance as easy as possible too.
- Using an avatar to hide the technical complexity of your solution and provide a natural way of interacting is a promising way forward. But facilitate direct human interaction too. Also, bear in mind that an avatar is only useful if it works reliably with dialects and different languages.

2.3 RelaxedCare—Unobtrusive Connection in Care Situations

HomeLab—Lucerne University of Applied Sciences and Arts, Trionic, Austrian Institute of Technology GmbH, 50 plus GmbH, New Design University, Mobili, Ralph Eichenberger Szenografie, Ibernex, soultank AG, Red Cross Switzerland Lucerne

2.3.1 Overview and Aims

Informal carers (ICs) always wonder how the person they care for is doing. Feelings of burden, stress and even burn-out are common because of all the different tasks the IC has to cope with. Currently, they reassure themselves about the assisted person’s (AP) well-being through regular phone calls and visits, which can cause even more stress. However, most APs do not want to burden their ICs even more or disturb them in their busy daily life, and often perceive their own problems as minor. With that in mind, the system we developed has identified three major challenges:

1. To answer questions about how the AP is doing in an easily comprehensible and unobtrusive way by providing valuable information about his or her well-being.
2. To provide an easy way to stay connected with loved ones.

Fig. 2.3 User interface of the system consisting of a cube shaped object with a "Wellbeing state" indication (dynamically lit area in front). On *top* of the cube there are 3 lens-shaped tags for messaging. Next to the cube is a smartphone running the RelaxedCare-App. *Source* RelaxedCare Consortium, Ralph Eichenberger Szenografie

3. To combine these functions in a aesthetically pleasing lifestyle product. It must be fun to use for all generations, providing the potential to strengthen bonds within families and facilitate mutual caring.

2.3.2 Implementation

An aesthetically pleasing cube and a smart phone application (see Fig. 2.3) are the primary user interfaces. The two main tasks here are to inform the user of the well-being state (WBS) of the relative (AP) and to enable easy communication using simple signals. The cube-shaped object can output audio-visual signals and display reactions on physical message tags. An indication of the WBS of the remote relative (AP) is provided by the colour of the illuminated circular area on the front. There are three levels of WBS with clearly defined colours:

- green for WBS above average,
- orange for WBS average and
- purple for WBS below average.

The system can display a colour gradient, which can be useful for visualising trends. To protect privacy, the WBS indication is not updated more than three times a day, thus uncoupling it from current events at the place of the remote relative.

Messaging through the cube is done by physical tags. These are lens-shaped with a diameter of around 4 cm, and in tests, symbols representing a blue telephone receiver, a red heart and a green circle were attached. All tags and the symbols on them were printed in 3D. On the top side of the cube an area sensitive to theses tags can be found. If a tag is put onto the cube into this area it is recognised and initiates a tag specific functionality (e.g. “please call me” in case of the phone symbol). Further, to see that the command has been taken up by the cube, the tag initiates an audio-visual feedback—through a sound and blinking LEDs. The LEDs also indicate different communication states of the cube (e.g. “message sent”, “message received” etc.). The feedback-sounds are pre-recorded and last less than five seconds. If a message received is not acknowledged by the user, such a sound may be repeated several times (e.g. every 10 min) with down-fading volume until it is finally discarded.

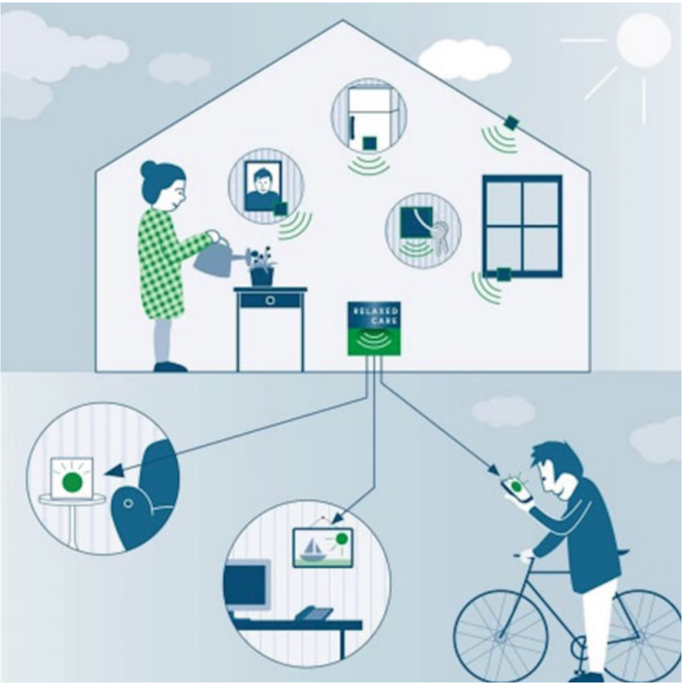

Fig. 2.4 System architecture. Sensors in the house of the AP are connected to the smart home server. The resulting wellbeing status (WBS) is shown to the IC via objects (cube, picture frame), or app. *Source* RelaxedCare Consortium, Ralph Eichenberger Szenografie

Although the system architecture allows for multiple cubes to be connected and synchronised in one apartment, they cannot serve as mobile devices. For users familiar with smart phones, a dedicated application has been developed, which, besides WBS and messaging, provides a history function. It allows users to obtain more detailed information on what has mainly influenced the WBS and to get an overview of the long-term trend (up to 6 months).

The algorithm infers the WBS based on sensor data. To detect the inhabitant's movement patterns and activities, at least three motion detectors, three contact switches and one bed sensor need to be installed in the home. All sensors are wireless and comply with the Enocean standard for data transmission. These sensors and the cubes are connected to the smart home server. It is based on an open, existing AAL platform supporting several (sensor) communication protocols (Fuxreiter et al. 2010). Located in the user's apartment/house, this server performs data fusion and executes the advanced pattern recognition algorithm for WBS analysis. Beyond that, it meets privacy requirements by ensuring that all sensor data is processed locally and only the WBS and messages leave the local network in an encrypted way. Figure 2.4 illustrates the system architecture for the use case where only the informal carer has a cube and sensors are placed in the older person's home. However, the system is designed to manage all modules (i.e. sensor and cube installations) on both sides.

2.3.3 Evaluation and Feedback

End users (i.e. ICs and APs) were involved in all project stages, from the elicitation of the user needs up to the planned commercialisation stage. A strong commitment

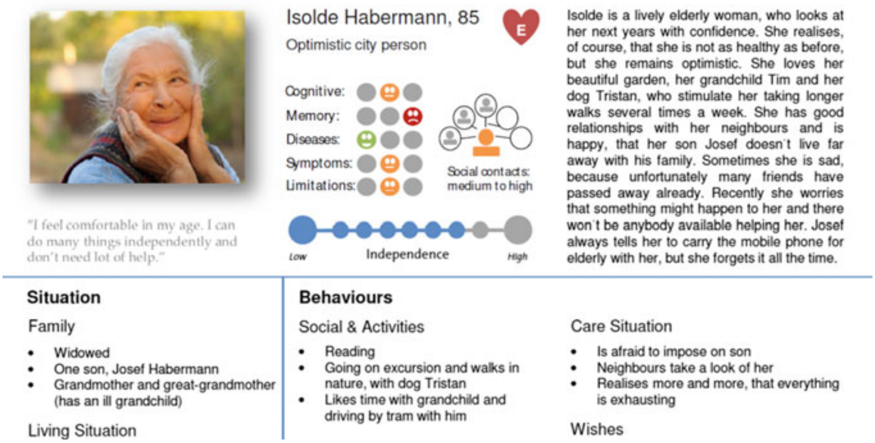

Fig. 2.5 Excerpt of a persona (AP) derived from initial requirements engineering. *Source* Relaxed Care Consortium, Soultank AG

Table 2.1 Characteristics of ICs

IC	1	2
Age	60	58
Gender	M	F
Family situation	Divorced Two children Already a grandfather	Married to Christian for 20 years Two children and one grandchild
Living situation	Lives in a company flat in a city Doesn't know his neighbours Daily routine is enough work for him	Lives in a house in the suburbs of a city Her father lives on the first floor of the same house Has lunch with the whole family and her father
Care situation	Two times a week he visits his mother He wants professional help for his mother	Cares for her aunt, as she feels alone sometimes Lives in the same house with her father-in-law and helps him several times a day
Technology usage	Technophobe Has an old computer for email	Technologically skilled If there is a problem, her husband helps, he works for an IT company
Communication	Uses only the landline phone If he has to communicate, he prefers face to face contact As his son lives abroad, they stay in contact by email	Uses a smart phone and iPad Can't afford the latest gadgets

of the project team to user-centred design resulted in applying ISO 9241-210 throughout the whole development life cycle. Furthermore, the 'user-inspired innovation process' was applied consisting of the following steps: ignite, perceive, collect, decode, assemble, experiment and merge. This process incorporates knowledge and methods from different disciplines of academic research, design and industrial practice (Fig. 2.5).

End-user involvement in Austria and Switzerland involved 207 participants, and the following methods were employed in the field of design research: (1) personas (assumption), (2) show and tell method, (3) cultural probes, (4) design workshop, (5) questionnaires, (6) focus groups, (7) discussion and contextual inquiry interviews. These methods are described in Dittenberger and Koscher (2015) and Dittenberger et al. (2016) (Tables 2.1 and 2.2).

Qualitative tests with end users have shown there is a need for a socio-technical system such as RelaxedCare. In preliminary trials a cube shape was identified as being sufficiently neutral to fit into any interior. The option of exchanging simple messages in the form of signals ensured that social contact by telephone was not impeded by the system and opened up the option to participants of sending short, non-urgent messages that did not require an immediate answer. The benefits of this are taken for granted by text message and instant messenger users, but are rarely

Table 2.2 Characteristics of APs

AP	1	2	3
Age	85	83	82
Gender	F	M	F
Family situation	Widowed One son Grandmother and great-grandmother	Widowed Two children and two grandchildren	Widowed No children Supported by niece
Living situation	Community housing, lives alone Friendly relationship with neighbours Loves her garden Adores her dog	Lives in his own flat on the first floor of his daughter-in-law and grandchildren's family house Has a good relationship with his family and the neighbours	Lives in the suburbs in an apartment for elderly people Half an hour away from her niece
Care situation	Is afraid to impose on son Neighbours look in on her Finds everything more and more exhausting	His daughter in law looks after him quite often during the day Grandchildren visit him for a chat a few times a week Eats with the whole family once a day	Never wanted to live in a nursing home Has visits from a professional carer two times a week Gets lunch daily
Technology usage	Technophobe Has landline phone Has mobile phone for the elderly, but doesn't use it	No affinity with technology A few times a week he listens to a midday talk show on the radio Likes to watch TV	Landline-phone Emergency-system
Communication	Likes face-to-face contact Sometimes telephone calls Visit from son two times a week	Uses the land line phone Has a lot of visitors Writes postcards	Loves visits from her niece Likes observing her neighbours Chats with neighbours a few times a day

accessible to those who are less information and communications technology (ICT)/mobile literate. Furthermore, the haptic nature of communication through tags was appreciated. The colour coding of the tags and the tangible symbols attached to them allowed people with low vision to recognise them, and a grandchild reported that handling tags was fun.

To allow prototypes to be developed rapidly, all technical system modules (server, cube, router) were kept separate. In addition, the dimensions of the cube were limited by the footprint of the electronics inside. Consequently, test users often suggested reducing the size of the cube and the number of separate components. From a technical point of view, this should be feasible for future products.

Although the system is different from medical devices or time-critical emergency and telecare solutions, it must be very reliable for the user to accept it. Otherwise the goal of bringing the informal carer peace-of-mind is defeated. The system becomes an additional burden if you have to wonder whether it's working. Therefore, if the connection between the AP and the IC is lost, this is indicated by a slowly moving white dot where the WBS would normally be. To avoid any suspicion that the system might have an adverse effect on the local Internet infrastructure, all systems were equipped with their own Internet access through a GSM router. In field trials, the connection through GSM routers proved not to be as reliable as expected.

Based on further end-user feedback, sound output could also be improved. Even after the sound output had been reduced to a minimum—earlier versions of the cube played continuous, soft, ambient sounds—people wanted to configure the sound output themselves. While this is technically feasible, creating a user interface that allows less computer-literate users to configure features themselves is difficult. To overcome configuration and installation obstacles, the IC was identified as the target customer group for this system. In future marketing, it might be best not to brand the system as an assistive system for the elderly but instead as a lifestyle product with the communication features in the foreground. Such a product could offer extra features, for example upgrades with additional sensors and functionalities, when changes in the AP require them. For the system to be accepted, it is important not only to upgrade it on the AP side, but also in a reciprocal fashion on the IC side. Running a system with sensors on both sides not only quashes the argument that a system such as this is only for surveillance of the AP, but also addresses the AP's legitimate interest in the well-being of their offspring (IC). Potential positive side effects from this principle of reciprocity are better acceptance of the system by the AP and because of the reassurance provided by a more ICT-literate relative trusting the system. Finally, the IC will be motivated out of self-interest to keep use of sensors to an absolute minimum in both households.

Additional information about the system developed is available in Morandell et al. (2016), Redel et al. (2015) and Morandell et al. (2013).

2.3.4 Conclusion and Lessons Learned

Ensuring stakeholder involvement in all development phases, rapid prototyping and testing with end users is an effective way of developing a product. It's worth remembering that such products are rarely purchased by less ICT-literate elderly people because of legitimate concerns about complex installation and configuration. Furthermore, the product should not be pitched as an assistive system for impaired people. Where possible, it should follow universal design rules and benefit as many different users as possible. In the context of this project, the IC is the main target customer group. This group appreciates products that can be configured by the user, and such products will therefore be more successful than static designs.

The approach of designing a reciprocal system, with sensors detecting movements and activities on both sides (those of the AP and the IC), is innovative and not widely used. It creates an equal relationship between the IC and the AP, increasing acceptance among the latter compared to unidirectional monitoring systems only letting IC observing their AP.

Products that help less ICT literate elderly people—beyond medical devices, telecare and emergency systems—are a seldom exploited niche in the market, which, in our view, would repay further exploration.

2.4 Confidence—Mobility Safeguarding Assistance Service with Community Functionality for People with Dementia

iHomeLab—Lucerne University of Applied Sciences and Arts, Salzburg Research Forschungsgesellschaft m.b.H. Raiffeisenlandesbank Kaernten reg Gen. m.b.H., ilogs mobile software GmbH, Presence displays bv. Ralph Eichenberger

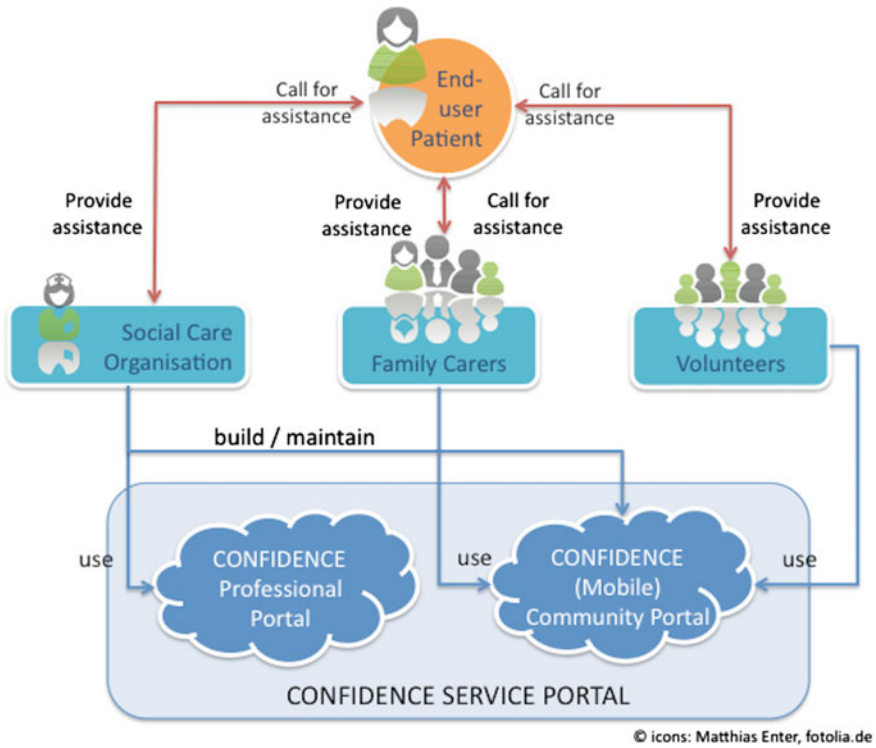

Fig. 2.6 Community support in Confidence. *Source* Confidence consortium

Szenografie, Hilfswerk Salzburg, Kanton Zug, Ana Asalan International Foundation, Swisscom Participations Ltd.

2.4.1 Overview and Aims

As the population ages, dementia is a growing problem. Dementia is an umbrella term for a group of diseases characterised by a progressive and irreversible decline in brain function with symptoms such as memory loss, disorientation, cognitive decline and inappropriate social behaviour. It is overwhelming not only for the people directly affected, but also for their families and carers. Dementia is one of the major causes of disability and dependency among older people worldwide.

Thus, Confidence aims to provide adaptable mobility and safeguarding assistance services to people who suffer from mild to moderate forms of dementia by combining assistive technologies with personal help. On the one hand, Confidence aims to support the affected people (primary end users) to be more independent and active for as long as possible; on the other hand, it seeks to decrease the burden on their carers (secondary end users). The project addresses the following issues: personal contact between the primary and secondary end users when help is needed;

Fig. 2.7 Primary end user assistance app. *Source* Confidence consortium

support in case of an emergency; assistance with spatial and/or temporal disorientation; and support of caring communities (Fig. 2.6).

Each issue is dealt with by a different Confidence service:

- *Voice and localisation service* allows the primary end user to request assistance from carers, who can—if consent has previously been provided—locate the person in need on an electronic map, see the immediate surroundings over the built-in smart phone cams and give instructions on where to go.
- *Video service* allows the primary end user to see the face of the carer, thus creating a feeling of confidence and security.
- *Mobile community service* enables carers to be mobile themselves while giving instructions to the person who is disoriented.

These three services are provided via two mobile applications and a web portal. The user interfaces were developed in close cooperation with end users. The implementation for the primary end user was done in the so called *Confidence Assistant* App which aims to support primary end users in their daily life, offering the following functions (Fig. 2.7):

- *Emergency*—Users press *SOS* if they need help urgently. In the background the system informs the responsible carer.
- *Assistance*—Users need help and would like to talk to somebody personally. Confidence enables a video or voice connection with the responsible carer when users press *Support*.
- *Daily schedule/reminders*—Pressing *Calendar* shows the users' tasks and appointments of the day. Further entries can be added. Reminders for entries appear automatically and are read aloud at pre-set times.
- *Navigation*—If primary end users need support on their way home, they click *Maps* and are able to see a map showing the route and distance from their current position to their home address.
- *Environmental service*—If users press *Weather*, the current or short-term (adapted to the appointment in the calendar) weather conditions are shown with tips on suitable clothing.

The counterpart to the *Confidence Assistant* is the *Confidence Helper* application for informal carers, which provides:

- *Alert management*—clicking *Alerts* shows all open alerts from one or more primary end users and their status
- *Call primary end user*—clicking *Support* means the connected primary end user is called
- *Localisation*—if there is an open alert, a map with the current position of the concerned primary end user is shown
- *Calendar management*—pressing *Calendar* enables users to view and manage their own and the primary end user's calendar entries. New reminders can be set up.

The web portal enlarges the Confidence Helper application. Most features (for example, localisation in case of an emergency, alert overview, calendar management and so on) are also available on the web portal. Additionally, secondary end users are enabled to administer their own as well as the connected primary end user's data on the web portal and to apply extended features such as geo fencing to the map.

2.4.2 Evaluation and Feedback

The project followed the human-centred design standard for interactive systems (ISO 134079). Therefore, end users were involved in all phases of the development process: (1) requirements analysis, (2) system design, (3) implementation and (4) field trials. The services were developed in two subsequent iterations.

After establishing the requirements, end users were involved in the design phase. Two so called acceptance tests were conducted to determine the usability and functionality of the system. Both tests were conducted as workshops, meaning that potential end users tested and evaluated prototypes in an open discussion. The first acceptance test focused on evaluating the design. Features were presented in different design variants. The user interface was evaluated by primary and secondary end users in Switzerland and Austria. After the feedback was evaluated, the advantages of the different prototypes were combined in one user interface. For example, user feedback on contrast, button size, fonts and colours were taken into account to develop the next version of the user interface. The second acceptance test was conducted in Switzerland, Austria and Romania and focused on evaluating the features of the mobile services. End-user feedback was again analysed and summarised to improve implementation further.

Once the acceptance tests and the initial development cycle were over, the first field trial was carried out in Switzerland, Austria and Romania. One hundred and eighty end users (126 elderly people and 54 formal and informal carers) tested Confidence over six weeks in their daily living situation. In order to involve suitable end users, the MMSE (Mini Mental State Examination method to diagnose dementia patients) was used to estimate the stage of dementia of the primary end users. Family members and friends tested the Confidence Helper in field trials by using their own smart device or a unit on loan. Employees of the end-user partners were trained to support the end users during the field trials (first-level support, train-the-trainer concept). The trainers also documented the trials at least once a week using a standardised protocol. At the end of the trials, they filled in questionnaires with the end users. In parallel, an evaluation guideline for the implemented service was prepared for the second field trial to measure the effects of usage (changes in quality of life, safety and mobility, autonomy and independence, daily assistance and usability).

This guideline was used to evaluate the second field trial where 168 end users (elderly people, volunteers, formal and informal carers) used Confidence over 6 weeks in their everyday life. During this last field trial, the Confidence application was generally accepted and considered useful for people with mild to moderate cognitive impairment. However, at the beginning of the field trial, almost two-thirds of the end users were reluctant to use the app. This was because they weren't acquainted with the system and weren't aware of the benefits of using the services provided by the Confidence app. They perceived themselves as being unable to learn how to use the various services. Both hurdles were diminished by sustained training with a human trainer. Despite frequent technical problems during the first phase of the trial, more than 60 % of the users were 'highly satisfied' with their use of the app at the end of the field trial. Reasons mentioned for this high acceptance rate were that the app provided an opportunity to communicate more easily with relatives, helped them to plan their daily activities properly and provided useful support through the 'Weather', 'Help' and 'Calendar' features. The least preferred services were 'SOS' and 'Map'. About 17 % of participants rejected the platform outright, believing they couldn't learn the necessary new skills or claiming that the services weren't useful in their daily lives, particularly at their age. Such attitudes were also found among a considerable proportion of the informal carers. Being elderly themselves and in the completely new and exhausting situation of having to care for their spouse, they didn't want to be confronted with a new ICT-based service at that time.

2.4.3 Conclusion and Lessons Learned

The above outcomes should be taken into careful consideration because services often malfunctioned due to poor network connections. At the beginning of the evaluation, there was some scepticism about this application. However, attitudes changed during the evaluation, mostly for the better. Broadly, user reactions can be divided into two groups: those related to technical problems and those related to the application services themselves.

It is therefore important to make sure that the application tested by end users is very stable and does not display messages or texts that are not intended for them. If the application relies on a network connection, it's important to ensure the testers have a sufficiently good connection where they live. This is especially important for tests in rural areas or abroad.

It's also useful to have a 'killer feature' that is greatly appreciated by end users. In Confidence, the 'Weather' service—though very simple and unspectacular—was one of most used services and contributed to Confidence being accepted. This service also provided clothing tips—reminding people to wear sturdy shoes in snowy weather or to take an umbrella when rain was forecast, for example—and almost everyone appreciated it. We believe it is important to make a product useful in day-to-day life and not just in emergency situations. It's also best not to focus on one very specific user group (such as 'people with dementia') but to include other

Fig. 2.8 AAL award 2014 ceremony. *Source* Confidence consortium

user groups as well. Our aim should be to develop solutions and create products that could potentially be useful for many people of different ages and backgrounds.

The Confidence project greatly benefited from the complementary expertise and experience that the partners brought in. The consortium consisted of 10 organisations from four European countries, including end-user organisations, small and medium sized companies (SME), large industrial companies and research organisations. Therefore we were able to rely on the expertise of technology providers, user interface experts, infrastructure providers, business developers and social care organisations. The end-user organisations in the three trial countries enabled user integration which was essential for creating and testing the Confidence services. Coordinating such a large and diverse consortium is challenging, but this was handled very well by the Austrian coordinator. All of this is proven by the fact that Confidence received the AAL award in 2014 (Fig. 2.8) and that the idea is pursued further by one of the commercial partners of the consortium with the aim to bring a product to the market.

2.5 iWalkActive—The Active Walker for Active People

iHomeLab—Lucerne University of Applied Sciences and Arts, Trionic, Austrian Institute of Technology GmbH, Careguide GmbH, Ith-Icoserve, Trikon AG, Geo7 AG, Kanton Zug.

2.5.1 Overview and Aims

2.5.1.1 Why iWalkActive?

Rollators have become very common mobility aids, and in countries such as Germany and Sweden about 4 % of the population uses a rollator. However, a significant problem with existing rollators is that people in need of support often hesitate or refuse to use them. When trying to encourage someone who would clearly benefit from using a rollator to do so, you often hear: ‘No, I’m not that old!’ or ‘Never, I’m not that sick!’

Instead of seeing opportunities to stay physically active, a lot of people tend to associate rollators with being old, ill and ‘handicapped’. Rather than blending in with other modern products, rollators stick out as being something for ‘the old’, creating stigma.

A few innovative rollator features have been developed in recent years, for example user-friendly folding. But the performance, comfort level and driving characteristics that a standard rollator offers when used for walking still leaves a lot of room for improvements. Problems often arise outdoors when the user needs to overcome a physical obstacle, such as a kerb or cobblestone, or go over uneven ground, such as gravel, grass, sand or snow. When compared with vehicles such as bicycles, baby strollers and cars, the rollator has not yet entered the new millennium.

The aim of iWalkActive was to offer people a highly innovative and attractive walker with additional services that greatly improve the user’s mobility in an enjoyable and motivating way. iWalkActive is designed to encourage/enable hobbies and physical activities that would be impossible or very difficult to pursue with a traditional rollator.

2.5.1.2 Problems Identified by the End Users

End user requirements were collected through an online survey, six focus groups that included end users and potential end users as well as healthcare professionals, a Delphi Study with five rollator and healthcare experts and finally two presentations followed by discussions among professionals who specialise in improving the living situation of elderly people. Through the involvement of end users and professionals, the following problems with rollators were identified or designated high priority:

1. difficult to pass obstacles like kerbs and rocks
2. difficult to walk on uneven ground, for example cobblestones and gravel
3. difficult to use public transport (car, bus, train)
4. difficult to walk downhill (rollator rolling away from the user causing falls)
5. pain or discomfort because of the rollator shaking on uneven ground
6. difficult to walk uphill.

The following areas of use were rated most important by end users as daily living and leisure activities that could possibly be supported by ICT-enhanced services:

- Shopping
- Traveling/sightseeing
- Hiking
- Fitness walking

2.5.2 Implementation

2.5.2.1 E-drive

The integrated e-drive consists of two hub motors in the rear wheels. One of the main challenges was to control the motors, since the end users naturally wanted the Active Walker to behave they way they expected it to behave. This is not very different from a standard rollator, which should allow users to walk in the direction they want at the speed they want. The user should be able to steer the Active Walker as intuitively as possible without noticing any difference when walking straight or up or downhill.

By implementing force control in the rollator handles a very intuitive human-machine interface was created. Users feel constant inertia when pushing the walker, irrespective of walker load. If users want to steer right or left, they intuitively apply more force to one hand grip, which means that the adjacent motor rotates faster (Fig. 2.9).

The e-drive and its controlling mechanism are composed of several key components:

1. force sensors fully integrated into the right and left hand grips
2. control unit offering two e-drive modes: a gentler and a more direct one
3. battery (rechargeable)
4. two independent rear motor wheels
5. push-button control for switching between the two modes of the e-drive
6. mechanical brake handles, integrated with the rear motor wheels

Fig. 2.9 The Active Walker with the major components of the e-Drive indicated. *Source* iWalkActive Consortium, iHomeLab

7. mechanical brake levers, electrically connected to the control system.

2.5.2.2 Localisation

For navigation purposes, the position of the user needs to be known. This is done with the help of wireless localisation technology. While outdoors, the global positioning system (GPS) is omnipresent, nothing comparable is available indoors. We used two technologies for indoor localisation: WLAN and iBeacons.

2.5.2.3 Seamless Transition

For the localisation service we faced the challenge of selecting the best source for localisation and for a seamless transition between outdoors and indoors. The method applied determines if users are indoors or outdoors based on available location sources.

2.5.2.4 Open Data Integration

During the project it became useful to gather geo-information from open data providers, for example to list walking routes or public toilets. The iWalkActive Open Data App showcases data that can be fetched from open data providers for free. The data is integrated into a Google maps view and can easily be used to help users in finding a hiking route or different points of interest (tourist attractions, restaurants, toilets etc.).

2.5.2.5 Navigation

Using seamless localisation technologies as described above, the Active Walker knows the users' position and whether he or she is moving indoors or outdoors. To give directions and guide the user along the right path, localisation is accompanied by a navigation system.

The navigation client app receives most of the data, such as calculated routes and geo codes, from the Geo Information System or short: GIS-server. Each client sends a routing request to the Network Analyst Extension on the ArcGIS Server. The client then receives a complete optimised route with directions. With the positioning information, it is now possible to guide the user to the destination. The navigation in iWalkActive requires the calculated route to avoid obstacles that cannot be passed by a user with a walker (no stairs are allowed, for example).

A further feature is the 'closest facility' function. With a separate button, users can select the shortest rollator-friendly route from their current position to the nearest barrier-free toilet. Of course, other facilities can be implemented, such as navigation to the nearest shopping centre.

2.5.3 Evaluation and Feedback

Using different tests, we ensured that all components in the iWalkActive system worked safely. We divided the tests into lab testsperformed internally by our research staff and field trials performed by potential end users.

2.5.3.1 Lab Tests

The scenarios investigated in the lab tests guaranteed the smooth functioning of all the integrated technologies and implemented software services. The emerging prototypes were tested at least twice at different stages of development. Where external people were involved, the lab tests were undertaken using the model to test user acceptance developed by Mollenkopf and applying some of the insights from mobility studies in which she was involved (Tacken et al. 2005).

Test results showed that most users found the motor in the active walker to be helpful when walking on rough and level surfaces outdoors. Many elderly people said that the motor was helpful when walking on smooth outdoor surfaces, but even more helpful on rough ground, and especially when going uphill or downhill with a load (for example, heavy groceries in the rollator bag). In general, they thought it could be of help for shopping trips, sports training and longer walks—especially on rough ground—and on holidays that would not even have been planned without such a motorised walking frame. Training aspects were mainly mentioned by men, while women liked the possibility of going for longer walks, travelling and making shopping easier.

2.5.3.2 User Field Trials

Field trials involving end users took place in different locations and under real conditions: Lucerne University of Applied Sciences and Arts in Horw, Switzerland; Austrian Institute of Technology in Wiener Neustadt, Austria; Sveriges Pensionärsvörbund in Uppsala, Sweden.

The rating of the e-drive support in different test settings showed that most subjects were very satisfied with it. The best ratings were given for rough ground (with or without a load). Ratings were also very good for how the rollator handled on bends and the motorised braking system. Only in the scenario 'going round a bend downhill with a load' did some of the test candidates say the support was too powerful.

For navigation functionality, the user interface is crucial. Tests have shown that it could be improved, especially with regard to intuitiveness (i.e. making it immediately clear to the user which control element stands for which function). Apps on standard tablets are affected by outdoor lighting conditions. Therefore, visibility, legibility and contrast need to be enhanced. The navigation function was not rated very highly. The benefits were regarded as 'medium' in the situation our users found themselves in. However, this may be due to the fact that the generation that took part in the study is not (yet) used to these kinds of devices. Additionally, it may not have been clear to the target group during the tests in which kinds of situations the navigation function could be beneficial. To improve this, test scenarios may have to be adapted and further, longer field trials may be necessary to get more insight into how the navigation features operate in daily life.

Among candidates using the rollator at home for several weeks, the outdoor capabilities of the Active Walker were greatly appreciated. One person, a multiple-sclerosis patient, showed great interest in buying the prototype. He lived out of town, and his wife told us that he liked the Active Walker because it allowed him to take a daily walk in the hills again, which he had not been able to do for a year before receiving the Active Walker in the trial.

2.5.4 Conclusion and Lessons Learned

From our point of view the project, which won the European AAL Award 2013, is very successful. We have shown that an e-drive powered rollator with seamless indoor and outdoor navigation is feasible. The consortium worked very well together, but there is room to improve the efficiency in future projects now that the partners know each other. A debriefing meeting confirmed that face-to-face meetings are important. The partners said they would meet more often in future, not only in plenum but also in smaller working groups focused on technological issues, business development, and planning and organising the end user involvement.

The involvement of end users and/or potential customers is crucial. Therefore, contact with end users should happen as often as possible. But this is also a challenge: to get useful feedback, you need to present working prototypes. As prototypes for a hardware-driven project such as iWalkActive can become quite complex, relying on different partners for the frame, brakes, motor, motor controller, sensors, mobile apps and so on, manufacturing, integrating, testing and delivering enough walkers is challenging. The costs of creating a hand-crafted prototype, for which many of the production process steps are still done manually and for the first time, should not be underestimated (in the case of iWalkActive, the motors for the e-drive powered rollator were a completely new development). In our project, the initial budget was enough to produce three complete walkers (others only had part of the functionality). In a similar future project, we would dedicate more manpower and material resources to that.

Another aspect is the business side. Although we developed several business models, we did it rather late. The business model should be on the agenda from the very beginning, and you have to deal with the fact that the business model evolves as the product does. Our three business partners decided to develop further a distributed business model. The provider of the geo information modules, which handle localisation and navigation, founded a start-up to promote the solution. The rollator and e-drive provider decided to develop a solution in which the e-drive is sold and delivered to the Swedish rollator company that integrates it and sells it to its customers. The biggest challenge will be to bring the price down to a level that end users will tolerate in order to make a business out of it. However, recently other projects and even manufacturers have also come up with the idea of e-drive rollators, creating prototypes and even first products. As awareness grows and the market expands, new opportunities may open up for our Active Walker too.

Acknowledgments The four projects Confidence, Dalia, iWalkActive and RelaxedCare were co-funded by the AAL Joint Programme and the following National Authorities and R&D programs in Switzerland (SERI), Austria (bmvit, FFG, Programm benefit), Slovenia (MIZS), Spain (National Institute of Health Carlos III, and Ministerio de Industria, Energía y Turismo (MINETUR)), Belgium (IWT), NL (ZonMw), Rumänien (UEFISCDI), Schweden (VINNOVA).

References

Dittenberger S, Koscher A, Morandell M et al (2016) RelaxedCare: an iterative user involvement project. In: Design and emotion conference. Amsterdam, 27–30 Sep 2016

Dittenberger S, Koscher A (2015) How much design does research need: an inquiry of the synergetic potential of methods of social and design research. In: International conference on engineering design. Politecnico di Milano, Milan, 27–31 July 2015

Fuxreiter T, Mayer C, Hanke S et al (2010) A modular platform for event recognition in smart homes. In: 2th IEEE international conference on e-health networking applications and services (Health.com), Lyon, 1–3 July 2010, pp 1–6. doi:10.1109/HEALTH.2010.5556587

Morandell M, Dittenberger S, Koscher A et al (2016) The simpler the better: How the user-inspired innovation process (UIIP) improved the development of RelaxedCare–the entirely new way of communicating and caring. In: Marcus A (ed) Design, User Experience, and Usability: Technological Contexts. 5th international conference, DUXU 2016, held as part of HCI international 2016, Toronto, Canada, July 17–22, 2016, Proceedings, Part III. Springer International Publishing, pp 382–391

Morandell M, Mayer C, Sili M et al (2013) RelaxedCare—Unobtrusive connection in care situations. In: Proceedings of the AAL Forum. Norrköping, 24–26 Sep 2013

Redel B, Uhr MBF, Morandell M et al (2015) RelaxedCare—Connecting people in care situations: user involvement to collect informal caregivers needs, AAATE Conference 2015, Budapest (Hungary). Will be published in the proceedings of the 13th AAATE Conference, Budapest (Hungary)

Tacken M, Marcellini F, Mollenkopf H et al (2005) Use and acceptance of new technology by older people. Findings of the international MOBILATE survey: 'Enhancing mobility in later life'. Gerontechnology 3(3):126–137. doi:10.4017/gt.2005.03.03.002.00

http://www.springer.com/978-3-319-42889-5

Safe at Home with Assistive Technology
Kollak, I. (Ed.)
2017, VIII, 230 p. 48 illus., 29 illus. in color., Hardcover
ISBN: 978-3-319-42889-5