



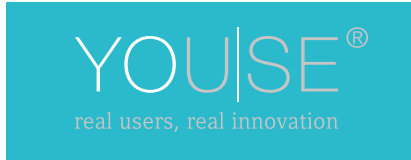
KNOWLEDGE BASE  
AAL STAKEHOLDERS  
AND THEIR REQUIREMENTS



**A collection of characteristics and requirements  
of primary, secondary, and tertiary users of AAL solutions,  
and a guideline for user-friendly AAL design**

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**About Ambient Assisted Living Association:**

The Ambient Assisted Living Association is organizing the Ambient Assisted Living Joint Programme (AAL JP). The AAL JP aims at enhancing the quality of life of older people and strengthening the industrial base in Europe through the use of Information and Communication Technologies (ICT). Therefore, the AAL JP is an activity that operates in the field of services and actions to enable the active ageing among the population.

The programme is financed by the European Commission and the 22 countries that constitute the Partner States of this Joint Programme.

See more at: <http://www.aal-europe.eu/>

**About YOUSE:**

YOUSE supports companies and research projects with its expertise in user experience design, usability engineering, user testing and user integration. Based on its user-centred design approach, YOUSE helps to develop innovative products, better and smarter services, user-friendly packaging and manuals, especially for the 'generation plus'.

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YOUSE has worked in various AAL projects and offers its services - together with its panel of “senior innovators” - at its two locations Munich and Berlin, Germany. The company is managed by Dr. Christoph Nedopil and Dr.-Ing. Sebastian Glende.

See more at: <http://www.youse.de/en>

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## 1 INTRODUCTION

Ambient Assisted Living (AAL) solutions have the potential to make their senior users' lives easier and more independent. While developing successful AAL solutions in the ICT area is an important and potentially very rewarding task, it can also be a daunting problem: rewarding, because AAL solutions offer their users independence or support and because the technology providers can reap economic benefits; daunting, because technologies are seldom easy to develop and the various user needs are too often hard to satisfy with single technologies.

A user-centred design journey has proved very successful in meeting this challenge and increasing AAL solution success rates. This document helps research projects close the gap between technical and financial requirements as well as user needs. It provides AAL projects with valuable information on basic user requirements, the daily lives of seniors, as well as on elderly people's self-perceptions and core values. In short, this document provides a key piece of the successful AAL solutions puzzle.

### 1.1 STRUCTURE OF THIS KNOWLEDGE BASE

In this knowledge base, we have collected basic data and information on the lives and requirements of various primary, secondary and tertiary users of Ambient Assisted Living (AAL) solutions. This data and information are critical for a user-centred design process. The document examines the lives of seniors as primary users (Chapter 2.1), focusing on general lifestyle aspects, typical age-related constraints and ICT usage. Chapter 2.2 deals with people suffering from dementia, their typical symptoms and how to design AAL solutions to meet their special needs. In Chapter 2.3, we describe the needs of secondary and tertiary users such as relatives or real estate managers. Chapter 3 provides specific design requirements for different AAL components: sensors (3.1), hardware (3.2), interfaces, (3.3) and robots (3.4). The document closes with a short summary and useful links to European statistics.

### 1.2 HOW TO USE THIS KNOWLEDGE BASE

This knowledge base provides sound knowledge for building user-friendly Ambient Assisted Living (AAL) solutions. It provides input on the needs of primary, secondary, and tertiary users, as well as practical guidelines for AAL component design, thus preventing replication of work already done.

While we collected the data from many different international sources, it cannot be exhaustive regarding technologies, or the needs of the many different user groups in all countries, nor can it always be current. However, this document should help speed up the process of researching user needs by providing a foundational understanding of user issues and trends. We encourage you to complement the presented knowledge with your references to deepen your research.

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## 2 AAL SOLUTIONS USERS

Ambient Assisted Living (AAL) solutions address many different user groups, sometimes called AAL end-users or AAL stakeholders. We encourage you to analyse your specific users, user groups or stakeholders to identify their needs, wants, fears, etc. The first step is to understand who these users are. The Ambient Assisted Living Association categorizes users into primary, secondary and tertiary users, which we use interchangeably in this report with AAL stakeholders (**Figure 1**):<sup>1</sup>

1. **Primary end-users** are older adults who are using AAL solutions.
2. **Secondary end-users** are persons (families, friends, neighbours...), companies or organisations that are accessing or using AAL solutions for the benefit of primary end-users. This group benefits directly from AAL products or services when they use these (at a primary end-user's home or remotely), and indirectly when primary end-users' needs for care are reduced.
3. **Tertiary end-users** are institutions and private or public organisations that are not directly in contact with AAL solution, but who play a role in providing, financing or enabling them. This group includes the public sector service organizers, social security systems, insurance companies. They benefit from the increased efficiency and effectiveness that AAL solutions provide in terms of reducing costs, or avoiding increasing costs in the mid and long term.

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<sup>1</sup> [www.aal-europe.eu/get-involved/i-am-a-user-2](http://www.aal-europe.eu/get-involved/i-am-a-user-2)





**Figure 1:** Three user groups of AAL solutions.

The Ambient Assisted Living Association’s categorisation of users into three user groups serves as a useful framework to analyse and prioritise user needs:

**Primary** users are seniors who have AAL solutions installed in their homes. **Secondary** users, such as seniors’ relatives or professional caregivers, may also use an AAL system, for instance, to receive information or emergency calls from a primary user. **Tertiary** users are those people who or organisations that organise or pay for AAL solutions: insurance companies, public health sector institutions, and others. However, the categorisation depends on the AAL solution; for instance, when the solution is software that connects doctors and seniors, both are primary users, but when software connects seniors to others, allowing them to socialise, they are the primary users.

Analysing the requirements of all of these user groups very early on in the development process is very helpful to ensure an AAL solution’s success. This can be done, for instance, by integrating users into the development process, but also through secondary data (there is no need to replicate work and to learn about user needs through qualitative research if others have already done the work). Without sound knowledge of specific users, important requirements might be neglected (e.g. when does an insurance company pay for technology?), which may later be a major obstacle during a system’s market implementation.

In the next sections, we therefore provide information on the different users and their needs – from seniors, to those with dementia as a special senior group, to secondary and tertiary users.

## 2.1 SENIORS AS PRIMARY USERS

Ambient Assisted Living (AAL) solutions seek to enhance elderly persons' quality of life. They address seniors' age-related needs, ranging from health impairments to changes in their social lives, and from mobility requirements to caregiving. However, the perception that AAL is for older people is an often skewed picture of seniors – old, poorly, and lonely people in need of care, but who refuse to use technology (except the TV).

Although some seniors do suffer from age-related deficits (see Section 2.1.3), this is not the full picture of their lives. Elderly people (defined as between the ages of 65 and 85 in the following statistics) can also be very active (see **Figure 2**): <sup>2, 3, 4</sup>

- 30% to 80% of seniors over 65 still travel.
- On average, seniors spend 5 of every 7 days outside their homes.
- 68% of seniors have their own cars.
- Two-thirds of seniors have a partner.
- 75% of seniors are grandparents.
- Approximately 70% of seniors with children see them several times per month or week.
- Only 4% of seniors feel lonely (correlation with health problems and single status).
- 45% of seniors engage in volunteering activities.
- 42% of seniors feel healthy or very healthy.

The “feel-age” of the majority of seniors is about 10 years younger than their biological age

Some seniors take care of their parents, their children's children, their neighbours, or friends<sup>4</sup>. This means they not only need care, but also give care. It is therefore important to question stereotypical images of older people, and to make sure that AAL solutions' design is based on new empirical data instead of on unrealistic biases or sheer guesswork.

Hard data is provided in the following sections, which present information on seniors from different perspectives: their life stages and critical events (2.1.1), ICT use (0) and typical health impairments (2.1.3). Although the data should be checked for nation-specific differences in any AAL projects, it is an initial starting point to understand the wide variety of seniors' lifestyles, their most pressing needs, and how AAL solutions can create added value for them.

<sup>2</sup> DESTATIS (2012): Alter im Wandel: Ältere Menschen in Deutschland und der EU.

<sup>3</sup> Generali Altersstudie (2013): Wie ältere Menschen leben, denken und sich engagieren.

<sup>4</sup> SHARE (2008): [www.share-project.org](http://www.share-project.org)

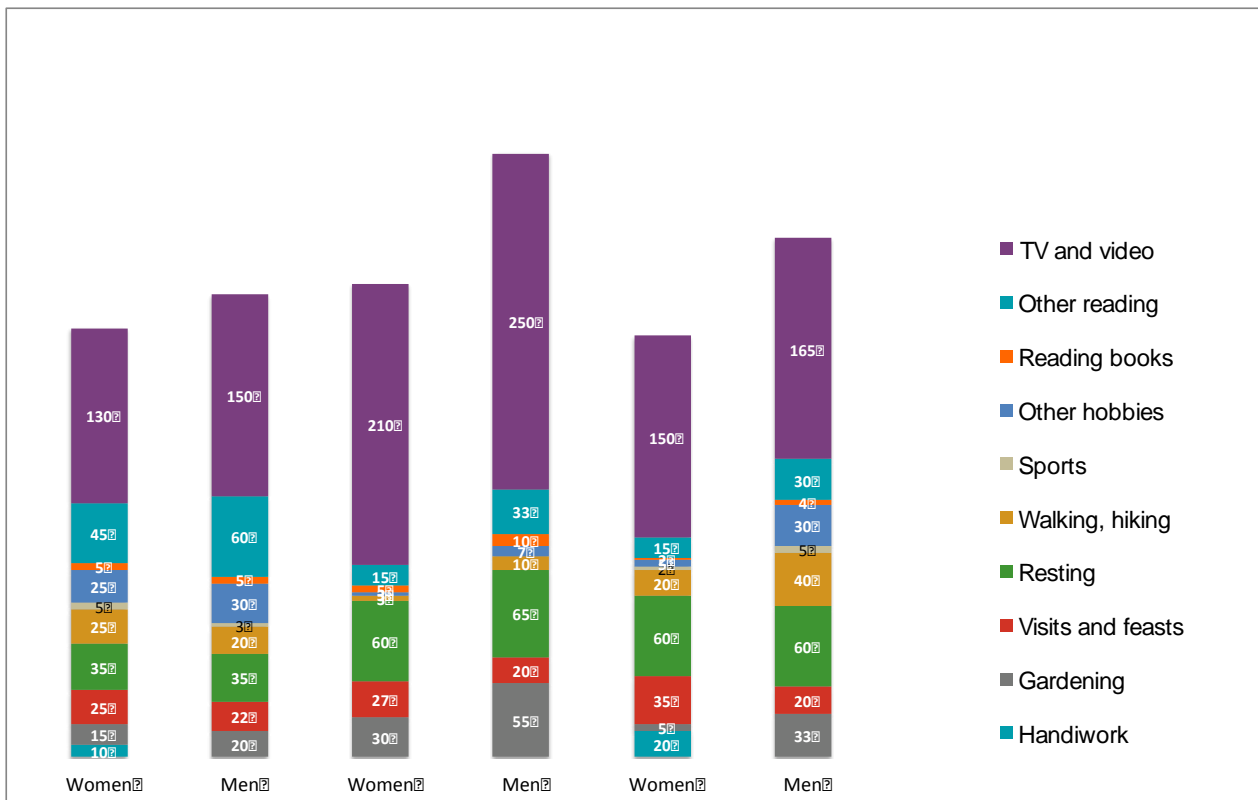
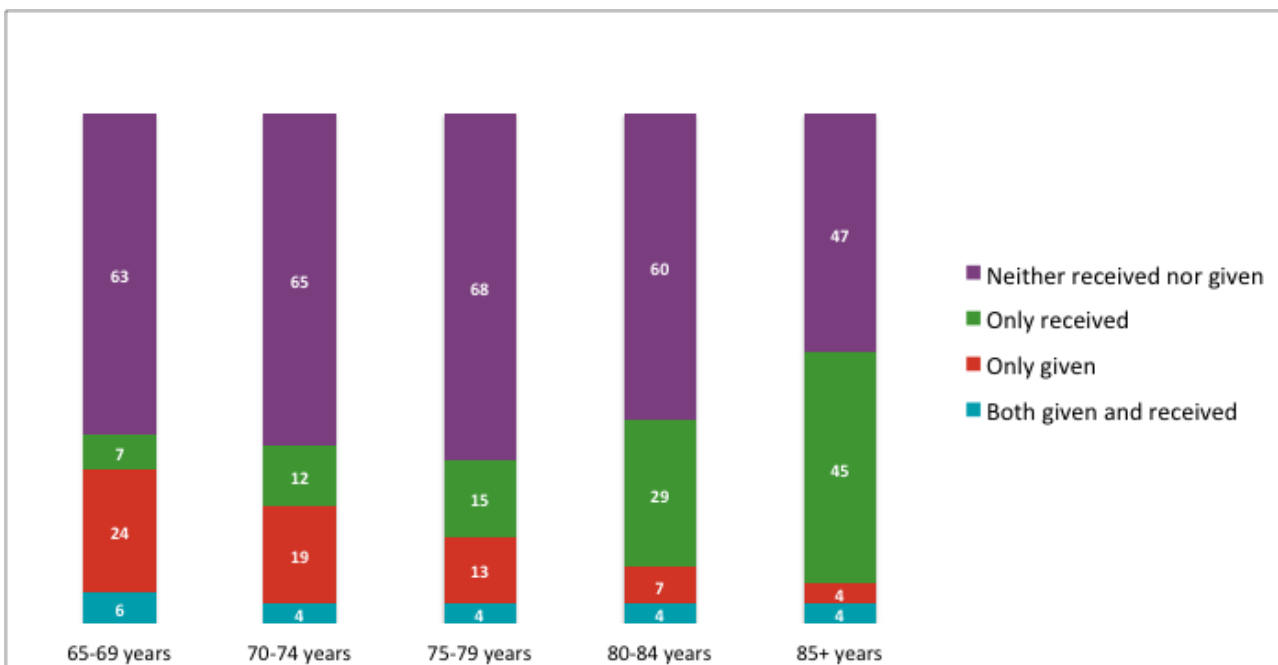


Figure 2: Leisure activities of seniors (65+) in minutes per day by gender and country (Becker, 2007<sup>5</sup>).



<sup>5</sup> Becker (2007). Living conditions and everyday activities of the elderly and their requirements concerning ambient assisted living.

**Figure 3:** Percentage of help received or given by age group (SHARE, 2008).

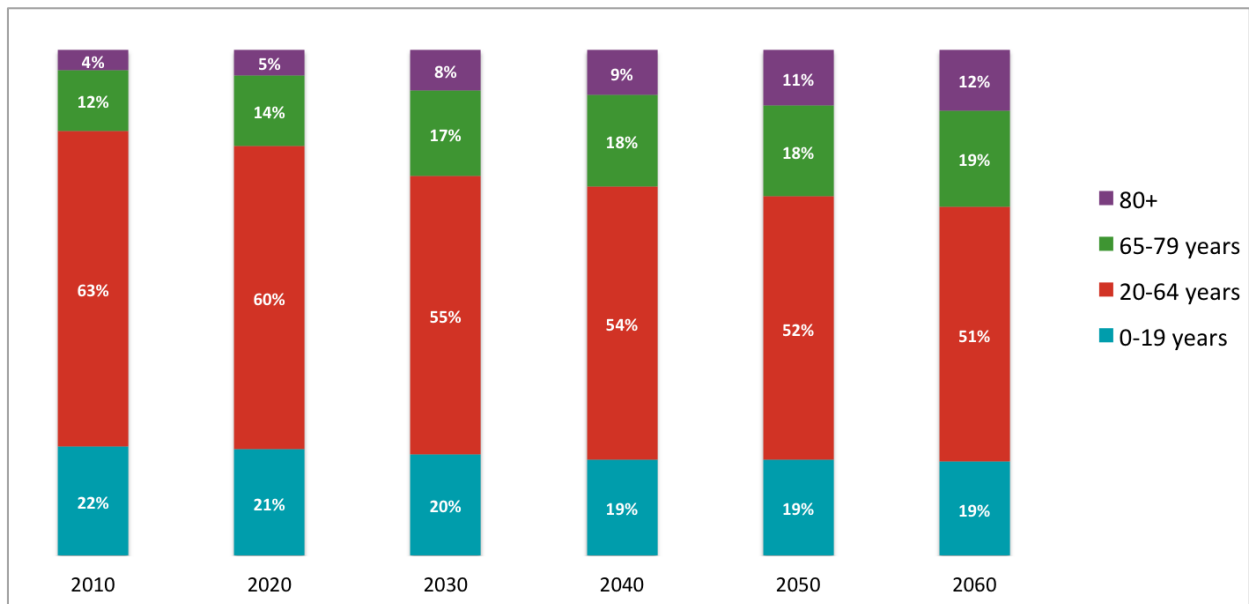
### 2.1.1 Life stages

When designing products for elderly users, it is important to know that *seniors* cannot be treated as a homogeneous population, but comprise different subgroups. The basic differentiation is between their third and fourth ages, as presented in Laslett’s (1991) stage model:

The **third age** (*young old*) describes older adults’ healthy and active life phase, which is characterised by the continuation of their former lifestyle after retirement (approximately from 65 to 80). The implications of this era are rather positive and are defined by personal achievement and fulfilment.

The **fourth age** (*oldest old*), beginning roughly at 80<sup>6</sup>, is associated with fading health and independence. High age often leads to weight loss, slower movements, tiring sooner and diminished physical activity. Comorbidity (i.e. simultaneously suffering from several medical conditions), institutionalisation and the need for medical and care services increase. In contrast to the third age, this life stage is characterised by biological and psychological dysfunctions, dependence and approaching death.

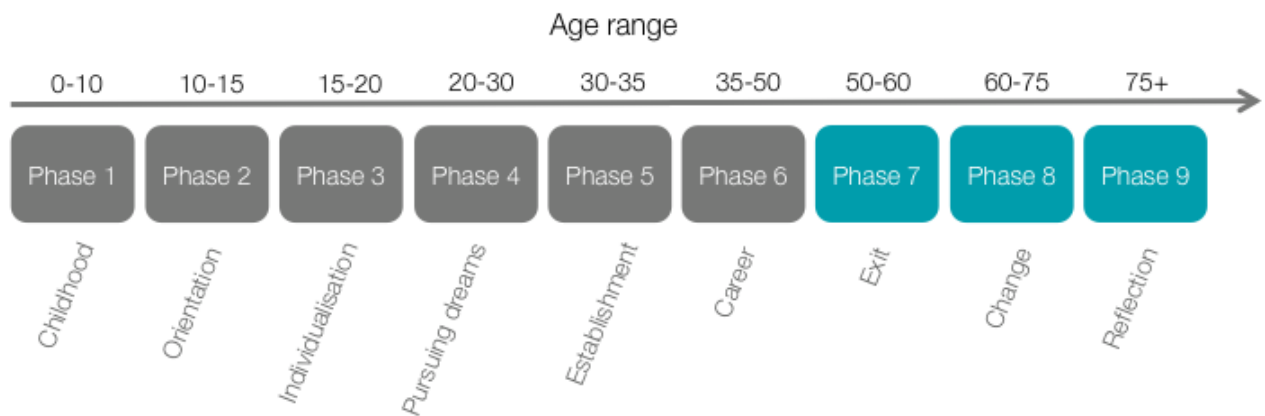
Figure 4 shows that the ratio of these two age stages (corresponding approximately to the green and purple age groups) will rise continuously in the EU-27 states within the next decades.



<sup>6</sup> The exact boundary between the third and fourth age is dynamic, depending on the individual health status or general life expectancy.

**Figure 4:** Projection of population structure changes by main age groups, EU-27 (EUROPOP, 2010).

Another approach to differentiate between senior subgroups is to focus in detail on the age ranges that correlate with specific life themes (or life course events / LCEs) with which people deal, for instance, children leaving home, retiring, or becoming grandparents. Figure 5 shows a basic model developed for the German population, which might be differ slightly in other countries, depending on specific historical events or retirement rules.



**Figure 5:** Life stages related to age groups and their predominant life themes (A.GE & rtv, 2010).

From an AAL perspective, it is especially interesting to consider the issues with which people deal from the age of 50 onward:

**Phase 7 – Preparing a work-related exit (50 to 59 years):** From the age of 50 onwards, people start planning their retirement (starting at about 60 to 65 years, even though the official retirement age is usually higher<sup>7</sup>). At this stage, people become more aware of growing old and that they will start losing loved ones: not only are seniors’ children leaving home, but their parents are aging, and their roles might change from being a recipient of care to that of a caregiver. In addition, the divorce rate is comparatively high in this group (about 25% of all divorces<sup>8</sup>). In line with these changes, their living environment is often changed, for example, by moving to a new (smaller) home, new furniture, or by utilising their home space differently.

**Phase 8 - Change and experience (60 to 74 years):** In this phase, when seniors retire, they reorganise their new leisure time for hobbies or events for which they did not previously have enough time, and that make them feel good or needed: travel, cultural activities, learning new skills, or volunteer work. Their spending power is usually higher than before, since their homes have been paid and their children are independent. The focus of this age group is enjoyment and activity.

<sup>7</sup> EUROSTAT: Retirement age of EU-27.

<sup>8</sup> INS - Instituto nacional de estadística: Divorce rates in Spain.

**Phase 9 - Reflection and reduction (75 years and older):** As long as seniors are still healthy in this phase, they try to prolong the conveniences of the former phase as long as possible, while trying to compensate for age-related or health-related limitations as far as possible. The focus is increasingly on social contacts and activities deemed most important. Since they value their remaining time very highly, they are less able to tolerate irrelevant issues, failure, or disappointment. If ailments and illness dominate their lives, support from others becomes very important.

These life themes provide a basic idea of the different AAL solution target groups and their needs, which AAL solutions can support.

**KEEP IN MIND:** Aging is related to different life phases with themes like: people's changing roles within their social network, spending time with enjoyable activities, and concentrating on the essential in life.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** AAL solutions' added value ought to capture these basic topics to ensure the target group's interest and acceptance.

**WANT TO LEARN MORE?**

- Baltes (1998). Theoretical propositions of life-span developmental psychology
- Laslett (1991). A fresh map of life: The emergence of the Third Age.
- A.GE & rtv (2010). Zeitreise durch 7 Jahrzehnte.

### 2.1.2 ICT use

Despite younger people’s perceptions, seniors’ use of technology is the rule rather than the exception. When questioned about their daily appliance use – for instance, microwaves, computers, and answering machines – seniors (age 65 to 75) report an average of between 19 and 31 interactions per day<sup>9</sup>. Users’ age, the market segment, their gender, personal experience, etc. all influence actual technology use.

Although elderly users are less inclined to accept new technology than younger people, they are motivated to use technology if it is compatible with their current lifestyle and routines, and if they are sure that the benefits clearly outweigh the effort of learning something new (Ryu et al., 2009).

Table 1 shows the factors that promote acceptance of and need for technology. It is clear that age alone does not predict technology acceptance – interest in innovation does. Furthermore, rejection of technology might stem from a lack of trust in one’s technological capabilities; that is, a lack of self-efficacy<sup>10</sup>. If seniors are afraid that they will be unable to handle technology, they are unlikely to use it.

**Table 1:** Factors promoting technology use (Flick, 2012<sup>11</sup>).

Factors influencing technology acceptance	Factors influencing the need for technology
Costs	User generation / cohort
Compliance with individual needs	Housekeeping style
Personal experience with technology usage	Number and type (partner, children) of inhabitants in household
Accessibility barriers (physiological, cognitive)	Personal attitude towards technology

Seniors of 65 and more are still far less experienced with ICT technology than younger users, but are rapidly catching up, as the following statistics from Germany prove<sup>3</sup>:

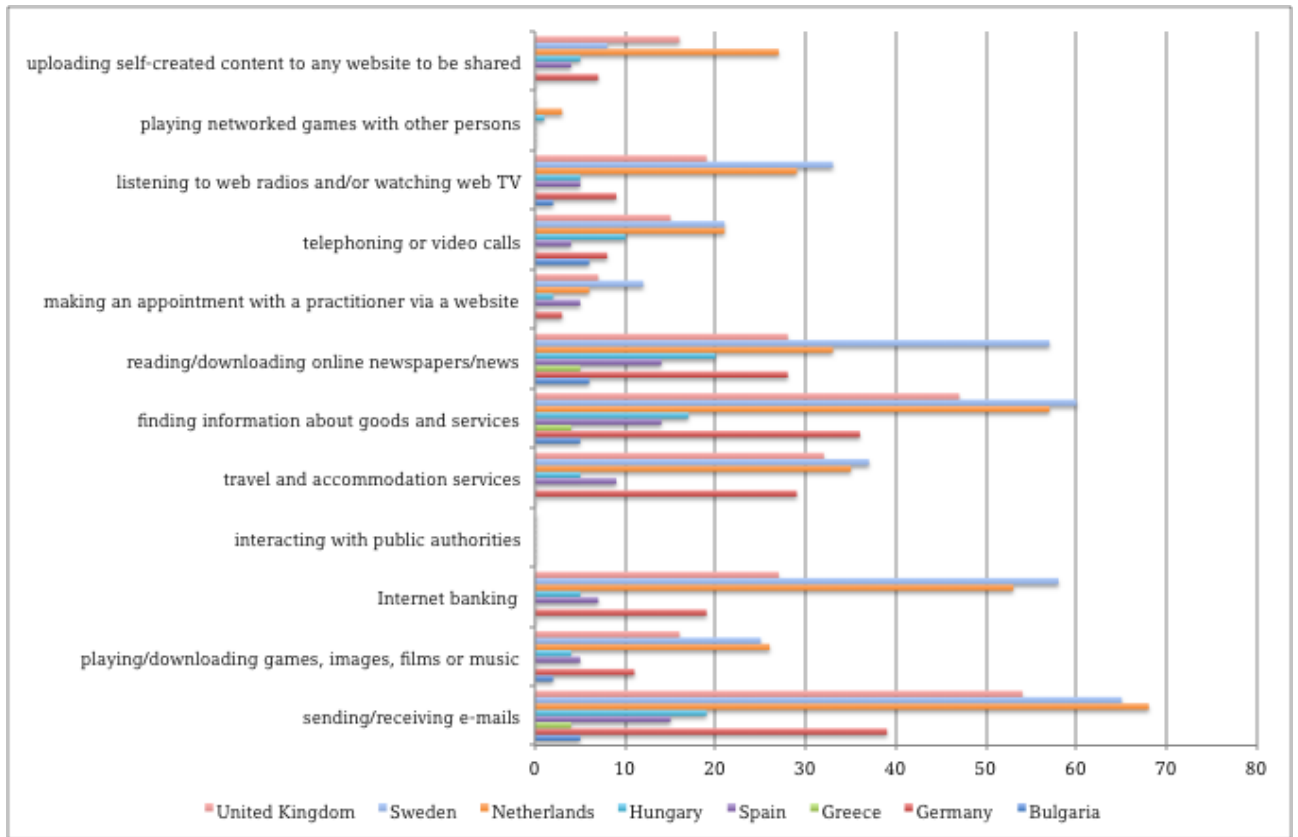
- 59% of seniors use computers
- 26% of seniors go online regularly
- 12% of seniors go online daily
- 3% of seniors are members of social online communities
- 55% of seniors own a mobile phone.

<sup>9</sup> O’Brian (2010). Understanding human-technology interactions: the role of prior experience and age.

<sup>10</sup> Bandura (2007). Self-efficacy in health functioning.

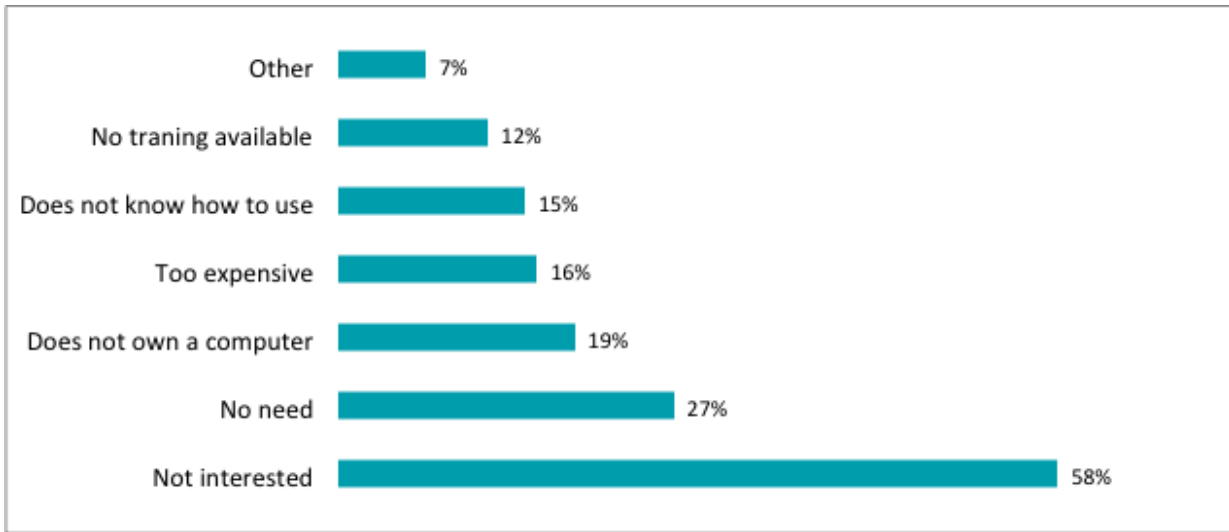
<sup>11</sup> Flick (2012). Bedarfs- und Akzeptanzanalyse von AAL-Lösungen.

The actual levels of technology use by users between 50 and 64 are often much higher. Figure 6 displays seniors’ most frequent activities online, from writing e-mails to online-banking. It clearly shows some strong differences among users in different European countries regarding their internet use and interests. Figure 7, which displays reasons for not using a computer from a Finish study with 1,555 respondents from 2006, shows that a lack of interest, or a lack of need, outweigh other factors such as the costs or a lack of training by far. In other words, if seniors see that using a computer has obvious benefits for them, they will probably learn to use one.





**Figure 6:** Internet activities of seniors aged 65-74 in selected European countries in 2012 (Source: Eurostat, 2013).



**Figure 7:** Reasons for not using a computer among Finnish citizens aged 55 to 90 (N = 1,555).

**KEEP IN MIND:** The number of seniors using ICT regularly is constantly increasing.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** The use of ICT is more a question of assumed benefit than of age. Seniors are willing to learn to handle new technology if it meets their core needs.

**WANT TO LEARN MORE?**

- Generali Altersstudie (2013). Wie ältere Menschen leben, denken und sich engagieren.
- Ryu, Kim & Lee (2009). Understanding the factors affecting online elderly user's participation in video UCC services.
- SHARE (2008): [www.share-project.org](http://www.share-project.org)

### 2.1.3 Physiological characteristics of normal aging

When developing Ambient Assisted Living (AAL) solutions, the changing physiological characteristics across a life span are an important driver of the need for new product. And although age-related physiological decline is not the only aspect, it is a natural process that must be considered in AAL systems' design.

Ageing is not an illness.

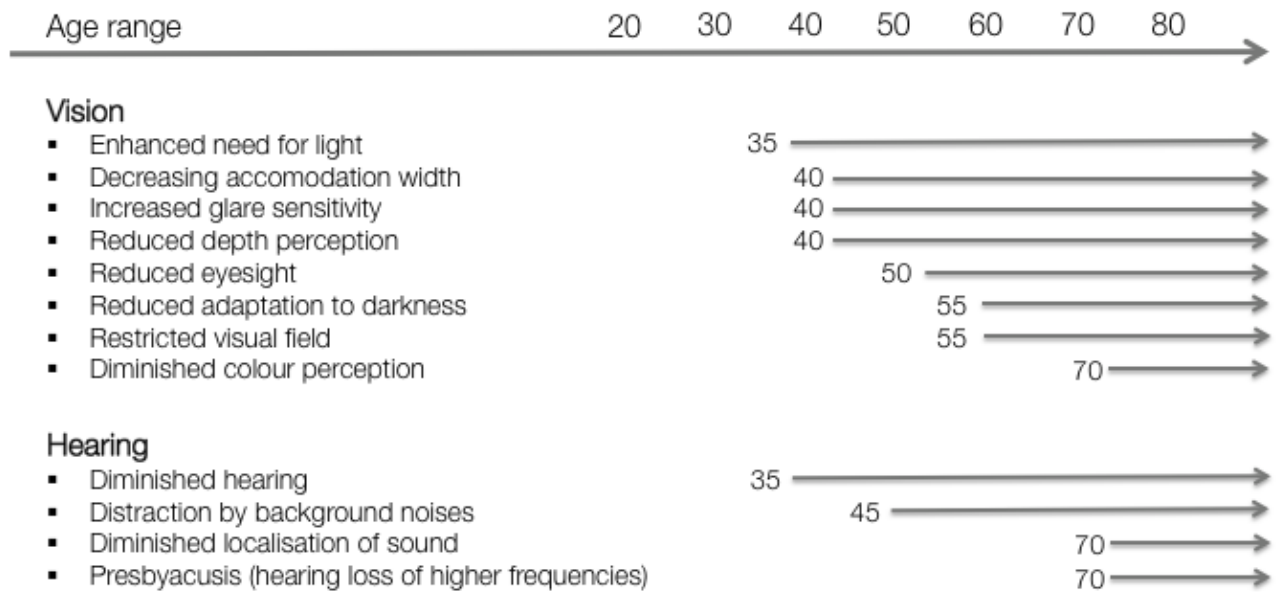
Typical age-related changes affect people's visual, sensual, motor and cognitive (mental) abilities, some from as early as the mid-20s (see Figure 8). Even if people's individual conditions vary significantly, one should also consider the following aspects when designing AAL solutions:

**Visual impairments.** From around 35, people require more light when reading or writing. Their perception of depth and adaptation to brightness decline, as well as the speed at which they generally process stimuli. From around 60 onwards, their visual sharpness diminishes, and their field of vision becomes smaller. These changes can cause problems when reading interfaces, websites, labels and manuals.

**Acoustic impairments.** About 30% of people in their sixties and 60% of seniors over 70 suffer from decreasing hearing. With increasing age, the correct perception and localisation of sounds (especially of high-pitched sounds) worsen. Understanding speech when there is background noise becomes more of a challenge. Hence, acoustic feedback should only be used infrequently.

**Motor impairments.** On reaching 65, humans have lost about one-third of their muscular mass and their joints stiffen. Consequently, their stability deteriorates and standing up becomes more difficult. At the same time, their coordination and fine motor skills diminish, especially under time pressure, or if they want to do quick, consecutive actions. Their precision and reaction times deteriorate. These changes affect – for instance – mouse control in terms of precise positioning, fast input (e.g. double-clicks or systems' waiting times), or pressing several buttons at the same time (e.g. short tabs).

**Cognitive (mental) impairments.** Owing to structural changes in the brain, the ability to process incoming information flexibly – one's *fluid intelligence* – already starts to decline at 25 (whereas one's gathered knowledge, or *crystallised intelligence*, grows with age). Split or focused attention also becomes a challenge, and one's memory slowly worsens. Thus, the amount of (multiple) information presented should be reduced. Interfaces should only focus on the most important aspects, a menu should be fairly simple, while visited links should be recognisable.

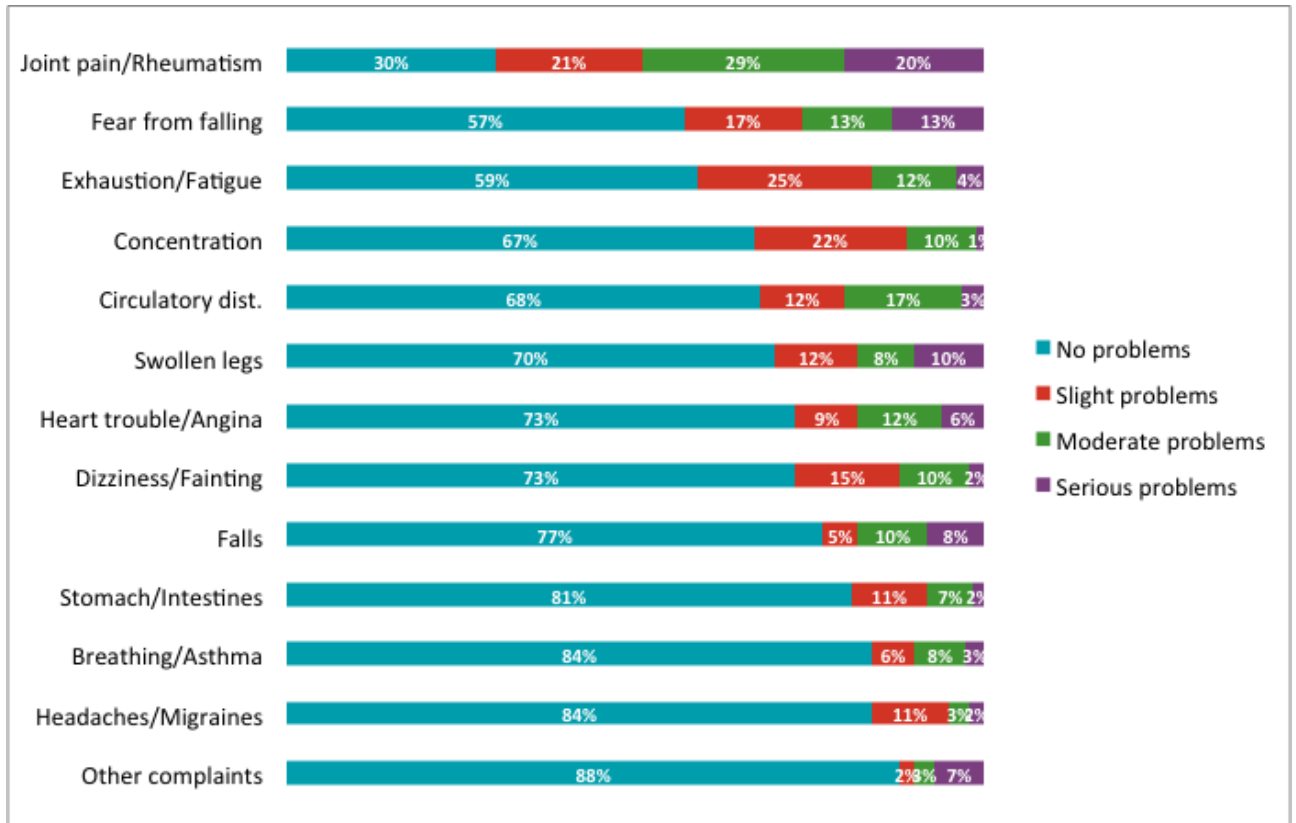


**Figure 8:** Progression of sensory abilities across a lifespan (translated from Saup, 1992<sup>12</sup>).

Figure 9 displays the prevalence of typical health-related complaints among 196 German and Italian seniors over 65. Joint pain, the fear of falling and de facto falls are considered the most severe health complaints.

Understanding age-related impairments can be very helpful – especially for young developers – to create an awareness of the different perspectives of end-users. Professional tools such as the *third age suit* (Ford) and the *age explorer* (Meyer-Hentschel Institute) mimic age-related changes such as constrained sight, hearing and mobility. Alternatively, spectacles with dots on the lenses, earplugs and thick gloves can also simulate the experience of higher age (e.g. understanding the difficulties when texting on a smartphone when you cannot see or type properly). It might be a great idea to integrate such tools into meetings to make sure that all the project members consider senior users’ needs realistically. However, because sudden aging (which is what these roleplays imitate) differs from real-life aging over time, which is more subtle, an AAL solution’s requirements should always be verified with real end-users rather than being simulated.

<sup>12</sup> Saup (1992). Alter und Umwelt: Eine Einführung in die Ökologische Gerontologie.



**Figure 9:** Prevalence of health-related complaints (in %) (N = 196) (Becker, 2007<sup>5</sup>).

Most of the developed AAL systems seek to improve typical health problems with which seniors have to deal. Thus, AAL projects need to measure the actual status frequently, either to control error variables, or to prove a system’s benefits in a long-term test trial. Table 2 lists the most common measurement instruments for assessing a person’s health status.

**Table 2:** Assessment instruments focusing a person’s health status in its broadest sense.

Instrument	Sight	Mobility	Cognition	Independence	Well-being
Wellness Profile	-	x	x	x	x
SF-36 Health Survey	-	x	-	x	x
WHO-5	-	-	-	-	x
Geriatric Depression Scale (GDS)	-	-	-	-	x
Elderly Mobility Scale (EMS)	-	x	-	-	-
International Physical Activity Recall (IPAQ)	-	x	-	-	-

Instrument	Sight	Mobility	Cognition	Independence	Well-being
Mars CST	x	-	-	-	-
Barthel Index	-	x	-	x	-
Lawton-Brody Scale	-	x	x	x	-
DEMTECT	-	-	x	-	-
Mini-Mental Status Examination (MMSE)	-	-	x	-	-
Get Up and Go (GUG)	-	x	-	-	-

**KEEP IN MIND:** Normal aging involves slight changes or requirements that include sensual, cognitive and motor aspects.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Remember to provide a senior-friendly interface and do pretests with real seniors to eliminate major usability weaknesses.

**WANT TO LEARN MORE?**

- NC State University (2006). Universal Design Principles.
- AARP (2005). Designing Web Sites for Older Adults: Expert Review of Usability for Older Adults at 50 Web Sites.
- Biermann & Weißmantel (2003). SENSI Regelkatalog.
- CEN/CENELEC Guide 6: Guidelines for standard developers to address the needs of older persons and persons with disabilities (in German: DIN Fachbericht 131).

### 2.1.4 General advice: Designing for seniors

Although the aim of Ambient Assisted Living (AAL) is the optimisation of age-related deficits, the design and marketing of user-friendly AAL solutions should keep in mind that elderly end-users do not want to be regarded as needy and frail.

When designing products and services for seniors, one should therefore consider the following aspects:

**Provide additional value.** Seniors’ decisions to use a specific product or technology depend on the perceived future advantages (e.g. safety, comfort) that they associate emotionally with this product or technology’s usage. On the other hand, the possible risks (e.g. interruptions of daily routines,

costs) of this product or technology predict their future usage to a much lesser extent<sup>13</sup>. We recommend that you clarify how users can benefit from a delivered AAL solution and ensure that what you promise is actually delivered. If a product or technology has personal relevance for a user, this lowers the mental hurdles that such users may have regarding its use.

**Provide adaptable support.** The purpose of AAL solutions is to help aging people retain their independence, and not to do things that they can easily do themselves. According to Lawton's model of person-environment fit<sup>14</sup>, technical solutions are only successful if they address individual abilities very precisely. Thus, AAL services need to find a balance between supporting individual users and activating them. Modular components allow easy, inexpensive adaptability and extension, and can be used in different products.

**Keep it simple.** As noted, concentration and memory decrease with age. Learning and usage requirements can be reduced by not providing too many functions and by clearly designing menus and structures that avoid complexity and distraction from goals. However, attractive design is as appealing to older people as it is for younger users.

**Enable a joyful experience.** If AAL solutions provide an enjoyable experience, they also seem easy to use, which in turn enhances the intention to use them<sup>15</sup>. Since emotionally positive experiences become more important as people grow older, enjoyment – in addition to mere goal-oriented functions – should be considered when designing for senior users.

## 2.2 SENIORS WITH DEMENTIA

Besides more or less healthy seniors, those suffering from dementia are another frequent target group for Ambient Assisted Living (AAL) solutions. They can be regarded an extreme user group with specific disabilities and, therefore, with specific needs. This chapter addresses typical dementia symptoms, measurement tools, common interventions and design guidelines. Thus, an initial overview of the basic terms, the user needs and critical aspects is provided for AAL solution research development projects for people diagnosed with dementia.

Owing to our increasing life expectancy, the prevalence of dementia is increasing: The World Alzheimer Association estimates that, worldwide, there will be three times more dementia patients by 2050, i.e. 115 million people<sup>16</sup>. Table 3 shows the current Alzheimer prevalence rates for

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<sup>13</sup> Melenhorst, Rogers & Bouwhuis (2006). Older adults' motivated choice for technological innovation: Evidence for benefit-driven selectivity.

<sup>14</sup> Lawton (1999). Environmental taxonomy: Generalizations from research with older adults.

<sup>15</sup> Ryu, Kim & Lee (2009). Understanding the factors affecting online elderly users' participation in video UCC services.

<sup>16</sup> United Nations, Department of Economic and Social Affairs, Population Division (2011). World Population Prospects: The 2010 Revision.

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different age ranges in Europe. Women have a slightly higher risk of developing dementia symptoms than men.

**Table 3: Prevalence of dementia in European countries (EUROCODE Review, 2013).**

Age range	Prevalence males	Prevalence females	Prevalence total
60 to 64	0.2%	0.9%	0.6%
65 to 69	1.8%	1.4%	1.6%
70 to 74	3.2%	3.8%	3.5%
75 to 79	7.0%	7.6%	7.4%
80 to 84	14.5%	16.4%	15.7%
85 to 89	20.9%	28.5%	26.2%
90 to 94	29.2%	44.4%	41.0%
>95	32.4%	48.8%	46.3%

### 2.2.1 Typical symptoms of dementia

Dementias are the most common and most severe psychological disorders at a higher age. Dementia describes a collection (‘syndrome’) of cognitive (mental) and behavioural symptoms with a progressive course, which is referred to as the behavioural and psychological symptoms of dementia (BPSD):

- **Cognitive symptoms:** decline in memory, thinking, orientation, learning abilities, speech and judgement.
- **Noncognitive symptoms:** changes in behaviour (agitated or aggressive, seems compelled to move, apathy) and in the sufferers’ emotional life (depression, hallucinations).

The **cognitive** symptoms result in difficulties with daily tasks that require organisation or planning, in forgetting routes or names (leading to questions being repeated) and in becoming confused in unfamiliar environments. Finding the right words and handling money when shopping are also potential problems of dementia patients. The **noncognitive** personality and mood changes include behaviours such as screaming, hoarding, cursing, or other culturally inappropriate behaviour that may occur during the disease’s course. Some dementia patients also suffer from delusions that their spouses are being unfaithful, are imposters, or strangers in the house, as well as visual or auditory hallucinations that make them believe people are talking or appearing when there is no one. Mood changes can be triggered by the sufferers’ loss of their everyday abilities and orientation (e.g. they can no longer slip into their clothes, nor recognise relatives), which makes them sad or aggressive.

Dementia symptoms not only reduce patients’ quality of life, but also mean that their families and caregivers are faced with severe problems. The disease leads to a progressive loss of independence, with the sufferers eventually being dependent on demanding care. Since the number of elderly people is increasing steeply, projections estimate that by 2025 there will be about 35 million people



dementia sufferers worldwide. On average, 80% of the affected seniors end up living in care facilities.

Dementia symptoms are caused by brain damage due to neurodegenerative diseases such as Alzheimer’s disease, vascular dementia, frontotemporal dementia and Lewy body dementia. These diseases cause the brain to degenerate more swiftly than it would do during the normal aging process. Patients can suffer from several of these conditions at the same time.

The progression depends on the type of underlying disease and occurs in stages. Dementia is often preceded by mild cognitive impairments (MCIs), an intermediate stage between normal age-related cognitive decline and dementia symptoms that interfere with daily life. The sufferers’ memory, language, thinking and judgment are impaired. Long-term studies suggest that 10% to 20% of those aged 65 and older may suffer from MCI. Although MCIs increase the risk of dementia, some seniors never get worse, while others even improve.

As dementia progresses, memory loss and communication difficulties often become very severe. In the later stages, the sufferer is likely to require constant care and attention. Table 4 provides an overview of typical problems occurring in different health dimensions among dementia patients. Increasing help is needed with everyday activities as the dementia progresses. Table 5 provides an overview of the typical restrictions of people with mild to moderate dementia, compared to people with severe dementia.

**Table 4:** Overview of typical symptoms in the later stages of dementia.

Symptom areas	Difficulties with...
Memory	<ul style="list-style-type: none"> <li>▪ recognising close family and friends</li> <li>▪ remembering where one lives or where one is</li> <li>▪ remembering recent or past events</li> <li>▪ carrying out or completing basic tasks</li> <li>▪ following instructions</li> </ul>
Communication	<ul style="list-style-type: none"> <li>▪ understanding simple information</li> <li>▪ finding words, eventually with speaking</li> <li>▪ reasoning clearly</li> <li>▪ interacting appropriately (loud, rapid, aggressive)</li> </ul>
Mobility	<ul style="list-style-type: none"> <li>▪ moving about unaided</li> <li>▪ carrying out everyday tasks</li> <li>▪ moving purposefully (vs. wandering)</li> </ul>
Eating	<ul style="list-style-type: none"> <li>▪ eating regularly and enough</li> <li>▪ eating at all or swallowing</li> </ul>
Hygiene	<ul style="list-style-type: none"> <li>▪ controlling one’s bladder</li> <li>▪ controlling one’s bowel</li> </ul>

**Table 5:** Restriction rates of basic daily activities (in %) (according to BMFSFJ, 2007: *Möglichkeiten selbständiger Lebensführung*).

Restricted actions	Moderate dementia	Severe dementia
Washing independently	90.4%	98.7%
Controlling one’s bladder	79.6%	94.3%
Controlling one’s bowel	59.4%	88.6%
Getting dressed independently or with some help	50.4%	83.5%
Using the toilet independently	39.7%	77.7%
Walking 50 metres without help	42.8%	62.8%
Eating independently or with some help	13.5%	51.9%

Measuring the quality of life of dementia patients ought to involve:

- Their health status (including health-associated disabilities)
- Their environment (including restrictions, activation, opportunity of choice)
- Their subjective perceptions of their mood, physical discomfort and frustration
- Behavioural observation of their activities, emotions and social involvement
- Caregiver reports on the patient’s behaviour and mood.

Table 6 presents the most common assessment tools that focus on different aspects of dementia, quality of life and health. They should be based on third-party evaluations by relatives, caregivers and clinicians, since dementia patients are mostly unable to provide valid information about themselves. Additional information about the lives of dementia patients, such as the natural interaction between the patients and their caregivers, can be gathered by observation (or shadowing). However, the collected data’s validation should be checked with relatives or caregivers and not with the patients.

**Table 6:** Assessment tools for dementia patients.

Restricted actions	Cognitive symptoms	Noncognitive symptoms	Everyday tasks
Geriatric Depression Scale (GDS)	-	X	-
Dementia Mood Assessment Scale (DMAS)	-	X	-
Dementia Quality of Life Instrument (DQoL)	-	X	-
Modified Apparent Emotion Scale	-	X	-
Pittsburgh Agitation Scale	-	X	-

Restricted actions	Cognitive symptoms	Noncognitive symptoms	Everyday tasks
Mini Mental State Examination (MMSE)	X	-	X
Clinical Dementia Rating (CDR)	X	-	X
Barthel Index	-	-	X
Behaviour Rating Scale for Dementia (CERAD)	X	X	-
Revised Memory and Behaviour Problems Checklist	X	X	-
Behavioural and Emotional Activities Manifested in Dementia (BEAM-D)	X	X	-

These measurement tools can help identify a target group (e.g. seniors with MCIs, moderate or severe dementia), and to monitor the effects of an AAL solution (e.g. by comparing the status of the experimental group with a control group). Experienced experts or trained interviewers should apply these instruments in order to provide valid results.

**KEEP IN MIND:** Dementia is a degenerative state that exceeds the effects of normal aging. It comprises mental, behavioral and emotional aspects. As the disease progresses, the patients' dependence increases, as well as the stress and strains of relatives and caretakers.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** AAL solutions can target not only memory loss, but also behavioral or emotional aspects of dementia. The individual health status and abilities of patients should be taken into account (in terms of adaptability). The system should neither patronize nor overstrain the users. Since patients and their caregivers are impacted by dementia, successful management has to comprise interventions for both.

**WANT TO LEARN MORE?**

- World Health Organization (2012): Dementia: A Public Health Priority.
- Thomas Pocklington Trust (2008). The experiences and needs of people with dementia and serious visual impairment: a qualitative study.
- Publications of the European Collaboration on Dementia (EuroCoDe): [www.alzheimer-europe.org](http://www.alzheimer-europe.org)

### 2.2.2 Coping with dementia

In addition to medical or ergotherapeutic treatments, there are several pragmatic measures to help dementia patients cope with their symptoms and to enhance their quality of life. These arrangements focus on providing support to counter these patients’ tendency to wander, their loss of orientation, their lack of social inclusion and stimulation. The more severe the dementia, the more important it is to initiate activity and social contact, since demented people tend to increasingly withdraw into themselves.

The interventions listed in Table 7 are frequently used by caring relatives and professional care facilities. They can also be utilised as a basis for developing supporting AAL solutions. However, these examples should not replace a thorough context and need analysis regarding the target environment and target user groups.

**Table 7:** Interventions to support dementia patients.

Target dimension	Measures
Enhancing temporal orientation	<ul style="list-style-type: none"> <li>▪ Regular meals</li> <li>▪ Visible calendars and clocks</li> <li>▪ Seasonal decoration</li> </ul>
Enhancing spatial orientation	<ul style="list-style-type: none"> <li>▪ Coding doors/rooms by colour, photographs of the patient, personal objects</li> </ul>
Supporting living environment	<ul style="list-style-type: none"> <li>▪ Corridors with seating arrangements</li> <li>▪ Corridors without dead ends</li> <li>▪ Tranquility room next to activity rooms</li> <li>▪ Protected outdoor areas</li> <li>▪ Neatly arranged furniture</li> </ul>
Offering stimulation	<ul style="list-style-type: none"> <li>▪ Moderate sensual stimulation: aroma therapy, music, light (e.g. Snoezelen rooms<sup>17</sup>), decoration objects</li> <li>▪ Moderate cognitive stimulation: learning or memory games, creative activities (crafting)</li> <li>▪ Activity stimulation: boxes for rearranging things, singing, creative activities (crafting), celebrations</li> </ul>
Supporting social interaction	<ul style="list-style-type: none"> <li>▪ Assignment of minor duties (e.g. cooking)</li> <li>▪ Communication via expressions, touch, gestures (if speech has already deteriorated)</li> <li>▪ Animal therapy</li> </ul>

<sup>17</sup> A Snoezelen room is a multisensory environment or room with a soothing yet also stimulating effect. It was developed in the Netherlands in the 1970s and is frequently utilised for autistic people or those with dementia.

**KEEP IN MIND:** Dementia patients need support with many aspects of their daily lives. Orientation and stimulation are very important to enhance their quality of life.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Typical interventions offer a good starting point for developing ideas regarding the added value of an AAL system. However, make sure that relatives, caregivers, and care facilities' perspective are also taken into account.

**WANT TO LEARN MORE?**

- Schulz (2005). *Dementia Care and Quality of Life in Assisted Living and Nursing Homes*.

### 2.2.3 General advice: Designing for dementia patients

A range of initiatives has been designed to include the needs of disabled people in the design process, for instance, *Universal Design*, *Design for All* and *Inclusive Design*. These initiatives have laid down basic design principles that can also be applied in the design of AAL solutions for users with dementia. Even though it might be challenging to meet all the suggested guidelines (since some might be contradictory), they can still serve as a practical guideline for a user-centred philosophy that addresses extreme users and their needs.

For example, the principles of the Universal Design approach are:

#### **Principle 1 - Equal use:**

- Provide the same means of use for all users; identical whenever possible, equivalent when not.
- Avoid segregating or stigmatising users.
- Provisions for privacy, security and safety should be equally available to all users.
- Make the design appealing to all users.

#### **Principle 2 – Flexibility in use:**

- Provide choice in the methods of use.
- Accommodate righthanded or lefthanded access and use.
- Accommodate the user's accuracy and precision.
- Allow adaptability to the user's pace.

#### **Principle 3 – Simple and intuitive use:**

- Eliminate unnecessary complexity.
- Be consistent regarding user expectations and intuition.
- Accommodate a wide range of literacy and language skills.
- Arrange information according to its importance.

- Provide effective prompting and feedback during and after task completion.

**Principle 4 – Perceptible information:**

- Use different modes (pictorial, verbal, tactile) to repeat essential information.
- Provide an adequate contrast between essential information and the background.
- Maximise the readability of essential information.
- Differentiate elements in ways that can be described (i.e. make it easy for those who have to instruct or give directions).
- Ensure compatibility with the variety of techniques and devices that people with sensory limitations use.

**Principle 5 – Tolerance of errors:**

- Arrange elements to minimise hazards and errors: the most used elements, the most accessible elements; eliminate, isolate or shield hazardous elements.
- Provide warnings of hazards and errors that could be made.
- Provide fail-safe features.
- Discourage automatic actions in tasks that require vigilance.

**Principle 6 – Low physical effort:**

- Allow the user to maintain a neutral body position.
- Use reasonable operating force.
- Minimise repetitive actions.
- Minimise sustained physical effort.

**Principle 7 – Size and space for approach and use:**

- Provide a clear line of sight to important elements for seated or standing users.
- Make reaching for all components comfortable for seated or standing users.
- Accommodate variations in hand and grip size.
- Provide adequate space for the use of assistive devices or personal assistance.

If these principles are applied, AAL solutions should be much more usable, intuitive and attractive – not only for dementia patients, but also for secondary users. In addition to these basic principles, the following design aspects should be considered regarding the specific needs of people with dementia as primary users:

- **Consider the diversity of users.** AAL systems are not only used by demented people, but also by their relatives or caregivers. Ensure that the system functions cover the needs of all of these user groups.
- **Avoid cognitive overload.** The interface should limit options and should be simple. Whenever possible, the dialogue should be linear and parallel tasks should be avoided. The

usability should be guided by providing an interface (appealing buttons), that does not rely on users having to recall any functions.

- **Take individual characteristics of dementia into account.** Systems for patients with cognitive impairments should be able to adapt to the user's personal conditions, which will change over time.
- **Model real-world objects.** When users lack ICT expertise, or their cognitive capacities are increasingly weakening, it helps them if symbols or objects from real life are presented to make an interface more intuitive. For instance, time can be presented as a clock rather than digitally, or the turning of pages can be displayed as if the user was in fact turning pages<sup>18</sup>.
- **Consider aesthetics.** An appealing design does not necessarily interfere with accessibility and will make products more appealing to their users.

**KEEP IN MIND:** The basic Universal Design principles and accessibility guidelines offer a good starting point for the design of AAL solutions.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Demented people can be regarded as extreme users that an AAL system should be able to handle. Make sure that the design of the system meets their disabilities.

**WANT TO LEARN MORE?**

- Mihailidis et al. (2011). Zero-Effort Technologies: Considerations, Challenges and Use in Health, Wellness, and Rehabilitation
- Newell & Gregor (2002). Design for older and disabled people – where do we go from here?
- Universal Design Principles. see e.g. <http://design-dev.ncsu.edu/openjournal>

## 2.3 SECONDARY AND TERTIARY USERS

Seniors are usually not the only users of Ambient Assisted Living (AAL) technology: their relatives, professional caregivers, medical doctors, staff from resident homes, and real estates managers, etc. are often also affected by the installation of an AAL solution. These additional stakeholders and their interests and needs should therefore also be integrated into the developmental process. The following sections provide information about these user groups to help ensure that their requirements are included in the technology design. As with all the information in this document, additional data should, if necessary, be collected for each project.

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<sup>18</sup> Examples taken from Hellmann (2011). Usability and accessibility for persons with dementia.

### 2.3.1 Relatives and informal carers

Seniors aged 50 and over are mostly cared for by their children or spouses (see Table 8); two-thirds of these carers are women. In central Europe, a spouse provides 42.3% of intensive care, as opposed to only 3.4% of non-intensive care. In southern Europe, however, children and other relatives provide intensive care more frequently.

If carers can no longer care for their partners, their children (or children-in-law) usually take over. These children are on average 25 years younger than the care recipient, and – depending on their age – might also have moderate health problems.

**Table 8:** Percentage of carers by relationship to the care recipient and by country (OECD, 2011).

Country	Spouse	Children	Relative	Friend
Austria	36.3	34.7	14.7	16.8
Belgium	33.7	40.4	16.6	23.4
Denmark	39.7	41.3	15.9	20.9
France	31.8	40.5	19.6	13.7
Germany	34.9	44.2	13.0	21.5
Greece	33.2	35.2	14.9	14.7
Ireland	28.5	35.2	22.4	18.8
Italy	23.1	36.2	22.6	24.1
Netherlands	27.4	46.9	17.2	24.7
Poland	33.8	10.6	27.9	8.0
Spain	28.0	39.9	20.6	10.9
Sweden	26.5	48.5	19.0	18.1
UK	34.1	32.2	5.4	27.4

While caring does not seem to affect work decisions at low care intensity levels (below 10 hours per week) and for extra-residential caring, it does for the providers of intensive care and co-residential carers. Providers of intensive care are more likely to be homemakers and are less likely to be employed. If they are still working, they usually reduce their working hours or stop working.

The reason for this is that providing personal care can be a very demanding task that is not compatible with a full-time or even part-time job. To date, available jobs are often not flexible enough in terms of working hours, or they do not leave enough options to accommodate caring responsibilities. Caring duties can also be unpredictable at times regarding their intensity, which



could lead to short-term absences from work. Hence, caregiving is associated with a higher probability of experiencing poverty across countries (except in southern Europe), especially for women.

The intensity of the provided care varies with the activities of daily living (ADL), the limitations of the cared-for seniors, as well as between countries (see Figure 10 and Figure 11). Caregiving relatives usually support those requiring care with virtually all of their daily activities such as:

- Healthcare and/or rehabilitation: wound care, medication control, health and mobility exercises, memory exercises.
- Activities of daily living (ADL): preparing meals, assisting with toileting needs, dressing and undressing, feeding, taking care at night.
- Instrumental activities of daily living (IADLs): financial affairs, shopping, laundry, cleaning up, providing social interaction.

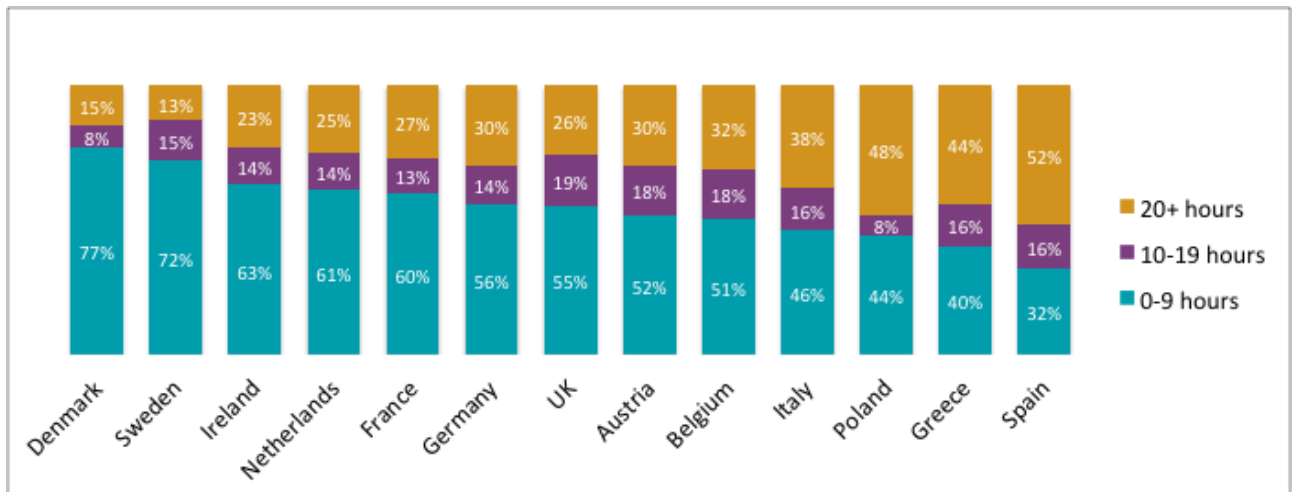
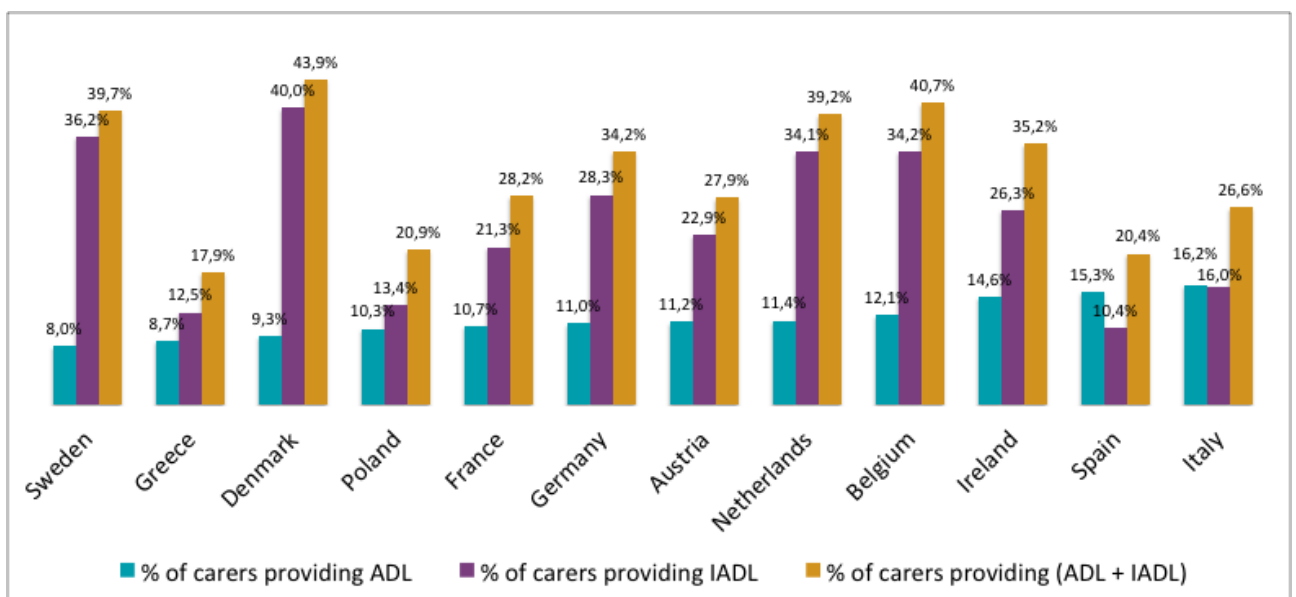


Figure 10: Percentage of weekly hours of informal care by country (OECD study, 2011).



**Figure 11:** Percentage of informal carers by type of help and country (OECD study, 2011).

On the one hand, taking care of another person can be a source of satisfaction, fulfilment and personal growth. But intensive care can also be especially stressful and strainful, potentially leading to burnout and stress. Drug consumption increases with caring activities, especially the intake of sleeping pills, tranquilisers and painkillers. Overall, the prevalence of mental health problems among carers is 20% higher than among non-carers. Relatives are often torn between their responsibilities towards the cared person and their own needs.

Among the issues with which informal caregivers struggle are:

- The burden of guaranteeing the cared person's well-being and safety, even when they cannot be with that person.
- Feelings of guilty when unable to take care of the recipient of care, or not as often as is presumed necessary.
- Crises of conscience when relatives are institutionalised, because it is interpreted as abandoning them.
- The need for information about their relatives' diseases (e.g. dementia) and their potential progression.
- The need for practical advice on and support strategies for treatment or coping strategies; sharing with other affected people.
- The need for information on support services (e.g. *meals on wheels*) or facilities, and the financing of this support.
- The organisation of caring time, and coordination with the workplace and own family.
- The need for leisure time for oneself in order to revive.
- The changes in the demented persons regarding their diminishing independence and/or their personality (e.g. aggression, lack of orientation).
- The psychological effects of being confronted with age-related decline ("Will I be the same when I'm older?").
- Conflicts with the recipient of care, other relatives, professional caregivers and/or insurance companies about care measures, responsibilities or financial matters.
- Conflicts within the family over preparation for the cared person's increasing independence (e.g. cost sharing for care facilities) or death (inheritance issues, funeral arrangements, etc.).

These issues are a good starting point to provide secondary users with useful support, i.e. AAL solutions. Since relatives are often the decision makers regarding the purchasing of AAL solutions, their requirements should also be addressed.

**KEEP IN MIND:** Caring persons are predominantly women and spouses. Care giving can provide positive experiences, but can also lead to severe stress and health complaints.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Provide information and support that correspond to the needs of the care givers, and make sure that these fits into daily routines.

**WANT TO LEARN MORE?**

- European Commission (2012). Ageing report.
- OECD (2011). The impact of caring on family carers (chapter 3).
- Schulz & Martire (2004). Family caregiving of persons with dementia: Prevalence, health effects, and support strategies.

### 2.3.2 Professional caregivers

According to data from Germany, professional care accounts only for around 10% of the total care provided<sup>19</sup>. The employment of professional caregivers is more likely in the following cases:

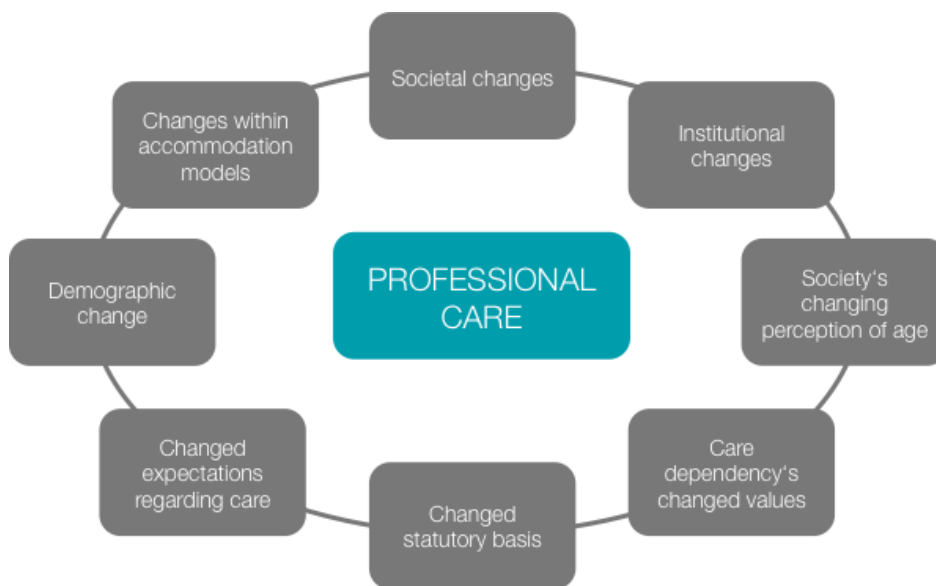
- For caring activities that require medical competence (e.g. changing wound dressings)
- For seniors with a higher level of care dependency or intensity
- For single seniors without permanent informal care
- For male seniors (about twice as much as for female seniors).

Professional caregivers are influenced by many different and changing factors and requirements (see Figure 12): societal issues such as the increasing need for mobility in the modern work environment, institutional motivations to reduce seniors' length of stay in hospitals, and changes in ethics towards technology use in order to remain independent. Professional caregivers are expected to meet the requirements resulting from these influencing dimensions: they have to be friendly, empathetic and active with elderly recipients of care, have to take the latest scientific findings into consideration, while complying with a facility's current quality standards, rules and routines. No wonder that working in the care sector is considered extremely stressful and burdensome, and the absence rate owing to illness is comparatively high<sup>20</sup>.

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<sup>19</sup> Blinkert & Klie (1999). Pflege im sozialen Wandel. Studie zur Situation häuslich versorgter Pflegebedürftiger.

<sup>20</sup> Wegner et al. (2003). Pflgeethermometer 2003: Frühjahrsbefragung zur Lage und Entwicklung des Personalwesens in der stationären Altenhilfe in Deutschland.



**Figure 12:** Factors influencing professional care for the elderly (adapted from Engels et al., 2007<sup>21</sup>).

The following are examples of issues with which professional caregivers deal on a daily basis:

- Strenuous labour due to having to lift or turn elderly people.
- Psychological stress due to experiencing sickness and mortality.
- A high workload, many organisational duties (e.g. documentation) and little time for personal contact.
- Strong time pressure due to a shortage of personnel and many patients.
- Conflicts with the recipients of care, their relatives or within the team/hierarchy.
- Keeping relatives informed about demented patients' status, or financial support they can receive.

Accordingly, caregiver goals involve the following aspects:

- Enhancing the healthcare of aged care residents by monitoring/managing their chronic condition.
- Providing early healthcare assessment, detection and prompt treatment of symptoms/conditions that would ordinarily lead to a medical emergency and the possible (re)admission to the acute care sector.
- Providing enhanced communication, coordination and monitoring of care to other healthcare providers, the client and/or their carers.
- Reducing hospital admissions (to casualty or as an in-patient; the frequency and length of hospital stays).

<sup>21</sup> Engels et al. (2007). Möglichkeiten und Grenzen selbständiger Lebensführung in stationären Einrichtungen (MuG IV).

- Enhancing the safety of care recipient, for instance, lowering the risk of demented persons disappearing or running away.
- Delegating minor organisational tasks and focussing on personal care activities
- Using an intuitive and appropriate documentation system.

Again, this information should be complemented on a case-by-case basis with further primary and secondary research results. Similar to informal carers, professional caregivers have the power to suggest or decide on access to ICT technology, which means they should be kept in mind regarding AAL solution development.

**KEEP IN MIND:** Professional caregivers have to deal with many different groups (e.g. relatives, managers, care insurance, doctors) and tasks (caring, monitoring, documenting, housekeeping, etc.). Thus, caregiving is a very demanding job with high stress levels.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Make sure that the wishes and fears of professional caregivers are appreciated in the developmental process. Keep the time required to include caregivers, but also to learn to handle a technology to a minimum.

#### WANT TO LEARN MORE?

- Genet et al. (2012). Home care across Europe: Current structure and future challenges.
- Publications of the EURHOMAP project
- Information from [www.carerplusproject.eu](http://www.carerplusproject.eu)

### 2.3.3 Other stakeholders

While senior end-users and their caregivers are often involved in AAL development, other stakeholders are mostly neglected (see the survey on user integration AAL-JP projects). AAL projects should also consider involving the following groups (at least in terms of keeping them informed):

- Medical doctors
- Physiotherapists / ergotherapists
- Rehabilitation centres
- Real estate developers
- Housing cooperatives
- Architects
- Insurance companies

- Social services
- Municipalities
- Ministries.

Depending on the specific secondary and tertiary AAL users involved, the following issues should be considered regarding AAL solution:

- The interoperability with the systems in use
- Proof of the AAL solution's (financial) benefits
- The financial costs of installation and the running expenses
- The effort and time required for installation (in terms of effects on ongoing operations, renting, occupancy)
- The usability of the AAL solution (influencing learning effort, user compliance)
- Ethical considerations: privacy issues but having to monitor, support but not paternalism
- Links to additional services (i.e. service providers)
- The quality and costs of the provided service (e.g. support, repair)
- The correlation with existing (quality) standards and practical requirements (e.g. wireless, cleanable, robust, adaptable, modular, energy-saving, etc.)
- Attractive design

It is often much easier to convince seniors and their relatives to participate in the development process, because their personal gain is clear. The stakeholders mentioned in this section are much more difficult to recruit for interviews or group discussions. Some AAL projects have reported positive experiences with a combination of analysis methods, providing workshops or training courses on related issues that are relevant to these stakeholder groups (e.g. demographic change, requirements of senior consumers).

**KEEP IN MIND:** There are many more crucial decision makers in the field of AAL solutions than seniors and their relatives. In fact, stakeholders like real estate developers or insurance companies may be the ones who will decide about the market success (or access) of AAL solutions, even if it is user-friendly and beneficial for the primary users.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Conduct a stakeholder analysis at the beginning of your project within the business model development. Attract secondary and tertiary users with information or workshops to give them a personal reason to participate in the developmental process. Keep them informed about (and interested in) your project.

**WANT TO LEARN MORE?**

- Tools for stakeholder analysis and management: [www.mindtools.com](http://www.mindtools.com)
- Tutorials and information on stakeholder management at [www.tutorialspoint.com/management\\_concepts/stakeholder\\_management](http://www.tutorialspoint.com/management_concepts/stakeholder_management)

### 3 AAL SOLUTION REQUIREMENTS

The following sections provide information about users' expectations regarding Ambient Assisted Living (AAL) technology in general (Chapter 3.1), and regarding specific AAL components such as interfaces or sensors (Chapter 3.2). This information is intended as a basic guideline for AAL solutions design: What application scenarios do elderly end-users generally favour? What does an interface that is usable and intuitive for elderly or disabled users look like? When do people like a robot?

The following sections will address these and other questions. However, the presented information serves as a basic orientation and needs to be complemented with a thorough analysis of the context and target group of each AAL solution.

#### 3.1 DESIGNING AAL SOLUTIONS TO BENEFIT

AAL systems involve many different aspects such as mobility, safety, and social inclusion. One of the first tasks within AAL solutions development is to identify application scenarios or services that support the users in their daily lives. They represent the additional benefit of an AAL solution from the user's point of view.

Favourite AAL application scenarios of **primary end-users:**

- Saving energy/costs
- Enhancing comfort

- Improving health status
- Preventing hazards such as smoke damage /a fall/water damage detection
- Acting as an alarm (to prevent burglary)
- Supporting everyday activities, for instance, shopping, remembering appointments, housework
- Electronic devices switching off automatically, for instance, when users leave the house

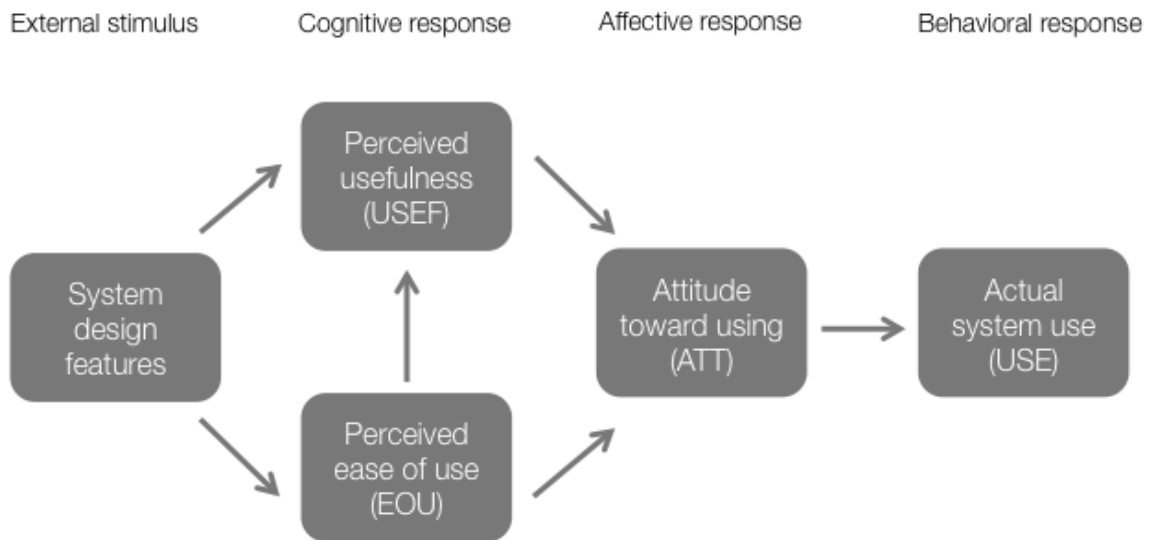
Favourite AAL application scenarios of **secondary users**:

- Monitoring the primary user's well-being
- Supporting communication with the primary user or other stakeholders
- Supporting demanding caregiving labour
- Supporting administrative activities (in the context of caregiving)

We recommend that AAL projects validate or complement these general needs with additional information regarding their specific system and specific user group. When defining potential use cases, keep in mind that user feedback will be more reliable if usage scenarios are presented in a lively and tangible manner (e.g. via > **Storyboards**).

As a rule of thumb, the technology acceptance model (TAM) introduced by Davis (1989) is a good basis to understand critical factors that promote or inhibit the purchase of an AAL solution. The model focuses on the cost-benefit considerations of the users and maintains that two particular constructs determine a user's acceptance of a technology: the perceived ease-of-use (EOU) ("Can the system be used effortlessly?") and perceived usefulness (USEF) ("Will the user profit from using the system?"). As shown in **Figure 13**, these factors are mostly influenced by the system's design, but also by individual user abilities, or by situational constraints. In the context of AAL solutions, the perceived usefulness is determined by the type and number of functions, whereas the ease-of-use refers to simple and intuitive design. Furthermore, Davis found that the influence of usefulness on actual use is about four times higher than the influence of ease-of-use. This means that helpful functions are even more important for AAL solution acceptance than the system's usability. In other words, if people see a clear benefit from using a given technology, they will be motivated to use it, even if they initially struggle to handle it.





**Figure 13:** Variables of the technology acceptance model (TAM) (according to Davis, 1993).

This rule also holds true when asking users about the usage of AAL solutions (see Meyer & Mollenkopf, 2010): An obvious added value is the most central aspect that can outweighs other disadvantages like bad usability.

Table 9 lists the usual arguments in favour of and against the purchase of an AAL solution from primary end-users’ perspective.

**Table 9:** Factors that promote or inhibit the purchase of an AAL system from the end-user perspective (derived from Meyer & Mollenkopf, 2010).

Factors for AAL solutions	1.1.1.2 Factors against AAL solutions
+ Enhanced quality of life and comfort	- Unclear personal benefit (e.g. compared to classical emergency systems)
+ Detection of an emergency	- Fear of stigmatisation
+ Enhanced security	- Disturbance of daily routine owing to the system
+ Enhanced autonomy and independence	- Fear of not being able to control or use the system
+ Improved contact with family/friends	- Possibility of (unwanted) surveillance, violation of privacy
+ Support in cases of helplessness	- Unclear follow-up costs
+ Living alone, having health problems	- Living with others, healthy

Turning these findings into design recommendations, including security or comfort functions (instead of only focusing on compensating for deficits) offers an opportunity to make AAL solutions more appealing to senior end-users (especially to healthy seniors living with others). Furthermore, it is important to ensure that application scenarios fit in the daily routines, otherwise they will not be used. End-users should also be provided with transparent information about financial costs and privacy aspects (e.g. the users should be able to disconnect the system). Finally, ambient and swift installation could also convince potential users of the advantages of an AAL solution to purchase it.

**KEEP IN MIND:** Perceived usefulness and good usability are the key elements of technology acceptance.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** AAL solutions should not only focus on compensating for impairments, but should also provide functions that improve comfort and allow an attractive lifestyle. Take the target group's possible fears or reservations into account when designing an AAL system.

**WANT TO LEARN MORE?**

- Flick (2012). Bedarfs- und Akzeptanzanalyse von AAL-Lösungen.
- Meyer & Mollenkopf (2010). AAL in der alternden Gesellschaft: Anforderungen, Akzeptanz und Perspektiven.
- Davis (1993). User Acceptance of information technology: system characteristics, user

## 3.2 AAL COMPONENTS

The following sections contain guidelines and general advice for the design of sensors, hardware, interfaces and robots. In addition to these guidelines, AAL projects should also consider the interoperability of individual components, since this is a critical premise regarding the more widespread use of AAL solutions (e.g., see the RAALI project<sup>22</sup>).

### 3.2.1 Sensors and data recording

Sensors (e.g. measuring motion or blood pressure) are often at the heart of AAL systems, since they monitor a user's well-being and detect critical situations that prompt the system to take action (e.g. detecting a fall prompts an emergency call). When installing sensors in people's homes, the following aspects should be considered (Flick, 2012):

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<sup>22</sup> [www.raali.de/en](http://www.raali.de/en)

**Type of sensors:** While motion sensors (e.g. PIR) or contact sensors (for doors etc.) are widely accepted among users, the usage of cameras or microphones is less favoured. If cameras or microphones need to be installed, placement is another critical aspect of acceptance (e.g. in the living room, but not in the bathroom). Regarding motion sensors, project teams should consider that seniors – especially those who live alone – might have pets at home that could interfere with a system’s detection.

**Installation of sensors:** Drilling holes in the wall or laying cables for connections are not a major obstacle for most users (but can be avoided by using wireless technology, e.g. from EnOcean or ZigBee). They usually find it more important that they can use a system in the place where they already live, since they are usually not willing to move to another home just to use AAL solutions. However, it is recommended that aesthetic aspects be considered, and that sensors be attached unobtrusively (in line with the idea of an ‘ambient’ system). Ensure that the implementing electricians share this notion if system installation is done by third parties rather than project members.

**Privacy:** Besides the normal ethical considerations regarding data management, many senior end-users would want to receive feedback on the collected data (e.g. in terms of an activity profile) or data retrieval (e.g. by their relatives). Data transfer to relatives must be checked with the target group, as some users would not accept this, while others would agree to the transfer of specific data (e.g. emergencies only rather than information on activity patterns). It has also been found that some seniors only want to use AAL solutions to share positive experiences with their relatives, while not disclosing problems or negative emotions.

**Accuracy:** The tolerance of an emergency system giving false alarms by senior end-users is less than 10 incidents per month (acceptance is especially low at night). If the choice was between longer recognition intervals and more false alarms, the preference is for longer time intervals. The validation of detected emergencies via telephone could be an accepted option to deal with this. However, seniors’ expectations of other detected events’ accuracy (e.g. motion-driven lighting) might differ and should be checked individually.

**KEEP IN MIND:** Users prefer the recording of data that does not allow others to draw inferences about them, thus protecting their privacy. Installing AAL solutions in familiar surroundings is preferred over relocating elsewhere.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Avoid using cameras or microphones (except for communication). Also discuss the tolerance of different system errors and take user preferences into account in the system design. Seniors should be given an opportunity to choose which data can be transferred to relatives (or others).

**WANT TO LEARN MORE?**

- Flick (2012). Bedarfs- und Akzeptanzanalyse von AAL-Lösungen.
- Becker (2007). Living conditions and everyday activities of the elderly and their requirements concerning ambient assisted living.

### 3.2.2 Hardware

When designing hardware for elderly users, AAL projects can rely on guidelines that define specific characteristics: There are general standards like those of Universal Design (see Section 2.2.3), but also very specific guidelines, for instance for the design of wheelchairs, alarm centres or smart housing. Here are general international guidelines that can be useful for AAL solutions development:

- ISO/IEC Technical Report – accessibility and usability of biometric systems
- ISO 9241 – a multipart standard with different standard series focussing on software, physical input devices and environmental factors
- ISO 28803 – the ergonomics of the physical environment; application of international standards for people with special requirements
- CEN/CENELEC Guide 6 – guidelines for standards developers to address the needs of older persons and persons with disabilities.

Figure 14 provides an example of how to translate such guidelines into design requirements, in this case of a wheeled walker for elderly users.

Requirements	low weight	comfortable seat	adjustable height	adjustable angle of handles	Exchangable handles	storage place for bags	Easy assembly of wheels	Easy folding for transport
Restrictions								
Vision							X	X
Tactile sense		X			X		X	X
Mobility	X		X	X	X			
Strength	X					X	X	X
Persistence	X	X				X		
Finger dexterity					X		X	X

**Figure 14:** Deduction of requirements for a wheeled walker based on the bodily restrictions of older age (translated from Stöber et al., 2010<sup>23</sup>).

<sup>23</sup> Stöber et al. (2010). Modularisierungsstrategie für Produkte für leistungseingeschränkte Personen.

From an ergonomic perspective, the following aspects should be taken into account in AAL hardware design:

- Low energy consumption
- Clearly visible on/off switch
- Sufficient size of hardware case for comfortable handling
- Sufficient size of controls for error-prone usage
- Easy to press/use controls
- No multiple use of controls
- No foreign language or specialist terms on the control labels
- Readable labels, even in bad lighting
- Recognisable and familiar signs and symbols on controls
- Careful arrangement of controls to eliminate confusion or unwanted operation of associated elements
- Adjustable multimodal feedback
- Easy-to-clean case / device
- Attractive design

Another important aspect (e.g. for field trials) is an understandable manual that concisely describes the most important functions, with text and/or figures that are easy to understand. In terms of the market launch of an AAL product, it is also important to have user-friendly packaging that is easy to open without the help of additional tools.

**KEEP IN MIND:** A senior-friendly design does not only refer to displays or interfaces. Other hardware elements also need to be designed to meet the users' needs.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Make sure that your target groups understand the hardware features and that they can easily use them. If necessary, identify more critical aspects that relate to your specific AAL solution.

**WANT TO LEARN MORE?**

- Publications at [www.tiresias.org/research/guidelines](http://www.tiresias.org/research/guidelines)
- Publications by the ICT standards board: [www.ictsb.org/activities/Design\\_for\\_All](http://www.ictsb.org/activities/Design_for_All)
- Greil, Scheffler & Voigt (2007). Optimierung der ergonomischen Eigenschaften für ältere Arbeitnehmerinnen und Arbeitnehmer – Anthropometrie (Abschlussbericht).

### 3.2.3 Interfaces

Besides larger buttons, many other adaptations can help elderly people use an interface. For instance, the seven dialogue principles defined in the ISO standard 9241-110 are a good starting point to consider different aspects of how to make interactive software systems user friendly:

- 1) **Suitability for the task.** A dialogue supports suitability for the task if it supports the user in the effective and efficient completion of the task. The dialogue only presents information that is related to the user’s task.
- 2) **Self-descriptiveness.** A dialogue supports self-descriptiveness if each dialogue step is immediately comprehensible through feedback from the system, or is explained to the user upon request.
- 3) **Controllability.** A dialogue supports controllability if the user is able to maintain direction throughout the interaction until the goal is met.
- 4) **Conformity with user expectations.** A dialogue conforms with user expectations if it corresponds to the user’s task knowledge, education, experience and to commonly held conventions.
- 5) **Error tolerance.** A dialogue supports error tolerance if, despite evident errors in the input, the intended results can be achieved with no or minimal corrective action. Errors should be explained to the user for him or her to correct them.
- 6) **Suitability for individualisation.** A dialogue supports suitability for individualisation if the dialogue system is constructed to allow for modification to the user’s individual needs and skills for a given task.
- 7) **Suitability for learning.** A dialogue supports suitability for learning if it guides the user through the learning stages, minimising the learning time.

Since these requirements are meant to be suitable for every possible interface, they are kept on a general level. It is up to developers to define the meaning of these principles in a given application. Table 10 provides an overview of more definite design recommendations, derived from several accessibility guidelines (e.g. Pak & McLaughlin, 2011).

**Table 10:** Design guidelines for interfaces for elderly users.

Supported dimension	Recommendation
Vision	<ul style="list-style-type: none"> <li>▪ Offer an adaptable display size with a minimum font of 12 to 14 point</li> <li>▪ Maintain a high contrast between the background and text or buttons (avoid green-blue contrasts)</li> <li>▪ Do not use colour as the only distinction variable; alternative grouping strategies include the organisation, size, volume and texture</li> <li>▪ Avoid background images, since they create visual clutter</li> </ul>
Hearing	<ul style="list-style-type: none"> <li>▪ Use low-range to mid-range frequencies and pulses of sound rather than sustained frequencies</li> <li>▪ Consider the loudness levels of potential background noise</li> <li>▪ Consider interactions with hearing aids</li> <li>▪ Avoid computer-generated voices</li> <li>▪ Use natural speech rhythm, stress and intonation</li> </ul>

Supported dimension	Recommendation
Mobility	<ul style="list-style-type: none"> <li>▪ Allow sufficient time for inputs</li> <li>▪ Keep motoric input for users with motor control problems to a minimum</li> <li>▪ Offer auditory, visual or sensory feedback to confirm a motoric input</li> <li>▪ Reduce the number of targets/buttons, increase their size and have sufficient space between them</li> <li>▪ Use static menus instead of dropdowns</li> </ul>
Cognition	<ul style="list-style-type: none"> <li>▪ Provide task-relevant information only</li> <li>▪ Present information in small, screen-sized chunks</li> <li>▪ Do not provide parallel information at the same time (e.g. video and text)</li> <li>▪ Indicate the user’s current position within the information space and task</li> <li>▪ Lessen the burden on users’ working memory (e.g. by marking visited sites, or by presenting all available functions instead of using hidden dropdown menus)</li> <li>▪ Use common metaphors (such as symbols of ‘folders’) that are intuitive and known from real life</li> </ul>

Besides age-related impairments, a design must also consider that most elderly users are novices regarding modern technological devices. Compliance with accessibility guidelines does not necessarily guarantee that elderly people can in fact use the interface. It is important to understand the user’s goals and mental models and to test a design with a user sample from the target population.

**KEEP IN MIND:** Make sure that AAL interfaces incorporate accessibility guidelines to consider elderly users’ typical age-related characteristics.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** Since guidelines might contradict each other and user expectations are not always known beforehand, make sure that you test your interface with a small sample before using it on a larger scale.

**WANT TO LEARN MORE?**

- Pak & McLaughlin (2011). Designing displays for older adults.
- International Organization for Standardization (2011). DIN EN ISO 9241-110.
- Bailey (2005). Age-related research-based usability guidelines



### 3.2.4 Robots

Service robot design is highly dependent on the tasks the robot has to fulfil: manipulating objects (arms), moving around (wheels, orientation) and communicating (listening, understanding, talking) all have different technical requirements. Mutlu (2006<sup>24</sup>) defines the nature of human-robot interaction according to the following three dimensions:

- Robot attributes (e.g. appearance, personality)
- User's personal factors (e.g. age, gender, mental models)
- Performed interaction task (e.g. measuring blood pressure, serving drinks).

Therefore, providing general recommendations on robot design has no real purpose. However, it is important that robot developers consider not only the technical parameters when creating a robot, but also the human perspective: How does the user perceive the robot's appearance and behaviour in a given situation? For instance, instead of using a path or speed that is technically optimal, it might be better to slow a robot's movements down to a level with which people are comfortable, thus enhancing predictability and safety. Developers should therefore always check the impression that their robot (or avatars) evokes in its users with, for instance, Bartneck et al.'s (2009) standardised questionnaire.

One major issue that needs close attention is the robot's anthropomorphism. According to the *uncanny valley*<sup>25</sup> theory, a robot becomes more likeable if its appearance and movements are more human-like, but only to a certain level. Beyond this level, human-like robots trigger repulsion and eeriness.

Furthermore, it is important to match a robot's appearance with its abilities. For instance, an anthropomorphic (human-like) appearance may mean that the users expect actions that the robot cannot technically fulfil (e.g. listening and talking), even though it has a human face.

These issues should be considered when designing robots and should depend on the target group and usage scenario:

- **Anthropomorphism:** make a robot not too human-like, and consistent with its abilities
- **Size:** test a comfortable for users, which depends on its tasks and the user's position (e.g. sitting vs. standing)
- **Speech:** use human voices instead of artificial speech
- **Emotions:** make the robot fun to use, but be careful not to evoke unrealistic expectations about its abilities

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<sup>24</sup> Mutlu, Osman, Forlizzi, Hodgins & Kiesler (2006). Task structure and user attributes as elements of human-robot interaction design.

<sup>25</sup> Mori (1970). Bukimi no tani (The Uncanny Valley).

- **Personality:** ought to match the user's personality; a serious personality enhances user compliance<sup>26</sup>
- **Timing:** ensure perfect timing, especially regarding communication and reaction times to user instructions
- **Safety:** prevent unwanted contact or collisions
- **Autonomy:** provide a robot if it is designed to help in critical situations, or help with proactive social behaviour; other actions (e.g. dispensing medication) should be left to people (e.g. a doctor).

Ethical considerations regarding human-robot interaction have been discussed (e.g. Turkle, 2007<sup>27</sup>), but have not yet been established – besides Asimov's classical robot laws<sup>28</sup>. Developers are encouraged to discuss the potential social implications of using robots in people's private homes with user groups: What happens when a robot breaks down, or is removed? Is the relationship between human and robot intended to be one of master and slave? Could a robot patronise the person for whom it is supposed to care? All of these issues should be considered when designing robots within AAL solutions.

**KEEP IN MIND:** Robot design depends on the robot's functions, i.e. the tasks it has to perform, and on the target group. Safety is a major concern whenever humans interact directly with robots.

**CONCLUSIONS REGARDING AAL DEVELOPMENT:** General recommendations cannot be made. Make sure to consider all aspects that are crucial in a given scenario.

#### WANT TO LEARN MORE?

- European Commission (2012): Special Eurobarometer 382: Public Attitudes Towards Robots
- Bartneck et al. (2009). Measurement Instruments for the Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety of Robots.
- Wada, Shibata, Saito, Sakamoto & Tanie (2005). Psychological and social effects of one year robot assisted activity on elderly people at a health service facility for the aged.

<sup>26</sup> Kiesler & Goetz (2002). Mental models and cooperation with robotic assistants.

<sup>27</sup> Turkle (2007). Authenticity in the age of digital companions.

<sup>28</sup> (1) A robot may not injure a human being or, through inaction, allow a human being to come to harm.

(2) A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.

(3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

## 4 SUMMARY

This knowledge base document has been designed to support a human-centred design process for successful AAL solutions development. With its information on different user groups, from seniors to caregivers, from people with dementia to service providers, it provides key insights into the needs, fears and decision drivers of different AAL stakeholders. With its design principles for sensors, hardware, graphical user interfaces and robots, it provides a hands-on guide to make technology more user friendly.

As we have stated throughout, we trust that this knowledge base helps accelerate the AAL solutions design process by providing sound knowledge. However, the knowledge in this document is not meant to be complete, and we encourage all researchers and developers to investigate which additional information is necessary to build a human-centred AAL solution. This can mean complementary primary or secondary research, as this document does not provide specific information for each target group in all regional settings – which will change over time. To help with this additional research, this document lists several sources of further information on statistics, user requirements and design principles.

We trust that you have gained insights into stakeholder needs for AAL solutions and will have even more fun with and success in your AAL solutions development.

## USEFUL LINKS

AAL solutions developers are encouraged to research additional data regarding their target user groups, for instance via one of the following links:

- **[www.epp.eurostat.ec.europa.eu](http://www.epp.eurostat.ec.europa.eu)** - website of the European Commission; provides statistics and publications on many different AAL-related topics for European countries (English, German, French).
- **[www.jpi-dataproject.eu](http://www.jpi-dataproject.eu)** - Data Mapping Project of the Joint Programme Initiative *More years, better lives – The challenges and opportunities of demographic change*. Collection of data sources on aging at the European and national levels (English).
- **[www.share-project.org](http://www.share-project.org)** - Survey of Health, Ageing and Retirement in Europe; a cross-national panel database on health, socio-economic status, and social and family networks of the 50+ generation in 19 European countries (English).
- **[www.knowledge.allianz.com](http://www.knowledge.allianz.com)** - Allianz portal with news and surveys on demography, mobility, finance and environment (English).
- **[www.oecd.org](http://www.oecd.org)** - statistics and publications of the Organisation for Economic Co-operation and Development (English, French).
- **[www.accessforall.eu](http://www.accessforall.eu)** - European website dealing with the inclusion of people with disabilities, providing news, project descriptions and field experts' contact information.
- **[www.carersuk.org](http://www.carersuk.org)** - advice and support for caregivers(UK); similar websites exist for other countries.