AALIANCE2

European Next Generation
Ambient Assisted Living
Innovation Alliance

Ambient Assisted Living Roadmap

September 2014

AALIANCE2 is a Coordination Action funded by the European Programme FP7-ICT-2011.5.4 ICT for Ageing and Wellbeing (Project ref.: 288705)

For information: http://www.aaliance2.eu/

Ambient Assisted Living Roadmap

September 2014

AALIANCE2 Project – Deliverable 2.7

AALIANCE2 – European Next Generation of Ambient Assisted Living Innovation Alliance

The AALIANCE2 Project is a Coordination Action funded by the European Programme FP7-ICT-2011.5.4 and aims to further develop the AALIANCE2 roadmap and strategic research agenda for AAL technologies, investigate the AAL market and develop a specific cost/profit models and business models for the implementation of Ambient Assisted Living solutions, address standardisation issues in Europe and worldwide as well as initiate corresponding standardisation activities, and enhancing the sustainable network of AALIANCE, involving the major actors (technology and service providers vendors and user groups) from European Member States.

The term Ambient Assisted Living (AAL) defines services and products based on advanced ICT technologies for ageing and wellbeing of older persons in Europe.

AALIANCE2 has been built upon the successful work and the wide network already established in the AALIANCE Network (2008-2010). The main objectives of the AALIANCE2 Project were:

- transforming the existing AALIANCE Community in a long-term sustainable network
  - to create the central entity for all AAL-related issues and stakeholder in Europe,
  - to form an European Technology Platform focusing not solely on technology but on integrated solutions for a societal challenge,
  - to provide a central node for global interaction;
- finding solutions for major challenges in AAL which consist of:
  - coordinating the various activities of European industry and research institutions in the field of Ambient Assisted Living by building consensus upon research priorities in a AAL roadmap and Strategic Research Agenda for the upcoming decades,
  - standardisation requirements in the field of ICT and Wellbeing (including care and healthcare standards),
  - providing recommendations for an overcoming market barriers and effective regulations in AAL markets,
  - investigating the current state-of-the-art and market developments in AAL in North America and Asia;
- supporting the implementation of coherent strategies of the public and private sector.

The AALIANCE2 AAL Roadmap and Strategic Research Agenda 2014 describe the main social, service and technological issues, challenges and recommendations which could favour the success of Ambient Assisted Living (AAL) solutions in the society.

This document, related to the deliverable D2.7 of the project, was developed by the AALIANCE2 Consortium with the contribution of many experts joining the AALIANCE Network.

AALIANCE2 Consortium

Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna - *coordinator* -

OFFIS EV Institute for Information Technology

TUNSTALL Healthcare Ltd

Deutsche Telekom AG

Fundatión Tecnalia Research & Innovation

AGE Platform Europe

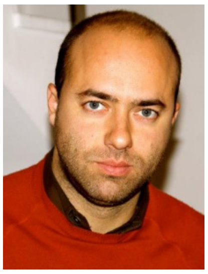
VanMorgen

ZuidZorg

Foreword

The current demographic statistics and projections for Europe indicate that the increase of life expectancy and the reduction in births are increasing the percentage of the population 65+ and inevitably impacting the social and economic balance of society. Indeed, the longer life expectancy combined with the higher risk in old age to become ill or to have a disability, could mean an increasing number of people who rely on care, and consequent higher cost of health and social care. Ambient Assisted Living (AAL) technologies can play a major role in order to re-think new models of integrated care organisation that may contribute to the ecomical and societal sustainability of health and care systems. In the close future, accelerating progress in sensing, artificial intelligence, robotics, human-machine interface and communication technologies will significantly extend the possibility to augment the human physical and cognitive capabilities of elderly persons and carers. Furthermore, if these technologies are designed closely oriented to the needs of patients and older persons, they are the basis for providing services and systems that may help to improve quality of life, stay healthier, live independently, and manage any reduced capabilities related to the ageing with a proactive and patient-centred approach. The AALIANCE2 Consortium has investigated these issues and proposes a useful instrument – the Ambient Assisted Living Roadmap and Strategic Research Agenda – to promote for all relevant stakeholders a common and strategic vision to ensure appropriate investments and successful deployments in the AAL market. In addition to exploit these documents to have an impact on the challenges and opportunities offered by demographic changes using AAL technologies, it is important that the AALIANCE Network actively continues to keep this analysis and recommendations updated in the next years by working very close to all stakeholders and to the European Community.

Prof. Paolo Dario
Director
The BioRobotics Institute
Scuola Superiore Sant'Anna
Pisa, Italy



Dr. Filippo Cavallo
The BioRobotics Institute
Scuola Superiore Sant'Anna
Pisa, Italy

Executive summary

The Deliverable D2.7 reports the final result of the work carried out by the AALIANCE2 Consortium and the AALIANCE Network of AAL experts in the WP2 context. In particular this document represents the updated and final version of the AALIANCE2 AAL Roadmap 2014. During the preparation of D2.7, a consistent participation of different AAL stakeholders, coming from the AALIANCE2 Network in Europe and Asia, ensured that the social, service and technological contents truly represent a global view of AAL stakeholders and also provides reliable recommendations useful for AAL future.

The AALIANCE2 AAL Roadmap 2014 introduces several changes respect to the AALIANCE AAL Roadmap 2010. It goes beyond the previous AAL application domains (AAL for Persons, AAL in the Community and AAL at work) and describes three main service areas, called Prevention, Compensation and Support, and Independent and Active Ageing, and ten AAL service scenarios more appropriate to the current social, economic and political challenges and objectives of our countries. For these AAL service areas, precise stakeholders' needs and the relative technological gaps have been identified and shared with the AAL community through different dissemination and workshop activities.
Furthermore other aspects, important for the implementation of AAL services and technologies inside the society, are faced, and in particular ethics, acceptability of technology, optimal service design, analysis of AAL market, standardisation, certification and interoperability of AAL tools, dependability and green sustainability.

This document is composed of nine main sections. The first part introduces the current and future situation of the ageing population in Europe and of its social and economic implications for the society, the concept of Ambient Assisted Living and finally the objectives of the AALIANCE2 Project (Chapter 1). Then it follows the description of the methodologies and activities carried out during the project to develop these AAL Roadmap and Strategic Research Agenda (Chapter 2). The third part of this docyument is an overview of the main needs and requirements of the AAL stakeholders (Chapter 3). The fourth section reports the main results of the studies about the current status of the AAL Market and its furute perspectives carried out in the WP3 of this project (Chapter 4). The fiveth part describes the three general AAL service areas and the main service scenarios identified during the project (Chapter 5). The sixth section depicts the main Key Enabling Technologies (KETs), i. e. Sensing, Reasoning, Acting, Interacting and Communicating, and their research priorities in short, mid and long term perspective (Chapter 6). The seventh part describes briefly the main issues related to the implementation of AAL (Chapter 7). The eighth section reports the main recommendations for AAL stakeholders suggested by the members of the AALIANCE Network (Chapter 8). Finally the nineth part depicts briefly the conclusions related to this work (Chapter 9). Furthermore the Appendix reports a concrete case of optimal designing of AAL service.

Table of Contents

1 Introduction

The current demographic statistics and projections for Europe indicate that increasing life expectancy and the reduction in births are increasing the percentage of the population aged 65 and older (Figure 1) (Eurostat, 2013 a). This trend will inevitably impact the social and economic balance of society. Further analysis of the current and projected values of the old age dependency ratio[1], undertaken by Eurostat (Eurostat, 2013 a), highlighted that in Europe the ratio between persons aged 65 and older and persons in the working ages (15-64) will pass from 26.8% in 2012 to 52.6% in 2060 (Figure 2) (Eurostat, 2013 a).

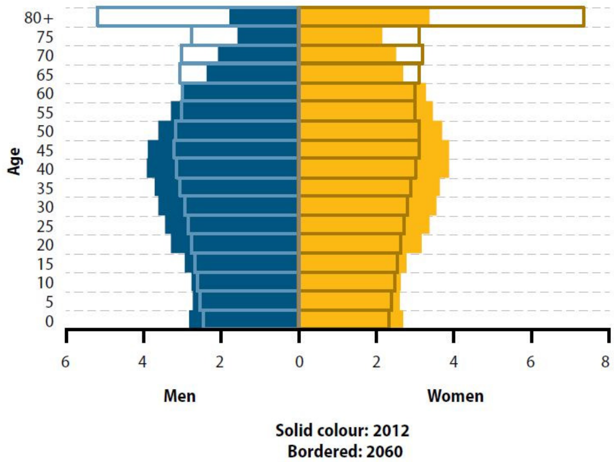


Figure 1. Population pyramid, EU-27, 2012 and 2060, percentage (%) (2012: observed population; 2060: data are projections) (Eurostat, 2013 a)

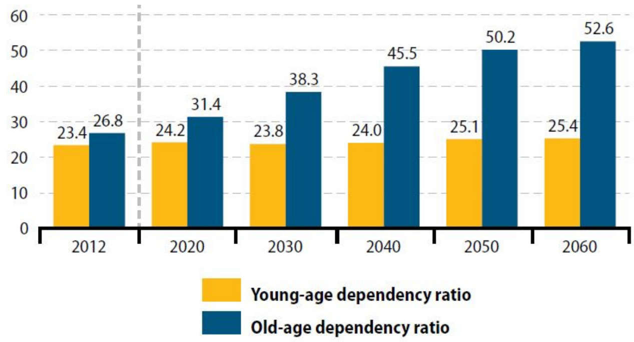


Figure 2. Projection of young– and old age–dependency ratios1, EU-27, 2012-2060, percentage (%) (2012: observed population; 2060: data are projections) (Eurostat, 2013 a)

An increase in life expectancy is a positive indicator of societal development, achieved in part by improved healthcare, nutrition, more diffused wealth, and useful technological innovations. Longer lives, lower birth rates, and the resultant increase in the proportion of older people will inevitably result in significant changes in society.

[1]The old age dependency ratio is:
"the ratio between the total number of elderly persons of an age when they are generally economically inactive (aged 65 and over) and the number of persons of working age (from 15 to 64)" (http://epp.eurostat.ec.europa.eu/tgm/web/table/description.jsp).
Similarly, the young-age-dependency ratio:
"is the ratio of the number of young people at an age when they are generally economically inactive, (i.e. under 15 years of age), compared to the number of people of working age (i.e. 15-64)" (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Young-age-dependency_ratio).

The imperative to determine how to ensure that longer lives will also mean an increase in the number of healthy years (or disability-free life expectancy)[2] is now unavoidable. An increase of life expectancy combined with the higher risk in old age to become ill or to have a disability could mean an increasing number of people who rely on care and help for their daily lives. This is already resulting in an increase of the cost of health and social care in most developed countries and thus drives the objective of finding ways to lower the need for care. So it is important to find solutions that help people to stay healthy and independent, to enjoy their life, and to continue to feel part of society. It is also important to recognise that this will only be achieved by supporting formal and informal caregivers, including family and the wider community.

For this reason, planning actions and policies to look for innovative solutions that would extend the number of healthy life years but that would also guarantee that older persons receive care and help in their daily life and enable them to live in dignity, are of interest to every citizen, young and old.

The financial crisis is an additional challenge for Europe. Together with fiscal consolidation measures, the European Union (EU) and the member states seek to find common pathways to ensure financial sustainability whilst reforming current social and healthcare systems to better address its citizens' changing needs. Member states are increasingly looking for cost-efficient and innovative solutions to tackle both financial and demographic challenges.

Over recent decades, the European Commission has supported several research programmes (e. g.. the FP6 Programme, the FP7 Programme, the AAL Joint Programme (AAL JP) and the upcoming Horizon 2020 Programme for Research and Innovation) that have financed and are continuing to finance international studies and research studies that investigate new ways of tackling these challenges in the healthcare and long-term care sectors by the development of new policies, services, and technologies.

Most recently, the European Commission has promoted the idea that Information Communications Technology (ICT) devices can be used by older persons, informal caregivers, and professional service providers, with the following benefits:

- improving the effectiveness and the efficiency of health and social care for older people;
- extending the independence and autonomy of older persons in need of care;
- improving the life style and conditions of older persons and consequently enhancing their health and Quality of Life (QoL);
- fostering and increasing the active participation of older persons in their communities;
- lengthening the ability of senior people to contribute to the society working in remunerated and voluntary activities;
- helping caregivers and service providers to monitor users, optimising their time and tasks and reducing their care burden;
- reducing the costs to society of early institutionalisation of older persons due to deterioration of their health or to their inability to live independently.

The Ambient Assisted Living (AAL) Joint Programme (AAL-JP) was set up in 2008 by the European Commission to promote common research activities between member states and to encourage actions that could use ICT solutions to improve European older persons' QoL and to increase their years of healthy living (AAL - Ambient Assisted Living, 2012).

Since 2008, the AAL-JP has funded more than one hundred AAL studies related to six topics:

1. ICT-based solutions for the prevention and management of chronic conditions of elderly people
2. ICT-based solutions for the advancement of social interaction of elderly people
3. ICT-based solutions for advancement of older persons' independence and participation in the "self-serve society"

[2] years when people will live autonomously without relying heavily on support and help for their daily lives

4. ICT-based solutions for advancement of older persons' mobility
5. ICT-based solutions for (self-) management of daily life activities of older adults at home
6. ICT-based solutions for life occupations.

Several of these topics and other projects funded by different programmes have achieved promising results. A notable example is the CIP-PSP project "ReAAL"[3], which currently is trying to equip 7,000 apartments across Europe with common ICT infrastructures. However, most of the AAL research studies have only been carried out and tested on a small scale so their usability in real socio-medical care contexts is still relatively far away.

The deployment of the AAL technology is mainly impeded by:

- the limitations of ICT technology not optimized for use in AAL services;
- the lack of extensive trials of AAL services in accordance with the current European and national laws and care systems;
- a shortage of sustainable business models, support policies, certifications, and standards suited for the introduction of AAL services and technologies in real care contexts and the market;
- a lack of user involvement in research and AAL market deployment.

Against this background, the European Commission funded the AALIANCE2 Project, a coordination action with the goal of analysing these barriers and identifying possible solutions to encourage the use and deployment of AAL systems. One of the main objectives of the AALIANCE2 Project is the definition of a Roadmap and Strategic Research Agenda (SRA) of AAL technologies and services. These documents describe the main AAL service scenarios and key enabling technologies (KETs) needed in the future (2014 to 2035).

[3] http://www.cip-reaal.eu/

2 Methodology

The study for the Roadmap and SRA definition was carried out by the AALIANCE2 Consortium in collaboration with many experts coming from several branches of the AAL field.

From the conceptual poit of view, a top-down methodology was adopted (Figure 3):

Phase 1: Analysis of needs and requirements of all AAL stakeholders

For identifying the next AAL technological and service challenges it is necessary before to clarify which are the necessities, requirements and issues of all AAL stakeholders, from older persons to governments.

Phase 2: Identification of the main AAL service areas and AAL service scenarios.

After having defined which are the main problems and needs of all AAL actors, it was studied which are the main service areas related to AAL field, which could contribute to satisfy the society's needs and consequently the key service scenarios, potentially able to improve the quality of life of older persons and the caregivers' work, were defined and described.

Phase 3: Definition of the main Key Enabling Technologies (KETs), necessary for AAL service scenarios identified in Phase 2.

At this point, the main technologies were identified and briefly described. These technological components were grouped in five main areas: Sensing, Acting, Reasoning, Interacting, Communicating.

Figure 3. Scheme of the methodology adopted in AALIANCE2 for the development of the AAL Roadmap and Strategic Research Agenda (SRA)

In parallel to this work, the main general issues for the implementation of AAL services and solutions were analysised and discussed because, if these aspects are disregarded, they could become barriers for the exploitation and the real deployment of these solutions inside the society. The key thematics discussed were the ethical and legal problems related to these AAL systems, the currect design methodologies of services and technologies, the standardisation and certification, the AAL market, the dependability of AAL technologies and the green and sustainable technologies.

Finally, from all contents developed till this point, the main recommendations for all AAL stakeholders were reported.

From a concrete point of view, these Roadmap and SRA were developed carrying out the following activities:

- Analysis of the AAL Roadmap and the SRA developed in 2010 by the AALIANCE project (Van Den Broek et al., 2010) and the results of other important projects of this field, such as BRAID (BRAID Project) (Camarinha-Matos & Rosas, 2011) and Technolage (Cenderello, et al., 2013).
- Five workshops organised on themes specific for the development of the Roadmap and SRA and involving experts and representatives of the AAL stakeholders

(exponents of elderly associations, service providers, scientists and reseachers, industries and SMEs, policy makers, etc.).

- Internal workshops and brainstorming with the members of the AALIANCE2 Consortium.
- Surveys and interviews carried out at three events of this sector, the AAL Forum 2013 (Norrköping, Sweden), the ForItAAL 2013 (Ancona, Italy) and the ICT 2013 (Vilnius, Lithuania).
- Online surveys published both on the web platform SurveyMoncky Inc. (https://www.surveymonkey.com/s/RJ5KDDZ) and on the section 'Experts' of the AALIANCE2 website (http://www.aaliance2.eu/private).

Thanks to these activities, the AALIANCE2 Consortium had the possibility to involve in the project more than 200 AAL experts. The Table 1 shows the detailes of the participation to the organised events.

Table 1 Deleils of the activities organised to involve AAL experts in the development of the AALIANCE2 Roadmap and SRA ('S1' = Primary Stakeholders, 'S2' = Secondary Stakeholders, 'S3u' = Tertiary Stakeholders (universities, research centres, etc.), 'S3i' = Tertiary Stakeholders (industries, SMEs,etc.), 'S4' = Quaternary Stakeholders, 'A' = anonymous experts*)*

ACTIVITY	EFFORTS							CONTRIBUTIONS
	S1	*S2*	*S3u*	*S3i*	*S4*	*A*	**TOT**	
Workshop 1 Pontedera, IT 14/02/2012	3	4	12	7	1	-	**27**	RM1 Needs, Services
Workshop 2 Eindhoven, NL 27/09/2012	2	4	15	10	0	-	**31**	RM1 KETs
Workshop 3 Osaka, JP 05/07/2013	1	0	14	4	2	-	**21**	SRA1 Services, KETs
Workshop 3bis Stanford, CA, US 18/03/2014	0	3	12	8	0	-	**23**	SRA2 Needs, services, KETs, recomemndations
Workshop 4 Norrköping, SE 24/09/2013	1	2	14	5	0	-	**22**	RM2 and SRA2 Services, KETs, recomemndations
Direct surveys AAL Forum 2013 Norrköping, SE 25-26/09/2013	1	15	37	15	12	-	**80**	RM2 & SRA2 Needs, recommendations
Direct surveys ForItAAL 2013 Ancona, IT 23-25/10/2013	0	8	11	2	1	-	**22**	RM2 & SRA2 Needs, recommendations
Direct surveys ICT 2013 Vilnius, LT 06-08/11/2013	0	1	32	9	1	-	**43**	RM2 & SRA2 Needs, recommendations
Online survey @surveymoncky.com	5	4	8	4	4	18	**43**	RM2 & SRA2 – needs, recommendations
Online survey @AALIANCE2 website	-	-	-	3		-		RM2 & SRA2 – needs, recommendations
TOTAL	**13**	**41**	**155**	**64**	**21**	**18**	**312**	

This document is part of Deliverable D2.7 of AALIANCE2 Project, which represents the final version of the AAL Roadmap. The following chapters describe the main results obtained from the WP2 activities and suggest some key enabling technologies for AAL's development.

3 Needs and expectations in the ageing society

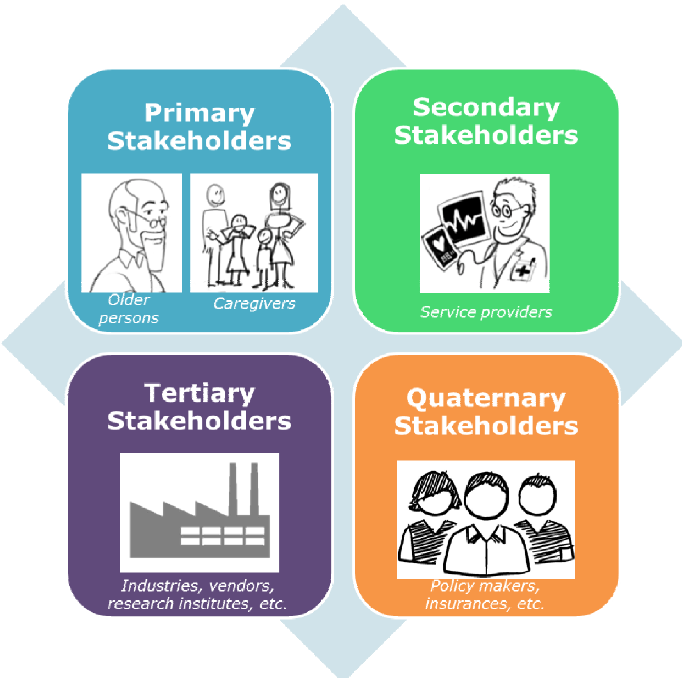
The field of AAL is really wide and complex and is characterized by various trends. These trends were identified and analyzed by means of a substantial interaction with the most important AAL stakeholders that suggested and highlighted the crucial societal drivers that are at the root of the AAL market.

As stated in the AAL Roadmap developed in 2010 by the AALIANCE project, it is essential to analyse all stakeholders' needs and requirements to design services and technological solutions that will effectively promote and support the idea of "ageing well" (Van Den Broek et al., 2010). Therefore during the AALIANCE2 project, a preliminary study was carried out to identify the needs of the AAL stakeholders and of the society. The main groups of AAL stakeholders identified were:

- Primary stakeholders, which includes elderly users and their informal caregivers (i.e. older persons and their families);
- Secondary stakeholders, which includes organisations offering services (i.e. service providers);
- Tertiary stakeholders, which includes organisations supplying goods and services (i.e. industries producing AAL technologies);
- Quaternary stakeholders, which includes organisations analysing the economic and legal context of AAL (i.e. policy makers, insurance companies, etc.).

Particularly, primary, secondary and quaternary stakeholders were involved to analyze societal needs, expectations and trends, while terziary stakeholders provided more information for market and technology aspects.

The results of this study are described in the following sections. It is important to clarify that the following considerations are not exhaustive because ageing is a very complex issue. Needs and expectations may also evolve with time and change as different generations. The following sections are aimed at giving an overview of the different perspectives of the primary, secondary and quaternary stakeholders, whereas the Chapter 4 reports the analysis of the current issues and the future challenges of the tertiary stakeholders.



3.1 Primary Stakeholders: Older Persons and Informal Caregivers

Older persons and informal caregivers are the primary stakeholders in the AAL field. As shown in Chapter 1, a growing number of European citizens are over 60 years old, so their needs are becoming increasingly important for society. The primary needs of senior people are to maintain, as long as possible, an adequate QoL, to be active, to participate in community life, and to retain control over their own lives even when they need care and assistance. However, ageing increases susceptibility to disease and infection as well as the consequent frailties and disabilities. This means that older persons, especially those who are 85 and older, increasingly need help in their daily lives, support provided by formal care services, and also support by informal caregivers. Some studies (Hoffmann & Rodrigues, 2010) have highlighted that informal caregivers deliver around 80% of all care activities in the EU, so their role in society is fundamental.

Because of the different ages, roles, generations, and personal dispositions, older persons and informal caregivers have complex and diverse necessities, which are, however, often underrated and ignored. Getting to know the needs of this group is, therefore, key to making sure that future solutions are adequate for their target users. For this reason, it is important to conceive future AAL solutions starting from a clear view of the primary stakeholders' features and needs.

Older Persons

Ageing causes a physiological decrease of motor, sensory, and cognitive abilities. Older persons have a higher risk than the average population of suffering from chronic diseases, meaning their independence may be reduced. However, older persons in need of care should also have the opportunity to enjoy life and to contribute to the society's welfare. The main benefits of AAL regarding their needs can be listed as follows:

- *Enabling older people to contribute to society as long as possible in their families, in voluntary associations, or in companies and public utilities*
  The current demographic and economic contexts are encouraging the society to change the work structure and to delay retirement (European Commission et al., 2011). Today most persons older than 60 are healthy and active, but they often cannot continue to work, even if they want to. Enabling them to continue to work would help to mitigate the impact of the crisis and of demographic trends. The European Commission has set up a yearly cycle of economic policy coordination, called the European Semester[4], to promote reforms that extend working lives and that ensure their overall financial sustainability in the EU. However, beyond the legal authorisation to work longer, policy makers should also promote and encourage preventive actions in favour of the ageing workforce for preserving their workers' health, maintaining their work abilities, and delaying their retirement (European Commission et al., 2011), including by transitional measures from work to retirement. Supporting measures should also enable older persons in retirement to be active in voluntary associations and in their families.
- *Reducing negative feelings like insecurity, vulnerability, loneliness, and depression*
  Older persons who live alone and/or who have had negative experiences (like accidents, falls) may strongly perceive their loneliness and vulnerability, so they are inclined to fear possible accidents and to have negative feelings. Loneliness may add to this condition and, in some cases, cause depression and a premature degeneration

[4] http://ec.europa.eu/europe2020/making-it-happen/index_en.htm

of both physical and cognitive health (Savikko, 2008). Beyond doing a great harm to the individual and to his or her family, this situation also means a potentially increased need of care.

- *Enabling social activity*
  Because of the extension of life expectancy (Eurostat, 2012), older persons live many years after their retirement in which they are healthy and potentially active. Most of them live as a couple or alone (Gasior, et al., 2012). With the decreasing of traditional social networks (family members being far away geographically, friends and older family members' deaths, etc.), senior people tend to have fewer possibilities of social contacts and active participation in community life. This situation underestimates senior citizens' value and damages the society. Promoting active ageing allows "people to realize their potential for physical, social, and mental well-being throughout the life course and to participate in society, while providing them with adequate protection, security and care when they need" (WHO, Ageing and life course). At the same time, active ageing is an important opportunity for society because healthy and active older citizens can continue to contribute to their communities' growth and welfare in terms of support to their children and grandchildren, voluntary work, consumption and purchases, work, etc. (European Commission et al., 2011).

- *Enabling their power to maintain an adequate purchasing power to satisfy primary needs*
  The current economic crisis is having different negative effects, especially among senior citizens. Eurostat studies (Eurostat, 2013 b) showed that in 2011 about 20.5% of the EU27 older population was at risk of poverty or social exclusion. Women were more at risk of poverty, generally having lower pensions. The decrease of purchasing power of older persons may consequently cause severe difficulties for them to access and to benefit from the healthcare system and long-term care services, which in turn also has a negative impact on their health and QoL (AGE Platform Europe, 2012). For this reason, AAL industries and policy makers need to organise new care and service systems in order to compensate for this economic weakness and to guarantee senior citizens' rights to be cared for and to live in dignity with an adequate QoL and health.

- *Reducing the risk of accidents, like falls and burns*
  Older persons, and especially those aged 75 and older, are more at risk for having accidents and, in particular, falls. This is due to many reasons, including physical weakness or to the effects of polypharmacy. These events can induce a temporary inability and may require a longer recovery time than younger persons need (WHO, 2007), (Braubach & Power, 2011). For this reason, older persons require some preventive actions, e.g. to improve the safety of their domestic environment, to carry out physical exercises, to maintain good motor abilities and balance, and to limit polypharmacy.

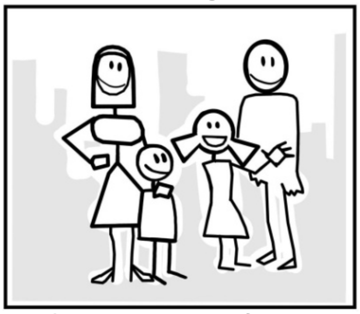
- *Properly managing multiple and chronic diseases at home*
  Most of older persons would prefer to be cared for at home or in an environment they choose to live in. When affected by one or several chronic diseases, they may require the frequent taking of different drugs, the performance of specific therapies, the periodic monitoring of health parameters, and the adoption of a specific and healthy lifestyle habits. These care procedures are often complex and can induce mental confusion in senior patients, a condition that can cause dangerous and sometimes lethal mistakes. Besides better managing the effects of polypharmacy among older persons, caregivers need to support and help in monitoring their treatment in these areas (Rechel et al., 2009), (AGE Platform Europe et al., 2010).

- *In rural areas especially, gaining access to services and limiting isolation*
  Most European citizens live in urban areas (Eurostat, 2010), and services are more concentrated in these areas, to the detriment of persons living in rural areas. Ageing populations in rural areas and the lack of access to community services is a

challenge (European Citizens' Panel, 2007). For this reason, senior people living in rural areas who cannot easily move outside their homes are highly at risk of isolation. In these situations, older persons rely a lot on the help of family and friends and also on some voluntary work and local services organized by the individual community, when they are available. However these forms of support are not always available, and some older persons are completely socially isolated.

- *Avoiding maltreatments*
  A study of the World Health Organization (WHO) highlighted that annually in Europe, about 4 million elderly older people are subject to maltreatments and abuses that often cause premature death (WHO – Regional Office for Europe, 2011). There are several forms of abuse: physical, psychological, financial, sexual, and medical abuse. Neglect is also a form of abuse. Persons with dementia and living with their caregiver are particularly at risk. Unfortunately in our communities, this problem receives little attention, with a consequent shortage of preventive and protective measures to protect older persons from abuse. Improving the monitoring of the physical and psychological wellness of elderly people and increasing the contacts with socio-medical experts could facilitate the early detection of these maltreatments and the adoption of the right strategies to solve the problems provoking these regrettable actions.

Informal caregivers



The term "informal caregivers" pertains to unpaid persons (mainly the partner, but also other family members, friends, neighbours, etc.) and private caretakers, generally having no professional experience in healthcare and long-term care services, who assist and provide support to older persons (WeDO, 2012). It is their support that enables many senior people in need of care and assistance to continue to live at home in a friendly environment and to have continuous help in most daily life tasks (Tarricone & Tsouros, 2008).

In the majority of EU countries, informal caregivers undertake, on average, 60% of care requests (Genet et al., 2012). These individuals manage a wide variety of tasks, from health care and therapy management to support for Activities of Daily Living (ADL) (bathing, dressing, cooking, house cleaning, etc.) (Reinhard et al., 2008). Informal caregivers are often unsupported by the formal care system and are also unpaid. Without adequate support and training, caregivers can be affected with serious negative effects on their physical and psychological health and also on their caregiving work (Reinhard et al., 2008). These informal caregivers often have difficulty finding a good balance between their caring role and other activities of their life (work, family, leisure, etc.). This may cause an increased sense of burden (Pavalko & Woodbury, 2000) (Schumacher et al., 1993) (Stephens et al., 2001). Working also in another job beyond the work as caregiver is a recommended for informal caregivers to prevent their social isolation and to help ensure adequate financial resources (Calhoun, et al., 2002) (Fillit et al., 2000) (Pinquart & Sörensen, 2003).

For these reasons, it is necessary to develop policies and to organise healthcare and socio-medical care systems in order to train and support informal caregivers in their work, to supply them with the right technological and sociological tools to provide older people the optimal services, and to prepare them for dangerous contexts and for making critical decisions.

3.2 Secondary Stakeholders: Care Providers

Secondary stakeholders are all the professional organisations that provide services to support elderly persons in need of care and assistance. They are mainly

- Public and private service providers supporting older persons in need of care, from occasional care to 24-hour-per-day care;
- Voluntary associations providing services periodically or occasionally at elderly persons' homes.

Depending on their health, personal preferences, and financial situations, elderly people receive services in their home, in sheltered/supported accommodations or in nursing homes or similar institutions. Secondary stakeholders provide different kinds of support: home-care, long-term care, and intermediate solutions, such as day care, night care, senior housing, etc.

The home-care services are usually suitable for persons that have no severe health conditions but who need some help and care that cannot be given by informal caregivers. In this case, formal caregivers and healthcare professionals periodically supply domiciliary services to older persons, allowing them to stay at home and to still keep control over their life and their care. These services may include help in specific tasks of daily life, such as going shopping, going outside for a walk or to a medical visit. The company and social interaction are equally important because they reduce elderly persons' sense of isolation and loneliness (Genet et al., 2012).

Home-care services are usually provided to older people under the recommendation of the public welfare systems and users' families, and the can be public or private, depending on the local policies. The frequency of this kind of support varies from a few hours per week to full-time care, depending on the specific user's needs and the monetary resources for the services, paid by public system, insurance companies, or privately by elderly users and their families.

In the last few years, the request for home care has been increasing so quickly and exponentially that current service providers are encountering several problems in meeting all of the requests (Tarricone & Tsouros, 2008).

Long-term caregivers are requested instead of home-care when elderly persons have complex health conditions that are difficult to manage, such as people suffering from severe diseases who are not autonomous and independent anymore and who need continuous care and monitoring. In these cases, older people move to nursing homes where they live together with other persons who have similarly severe conditions, and they are followed by a team of professionals that take care of them 24 hours per day. This solution does have some drawbacks, however:

- *Care costs*
  Long-term care inside nursing homes is very demanding in terms of professional workers' hours and environmental infrastructures, so it is very expensive. For this reason, only a restricted number of senior users have the possibility to enjoy it.
- *Variety of older users and complexity of care*
  Inside nursing homes, older users with different characteristics, pathologies, and necessities live together, and this implies the need for a flexible and holistic range of available services, which may be difficult to manage for professional caregivers as it makes person-centred care more difficult to be delivered.

Moreover, in the coming years the requests of long-term care by service providers will increase more and more, so it will be difficult to enable all people in need to use these services (European Commission, 2012a).

Beyond these forms of cares, there are some intermediate solutions that combine different services in order to face this extended and increasing demand for care (European Commission, 2012a), (Stula, 2012). For example, in some countries there is the possibility for elderly people to spend part of the day or the night at residential centres managed by professional service providers. In this way, the older person can spend some time at home, while still having the support of the residential care when needed. These solutions can be very effective in elderly persons' care, leaving them the possibility to stay at home, and can also provide different services to a higher number of users.

Senior housing is another example and can be considered as the transition between home care services and nursing homes, allowing for a delay of the need of nursing homes and limiting their use to extreme cases. The idea of senior housing (also called sheltered housing or assisted-living facilities) is based on smart apartments designed for elderly persons' needs and connected with a central service provider situated in the same building. According to the single person's necessities, the professional caregivers provide older persons specific services and continuously monitor the users' health conditions, while at the same time respecting the users' privacy and independence (Wikipedia, 2013).

Another important form of care consists in the services provided by voluntary associations. As a matter of fact, in Europe voluntary associations have a fundamental role in the long-term care (CEV, 2012), especially in those countries in the Mediterranean area and in Eastern Europe, where the budgets for socio-medical services have decreased because of the current economic crisis. Older persons in need of care thus increasingly rely on informal caregivers and on volunteers who are often senior people themselves. These people usually support elderly persons by accompanying them outdoors for visits and for specific services such as visiting the family doctor, shopping, taking care of their house, keeping company with them, organizing cultural and social activities in leisure centres, etc.

All of these services require the massive involvement of professional caregivers; however, these services are having difficulty managing the increasing number of requests. For this reason, it is essential to improve the working conditions of formal caregivers by providing them with appropriate and effective tools to manage care demands. ICT devices can enable them to efficiently follow more elderly users and to assist them in daily life. AAL can offer the technological and methodological tools to renew the current services. The aim of AAL technologies applied to these services is to satisfy the particular necessities of service providers. Furthermore, AAL technologies can enable the integration and coordination between other parties involved in the users care, including the family, the municipality, the shops, the clinicians, etc. Such AAL services can therefore become tools to enhance formal caregivers' actions, but not to substitute them in elderly persons' daily lives.

In the case of long-term care in the nursing home context, AAL devices should

- help caregivers in ADL tasks for the older persons;
- help older users and caregivers to monitor the users' health condition and to provide adequate alerts if there are dangerous changes;
- recognize "crisis situations" (i.e. the presence of too much water on the bathroom floor, smoke/fire, dramatic/falling event, etc.) in order to prevent incidents;
- support healthy ageing by helping the regular performance of motor and cognitive rehabilitative exercises, and by developing games and activities, thus avoiding the worsening of the motor and cognitive abilities or just to have fun;
- monitor medication adherence.

In senior housing and home-care services, AAL technologies should

- support activities to be carried out by the older users;
- favour the older persons' social inclusion and the involvement in community life activities.
- help older persons to live autonomously, e.g. by helping them to cook or to prevent incidents, giving them opportunities to participate in social activities by providing them with information about the services they can benefit from, etc.;
- monitor health conditions of elderly persons;

- localise users in outdoor environments in case of people with cognitive diseases or in case of dangerous situations (i.e. falls);
- recognise activities carried out by the older users, in order to prevent critical situations or to understand as fast as possible symptoms of diseases (i.e. heart attack, etc.);
- monitor and support drug taking and preventive and rehabilitative activities;
- recognise dangerous situations (i.e. the presence of water on the bathroom floor);
- facilitate the housekeeping.

A use of AAL technologies could improve the services provided by caregivers, allowing them to spend more time with the older persons.

AAL devices could also help volunteers in their work with elderly people. Here AAL devices could enable voluntary associations to

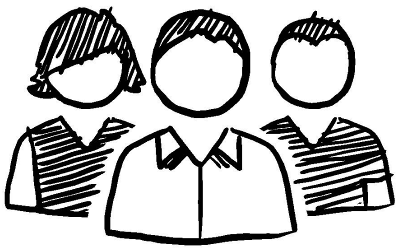
- efficiently organise their actions and coordinate their volunteers together with formal care services and with their families;
- use new technologies to support social inclusion and social activities; and
- increase older persons' feeling of safety when they are in need of care, through regular visits and through providing opportunities for activities.

In order to be effective and efficient, the following principles need to be observed in the design of AAL devices and services:

- being user friendly for formal caregivers and for older users independently of their feelings and attitude with regard to the use of technologies;
- providing correct and reliable information about the senior users' health and daily status and being able to alert caregivers in case of need;
- supporting elderly persons in case of dangerous situations;
- creating a network between all agents related to the older persons' lives (relatives, clinicians, shops, municipalities, recreational associations, etc.).

3.3 Quaternary Stakeholders: Policy Makers

The quaternary stakeholders are all public and private agencies and entities (such as policy-makers, insurance companies, public administrations, standardisation organisations, civil society organisations, and media) working at local, regional, national, and international levels to manage, regulate, and govern the society and to organize services for its citizens (Van Den Broek et al., 2010), (Finn & Wright, 2010). These actors are very important in AAL because they could politically and economically influence the future development and use of ICT for ageing in the society.



The ageing of the population is an issue that quaternary stakeholders are dealing with in order to prepare the society to manage this development. Technological solutions are able to change social behaviours and also could facilitate the creation of new tools and approache for social support.

Among all the challenges that quaternary stakeholders should face (Finn & Wright, 2010), some important ones are the following:

- *Making healthcare and long-term care services efficient and financial sustainable*
  In the last few years, the request of healthcare and socio-medical services by older citizens has been increasing so quickly that the current private and public systems of healthcare and long-term care services are turning out to be inefficient and insufficient. Moreover the economic crisis of the recent years is obligating governments to revise the budget for the public health care and socio-medical services and, at the same time, for the increasing number of citizens, and especially older persons, with precarious finances that cannot afford private services (Basu et al., 2012). For this reason, policy makers and economists should elaborate on new strategies and policies to reorganise these service systems for their older and frail

citizens (Karanikolos et al., 2013) and also optimise the resources (e. g. care needs, funds, and workers' time efficiency). An example of successful strategy is the "universal versus targeted services" adopted in California by the agency Jewish Family and Children Services (JFCS), which consists in providing good quality services to older people able to pay for them and consequently having financial resources for providing services also to poor elderly (Chang, 2012). According to this necessity, AAL could be an important building block to update and improve the quality of healthcare and socio-medical services and could facilitate care coordination (Karanikolos, et al., 2013). However, policies and strategies for the integration of AAL-based services into the health and social care and for making their costs sustainable for the communities are still missing in most European countries.

- *Facilitating the access to services by all citizens (smart cities and infrastructures)*
  Various statistical studies on European and worldwide population have highlighted that a progressive movement of people to urban areas is underway: in 2010 more than half of the worldwide population lived in an urban area (GHO, 2013). This share will further increase to 7 out of 10 people living in cities by 2050 (GHO, 2013). This phenomenon has two effects on the society. From one side, the cities are becoming so extended that frail persons, like older and disabled people, are having many problems accessing community services. On the other side, people living in rural areas are more and more isolated from the society. In both cases, the quaternary stakeholders are called to make cities and services more friendly and accessible in order to improve the QoL of their citizens and to favour their participation in the community's life. ICT solutions can be facilitators to develop smart and friendly cities (WHO, 2007). However, this implies the development of a good technical infrastructure (i.e. broadband coverage) (Point Topic, 2011) in order to connect and link all citizens everywhere, the knocking down of architectonical barriers, and the development of new solutions for improving the mobility and degree of independence of both older and disabled people. Only in this way will people be able to "live" and stay active in their cities and communities.
- *Having healthy and active citizens contributing to the welfare of the community*
  For the governments, it is important that all citizens contribute to the welfare of the community, as worker or as volunteer. For this reason, it is essential to keep citizens healthy, active, and involved in the community life as long as possible. An example of effective involvement of elderly people in the community is the Seniorlab, a civic laboratory in Spain where participants over 50 years old can find the necessary tools to conceive design and develop their own projects[5]. In order to obtain this result, governments should encourage actions devoted to disease prevention and the adoption of healthy life styles. These preventive activities should be promoted to all citizens, young persons, adults, and older people.
- *Revising regulations and funding instruments*
  The social and economic changes of the society and the presence of technologies and innovation in the life of every person promote a revision and renewal of current regulations. Of particular concern are security and privacy regulations and ethical considerations. Legislation needs to keep up with technical development at least to the degree of not hindering the implementation of new, beneficial health and social care tools, while at the same time preventing a "discount" of older citizens' human rights to privacy, independence, and well-being due to economic pressure.

  Furthermore the presence of new technological systems and services in the citizens' lives require an analysis about the standards available today and the certifications tools needed to regulate the development and the use of these services.

  Finally, quaternary stakeholders should identify new funding instruments for the novel generation of services in order to allow all citizens access to the various forms of assistance in the community.

[5] Seniorlab web site, http://citilab.eu/en/projects/seniorlab

4 AAL Markets and Business Models

The contents of the previous paragraphs represent the main societal drivers and motivations to foster AAL products and services. However, it is important also to examine the current AAL market conditions and to assess the reference business models within this market. More details about the analysis of the AAL market and business models carried out in the AALIANCE2 Project are reported in the Deliverables D3.2, D3.3, D3.4 and D3.5.

4.1 AAL Market: definitions and segmentation

A segmentation of the ICT Market was proposed by Kubitschke & Cullen and included three main sectors: *telecare*, *telehealth* and *smart homes* (Figure 4) (Kubitschke & Cullen, 2010). Telecare refers to the provision of social care from a distance, supported by telecommunications. It includes both simple telephone units with an alarm button and systems involving the monitoring of everyday activity, based also on mobile phones, videos and GPSs. Home Telehealth provides support for typical chronic diseases and health problems that become much more prevalent with increasing age. Smart homes and assistive technologies is a field that covers a broad range of “domotics” technologies and applications, from standalone devices that address particular needs (such as augmentative communication devices) to fully integrated smart homes through various types of environmental control systems.

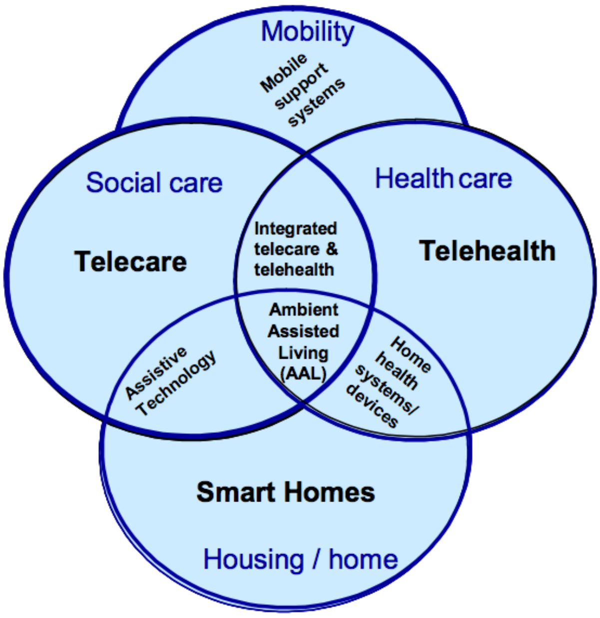


Figure 4. The three main core technology sectors presented by (Kubitschke & Cullen, 2010).

In this approach, the AAL market has been considered the convergence of the three main technology sectors, highlighting the importance of more holistic and integrated services for older people who have social and health care needs. The integrated concept of long-term care services, incorporating social, health and housing components is seen as having a particular relevance in this regard. Even here, however, it seems that traditional demarcations may persist, for example, by the differentiation between what is funded under long-term care insurance (social alarms) and health insurance (increasingly, home telehealth is beginning to be covered). A number of RTD, pilots and trials are taking a more integrated, holistic approach, but the majority of mainstreamed services tend to focus on one or another dimension and to be firmly located within one or another of either the social care or the health care domains. More promising seems to be a closer integration of telecare and smart home/assistive technology markets. Already there is a considerable overlap/integration of such services in some countries (assistive technologies being provided by the social care system, for example). Also, smart homes systems incorporate many of the elements of telecare, with the only difference being the local area networking of smart homes and the wide area networking of telecare. Another important dimension here is the evolving concept of 'housing-with-care', where dedicated housing (sheltered housing or service flats) for older people is increasingly being viewed as a focal point for integrated delivery of social (and sometimes health) care. As the population ages, the issue of supporting people at work will increase. This topic has been discussed in past studies but is likely to increase in importance. Since 2010 Spain, Austria and Slovakia have raised the retirement age. The UK and Germany have enacted gradual increases, spanning to 2029. These policy changes are one factor influencing how long people work, but it is not the only indicator. The long-term economic growth projections for Europe predict slower growth in the future than what has been experienced in the previous decades (Economic Outlook, 2012). The projected slower economic growth, the raising of the retirement age and the larger aging population indicate that more people will be working to an older age in the future.

4.2 Business model analisys

In order to study and to identify possible AAL business models, we considered the work performed from 2012-2013 by the ICTecholAge Project, which studied a number of projects, businesses and trials to perform a detailed market survey and which evaluated business models on ICT and Aging. From all the ICTecholAge material onto the area of AAL, three examples were addressed: the *Scottish Telecare Programme Board (STPB)*, *SIMAP*, and *SOPHIA*.

- The *Scottish STPB* forecasted the expected costs to society and then worked with the private sector technology providers as well as all the care providers to create cost savings scenarios that were then reviewed in a consultation process that included the public. The results focus on reduced loading on hospitals, increased independence for the elderly and lessening the stress of casual caregivers. The Scottish experience is growing from telecare to include telehealth and is becoming an example of a public sector-managed service. Managed service business models look across the care delivery value chain and treat spending on social care and social health holistically. This enables service redesign and has potential to be a key tool to change spending from treatment to prevention.
- *SIMAP* is a service of the Spanish Red Cross designed to support older people in local travel by means of a mobile phone-sized device that is able to send location data in critical situations and then to permit a prompt intervention. Unlike the STPB, which is modelling for Scottish society to balance investment, SIMAP is modelling for civil society as a service extension. SIMAP's service, offering an alert button that can be activated by the user or by pre-set conditions, places it as a telecare solution. From the service description, it is unclear if the Red Cross is expanding the service to include elements of telehealth or smart home systems.
- *SOPHIA* is a German telecare service offering elderly and handicapped people 24 hour-support in their own flat as long as possible, including care visits as well as virtual care visits via video calls. SOPHIA has a dual focus of supporting the residents' needs and wishes while also supporting the housing companies' needs and desires. To keep labour costs down, SOPHIA depends on volunteers for much of the face-to-face contact as well as it uses a franchise model for sales and distribution.

Out of the three reference business cases, only one is beginning to offer clinically valid telehealth – STPB. Trials like STPB are occurring in several member states and do not have a single, established business model.

One model that is being used is an aggregated focused on providing support led by government's need to care, shelter and provide health services to their citizens. This unified service model or managed service model places an organization between the existing care, health and housing structures, and it behaves much like STPB to manage the societal outcomes of the three parties rather than to address isolated needs.

4.3 Managed service models analysis

The big drivers for the adoption of new models in integrated care in the community are as follows: the aging demographic profile in Western Europe, the need to manage long-term conditions out of the hospital, and the commitment by governments to improve patients' ability to live independently in the community without resorting to expensive residential care. The overriding objective is to achieve improved patient outcomes and satisfaction levels on a cost-effective basis.

The financing of care in the community is typically funded from a variety of health, local government, insurance, and private pay sources. Commissioning for social care, housing and healthcare is also separate and typically geographically dispersed. Although several governments aspire to achieve integrated health and social care commissioning and delivery, realising this objective will take many years.

Across Western Europe there is increased interest in the role that various forms of technology can play in conjunction with healthcare service delivery to meet the twin objectives of improved patient outcomes and cost effective healthcare delivery in the community. Telecare, telehealth, and smart homes are components of a future, more integrated solution. An AAL service or AAL models envisage an overlap between these different solutions that can achieve the benefits of integration in a managed service model, which can provide benefits to care commissioners without the need for a full integration of social care and healthcare.

We have reviewed activities in the development of telecare and telehealth in larger markets in Western Europe and looked for the potential of managed service models where third parties could potentially accelerate the development of a more integrated offerings by managing the whole value chain on a fee-per-service basis. The following chapter describes developments in three major markets: the UK, Spain and Germany.

The United Kingdom

The UK telecare market is well developed and continues to experience growth. The provision of Preventative Technology Grants (PTG) in the last decade became a catalyst for the strong adoption of telecare services by the local authorities. The combination of local government budget constraints and demographic pressures (1 million people by 2016 could not receive any homecare service) will necessitate the development of new and cost-effective models of care delivery that are driving policy and regulatory framework developments and the increasing use of technology to support them (e.g., Building the National Care Services, Liberating the NHS White Paper and QIPP - Quality, Innovation, Productivity and Prevention). In The UK, the government promoted several initiatives (e.g. 3 million lives) to drive awareness of telehealth and telecare and to encourage the sharing and development of best practices of services. Within these initiatives, the Seven Pathfinder sites have already demonstrated the benefit of telecare and telehealth services with a substantial reduction of A&E visits, mortality, emergency admissions, elective admissions, bed days and tariff costs. Currently there is a range of business models being deployed to support telecare programmes. Market interviews suggest that the most advanced local authorities are adopting managed service models, often to handle larger, more complex programmes. At the heart of the managed service model is the transfer of responsibility to a third party service provider to manage the efficient operation and delivery of telecare and telehealth services on a fee-for-service basis. There are a variety of different revenue models that can be incorporated in managed services contracts:

- Equipment only: outright purchase of the equipment and on-going maintenance and replacement fees;
- Equipment plus: outright purchase of the equipment and a per-patient fee for triaging services, or upfront percentage of the equipment purchase with the remainder included in a monthly fee;
- Patient revenue to provider: both local authorities and the service user pay for the services;

- Pay-per-month: all the cost of the equipment and service is wrapped up in monthly instalments to the service-provider partner.

In the UK telehealth is a nascent market with strong underlying drivers for adoption, with pressure to develop more cost-effective care-delivery models whilst adopting a more holistic view of patient management. It is estimated that there are about 15 million patients in England with long-term conditions, many who have multiple morbidities. Given the substantial and increasing funding allocation for managing long-term conditions, the NHS is exploring how current care pathways can be evolved to be more cost effective. As part of this plan, the Clinical Commissioning Groups (CCGs) are encouraged to focus capacity on increasing care in the community and to create care services that facilitate management of the conditions using home care with telehealth-care. Various funding scenarios could lead to a range of telehealth connections in the future. Primary care telehealth services are typically structured to include four major elements: home patient monitoring, data triage, patient follow-up, and clinical care.

Spain

The Spanish telecare market, driven by the increasing aging population, is well developed and dominated by full delegation of telecare services from equipment supply to installation and call centre management. Spain had a well-developed national funding and distribution environment for telecare until January 2013 when it moved funding responsibility to local administrations. Then local authorities made efforts to not reduce the service levels or the number of users by using part of the local authority budgets, using end-user funding through co-payments and re-tendering provision contracts with telecare providers. The result of this process is that now the full delegation of telecare services is preferred to a single provider by outsourcing under a ‘managed services’ model. The revenue model used is a monthly fee per user, which would cover the equipment and all the other service provisions.

The market potential for telehealth in Spain is driven by the increasing life expectancy and the growing incidence of chronic diseases (about 19 million patients with chronic conditions, in 2013). Although telehealth trials are underway in Catalonia, Andalusia and Basque countries, a business case for telehealth is still inconclusive and there is no dedicated funding yet. Particularly, the Basque country has become the pioneer for integrating telecare and telehealth services through a social and healthcare scheme to manage long-term chronic conditions in the community. Experts agree that investing in telehealth-care will shift the costs from other, more expensive healthcare treatments and will free up large amounts of public funds through cost-efficiency.

Germany

The German telecare market is relatively underdeveloped compared to some other Western European markets due to funding constraints, mandatory insurance funds, low awareness of eligibility within the population and a relatively passive delivery channel. Typically, mandatory health insurance in Germany supports the provision of telecare with a fixed amount for three care levels, even if charities are the main providers of telecare and offer full-service provisions. Since January 2013, the employee contribution to the care insurance has increased to fund and to promote care levels for people living at home and to help them stay home for longer. However, the market for telehealth is still nascent in spite of a series of trials being underway to improve patient care and to reduce costs through telehealth. The recent Versorgungsstrukturgesetz legislation identified telehealth / telecare as a means of improving care delivery in rural, under-served regions, and this could act as a useful medium-term driver of market growth. This leads to a belief that Germany may be less likely to develop an AAL market as there is no government initiative to promote the integration of social and health care services in the medium- to longer-term, although with more evidence on efficiency benefits, the insurance providers are likely to promote this model much more proactively.

4.4 AAL Business Model

Proven Ambient Assisted Living business models that meet the criteria of delivering the benefits of telecare, telehealth and smart homes have not been identified. What we identified was the expansion of telecare business models to include new care technologies (especially video virtual visits) and the first examples of the convergence of telecare and telehealth.

Due to the existing government subsidies for care and health, the likelihood of a purely private AAL market developing in Europe is low. In Europe, people expect the government to play a role in defining services and subsidy levels. Companies entering a market where the government policy is not clear run the risk that individuals will delay purchasing until there is a clear policy. Without active government participation in defining AAL business solutions, the market will continue to develop, as it has to date, either as an evolution of telecare, of telehealth or of smart homes. These approaches are likely to result in a more fragmented market place where care, health and housing are dealt with in isolation rather than holistically.

In the midterm, European states are the most likely stakeholders to benefit from scale AAL deployments similar to the Scottish case. Projects are underway in The UK and in Spain to combine telecare and telehealth services to address funding and sustainability issues. These changes are increasingly through managed-service partners who do not fundamentally change the existing structures of social and medical care structures, but enable health and service redesign by keeping people healthier through prevention.

In the longer-term markets, where the needs and benefit are less formally aligned like Germany and other European markets where care is typically delivered by civil organisations and health by insurance companies or public entities, are likely to be served by offshoot business models from the midterm service providers. In Germany and in other markets where insurance companies are active in providing health solutions, a high-end model may also develop where social care is added to health benefits. This is one of the expected models in the US and in Japan where private insurance often is involved in corporate benefits packages.

4.5 Ethnographic studies

Four European markets (Italy, Poland, Sweden, and the United Kingdom) were chosen as representatives of the various cultures and contexts (Mediterranean, eastern Europe, northern Europe, and western Europe, respectively) existing inside the European Union. The WP3 studied how each country differs with regard to the following:

- implementation and use of AAL services and devices
- the aging population by country (percentage increase over the next several years)
- topography (rural and urban splits)
- affluence.

The data on postal code areas came from CAMEO,[6] a database that uses transactional data, population census and governmental registers for the classification of areas (by postal codes).

Although CAMEO's affluence spectrum has five classifications (wealthy, prosperous, comfortable, less affluent and poorer), for this project we combined and narrowed down the classifications into two: *Comfortable+* and *Less Affluent*.

By combining the five classifications into *Comfortable+* and *Less Affluent,* we simplified not only the data but also the topography (map views). The margin between an area being classified as either *Comfortable+* or *Less Affluent* was very slim.

[6] Available from Callcredit Marketing Solutions: http://www.callcredit.co.uk/products-and-services/consumer-marketing-data/segmentation-analysis

4.5.1 The AAL matrix

The main findings coming from the information of CAMEO were summarised and schematised in an AAL matrix (see Figure 5).

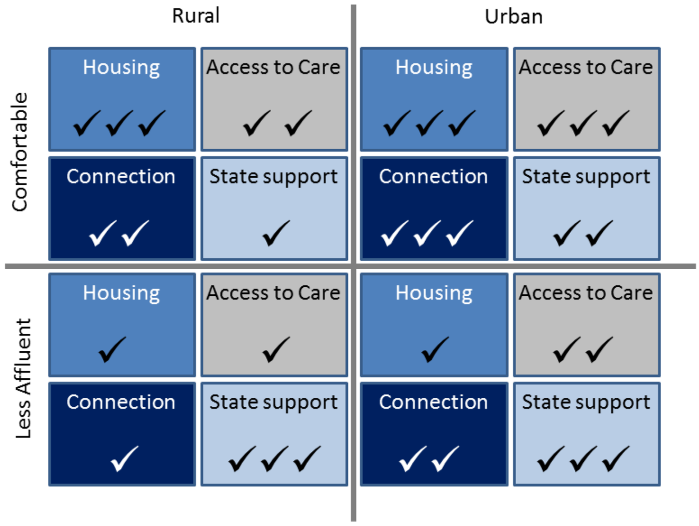


Figure 5. AAL matrix developed in the AALIANCE2 deliverable D3.5.

The AAL matrix takes into account several factors such as housing, access to care, connectivity (i.e. ICT) and state support (funding). These factors are then set against the backdrop of affluence and topography.
The matrix was applied to each country investigated for the deliverable D3.5 using the CAMEO data classification, national policy information, Eurostat data and information available from the OECD.
Figure 5 above is a simply designed example of the AAL matrix. To create it, we combined the information listed above and put a tick mark in each cell. The more tick marks in each cell, the better the situation was for the AAL market. For example, in Figure 19, people living in a Less Affluent postal code in a rural area are more likely to have state support in obtaining AAL services/devices than those living in a Comfortable+ postal code in a rural area. However, the AAL matrix does heavily rely on government policies with regard to healthcare– specifically telecare and the provision of social alerts.

4.5.2 Market influences

Within the areas covered in the research scope (age, topographical influence and affluence), it became evident that topographical influences and affluence – the effects of topography on affluence and the ability to pay for services – differed by country. This difference was most evident in the United Kingdom where the rural areas of the country had a higher concentration of wealthy neighbourhoods. This situation contrasted sharply with Poland's topography and affluence, where the rural areas of the country showed a higher concentration of less affluent/poorer neighbourhoods.

We emphasise that affluence was not evident at an individual or personal level, rather it was present at the neighbourhood, or postal code level. However, poorer individuals were also found within some postal code areas that were otherwise classified as wealthy sectors.

When developing products for countries organisations and stakeholders must take this information into account where the high percentage of the population lives in rural or non-urban areas as the available infrastructure will be a key to service offerings and market entry.

Moreover also the support by national and local governments for AAL services introduction is another important factor which influences the success and the market growth of a new AAL product.

The extensive description of the results of this research was reported in the deliverable D3.5 of the AALIANCE2 Project.

4.6 AAL Technology drivers

The tertiary AAL stakeholder category mainly includes suppliers of ICT and aging solutions that, driven by commercial interests, develop B2B (business to business) and B2C (business to consumer) models. The main suppliers could be listed as the following:

- research centres close to commercial actors that focus on research, development, and innovation activities with medium- or short-term deployment and that offer access to pilot sites for real testing;
- enterprises that produce and commercialise ICT devices and solutions for aging-well applications;
- service providers that integrate solutions into their services;
- enablers of infrastructures with ICT features, such as telecommunication, cloud, transportation, etc. providers;
- solution packagers and system integrators; and
- distributors and vendors. (Huch, 2010)

The rising demand for sustainable healthcare systems, the increasing aging population, and the longer retirement have increased the importance of AAL developments, services, and products.

The growth of the medical electronics market (Figure 6) is leading to the need for better understanding of the technical challenges associated with medical electronics manufacturing. These challenges concern not only materials and components, but also methods, mainly focusing on personal medical electronics that favour a shift towards home- or patient-centric health care and that promote a very rapid growth in personal healthcare monitoring, diagnostics, and preventative medical electronics. It is estimated that medical electronics equipment production will increase from 91 billion USD in 2011 to 119 billion USD in 2017, with an average rate of 4.6% per year (iNEMI Advancing manufacturing technology, 2013).

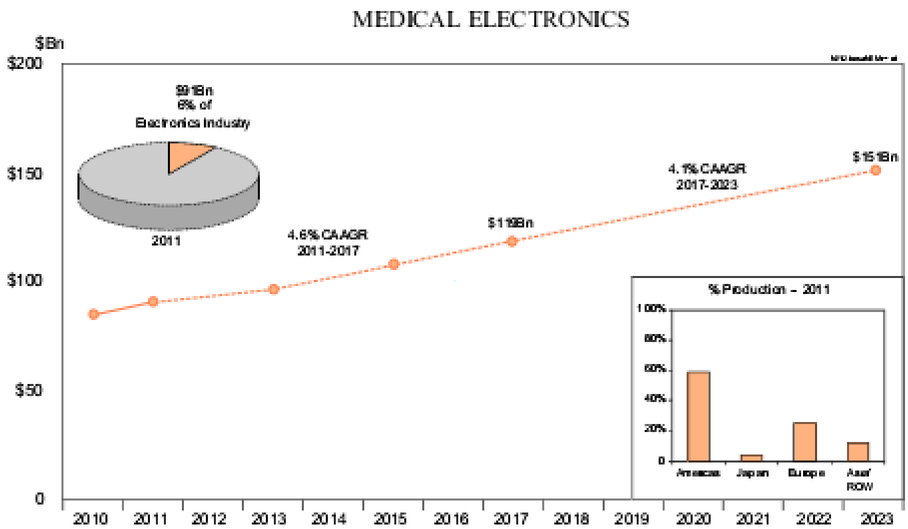


Figure 6. Prismark estimation of medical electronics market size (iNEMI Advancing manufacturing technology, 2013).

The EU smart home market is estimated to grow from 1,544.30 million USD in 2010 to 3,267 million USD in 2015 (Markets and Markets, 2011a). Smart homes have already started attracting architects, developers, and device manufacturers attempting to address the challenge of reducing costs and adopting ICT technology. Furthermore, with the active participation of stakeholders in developing new and improved standards, this market is expected to continue to grow at a good pace over the coming years (Markets and Markets, 2011b). Similarly the forecasted market value for telecare was predicted to triple from $9.8

billion (2010) to $27.3 billion (2016); 18.6% being the compound annual growth rate, having insubstantial hindrances on its growth (Wellesley, 2011).

Developments in portable medical technologies, patients' preference for in-home care and the necessity to reduce hospitalization costs are driving growth in home care services. In the health industry, this segment of home care has grown considerably during the last few years and will continue to grow with a predicted rate of 20% per year (The National Association for Home Care & Hospice, 2010). Companies involved in this segment usually provide skilled nursing and other health care services (such as medical equipment, supplies, and medication), therapeutic services (e. g. physical and respiratory therapy), personal care services (such as bathing and transportation), and psychosocial services (including counselling and spiritual care) to patients in their homes. These services require strong cooperation between hospitals, home health agencies, and end-users, and this is leading to other forms of care being introduced in different environments (mobile care) with end-users increasingly in control of their own care programmes (self-care). Indeed, the mobile Internet, easier-to-use interfaces, and broader features and capabilities of mobile devices enable end-users to manage personal, customisable healthcare services that have the great potential to facilitate end-user participation and to reduce costs.

The home healthcare industry is also testing tele-homecare and tele-monitoring services that represent a valuable opportunity to balance quality of care with cost control. By using telephone, satellite, and Internet-based communication, these services allow medical care professionals to stay in touch with patients without travelling to the patients' homes.

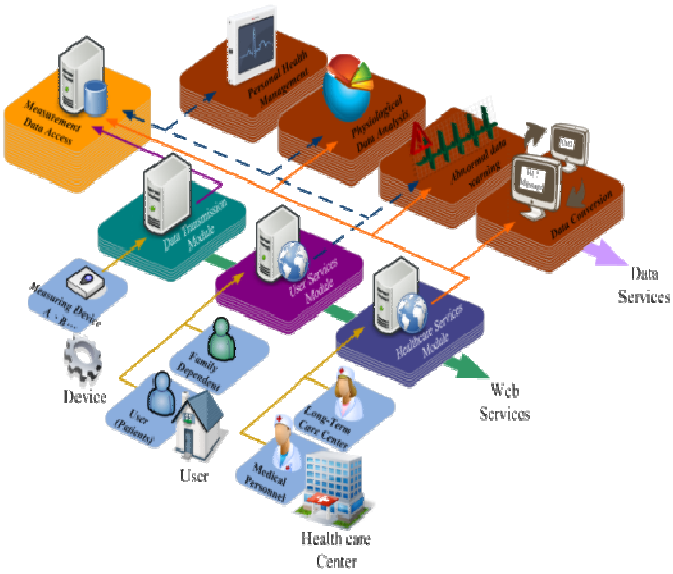


Figure 7. Implementation of a Tele-Homecare System with Service-Oriented Architecture (Wang, 2013).

According to the Cisco Customer Experience Report for Healthcare conducted by InsightExpress (2013) the digital impact on customer experience led to 70% of users preferring communication with doctors via texting, email, video over seeing them in person (19% preferred a video chat consultation with a doctor, 20% preferred an online consultation via instant message with a doctor, 21% preferred an email consultation with a doctor, 23% preferred telephone consultation with a doctor, and 20% preferred text message-consultations with a doctor).

Actually among the customers who welcomed the role of the Internet in Healthcare, 30% used computers or mobile devices to check for medical or diagnostic information. The services end-users found valuable if offered online via Internet include the following: 40% appointment reminders, 29% treatment reminders, 30% information for managing drugs side effects, 28% discounts or coupons for health related products, 22% information about clinical trials, 22% ways to review a health care experience, and 19% online support groups for costumers with similar health issues.

The wearable wireless device market is similarly growing with the advancement of wireless communication technology, either using short range or cellular radio. Wearable devices are now coming to market with form factors that can be worn without restriction or discomfort during any daily activity. An ABI research study expects that the number of wearable devices in 2017 will make up 22% of the home monitoring market, 8 out of 36 million devices (ABI Research, 2012).

Mobile health (mHealth) is a term used for the practice of medicine and public health, supported by mobile devices. Actually more than 97,000 mobile apps are available related to health & fitness, with 52% of smartphone users gathering health information. To date the top 10 mobile health apps generate up to 4 million free and 300K paid downloads per day, and by 2017 it is expected that the 50% of smartphone users will have downloaded mHealth applications with a mobile health market revenue that will reach 26 billion dollars. The rising popularity of mHealth apps leads to a large number of downloads: 50 million about weight loss, 26.5 million about exercise, 10.5 million regarding women's' health, 8 million on sleep and meditation, 7.5 million about pregnancy, 6 million about tools and instrument, and 18 million about other topics. Also doctors recommend the use of mHealth applications; 40% of physicians believe mHealth technologies can reduce the number of visits to doctors' offices, more than 25% of physicians are using mobile technology to provide patient care, 80% of physicians use smartphones and medical apps, 93% of physicians believe that mobile health app can improve patient's health, and 93% of physicians find value in having a mobile health app connected to emergency health.

ABI Research (Solis P., 2013) predicted that by 2015, robot sales would exceed $15 billion, due in large part to advanced sensor technology and cheap, powerful cameras. In the personal service robotics market, the domestic robotics market is the largest segment and is expected to reach $1.97 billion by 2014. The high market size of domestic robots is mainly due to the demand of robots for assistance in household tasks and acts as companion. The aging population and continuous research has made Asia the dominant player in the service robotics market. In 2009, the market share was estimated to be 52% with a size of $3.7 billion. Europe is expected to have the second-highest market for service robots. However, the large consumer base of domestic robots in the U.S. and Europe makes them the most attractive market for vacuum cleaners and other domestic products.

5 AAL Service Areas and Scenarios

One of the main objectives of the AALIANCE2 Project is to identify and suggest the most important and innovative scenarios and services that could positively impact the QoL of the ageing population and identify and prioritise the principal technologies necessary to implement them. Starting with a consistent analysis of end-users' needs, coming from state-of-the-art literature, results of the EUROPEAN INNOVATION PARTNERSHIP ON ACTIVE AND HEALTHY AGEING (EIP-AHA) initiatives (EIP-AHA, 2011), and from workshops carried out during the AALIANCE2 Project, the main solutions conceived to support older people in need of care can be grouped into three main AAL Service Areas: Prevention, Compensation & Support and Independent & Active Ageing (see Figure 8).

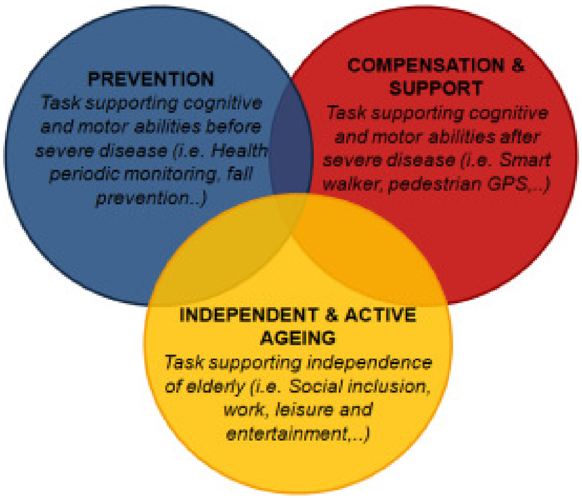


Figure 8. Scheme of the three AAL Service Areas of the AALIANCE2 Project: Prevention, Compensation & Support and Independent & Active Ageing.

These three Service Areas are complementary, and at the same time overlapping, because the boundaries surrounding them are often very thin. They include different services, enhanced by the use of appropriate AAL technologies that can satisfy users' needs and favour a better QoL and active and fruitful participation in society. Figure 9 shows how the services, based on the use of AAL technologies, could contribute to increase perceived QoL.

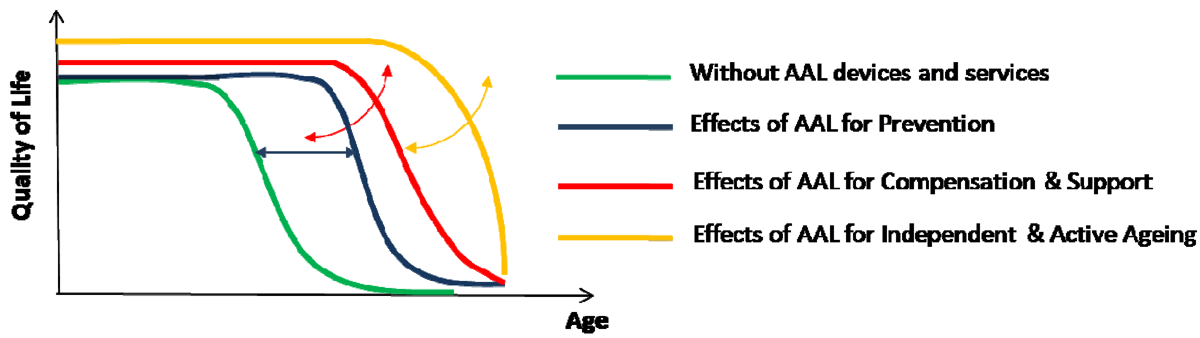


Figure 9. The model of QoL during ageing and the potential effects of AAL service scenarios related to the three AALIANCE2 Service Areas.

The green line represents the standard QoL of an elderly person, which would normally decrease after a certain age due to morbidities and disabilities related to age, as well as decreasing social interactions. The blue line shows how the decrease of QoL could be delayed when some prevention activities are undertaken in order to delay or reduce morbidity. The red line highlights how QoL decreases more slowly in cases where compensation or support actions are engaged in. Similarly, the yellow line shows how independent living and active ageing can help to maintain high levels of QoL and further slow down decrease with age. All of these actions can be supported by technologies that can help people engage in activities that aim at improving perceived QoL.

These concepts provide evidence that by using AAL technologies and exploiting AAL services it is possible to have a higher QoL at all stages, and to live longer while not being a burden to society and the welfare system.

5.1 Prevention

Prevention can be defined as an "action to reduce or eliminate the onset, causes, complications or recurrence of disease" (National Public Health Partnership, 2006). Four kinds of prevention can be identified, according to which stage of disease they are applied to:

- *Primary prevention:* Consists of activities that can help avoiding a specific disease or bad health conditions. These interventions aim at eliminating or reducing the factors considered as causes of the onset of the disease (National Public Health Partnership, 2006).
- *Secondary prevention:* Aims at delaying the onset of significant morbidity when a disease or serious risk factor has been already diagnosed. This kind of prevention is aimed toward asymptomatic individuals with early onset of disease or established high-risk factors (Trust for America's Health, 2009).
- *Tertiary prevention:* Concerns individuals already living with a disease and aims at limiting the progression of the disease, including complications and disabilities. This kind of prevention aims at reducing the impact of the disease on the patient's life.
- *Quaternary prevention:* Concerns those that cannot be properly considered as patients because they do not have any diseases, but feel as though they do. Here prevention aims at reducing an excess use of unnecessary medical procedures and medicine.

In the AALIANCE2 Roadmap, Prevention focuses mainly on primary and secondary prevention. In both cases, AAL technologies and services have the potential to avoid the development of specific diseases or delay the onset of morbidities and, as a consequence, to preserve a stable QoL.

Examples of primary prevention are:

- cognitive stimulation programmes for preventing both the decline of cognitive functions and dementia (Nouchi, et al., 2012);
- physical activity stimulation (Clemson, et al., 2012) (Kramer, et al., 2006);
- social participation in the community (Polidori, et al., 2010);
- domestic risk avoidance (RISDOM, 2006);
- risk prevention at work (Van Den Broek, et al., 2010).

Examples of secondary prevention are:

- physical activities in cases of people that already have chronic diseases, e.g. cardiovascular disease (NCSL, 2012);
- early diagnosis of diseases, e.g. Parkinson's disease (Noyce, et al., 2014);
- healthy diet: a higher-quality diet is associated with lower risk of recurrent chronic diseases, such as cardiovascular disease, diabetes, etc. (Dehghan, et al., 2012).

In the AALIANCE2 Roadmap, different ICT solutions are described to help older people undertake prevention activities. In particular, the following fields of application are analysed:

- prevention at work;
- fall prevention;
- prevention of cognitive disease (Parkinson's disease, Alzheimer's disease, dementia);
- chronic disease (cardiovascular disease, chronic obstructive pulmonary disease, diabetes);
- domestic risk prevention.

5.2 Compensation & Support

The Compensation & Support Service Area concerns older people with physical or cognitive impairments that need help in their daily activities. Often, for older people recovery after severe injuries or diseases takes much more time and all functions do not return as before the injuries. These impairments, derived from diseases and injuries, make the management of daily routines difficult and reduce independence in completing tasks – this causes the further decline of other capacities and the consequent need of assistance by caregivers.

Compensation & Support includes the AAL services and devices that could help the elderly in compensating some physical and cognitive limitations and in supporting them in their daily life. These could be useful not only for elderly persons, by assisting them in daily activities, but also for caregivers in order to optimise and facilitate their assistance to the elderly.

In this way, senior subjects could enhance their QoL and, on the other hand, caregivers could increase quality of services, such as managing diseases and disabilities, accomplishing daily activities and encouraging social inclusion.

Compensation & Support includes the following scenarios:

- domestic care;
- telecare;
- home adjustments for physical decline;
- personal care;
- assistance in the activities of daily living;
- nursing care.

5.3 Independent & Active Ageing

The Independent & Active Ageing Service Area includes services that allow older people to live and complete daily tasks on their own, participate in social activities and remain longer at work. Independent living and active ageing are two complementary concepts that influence the self-esteem and perceived QoL of senior persons. The majority of older people wish to remain at home and to maintain their autonomy and to be able to perform daily tasks on their own. Unfortunately, often because of limitations and diseases, senior people should ask for help to manage and accomplish daily life activities, without negative feelings of being dependent on others.

Furthermore, participation in social activities and community life are problems for most elderly people, caused, for example, by lack of mobility, difficulty in staying updated on events or in keeping up with transport changes. Active ageing is a concept related to different sectors – work, leisure and voluntary service – which fosters older people’s participation in society. The aim of the Independent & Active Ageing Service Area is the inclusion of older people in society. This concerns AAL services and technologies that can contribute to making elderly persons safer in their own homes, i.e. able to manage their daily routines and become more a part of the community, and help them to be socially included.

The use of ICT for independent living and active ageing is often considered as a key element to tackle current challenges of care and ageing, such as empowering people with age-related dependencies or disabilities to live independently, delaying/avoiding institutionalisation, and staying active as much and as long as possible. Solutions may combine health, social care and smart living systems and ‘age-friendly’ environments. The main needs of older persons associated with Independent & Active Ageing are the following:

- safety and security;
- keeping social contacts;
- having fun;
- friendly environments in which to live;
- retaining control over life and decisions;
- being active, also at work;
- appropriate response when things go wrong.

5.4 Key AAL Service Scenarios

This section reports on the key AAL service scenarios identified merging information obtained from the analysis of state-of-the-art AAL services; the results of the AALIANCE2 stakeholder workshops; and the data coming from the interviews with AAL experts involved in the AALIANCE2 Project.

These service scenarios are:

- *Scenario 1:* Prevention of early degeneration of cognitive abilities.
- *Scenario 2:* Healthy living.
- *Scenario 3:* Management of chronic diseases.
- *Scenario 4:* Age-friendly and safe environments.
- *Scenario 5:* Fall prevention.
- *Scenario 6:* Management of daily activities and keeping control over own life.
- *Scenario 7:* Maintaining social contacts and having fun.
- *Scenario 8:* Outdoor mobility (i.e. pedestrians, public transport and private cars).
- *Scenario 9:* Avoiding caregiver isolation.
- *Scenario 10:* Senior citizens at work.

It is important to note that these ten AAL scenarios are the main services, identified during the AALIANCE2 Project, which should be representative of the main aspects of AAL in improving older people's QoL, extending their independence and autonomy and facilitating their longer inclusion and active participation in society.

The following are examples of how socio-medical services for older persons could evolve in the future. The list is not exhaustive as many other services could be provided using AAL solutions and systems. The description of these scenarios reflects the methodology used to develop the AALIANCE2 Roadmap (see Chapter 2, Figure 3), namely:

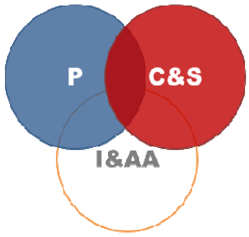
- needs and opportunities of the main actors of the AAL service (e.g. older persons, their families, workers, service providers, local communities, etc.);
- the AAL Service Areas that inspire each scenario;
- possible use cases of these services;
- key enabling technologies related to each scenario.

From the studies carried out during the AALIANCE2 Project, and according to opinions of experts involved, it emerged that the scenarios should be associated not only with one Service Area but with each of them because every service can have several implications in the lives of older persons, caregivers, etc. So, in each scenario, the scheme of the three AAL Service Areas (see Figure 8), is presented, but only the Service Area of particular interest is highlighted.

Moreover the KETs related to the scenario are cited according to the specific task of the service and also to the temporal area in which they will be ready to be implemented. Furthermore each scenario reports the list of the main actors of the services and briefly indicates which are the related business areas and market perspectives. A more in-depth analysis of these aspects is reported in the Chapter 4 and in the deliverable D3.5 of the AALIANCE2 Project[7].

[7] See http://www.aaliance2.eu/sites/default/files/files_list/AA2_WP3_D3.5_Summary%20report%20on%20Markets%20and%20Business%20Models.pdf

5.4.1 Scenario 1: Prevention of Early Degeneration of Cognitive Abilities



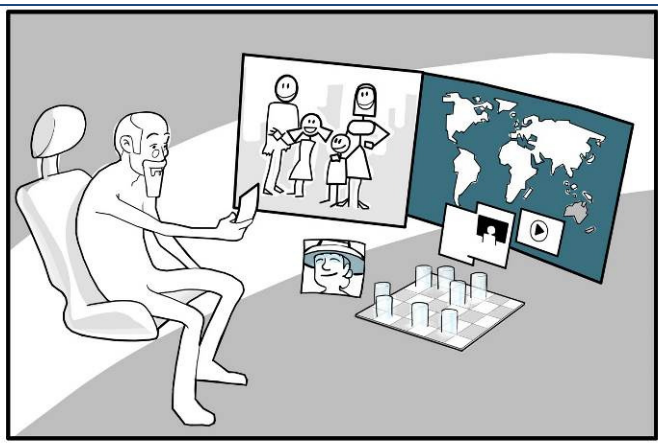
This service scenario consists mainly in different activities for the stimulation of cognitive abilities. AAL solutions can support these tasks offering effective apps and tools and also intuitive and facilitated interfaces for providing cognitive inputs and personalised games to older people both at home and medical and community centers.

This scenario is associable to the service areas *Prevention* and *Compensation and Support*.

- ***Main needs and opportunities related to Scenario 1***

Older persons:	- To avoid the early worsening of cognitive and manual abilities.
Families, informal carers:	- To delay the need for continuous support because of the decrease of cognitive capability.
Service providers, formal caregivers:	- To be aware about the health status of their patients. - To prescribe the right therapies and stimulations on the basis of current cognitive conditions.
Local community, society, healthcare systems:	- To longer maintain the cognitive and manual abilities of older persons. - To encourage active and social older persons. - To delay the provision of dedicated services and optimise social and healthcare costs.

- ***Possible use case***



Johanna is 78 years old and lives alone. Five years ago, her family doctor noticed that she had a worsening of short-term memory and the ability to make calculations. For this reason she enjoys a personalised AAL service for delaying the degeneration of cognitive abilities. When she wakes up, her smart TV shows her current data, the planned events of the day and major news. Together with her friends at the community centre, she plays specialised AAL games stimulating her capabilities in computation, logic, drawing, general knowledge, etc.
Thanks to these AAL systems she interacts with others both at the community centre and also remotely at home. She uses personalised devices and interfaces according to her preferences and different contexts (e.g. at home she uses a tablet, smartphone and smart TV, and at the community centre an interactive white board, haptic interfaces and tools for gesture recognition).
These AAL games are planned and refined by clinicians and socio-medical workers on the basis of older users' characteristics, preferences and needs, such that when the interfaces recognise Johanna, they propose exercises suited for her.

Moreover, these specialists receive remote, periodic feedback about the results of the stimulations in order to monitor senior patient status and to plan specific corrective actions.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 1

TIMELINE	SCENARIO 1				
	Task 1 *Reminder and informer*	**Task2** *Cognitive gaming at community centres*	**Task3** *Cognitive gaming at home*	**Task4** *Remote control by clinicians*	
Short Term	▪ Multimedia appliances (e.g. smart TV) ▪ Personalisable software applications to remind events and to provide information and news	▪ Multimedia appliances to be used in group (e.g. smart TVs, interactive white-boards, etc.) ▪ Natural language interfaces and spatial interfaces (e.g. tools for gesture recognition) ▪ Personalised gameing applications for the stimulation of cognitive abilities	▪ Multimedia appliances to be used alone (e.g. smart TVs, tablets, smartphones, etc.) ▪ Natural language interfaces and spatial interfaces (e.g. tools for gesture recognition) ▪ Personalised gameing applications for the stimulation of cognitive abilities	▪ Control interfaces for the caregivers and clinicians	
Middle Term	▪ Safe data transfer and protection ▪ Wide area network	▪ Safe data transfer and protection ▪ Wide area network ▪ Reasoning tools for the modelling and recognition of congnitive abilities from gaming data	▪ Safe data transfer and protection ▪ Wide area network ▪ Reasoning tools for the modelling and recognition of congnitive abilities from gaming data	▪ Safe data transfer and protection ▪ Wide area network	**KETs**
Long Term		▪ Advanced sensorial interfaces (e.g. haptic interfaces, augmented reality) ▪ Advanced intelligence for self-learning-modelling of congnitive abilities and automatic modification of games	▪ Advanced sensorial interfaces (e.g. haptic interfaces, augmented reality) ▪ Advanced intelligence for self-learning-modelling of congnitive abilities and automatic modification of games		

Key actors and infrastructure of the Scenario 1

- Older persons
- Informal caregiver and older persons
- General practitioner / Family doctor and Neurologists
- Service providers and community centres organising activities for older persons
- Companies developing applications and smart games for smartphones, tablets and smart TVs
- Developers of smart TVs and smartphones, interactive white board
- Companies producing haptic interfaces and tools for gesture recognition

Business prospectives related to the Scenario 1

The main business sectors related to Scenario 1 are:

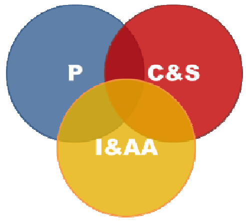
- Multimedia appliances and facilitated interfaces
- Gaming software and applications suited to older persons that stimulates their cognitive capabilities
- Service providers organising activities for entertaining and stimulating older persons' abilities

Currently there are a number of organisations within the AAL industry that are developing aids in order to prevent the early degeneration of cognitive abilities. However, it is significant to mention that regardless of the services that are being developed and tested, the key is early engagement of these services amongst the elderly segment.

5.4.2 Scenario 2: Healthy Living

Healthy living is very important especially for older persons. AAL devices can help elderly people to carry easily and pleasantly out motor activity at home or outdoors with other persons and help them to adopt a healthier and personalised diet.

This scenario is associable to the service areas *Prevention*, *Compensation and Support*, and *Independent and Active Ageing*.

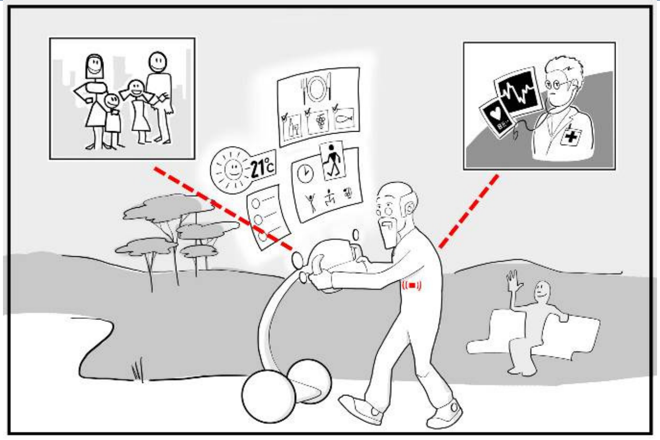


■ *Main needs and opportunities related to Scenario 2*

Older persons:	- To consciously improve their lifestyle and thereby their wellness.
Families, informal carers:	- To be constantly informed about their relatives' conditions. - To avoid continuous presence to correct users' bad habits.
Service providers, formal caregivers:	- To be aware about the real needs and health status of their patients. - To provide the right suggestions to improve users' lifestyles.
Local community, society, healthcare systems:	- To maintain the good health status of senior citizens. - To maintain older persons' activity in society. - To delay the provision of dedicated services and optimise social and healthcare costs.

■ *Possible use case*

Carsten is 65 years old. Two years ago he had a severe heart attack because of work stress, an inactive lifestyle and a smoking habit. After this event he retired early following the suggestions of his cardiologist and family doctor in order to take more care of his health and improve his lifestyle. To obtain this goal, he agreed with his doctors and family to make use of some AAL services and devices that could help him to adopt a healthier lifestyle and to correct inappropriate habits.



During the past two years he used some special AAL apps on his smartphone and tablet connected to his domestic appliances (e.g. refrigerator), reminding him of events, suggesting specific trainings and prompting him on the right foods to eat and drink.

In terms of training, he joins a sports group that organises outdoor physical activities for older persons. When he jogs and carries out motor exercises outdoors, he uses wearable sensors, smart glasses and has an app on his smartphone that monitors in real time his health parameters and provides him indications about how to carry out the exercises. When the weather is bad, he carries out exercises at home using the wearable sensors, his smart TV and some special interfaces for virtual reality that, through an avatar trainer, show him the exercises, monitor his movements and correct the wrong ones.

These services are planned in accordance with his trainer and his doctors.

The AAL tools provide Carsten feedback about his health and weight as he should always be aware of his status, his improvements and also wrong actions. Furthermore, his doctors and family receive remote feedback about his lifestyle and health conditions for awareness of his status and, when present, wrong approaches that should be corrected.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 2

TIMELINE	SCENARIO 2				
	Task 1 *Reminder of events and trainings*	**Task2** *Support for right diet*	**Task3** *Physical training*	**Task4** *Remote control of clinicians*	
Short Term	▪ Multimedial appliances ▪ Personalisable software applications for multimedia appliances to remind events and trainings	▪ Multimedia appliances ▪ Smart domestic appliances (refrigerator and hob) ▪ Personalisable software applications providing suggestions for the right and healthy diet	▪ Multimedia appliances ▪ Smart accessories (glasses, watch, bracelet, etc.) ▪ Personalisable sport applications for smartphones and smart TV ▪ On-body (wearable) sensors for health and motor monitoring ▪ Spatial interfaces for recognising movements and gestures ▪ Reasoning tools for training modelling and recognition of user's motor abilities	▪ Control interfaces for doctors and trainers	**KETs**
Middle Term		▪ Safe data transfer and protection ▪ Wide area network	▪ Safe data transfer and protection ▪ Wide area network ▪ Body area network	▪ Safe data transfer and protection ▪ Wide area network	
Long Term			▪ Advanced sensorial interfaces (e.g. virtual reality, holograms) ▪ Advanced intelligence for self-learning-modelling and automatic modification of motor training		

Key actors and infrastructure of the Scenario 2

- Older persons
- General practitioner / Family doctor and other clinicians
- Sport groups
- Service providers and community centres organising motor activities for older persons
- Companies developing health and fitness applications for multimedia tools and smart accessories
- Developers of multimedia tools and smart accessories
- Companies producing advanced interfaces for virtual realities
- Industries developing the electronic appliances

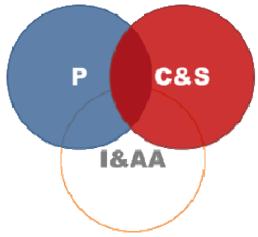
Business prospectives related to the Scenario 2

The main business sectors related to Scenario 2 are:

- Multimedia appliances, smart accessories and smart jewellery
- Domestic electronic appliances
- On-body (wearable) sensors for health monitoring
- Virtual reality
- Software and applications to control health, personal diet and motor activity
- Service providers and sport groups organising fitness activities for older persons

There are a number of products related to Healthy Living that have a high uptake amongst the Comfortable+ segment. This is due to the affordability of services and early investment in a healthier lifestyle by this segment; this is supported by profiling which indicated that the Comfortable+ segment are more apt to invest in a healthier lifestyle.

5.4.3 Scenario 3: Management of Chronic Diseases



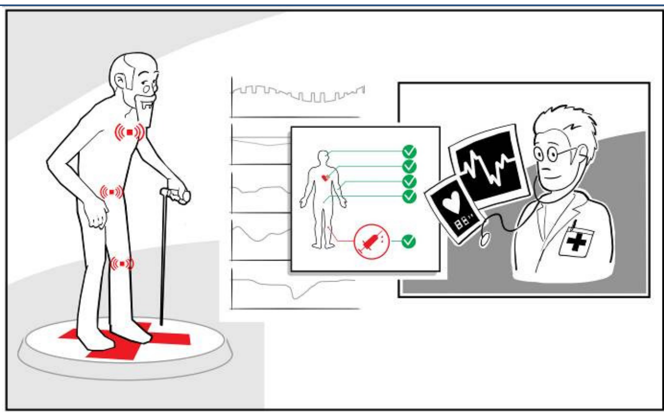
AAL technologies could support older persons in manage easily their chronic diseases: smart interfaces and tools can be used for tele-care helping clinicians to remotely control their patients and to interact more frequently, smart drug dispenser can help users in taking correctly drugs, portable rehabilitative devices for carrying out rehabilitation frequently and also at home, point-of-care and wearable sensors to monitor often and easily their health parameters.

This scenario is associable to the service areas Prevention, and Compensation and Support.

- ***Main needs and opportunities related to Scenario 3***

Older persons:	- Support in managing their health and to avoid its deterioration. - Help in managing chronic diseases (therapies, taking drugs). - To live freely and independently.
Families, informal carers:	- To be always aware about the health status of the elderly persons. - To facilitate and improve the effectiveness of the assistance in managing their health status.
Service providers, formal caregivers:	- Awareness about the health status of their patients (also remotely). - To prescribe the right therapies for current health conditions.
Local community, society, healthcare systems:	- To maintain the good health of citizens and reduce frequent accessing of hospitals and house-to-house medical examinations. - To intervene promptly in cases of worsening of patients' health.

- ***Possible use case***



Maria is 80 years old and suffers from cardiovascular disease, diabetes and glaucoma. She lives in the countryside with her husband but her children live afar. She is not able to manage all therapies and drugs alone, so clinicians suggested some AAL solutions to her.

To monitor her health parameters, she uses wearable physiological sensors and a smart point-of-care instrument. These systems acquire her health information both on the demand of clinicians and automatically according to her current status, transmitting the data safely.

Clinicians can remotely monitor her health and follow the evolution of her diseases.

To manage use of drugs, Maria uses different types of smart drug dispensers, chosen according to her conditions (e.g. implantable collyrium dispenser for glaucoma, ingestible drug dispenser for insulin and stand-alone dispenser for cardiovascular disease). In case of doubt, she asks the AAL system to provide her the most appropriate indications, thanks to its advanced reasoning system and the remote intervention of her doctor.

Furthermore, every morning Maria carries out prescribed cardiovascular rehabilitation using a smart bike that works both outdoors and indoors. This tool is remotely programmed by clinicians with particular exercises which help Maria to carry out the right training. This system communicates with Maria through a touch display on the handlebars and a smart wireless earpiece. This device works together with wearable physiological sensors (to monitor Maria's health) and transmits acquired data safely to clinicians.

When the AAL system observes potentially dangerous conditions, it promptly alerts her children and clinicians to get in contact with her and provide assistance.

■ *Priorities and timeline of activities and Key Enabling Technologies of Scenario 3*

	SCENARIO 3				
TIMELINE	**Task 1** *Health monitoring*	**Task2** *Taking drugs*	**Task3** *Rehabilitation*	**Task4** *Remote control by clinicians*	
Short Term	▪ Standalone point of care ▪ Multimedia appliances and software applications for health monitoring ▪ On-body sensors for health and mo-tor monitoring	▪ Standalone drug dispenser ▪ On-body (sticking plaster and wear-able) drug dispenser	▪ Sensorised indoor rehabilitative de-vices (exercise bikes, weights, bal-ance boards, …) ▪ Smart accessories (glasses, watch, bracelet, etc.) for health monitoring ▪ Personalisable rehab-applications for smartphones and smart TV ▪ Spatial interface for recognising movements and gestures ▪ Reasoning tools for the modelling and recognising health conditions	▪ Control interfaces for doctors and trainers to remotely monitor the user conditions and adjust therapies and rehabilitation	**K E T s**
Middle Term	▪ In-body (ingestible, implantable) sensors for health monitoring ▪ Safe data transfer and protection ▪ Wide area network ▪ Body area network	▪ Ingestible and implantable drug dispensers ▪ Safe data transfer and protection ▪ Wide area network ▪ Body area network	▪ Safe data transfer and protection ▪ Wide area network ▪ Body area network	▪ Safe data transfer and protection ▪ Wide area network	
Long Term	▪ Advanced intelligence for self-learning-modelling and prediction of health conditions		▪ Advanced sensorial interfaces (e.g. virtual reality, holograms) ▪ Advanced intelligence for self-learning-modelling and updating the rehabilitation programme		

Key actors and infrastructure of the Scenario 3

- Older persons
- General practitioner / Family doctor and other clinicians
- Service providers and rehabilitation centres
- Companies developing health applications for multimedia tools and smart accessories
- Developers of multimedia tools and smart accessories for health monitoring
- Companies producing advanced interfaces for virtual realities
- Industries developing in-body and on-body sensors for health monitoring
- Companies producing smart drug dispences
- Companies developing rehabilitative systems

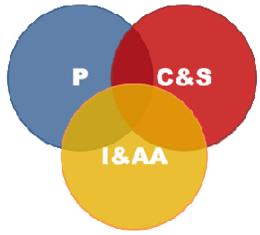
Business prospectives related to the Scenario 3

The main business sectors related to Scenario 3 are:

- Multimedia appliances and smart accessories
- In- and on-body drug dispenser
- In- and on-body sensors for health monitoring
- Indoor and outdoor tools for remote-controlled rehabilitation
- Virtual reality
- Software and applications to control health, drug therapy and rehabilitation
- Service providers and clinical centres

For this scenario there are already a number of services related to telehealth - the management of chronic diseases, such as COPD and diabetes.

5.4.4 Scenario 4: Age-friendly and Safe Environments



To make houses safer and age-friendly environments in which living, several AAL technologies, like imperceptible environmental sensors, advanced processing tools for events recognition and prediction, smart electronic appliances and robots, could be adopted.

This scenario is associable to the service areas *Prevention*, *Compensation and Support*, and *Independent and Active Ageing*.

Main needs and opportunities related to Scenario 4

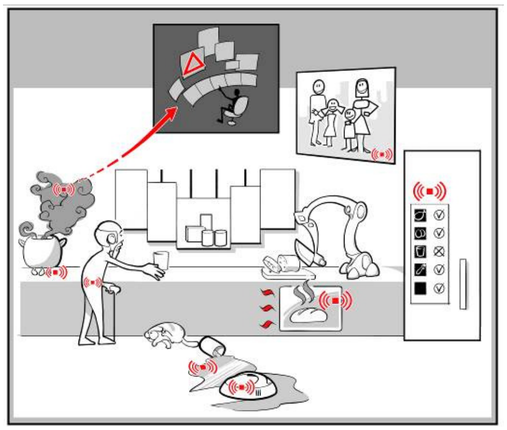
Older persons:	- To easily manage the household and its care. - To live in a safe environment.
Families, informal carers:	- To be aware of health and safety of older persons at home. - To be informed immediately about dangerous events. - To reduce the burden of supporting the elderly to manage their own houses.
Service providers, formal caregivers:	- To be aware (also remotely) of health and safety of the elderly while at home. - To be informed immediately about dangerous events. To facilitate assistance in managing elderly persons' houses.
Local community, society, healthcare systems:	- To maintain the health and safety of citizens. - To reduce domestic accidents.

Possible use case

Stephan is 75 years old and lives alone because his wife had passed away a number of years ago. He is not able to manage his household alone so he decided to use some AAL solutions to facilitate this task and ensure his safety. In particular he installed a system of:

- *some miniaturised environmental sensors for monitoring and optimising the environmental climate and recognising dangerous conditions (e.g. water on the floor or smoke in the environment);*
- *some automations for kitchen and bathroom to facilitate access to furniture and objects (e.g. automated kitchen cabinets, robotic arms to take objects from inaccessible points);*
- *some smart electronic appliances (e.g. cleaning robot and a smart refrigerator) to facilitate house cleaning and the management of food (e.g. recognition and alerts regarding expired foods).*

These solutions were chosen together with his children, family doctor and socio-medical worker on the basis of Stephan's needs and his apartment.



Stephan can also remotely control his house using apps installed on his smartphone and tablet. Furthermore, when dangerous events are recognised, the AAL system alerts both Stephan and his family.

Periodically his doctor and socio-medical worker monitor his lifestyle using information collected by his AAL system and, in cases of necessity, intervene.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 4

SCENARIO 4				
TIMELINE	**Task 1** *House safety*	**Task2** *House management*	**Task3** *Remote control by caregivers*	
Short Term	▪ Miniaturised environmental sensors ▪ Automations for furniture (e.g. cabinets) ▪ Ambient Intelligence for recognising dangerous conditions ▪ Multimedia appliances and applications for remote control of the house	▪ Automations for air-conditioning and lighting ▪ Smart electronic appliances (e.g. refrigerator, vacuum cleaner, hob, etc.) ▪ Ambient Intelligence for managing the house ▪ Multimedia appliances and applications for remote control of the house	▪ Multimedia appliances and applications for remote control of the house and of user's status	**KETs**
Middle Term	▪ Robotic arms ▪ Safe data transfer and protection ▪ Wide area net-work	▪ Safe data transfer and protection ▪ Wide area net-work	▪ Safe data transfer and protection ▪ Wide area net-work	
Long Term		▪ Assistive robots		

Key actors and infrastructure of the Scenario 4

- Older persons
- Caregivers
- General practitioner / Family doctor
- Industries producing miniaturised environmental sensors
- Companies developing applications for multimedia tools to remote control the house
- Developers of multimedia tools
- Companies producing furnitures and automations for furnitures
- Industries developing smart domestic appliances
- Companies producing robotic arms and assistive robots

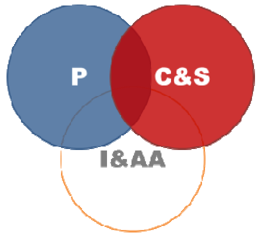
Business prospectives related to the Scenario 4

The main business sectors related to Scenario 4 are:

- Multimedia appliances and smart accessories
- Environmental sensors
- House automations
- Furnitures
- Smart domestic appliances
- Assistive robots for assistance at home

Age-friendly and safe environments are currently provided through telecare services in offerings such as social alarms, flood sensors, fire and smoke detectors, and motion/movement sensors.

5.4.5 Scenario 5: Fall Prevention



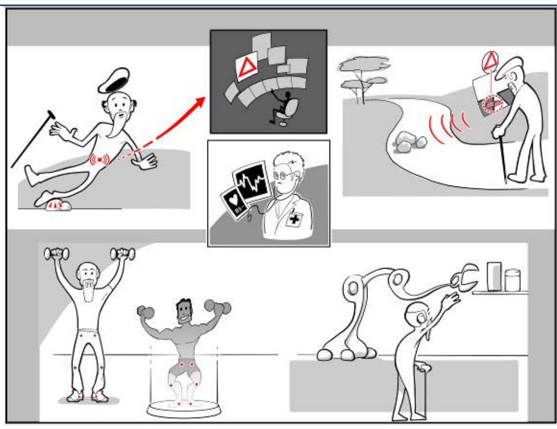
Fall is the accident more frequent and dangerous among elderly people. AAL solutions can help to provide services to prevent this event (e.g. tools to carry out preventive gymnastics, smart stick to help users to safely move outdoors, environmental sensors to recognise and advise about dangerous conditions, robots to execute risky tasks) and also to intervene rapidly in case of necessity.

This scenario is associable to the service areas *Prevention*, and *Compensation and Support*.

- ***Main needs and opportunities related to Scenario 5***

Older persons:	- To avoid falls. - To maintain good motor abilities and balance.
Families, informal carers:	- To maintain the health and independence of older persons. - To be informed promptly about eventual falls.
Service providers, formal caregivers:	- To train older persons frequently and effectively to maintain and improve their balance and motor abilities. - To reduce time of a single direct care and to increase, at the same time, the number of senior users monitored.
Local community, society, healthcare systems:	- To longer maintain the health and autonomy of older citizens. - To reduce the healthcare costs related to falls. - To allow caregivers to work longer and more efficiently.

- ***Possible use case***



Helena is 80 years old and suffers from arthritis and sight problems. Ten years ago Helena's older sister fell down at home and died a few days later. After this event, Helena became afraid of falling so she decided to adopt some specific preventive actions. Following the suggestions of her family doctor and a local service provider she agreed to use some AAL solutions for preventing falls.

Today her house is equipped with:

- *smart environmental sensors that recognise dangerous conditions (e.g. water on the floor) and alert her;*
- *smart automatic lighting system for moving safely during the night; and*
- *a robotic arm, that helps her in taking objects placed on high shelves and cabinets*

When she goes outdoors she uses a smart stick that helps her to walk and also recognises the presence of obstacles in the path (e.g. steps, holes, small objects, etc.) and alerts her through an unobtrusive hearing interface. All these indoor and outdoor solutions are also able to detect and recognise potential fall scenarios and to promptly alert family members, caregivers and healthcare workers in order to help older persons quickly. Furthermore, once a week she attends a course for physical training to maintain and improve her motor abilities and balance. During the course she wears smart sensors, that acquire her health and motor data, and uses some smart gymnastic tools (a balance board, two handles and a stick) that are remotely connected to her trainer's tools which allow her to learn how the exercises should be executed. During the week she repeats this training at home using smart gymnastic tools and a specific app installed on her smart TV that shows her the exercises and alerts her when she incorrectly executes the movements. This equipment sends Helena's health and motor data to her trainer and doctor so they can monitor her motor conditions and correct the training if necessary.

■ ***Priorities and timeline of activities and Key Enabling Technologies of Scenario 5***

TIMELINE	SCENARIO5					
	Task 1 *Avoiding accidents at home*	**Task2** *Moving safely at home*	**Task3** *Moving safely outdoors*	**Task4** *Preventive motor training*	**Task5** *Alert for caregivers*	KETs
Short Term	▪ Smart environmental sensors to monitor house ▪ Ambient intelligence to recognise dangerous conditions	▪ Smart lighting systems to facilitate moves during the night		▪ Smart TV ▪ Applications for smart TV to train elderly ▪ On-body (wearable) sensors to monitor health, balace, motor abilities	▪ Interface for caregivers	
Middle Term			▪ Smart stick recognising obstables ▪ Smart accessories and multimedia tools connected to the smart stick	▪ Smart gymnastic tools	▪ Data fusion ▪ Advanced processing system for recognition of dangerous situations	
Long Term	▪ Robotic arm for reaching inaccessible points and objects					

■ ***Key actors and infrastructure of the Scenario 5***

- Older persons
- Caregivers
- General practitioner / Family doctor
- Industries producing miniaturised environmental sensors
- Companies developing applications for multimedia tools to remote control the house
- Developers of multimedia tools
- Companies producing furnitures and automations for the house
- Developers of assistive devices (e.g. smart stick)
- Industries developing smart gymnastic tools
- Companies producing robotic arms and assistive robots
- Developers of smart accessories and multimedia tools

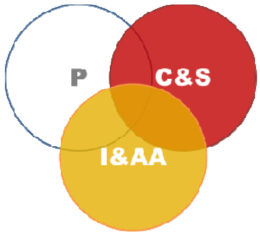
Business prospectives related to the Scenario 5

The main business sectors related to Scenario 5 are:

- Multimedia appliances and smart accessories
- Environmental sensors
- House automations
- Assistive devices for mobility
- Assistive robots for assistance at home
- Smart gymnastic tools for training

Falls Prevention is currently supported by technologies for falls detection – services that support end-users by contacting carers (formal and informal) informing them via a monitoring centre that the person has fallen. Currently, falls prevention is managed by providing safer living environments and employing some of the telecare services mentioned in Scenario 4.

5.4.6 Scenario 6: Management of Daily Activities and Keeping Control over Own Life



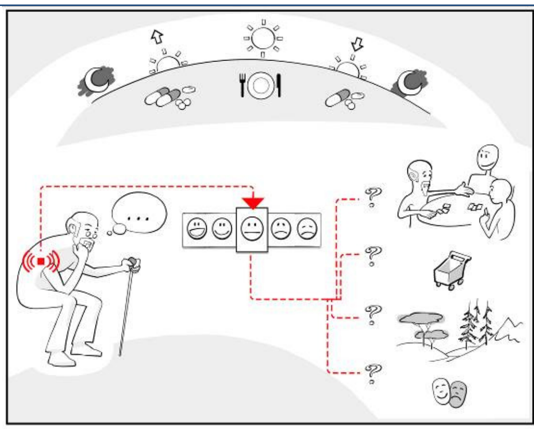
This service scenario is very important because many older persons live alone and need help to manage easily their daily life. AAL tools can help them in this direction because they could simplify the managing of house and daily activities, facilitate their interaction with other people and also supervise on their safety and alert caregivers in case of necessity.

This scenario is associable to the service areas *Compensation and Support*, and *Independent and Active Ageing*.

- ***Main needs and opportunities related to Scenario 6***

Older persons:	- To be supported in managing daily life activities. - To maintain the control over their own life.
Families, informal carers:	- To be aware always (also remotely) about the older person's status.
Service providers, formal caregivers:	- To be aware about the older person's status. - To provide the right suggestions to patients (also remotely).
Local community, society, healthcare systems:	- To maintain the activity of older citizens. - To reduce mood and behaviour crises among older citizens. - To reduce the cost of direct interventions of socio-medical workers, increasing the remote intervention of these professionals.

- ***Possible use case***



Theo (70 years old) lives alone because his son works abroad. Because of some motor problems he spends most of his time at home alone which caused some psychological problems. Last year he was often in a bad mood, neglected his health and his house, and didn't frequently contact friends. His son noticed that there was something wrong so he contacted the family doctor and convinced Theo to talk with him and a psychologist in order to understand the problems and find the right solutions.

He wanted live at his home and independently so this team of specialists together with him identified some AAL tools and services that could help to manage daily activities and allow him to retain control over his own life.

Theo's house is equipped with some smart sensors that monitor the environment and alert him when there is something wrong. Moreover, he has a smart refrigerator (which recognises expired foods and suggests healthy foods to buy and easy recipes to cook); a smart vacuum and cleaner (which autonomously cleans the house); and a smart TV (which reminds him to take drugs, to execute tasks in the house –, e.g. to wash clothes and to pay bills, – and plans events). If this network recognises a worsening of Theo's health and mood and also of the house conditions, it informs family, professional caregivers and medical specialists. Furthermore, clinicians convinced Theo to hold a 'do-it-yourself' course at the community centre (he is very good at carpentry tasks), an activity which allows him to have social interaction and improves his self-esteem.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 6

	SCENARIO 6					
TIMELINE	**Task 1** *Monitoring of house*	**Task2** *Management of house*	**Task3** *Reminder of events*	**Task4** *Social activities*	**Task 5** *Monitoring for caregiver*	
Short Term	▪ Smart environmental sensors to monitor house ▪ Ambient intelligence to recognise dangerous conditions ▪ Multimedia interfaces for remote control	▪ Smart domestic appliances (e.g. intelligent vacuum cleaner, smart fridge, …)	▪ Smart TV and other multimedia appliances ▪ Applications for reminding events, tasks and drugs	▪ Smart tools for facilitating hobbies	▪ Smart environmental sensors to monitor house and activities ▪ Multimedia interfaces for remote control ▪ Applications for remote control	**KETs**
Middle Term					▪ Ambient intelligence to recognise dangerous events and also user mood ▪ Safe data transfer	
Long Term		▪ Assistant robot				

Key actors and infrastructure of the Scenario 6

- Older persons
- Caregivers
- General practitioner / Family doctor
- Industries producing miniaturised environmental sensors
- Companies developing applications for multimedia tools to remote control the house
- Developers of multimedia tools
- Industries developing smart domestic appliances
- Companies producing robotic arms and assistive robots
- Companies developering smart tools for hobbies

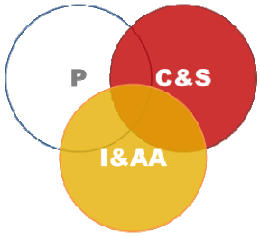
Business prospectives related to the Scenario 6

The main business sectors related to Scenario 6 are:

- Multimedia appliances and related applications
- Environmental sensors
- Smart domestic appliances
- Assistive robots for assistance at home
- Tools for hobbies

There is a high degree of uptake in the Management of daily activities and keeping control over one's own life – this scenario is closely related to Scenario 4 with the use of telecare services such as social alarms.

5.4.7 Scenario 7: Maintaining Social Contacts and Having Fun



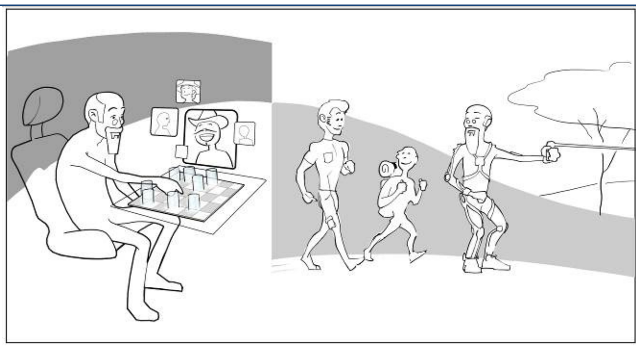
This service scenario is very important for guarantying an adequate quality of life to older persons. AAL technologies could provide useful devices (like smart facilitated interfaces, smart tools for practice hobbies, exoskeletons, etc.) able to favour the social interaction, to compensate their motor deficits and to accomplish easily hobbies and leisure activities.

This scenario is associable to the service areas *Compensation and Support*, and *Independent and Active Ageing*.

- ***Main needs and opportunities related to Scenario 7***

Older persons:	- To carry out their favourite hobby. - To contact friends and to meet new ones. - To reduce their loneliness.
Families, informal carers:	- To ensure older persons are active and less alone. - To improve the independence of older persons.
Service providers, formal caregivers:	- To facilitate the access of older persons to the activities organised by community and recreational centres. - To make elderly persons more active and social, reducing the necessity of direct visits at home. - To stay in contact with older persons.
Local community, society, healthcare systems:	- To maintain the activity of their older citizens. - To encourage the participation of senior people in the activities of the community.

- ***Possible use case***



Yvonne is 68 years old and a very active and social person. She likes hiking and alpine environments so she always spends holidays in the mountains. However in the past few years she has suffered from arthritis and so cannot easily practise her hobby. She consulted her family doctor and he suggested that she rents from a local service provider a smart exoskeleton for the upper limbs which would be able to reduce the burden on her legs, facilitating her movement.

Two weeks before her next vacation she went to the service provider centre to personalise the exoskeleton dimensions according to her body and to carry out preliminary training to learn to manage it. A technician and a therapist provided her indications to set the exoskeleton parameters according to the ground characteristics and to execute the right movements. During this training, under their supervision, she could also practise in a simulated mountain-like environment. Moreover, she installed a specific app on her smartphone that is able to communicate with the exoskeleton and, in case of problems, remotely contacts a technician and her therapist to help her manage the situation on a mountain.

Beyond mountaineering, Yvonne also likes to play cards with four friends at the community centre. However, one of them had a severe accident and cannot attend the centre anymore. In order to continue her involvement with this person, Yvonne and other friends presented her with a smart platform based on a avatar for playing cards virtually with friends located in the community centre and participating in events and activities organised by the centre.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 7

TIMELINE	SCENARIO 7 Task 1 *Facilitating sport and hobbies based on movements*	Task2 *Support for manual hobbies*	Task3 *Playing cards*	Task4 *Participation to social activities*	
Short Term		▪ Smart accessories and assistive devices (e.g. glasses, earpiece) to compensate sensor deficits ▪ Smart tools for facilitating hobbies (e.g. gardening, do-it-yourself)			**KETs**
Middle Term	▪ Smart stick and walker		▪ Smart platform to play cards based on advanced interfaces (virtual realities, avatar, …)	▪ Smart platform on advanced interfaces (virtual realities, avatar, …) to participate remotely to social activities	
Long Term	▪ Light exoskeletons for lower and upper limbs	▪ Light exoskeletons for arms and hands to facilitate fine movements			

Key actors and infrastructure of the Scenario 7

- Older persons
- Service providers
- Community centres
- Industries producing exoskeletons
- Companies developing tools for mobility (e.g. sticks and walkers)
- Developers of multimedia platforms for the remote participation to social activities
- Companies producing smart accessories and assistive devices
- Industries developing tools for hobbies

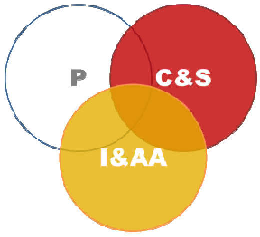
Business prospectives related to the Scenario 7

The main business sectors related to Scenario 7 are:

- Multimedia platform for remote participation to games and social events
- Exosteletons
- Smart accessories and assistive devices
- Smart tools for hobbies

Maintaining Social contacts and having fun. While recent research has shown how vitally important social contacts are for the prevention of social isolation and maintaining good health; there are few services available to elderly or disabled people living within their own homes.

5.4.8 Scenario 8: Outdoor Mobility (pedestrians, public transport, private cars)



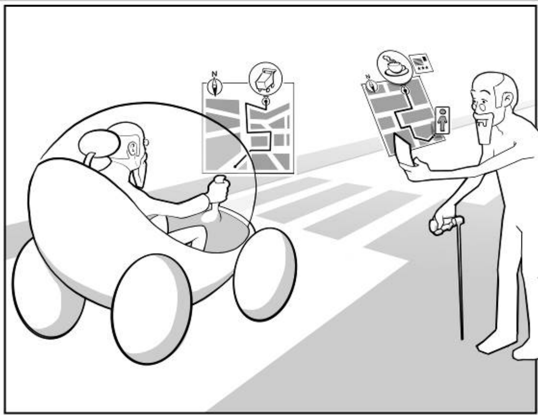
AAL technologies could develop interesting solutions useful to simplify the mobility of elderly people, like easy tools for pedestrians, smart cars helping user in driving, and accessible buses and public transports.

This scenario is associable to the service areas *Compensation and Support*, and *Independent and Active Ageing*.

- ***Main needs and opportunities related to Scenario 8***

Older persons:	- To move outdoors safely. - To have easy access to public transport. - To be supported in driving (compensating deficiencies).
Families, informal carers:	- To maintain the safety of older persons in outdoor environments. - To increase the independence of older persons to move outdoors and thus to reduce related burdens.
Service providers, formal caregivers:	- To improve the safety of older pedestrians, passengers and drivers.
Local community, society, healthcare systems:	- To maintain the safety of pedestrians, passengers and drivers. - To reduce accidents inside urban areas and on the roads.

- ***Possible use case***



Cecilia and Laura are twins (both 72 years old) with different characters: Cecilia never learnt to drive and always walks or uses public transport; in contrast, Laura likes to drive because she feels more independent when doing so.

Cecilia likes the buses of her city because the public administration had renewed them two years previous making them more comfortable: the buses have smart automated chairs, which rotate and are personalisable in height, with simplified access for persons with motor deficits. Moreover, she uses a special application on her smartphone that allows her to plan her path with public transport; to buy a ticket; to connect her with the network inside the bus; and to inform her on bus stops and other connections. Otherwise, when Cecile wants to go into the city for a walk, she consults her tablet which has a special app for planning pedestrian paths and provides information about the places and shops she can reach, weather forecasts and tourist and historic information about places to visit. She then transfers the useful information to her smartphone which, thanks to a smart hearing interface, communicates the relevant information to her.

Laura, on the other hand, has a smart automated car that makes driving easy because it is able to compensate for possible lapses of attention, as well as precision and sensory deficits (i.e. hearing). Thanks to cloud technologies, new vehicles share information about traffic, measure relative distances and velocities of nearby cars and inform other drivers around them. Laura tested this new generation of vehicles at a car-sharing provider and later decided to buy one.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 8

TIMELINE	SCENARIO 8 Task 1 *Public transportation*	Task2 *Pedestrians*	Task3 *Private transport*	
Short Term	▪ Buses and other means of transport with accessible seats (able to rotate and personalisable in height) ▪ Smartphone and applications for easily planning and managing the travel	▪ Multimedia tools (tablet, smartphones,…) and smart accessories (e.g. earpiece) ▪ Software applications for pedestrians	▪ Semi automatic cars	KETs
Middle Term		▪ Smart sticks and walkers to safely move inside	▪ Cars sensors and intelligence for compensating sensory deficits, lack of precision and lapses of attention ▪ Sensors and intelligence to acquire information from surrounding cars ▪ Cloud information processing for traffic management	
Long Term		▪ Wearable robotic solutions, i.e. prosthetics	▪ Autonomous cars (self parking, no-pilot drive) ▪ Advanced infrastructure for transportation in smart cities and rural areas	

Key actors and infrastructure of the Scenario 8

- Older persons
- Caregivers
- Public transportation
- Care-sharing providers
- Local centres for traffic management
- Companies producing multimedial tools and smart accessories
- Companies developing applications for outdoors mobility (for pedestrians, public transportation and for car drivers)
- Industries producing smart sensors for car
- Industries developing buses and other means of transport
- Companies developing smart stick and walker

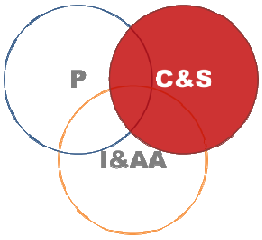
Business prospectives related to the Scenario 8

The main business sectors related to Scenario 8 are:

- Multimedia appliances and smart accessories
- Software applications for outdoor mobility
- Assistive devices (e.g. sticks and walkers) for pedestrians
- Smart car
- Accessible means of public transport
- Smart sensors for cars
- Cloud system for intelligent traffic managements

There is limited uptake to outdoor mobility services using the technologies described in this section due to services not being available in the context of the scenario. However, there is a demand for outdoor mobility which would be linked to Scenario 6.

5.4.9 Scenario 9: Avoiding Caregiver Isolation



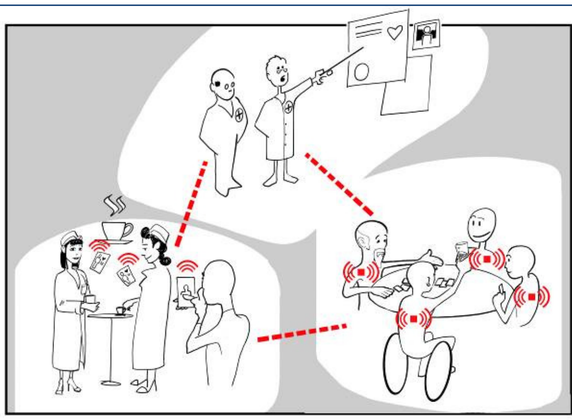
Informal caregivers cover an important role into the society but however they are often disregarded and not supported in this task. AAL solutions could be used to favour the interaction, also remote, of informal caregivers with clinicians and experts able to help them to manage easily and properly older persons and also to carry out minor task on their behalf.

This scenario is associable to the service area *Compensation and Support*.

- ***Main needs and opportunities related to Scenario 9***

Older persons:	- To receive the right care from families and informal caregivers.
Families, informal carers:	- To avoid isolation in taking care of older persons. - To be assisted and guided to provide the right care to older persons. - To have more time for themselves.
Service providers, formal caregivers:	- To easily contact informal caregivers. - To ensure care provided by informal caregivers to older persons.
Local community, society, healthcare systems:	- To avoid diseases among informal caregivers caused by care burden. - To make sure that older persons receive the proper care from informal caregivers.

- ***Possible use case***



Gerard is 50 years old and lives in the countryside together with his family. His father Nicolas (80 years old) also lives with them; he has suffered from Alzheimer's disease for five years. Initially, Gerard could easily manage Nicolas, however in the past year the situation worsened quickly and he is no longer prepared and trained to manage his father due to his physical and psychological problems and necessities. So in the past few months Gerard has been very stressed and in a bad mood and also has personal bodily health problems, probably caused by the excessive and badly-managed burden.

For this reason, clinicians looking after Nicolas introduced him and Gerard into an AAL service programme that assists both and helps Gerard to care for and manage his father. At home Gerard installed an AAL system that allows him to interact frequently with psychologists, clinicians and socio-medical workers. Periodically the healthcare professionals contact him remotely through video calls in order to assess and revise problems in caring for Nicolas. Moreover, Gerard also calls them every time he needs suggestions. Through a smart sensor network inside the house, clinicians and socio-medical workers are informed immediately about anomalous or dangerous events (e.g. Nicolas's aggressive behaviour) so they can directly contact Gerard and help him to manage these situations. Furthermore, thanks also to the sensor network and other smart electronic appliances, Gerard can have more time to himself, go away more often and engage in sporting activities because these tools carry out some minor tasks for him (e.g. cleaning the house), remotely monitor his father and also alert him promptly in case of necessity .In this way Gerard and his family are not isolated in caring for Nicolas: they have more time for themselves and are at less risk of problems caused by care burdens.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 9

SCENARIO 9				
TIMELINE	**Task 1** *Remote consulting with experts*	**Task2** *Context awareness*	**Task3** *House management*	
Short Term	▪ Multimedia interfaces and applications for remote consulting between informal caregivers and clinicians and sociomedical workers	▪ Network of environmental sensors ▪ Ambient intelligence for the recognition of dangerous events	▪ Smart domestic appliances	**KETs**
Middle Term		▪ Ambient intelligence for the recognition of anomalous behaviours ▪ Safe data transfer		
Long Term		▪ Big data management		

Key actors and infrastructure of the Scenario 9

- Older persons
- Caregivers
- General practitioner / Family doctor
- Service providers and healthcare system
- Industries producing miniaturised environmental sensors
- Companies developing applications for multimedia tools to remote control and consulting
- Developers of multimedia tools
- Industries developing smart domestic appliances
- Companied developing ambient intelligence for context awareness

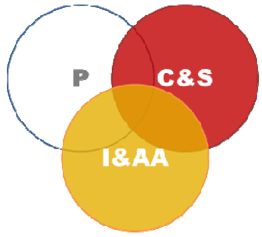
Business prospectives related to the Scenario 9

The main business sectors related to Scenario 9 are:

- Multimedia appliances and applications for remote control and consulting
- Ambient Intelligence for context recognition and awareness of behavour
- Environmental sensors
- Smart domestic appliances
- Assistive robots for assistance at home

Similar to Scenario 7, caregivers (formal and informal) can be as isolated as those under their care. The University Laval in Quebec, Canada has started a web-based group intervention for caregivers of individuals with dementia. The university's "PIANO" web platform has helped caregivers to combat caregiver isolation.

5.4.10 Scenario 10: Senior Citizens at Work



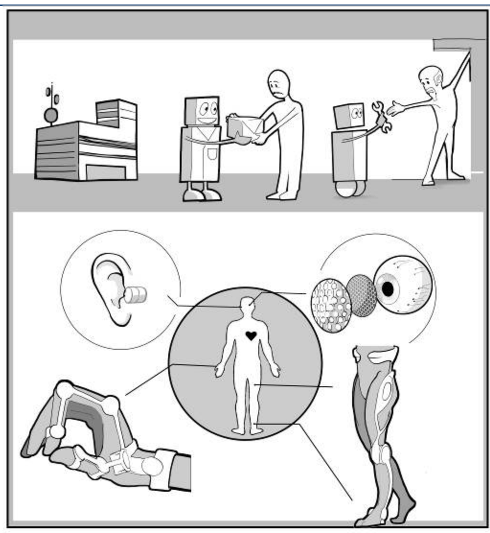
Senior working is a phenomenon which is becoming more and more common inside worldwide communities. AAL technologies can develop new working tools, like assistant robots and work equipment, able to facilitate work tasks of older persons. Moreover AAL devices can also be used to carry out preventive actions (like gymnastics) for preserving senior workers' health.

This scenario is associable to the service areas *Compensation and Support*, and *Independent and Active Ageing*.

- ***Main needs and opportunities related to Scenario 10***

Older persons:	- To be able to work longer and more safely.
Families, informal carers:	- To ensure the health of older persons, also at work.
Service providers, formal caregivers:	- To ensure the health of older persons, also at work. - To carry out preventive actions for older and younger workers.
Local community, society, healthcare systems:	- To benefit older workers' experiences and contributions to community life. - To reduce work-related injuries.

- ***Possible use case***



In the past few years more and more older persons have decided to work longer and carry out voluntary activities useful for the community. For this reason communities and companies favour the use of AAL solutions among older workers (and not only them) in their activities, because these tools can compensate for both sensory and motor deficits of workers and also support them to carry out preventive tasks (e.g. stretching and motor exercises) to reduce the risks of work-related injuries.

Two examples of such older workers are Thomas and Angela. Thomas (70 years old) paints car components professionally; during the last three years he has been helped by a robot that transports and manipulates heavy objects on his behalf. Angela (72 years old) works voluntarily at a community centre teaching other people how to paint.

To carry out this task she uses smart glasses, which show her the details of a painting clearly, and an exoskeleton for her upper limbs that compensate for tremors and help her to maintain the same position.

Both Thomas and Angela carry out periodic stretching and motor exercises using a virtual trainer; some smart gymnastic tools, which guide them in the training; and wearable sensors, to monitor their health and motor parameters.

Priorities and timeline of activities and Key Enabling Technologies of Scenario 10

SCENARIO 10				
TIMELINE	**Task 1** *Heavy work activities*	**Task2** *Precision work activities*	**Task3** *Preventive training*	
Short Term	▪ Smart work tools	▪ Smart accessories and assistive devices compensating sensory deficits	▪ On-body (wearable) sensors for health and motor monitoring ▪ Multimedia interfaces and training applications	**KETs**
Middle Term	▪ Assistive semi-autonomous co-worker robots	▪ Advanced active hand held devices compensating motor deficits	▪ Advanced interfaces, like avatars and virtual trainers, to guide the preventive motor training	
Long Term	▪ Advanced co-worker robots with high cognitive and physical interaction capabilities	▪ Exoskeletons	▪ Reasoning systems to manage work activities and prevent related risks	

Key actors and infrastructure of the Scenario 10

- Older persons
- General practitioner / Family doctor
- Companies, industries and public administrations
- Industries producing robots and exoskeletons
- Companies developing applications for multimedia tools to motor training
- Developers of multimedia tools
- Companies producing on-body sensors for health and motor activity
- Industries developing smart accessories and assistive devices compensating senro deficits
- Companies producing smart work and hobbies tools

Business prospectives related to the Scenario 10

The main business sectors related to Scenario 10 are:

- Multimedia appliances and smart accessories
- Assistive devices compensating sensor deficits
- On-body sensors
- Advanced interfaces (e.g. virtual reality)
- Assistive robots and exoskeletons
- Smart tools for working and hobbies

Due to the increase in population aged 65+ over the next 10 – 20 years, it is predicted that many elderly people will stay at work due to financial need or look for voluntary positions outside of their home to combat social isolation. If this were to fruition, AAL support services would be in demand.

5.5 Scenario Matrix: aligning segmentation, funding and business models

The real value and implementability of the proposed service scenarios depend from their roots inside the AAL market. This section shows briefly for each scenario the interested market segment, the possible funding sources and the possible business model. More details on these aspects are reported in the deliverable D3.2 of the AALIANCE2 project[8].

Scenario	Market segment	Funding	Business Model
Scenario 1: **Prevention of early degeneration of cognitive abilities**	High degree of prevention aids (support, equipment, etc.) in Urban areas and moderate in Comfortable+ rural areas. In poorer rural areas financial means for prevention is limited.	Country specific Dependent on healthcare system. Can be privately funded, reimbursed through insurance or users may have recourse to public funding	This could be either the telecare or telehealth models covered in D3.2 i.e. Spain - Telecare
Scenario 2: **Healthy living**	High agree of healthy living in Comfortable+ areas (urban and rural) as this segment does invest in healthy living. Poorer areas (urban and rural) are less likely to invest in healthy living.	Mostly Private funding in many Comfortable+ areas.	The German telehealth system (like many) makes use of equipment for preventative care monitoring i.e. weight measurements.
Scenario 3: **Management of chronic diseases**	Comfortable+ and Less Affluent (rural and urban). Many countries offer services for the management of chronic diseases.	Depends on national healthcare system. For many there is government funding or combinations of private and insurance reimbursement. There is a lot of movement towards marketing direct to the users, making some products privately funded.	The Telehealth models as described in D3.2 (UK, Spain, Germany) are the best fit models for this scenario.
Scenario 4: **Age-friendly and safe environments**	Offered to a high degree in rural and Urban areas. Prevalent in countries that allow this to be funded by healthcare system.	Available in many countries with a combination of funding (private, insurance and public).	The UK telecare model covers the range of services offered for Age-friendly and safe environments.
Scenario 5: **Fall prevention**	**Limited uptake in all sectors. Fall detection is more common.**	**Limited (but not unattainable) funding from public funds or insurers.**	**Unknown due to lack of investment and deployment**

8 http://www.aaliance2.eu/sites/default/files/files_list/AA2_D3.2_Business_Model_Analysis_rev1.4_20140314.pdf

Scenario	Market segment	Funding	Business Model
***Scenario 6:* Management of daily activities and keeping control over own life**	High uptake in countries where equipment is available for Comfortable+. For the Less Affluent in rural areas this is limited	Combination of funding (private, insurance and public). In the UK this is mostly publically funded.	The SOPHIA model best fits this scenario. SOPHIA was modelled on elderly and handicapped/disabled living within their own home as long as possible.
Scenario 7: Maintaining social contacts and having fun	Limited but growing uptake regardless of country and segmentation (Comfortable+ or Less Affluent). Currently users are reliant on landlines, mobile telephones, or internet for maintaining social contacts.	Privately funded in many countries currently. While some of the services (SKYPE) may be free	Many telecare models encapsulate customer segments including those people that would be socially excluded. See the Scottish Telecare Programme board, SOPHIA
Scenario 8: Outdoor mobility	Limited uptake due to services not being available.	Unknown – however could be a combination of private and public funding.	Unknown due to lack of investment and deployment
Scenario 9: Avoiding caregiver isolation	Limited but growing market. Will grow as services become available similar to Scenario 7.	Unknown	SOPHIA specifies caregivers and family/relatives (informal caregivers).
Scenario 10: Senior citizens at work	Forecast – increased uptake more prevalent in areas where seniors need to work in order to maintain lifestyle.	Forecast – private funding by employer with possible funding support from government.	Unknown due to lack of investment and deployment

6 Key Enabling Technologies

Key enabling technologies (KETs) are considered to be possible drivers in guiding EU policy for growth and attaining responsiveness to societal challenges, industrial leadership, sustainability and excellence in science. They are the basis for the development of ambient assisted living (AAL) systems and services, that typically comprise sensors ("Sensing"), IT components that process the sensor data and derive conclusions ("Reasoning"), human–machine interface components ("Interacting") and actors that execute actions initiated by the system, such as switching lights on/off, or raising an alarm in the case of an emergency ("Acting"). Obviously the different system components need to communicate with each other in order to provide the overall assistive service for which the system has been designed ("Communicating").

6.1 Sensing

This section debates the "sensing" aspects of AAL services and the new sensing principles and technologies that are needed to meet future sensor requirements. In particular, "sensing" is related to all devices and systems able to measure physical, chemical, electrical, optical, etc. quantities of a phenomenon and to produce an output related to that quantity. A sensor with built-in processing capabilities and embedded with a network interface is usually called a "smart" sensor. These smart sensors will progress, in terms of cost, power consumption and functionality, at rates similar to those experienced by other integrated circuits, such as microprocessors and memory, because they use much of the same technology (Frank, 2000). The research and development of sensors are very wide and complex and reserve many technologies for various AAL applications.

6.1.1 Application Field of sensing technologies

Before delving into technology solutions, it is worth discussing the type of information needs to be sensed. For this it is worth considering the situation at the beginning of 2013 in the three market areas that define AAL – telehealth, smart homes and telecare.

Telehealth is changing the way healthcare is delivered and consumed. It gives patients the tools to manage their health, extends services to rural areas and enables specialists to intervene in real time (NTT Data, 2014). Telehealth focuses on gathering biometric information, related to healthcare, wellbeing or lifestyle management, through specialised peripherals, which work in a system to capture a reading, send the results, store the results and represent the results over time. Sensors are customised, based on the health condition being monitored, but can include a blood pressure cuff, a glucometer, thermometer, weight scale, spirometer, pulseoximeter, peakflow monitor/spirometer, ECG and coagulation meter.

While wellness and lifestyle products are not clinically approved, they do suggest the direction in which sensing will develop. Non-clinical sensors for pulse rate, pedometers and respiration are increasing in common use together with smart phone applications where data is captured and represented similarly to telehealth solutions, but with the end user as the target user of the data instead of a medical practitioner.

In the future, sensors are likely to be ingested or worn on the skin for extended periods to supply clinical monitoring of specific conditions, such as the amount of chemicals in the blood stream. Information about real-time or near-real-time chemical concentrations in the blood could work with similarly ingested medication release systems to adjust dosages based on the person’s chemistry (Inmann&Hodgins, 2014).

Smart homes are more traditional in sensing the physical state of an enclosed area (Li, 2012). Traditionally they monitor movement (motion detection), gasses (CO, Smoke), entrance/exit (door entry), heat and water. In addition to monitoring, the solutions also include remote actuators to perform simple tasks like opening curtains and turning electrical equipment on/off. More recently, innovations have occurred around the holistic monitoring of the home electrical grid and usage. With the EU push to deploy smart metering for electrical systems across the EU by 2020, mass deployment of smart electrical meters is underway.

Telecare, in its simplest form, is a home gateway for automated and actuated alerts that are often life threatening. It is the life threatening aspect that has shaped the industry more than any other. Telecare is a service contract, typically twenty-four hours a day seven days a week including holidays. If an alert is raised a response happens. This requires systems to typically have redundancy in place to ensure operation in adverse conditions.

As AAL evolves it is likely that the clinical/non-clinical and life critical/non-critical will be managed together in an accountable manner that will result in a “user support cloud” (Xu &Zhong, 2014). Information will be collected by a number of disparate sensors, aggregated by different hubs and shared to create holistic views of the individual, his or her surroundings and the interactions between people and things. The degree of complexity is conceivable today but the scale implementation of this type of solution is difficult to achieve.

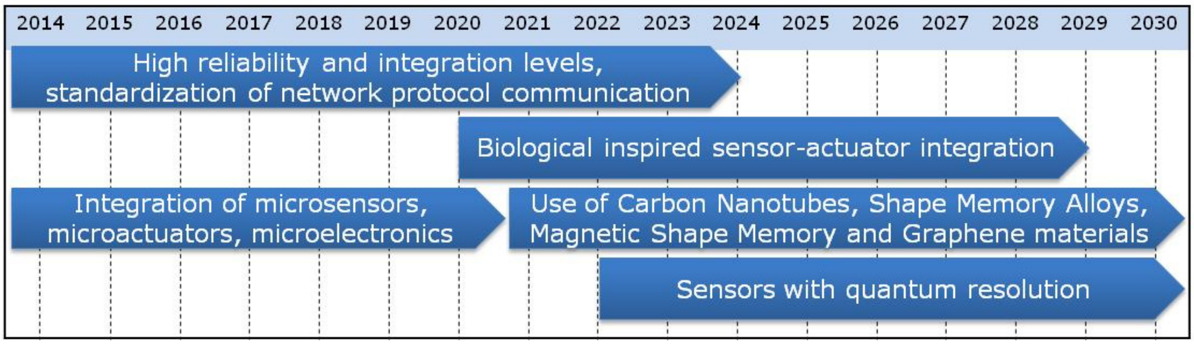
6.1.2 General sensing technologies

Smart sensors are intelligent systems that exhibit the integration of the sensing element with an electronic circuit that supports data storage, and computation and communication software at the chip level. They can carry computation capability that enables on-chip data processing, are capable of detecting and triggering selected events and performing self-diagnostics, self-calibration and adaptability. In the future, the main challenging developments of smart sensors will be concerned with the utilisation of new materials, i.e. Micro-Electro-Mechanical Systems (MEMS), miniaturisation entailing reduced mass and power consumption, high reliability and high integration levels, and the standardisation of network protocol communication. Smart sensors working autonomously or as part of a sensor network can expand from the relatively simple tasks of monitoring the consumption (and generation) of buildings (electricity, natural gas, water and the like) and monitoring for gross signs of life (motion detection, door movement, sounds) into the finer areas of consumption, energy use and the elimination of individual people.

MEMS are micro system-based sensors for the mechanical, optical, magnetic, and chemical measurements that are produced through the techniques of micro fabrication. MEMS provide potential benefits for future sensor technology, including miniaturisation, increased reliability through redundancy, reduced costs and the potential for development of smart sensors. One of the challenges of MEMs is to integrate microsensors, microactuators, microelectronics and other technologies onto a single microchip. Moreover, in the future, different materials, such as carbon nanotubes, shape memory alloys and magnetic shape memory materials will have to be put onto silicon. Then graphene materials could be used as MEM materials (iNemi, 2013).

The exquisite control and design of **quantum systems** (atoms and photons) at the almost unimaginable level of single particles has become reality in the last decades, as testified by recent Nobel prizes (e.g. 2012). In a fast approaching future, the already emerging, quantum properties will come out of labs to be exploited in a number of different practical applications. Quantum cryptography has already passed the proof-of-principle phase and has been pushed to the industrial market. Quantum sensors are devices that make use of peculiar but fragile quantum correlations and entanglement to achieve sensitivity and resolution that cannot be reached through classical methods. Indeed, even tiny perturbations of the surrounding environment can deeply influence and distort a quantum state, which in turn affects the outcome of, e.g., interferometric measurements. This paves the way for applications in bio- and magneto-/electro-sensing at lengthscales down to a few nanometres.

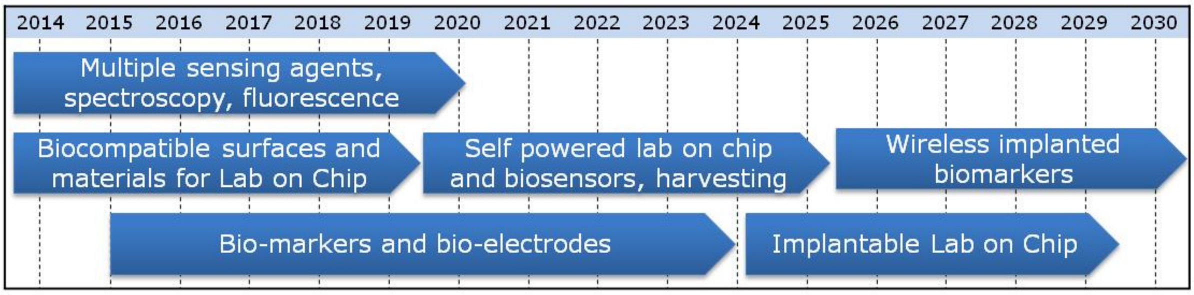
Roadmap 1: *Smart Sensors, MEMs, Quantum*



One or several laboratory functions can be integrated on a single chip of few squared centimetres. Thanks to **lab-on-a-chip** it is possible to handle very small volumes of liquids, allowing faster analysis, high-throughput analysis and reduced costs (Daim&Suntharasaj, 2010). Future developments will allow a self-powered lab-on-a-chip, so allowing power and sense/analysis combined. Lab-on-a-chip should be integrated into biocompatible surfaces or materials, including also small packaging to make them wearable or implantable and less intrusive. Moreover, whispering-gallery mode (WGM) resonators could be applied to lab-on-a-chip together with other technologies. Lab-on-a-chip systems can revolutionise point-of-care medical testing and diagnosis by making testing and diagnosis fast, cheap and easily accessible.

Biosensors are analytical devices composed of a biological component and a physiochemical detector used for the detection of an analyte. In future, biosensors will be able to harvest the necessary energy from external (environmental) sources, so it will be possible to have wearable or implanted biosensors. Future developments will move towards human inspired sensors and biologically based sensors. Moreover, new biosensors will also integrate actuators so that active and sensing parts will be coupled.

Roadmap 2: *Lab-on-Chip,Biosensors*

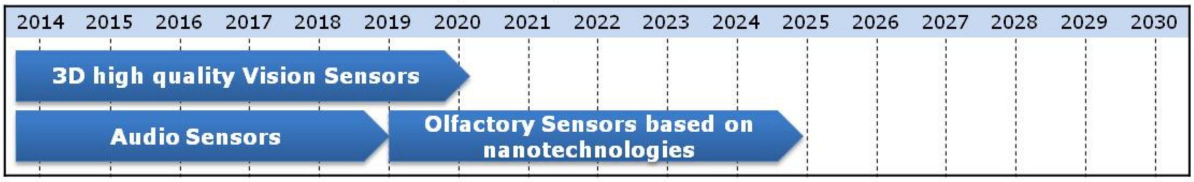


In future, through **vision sensors,** it will be possible to extract useful information from the geometry of visible surfaces, also capturing colour and depth images simultaneously, and interpreting 3D coordinate data. Vision systems will be improved at a micro level, increasing the quality of the images. Starting from quantum optics, quantum imaging will be studied developing sensors with a higher resolution and other imaging properties not achievable from the classical optic. This kind of sensor targets automated recognition and the raising of the alarm of critical situations (like falls) also using real-time processing. They could be used for the tracking of elderly persons at home. This real-time information has been exploited for incident detection (e.g., fall detection, personal immobilisation), and the instantaneous raising of the alarm with concerned parties.

In recent years, many academic and industrial research groups have designed hearing aids, both wearable and implantable, that could compensate hearing deficits, distinguish and recognise sounds and help older persons to live normally. The important challenge related to these devices is the development of **smart audio sensors**, with reduced dimensions and requiring low power supply, able to capture sounds, elaborate the signals on-board and transmit them to the human cochlea without distortion. Furthermore, acoustic sensors are relevant in AAL also for the discrimination of environmental sounds and the recognition of abnormal conditions, like behavioural crises or the presence of strangers inside the house.

Olfaction is a very important sense that provides much information about the environment and ongoing events (D'Amico & Di Natale, 2014). At the same time, this human and animal capacity is very complex to replicate in miniaturised devices. In recent years, many researchers in the ICT field have focused on developing **smart olfactory sensors** able to capture and distinguish odours. These tools have also an important role in AAL because, applied to older persons, they could provide information about the status and quality of food and home security.

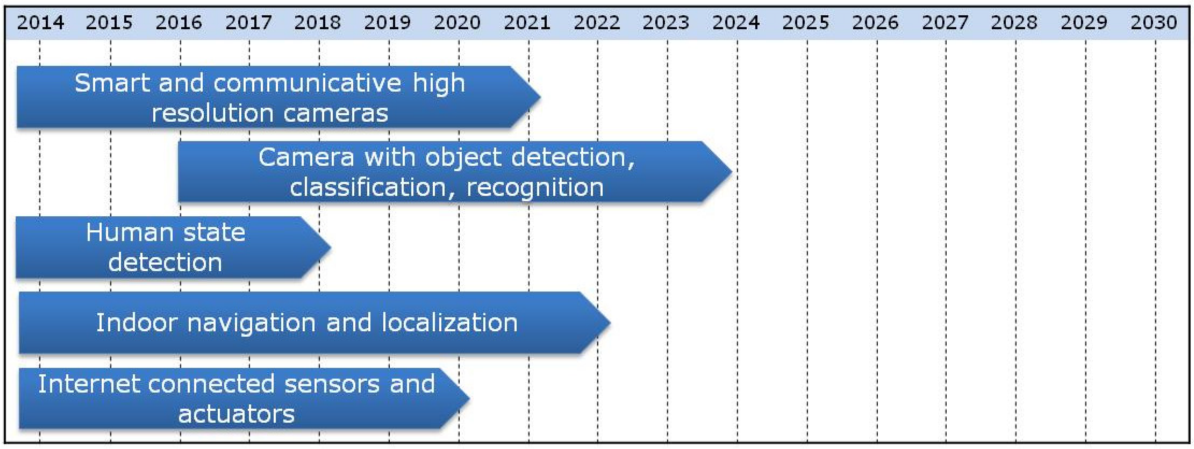
Roadmap 3: *Vision, Audio, Olfactory Sensors*



6.1.3 Environmental sensors

Environmental sensors consist of pervasive sensor networks able to provide widespread computing and sensing capabilities in order to create smart environments that can sense, process and act by considering input coming from both people and devices. R&D trends in this important class of enabling technologies include the development of new families of contactless sensors, such as 3D CMOS image sensors. In surveillance and reconnaissance applications, CMOS image sensors are able to extract visual information from the geometry of visible surfaces, interpret the 3D coordinate data and capture both colour and depth images simultaneously (Suntharalingam V. et al., 2009). One example is the Microsoft Kinect motion sensor that was released at the end of 2010 for use as a game controller for Microsoft's 360 game terminal. The infrared projector and camera of the sensor make it possible to sense the observed scene and track the movement of individuals in three dimensions. Kinect-based, real-time, 3D tracking is a new approach in AAL applications. Many solutions have been presented that are built using the Kinect motion capture system. One example is JózsefPálfalvi's (Pálfalvi J., 2011) exploration of how the Kinect camera can be applied to AAL systems and to design an application which can solve basic AAL tasks, such as fall detection, gesture recognition and ADL activity recognition. This is just one example as many projects have used the Kinect motion capture for AAL proof of concept.

Roadmap 4: *Environmental Sensors*



6.1.4 Personal Sensors

In the field of human activity (Logan B. et al., 2007) and status recognition, we can distinguish systems that use wearable sensors with sensors mounted in the environment, like cameras or motion sensors. In 2013, with the wide spread use of smart phones and tablets, it is obvious that wearable sensors are spreading due to the technological improvements in miniaturisation and energy consumption and will help expand the physical space that can be monitored. These sensors are useful in an AAL context, because they enable continuous monitoring of various physiological and biomechanical parameters while balancing invasiveness and comfort (Ranck, 2012).

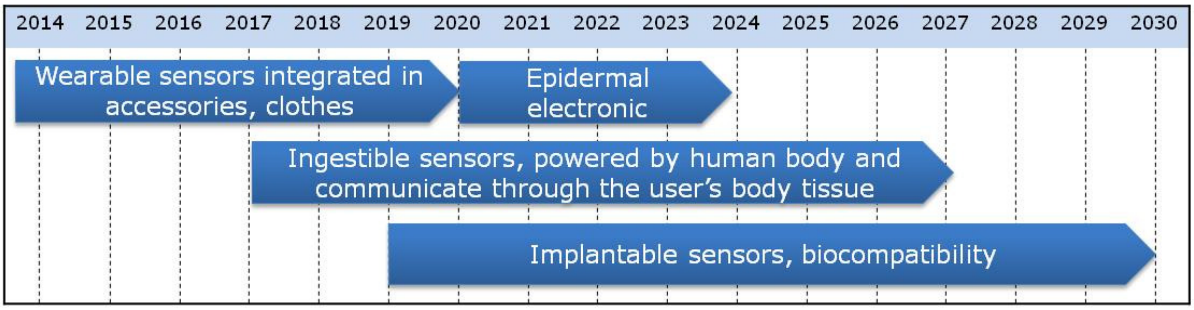
Wearable sensors are common today with most coming from the mobile phone and the wellness industries. They are systems with physiological, biochemical and motion sensing capability that allow patient status diagnostics. They are typically worn on the body or endowed in clothes, but in the future they will be more and more integrated into accessories (glass, jewels, shoes, etc.) and printed on or attached to the skin (tattoo). A crucial role will be played by the advancement in miniaturisation and long life duration of batteries and in the development of a wireless body network with low power consumption and high data rate (UWB). E-textile based systems for clothes will include electrodes and printed conductive elastomer-based components in the fabric. In future, a variety of wearable devices should also interface wirelessly with home sensors, assistive robots and cloud platforms, providing not only status diagnostics and monitoring but also some measure of prediction. Furthermore, wearable sensors will be interoperable with bio-feedback systems to facilitate human–machine interaction. Finally, so-called "epidermal electronics" are demonstrating that new kinds of sensors, based on ultrathin electrodes, electronics, sensors and wireless power and communication systems, could be attached to the skin and record and transmit electrophysiological measurements for medical purposes with limited perceived invasiveness. This technology was described as similar to a child's temporary tattoo, where a flexible circuit board was attached to an elastomer backing and transferred to the skin. In

2011, a paper published from the University of Illinois explained the methodology for creating an electronic system that has properties matched to the epidermis for bending stiffness, effective elastic moduli and areal mass density (Kim D.H., et al., 2011). In 2012, the same research team presented further developments that enabled the circuit to be printed directly onto the skin, removing the elastomer to increase comfort (Kim D.H. et al., 2012). Energy harvesting and power management also represent a challenge in the field of sensors. In 2013, the consumer electronics industry was buzzing about smart watches with rumours that Apple, Microsoft and others were actively developing wrist-worn smart watches (Windows Smart Watches, 2013). Not to be left out, Google has launched a public beta development for smart glasses with the Google Glass project (Google Glasses). Ideally, devices for AAL would be unobtrusive, have a functional life of at least weeks and be difficult or impossible to forget to wear.

Ingestible sensors are systems integrated into ingested devices, i.e. pills, which are conceived to be powered by the human body and communicate through the user's body tissue. These sensors foresee the control of food, weight, physiological parameters, body position and activity, favouring users sustaining healthy habits, families making better health choices and clinicians providing more effective healthcare services. In conjunction with the wireless infrastructure, ingestible sensors represent a new standard for influencing medication adherence and significantly supporting chronic disease management (Proteus Digital Health, 2012).

Further challenges are represented by **implantable sensors**: in this case they have to be biocompatible and have low invasiveness (high level of miniaturisation). Implantable sensors allow parameters to be continuously monitored, but they also need to have optimal data transmission and power management. In 2013, a new sensor was announced that looks like a small coil. The device, measuring only 4 millimetres in diameter and 500 microns thick, can be attached to commonly-used orthopaedic musculoskeletal implants. Once implanted, the sensor can monitor and transmit data about the load, strain, pressure, or temperature of the healing site of surgery. The device is passive, i.e., it is not actively powered; and works with an external coil that inductively energises a coil in the implant allowing it to transmit data, much in the same way as an RFID reader energises a passive tag (RPI News, 2013).

Roadmap 5: *Personal Sensors*



6.2 Reasoning

Reasoning is the enabling technology that allows to convert data acquired from sensors in information about the status of elderly user, environment and AAL system, information that could be used by users to execute and improve the service and to activate adequate tasks for the current and future conditions.

The main proprieties related to the reasoning are: sensor data collection and processing, modelling of events for the recognition of status and contexts, prediction of possible events and conditions, learning from the surrounding information, activation of actions and alerts.

Several challenges should be faced in the next years to improve reasoning for the next generation of AAL services.

6.2.1 Context Awareness and Sensor data fusion

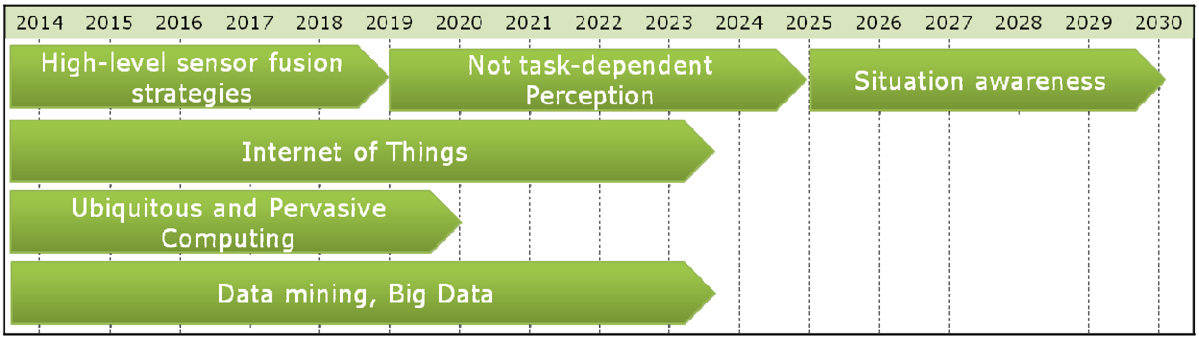
The new generation of AAL services should be characterized by the use of "smart" adjective, feature that should be obtained making AAL systems aware about what is happening and able to recognize events and conditions. The reliability in identifying contexts and status is strongly related with the capability of acquiring and integrating information from different kinds of sensors and sources that allow to have more details about the context. This propriety, called "sensor fusion", is fundamental for the new AAL services and tools and in the next years many efforts should be put in this direction.

Smart environments: AAL systems should be able to integrate and elaborate information coming from surrounding sensors (body sensors and environmental sensors) in other to provide advanced, appropriate and optimum service solutions and make elderly persons living and working inside a "smart" environment.

Internet of Things, Ubiquitous and Pervasive Computing: according to the specific complexity of the services, AAL tools should go beyond the physical surrounding environment and take in consideration also information accessible by internet and coming also from other related contexts. This approach is known as Internet of Things and Ubiquitous and Pervasive Computing.

Cloud Computing: in the future, AAL services will take advantage from Cloud Computing, in which the actions of an AAL device will be guided not only by information coming from sensors but also from other servers and computational units that are connected to the web network and process data coming from other sources.

Roadmap 6: *Context Awareness and Sesor Data Fusion*



6.2.2 Artificial (quasi-Human) Intelligence

The society needs a concrete and effective support from AAL services and devices in assisting both elderly citizens, making them more healthy, active and independent, and caregivers, facilitating their work in monitoring senior status and executing appropriate support actions. For this reason AAL systems should be characterized by advanced reasoning capabilities that could be defined "Artificial (quasi-Human) Intelligence".

Advanced recognition of human inputs: this request implies that AAL system should be able to recognize and comprehend situations and contexts from natural inputs expressed directly and indirectly by the users.

- *Voice & Speech*: understanding of words expressed also in slang, identification of the subject-speaker and comprehension of the semantic meaning of sentences.
- *Images and body gestures:* understanding of body language.
- *Emotions*: recognition of emotions and moods for the comprehension of the real user status.

Models & Learning: the daily life of persons is mainly characterized by dynamic events, having multiple possible consequences and often unpredictable, because of the involvement of different agents/actors. So reasoning technologies in AAL domain should evolve to understand tasks and status not only by using static rules and patterns (*context-modelling*),that associate specific inputs to a specific modelled contexts, but also dynamic and reactive models that take in consideration also complex information, like the behaviour of involved users, extract the main information (*Data mining*) and update the same models (*learning machine*).

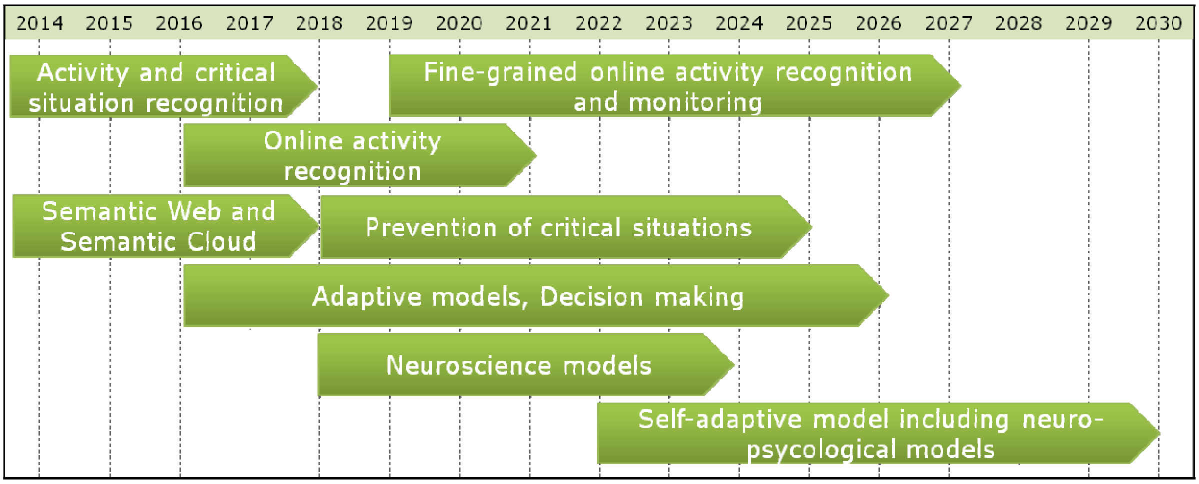
- *Machine Learning and eLearning:* to be really effective, AAL systems should have reasoning capabilities, going beyond the classic forms of machine learning and integrating at the same time different approaches such as *Reinforcement Learning* (learning from the world observation), *Learning to Learn* (learning from previous experiences), *Developmental Learning* (learning from the world exploration) and *e-Learning* (learning from web and information technology).
- *Semantic Web and Semantic Cloud:* the semantic web enables machines to interpret and process information in the World Wide Web in order to better support humans in carrying out their various tasks with the web. For the new generation of AAL services it is necessary to implement both Semantic Web approaches and more advanced one called "Semantic Cloud" that will include also data coming from other connected networks of sensors and services. These data should be used in machine learning phase to update the context models.

Prediction: this advanced aspect could allow to recognize activities but also to predict possible and probable status and contexts and also to provide support in decision making. This property is fundamental in AAL services to anticipate possible negative events and conditions and act in order to avoid them.

Decision making: this capability is very important for informal caregivers, like family members, that are not socio-medical experts but often should decide how to act in critical situations of their relatives. AAL system should support them in making a resolution especially during critical events.

Neuroscience-inspired Control: neuroscience studies the functioning and control strategies of human and animal being; these researches show continuously how nature is able to be effective and efficient obtaining the target-object with an optimized use of the resources. AAL systems should draw inspiration from these neuroscience approaches in order to improve the effect of the service and optimize the energy and force use.

Roadmap 7: *Advanced Intelligence*



6.3 Acting

The applications of robotics in AAL systems aim to meet the physical and cognitive needs of disabled and elderly persons. Systems and services, which proactively act to prevent, compensate, support, provide well-being and increase the independent living of senior citizens or disabled people in an assisted environment, revolve around technological aspects that could be identified as enabling technologies. More appropriately, these are sensor-motors, actuators and other agents that could perform concrete actions based on their perception of the environment, on behalf of and emotionally for their users and on information gathered by some other device and/or background knowledge.

6.3.1 Application Fields of acting technologies

The "acting" technologies address social and medical applications, mainly within the healthcare and consumer market of robotics, with specific reference to such societal problems and market opportunities as advanced service and social robotics in support of ageing, independent life, work, social innovation, inclusion, etc. These markets are dominated by different customers, such as single citizens, elderly persons, their families and carers, and involves also public and private service providers, voluntary associations, shopping service stores, enterprises producing technologies, IT infrastructure developers, policy makers, insurance companies, public administrations, standards organisations, etc.

The economic think-tank, McKinsey Global Institute, stated that advanced robotics is in the top five of disruptive technologies that will transform life, business and the global economy, stating that the impact in 2025 will be higher than the current PC market. An important new industry will be products and services to support assisted living by companion robots and Europe has to play a leading role in this global new market (Manyika et al., 2013).

Robotics for AAL applications address the fundamental issues of creating a new class of companion robots, working with people and for people in their different activity sectors, such as when they need care in old age, when they need help in flexible manufacturing on the factory floor and in leisure pursuits. The key difference and step-change is getting robots to interact with humans intuitively and safely. This requires new thinking and robotic engineering that treats humans as intentional agents and not just as objects to be manipulated or elements in the world. This demands new kinds of AI – socially intelligent AI – as well as exploiting and advancing new materials and ICT architectures and infrastructure for both intra- and inter-communication with other relevant internal and external infrastructures.

Robots will then be connected with other devices and appliances used in everyday life, such as smart environments, wearable watches and eyeglasses, through Internet connectivity, thus multiplying exponentially their capabilities and abilities (World Economic Forum, 2014). This will drive towards an integrative approach of science and engineering to overcome the bottleneck affecting traditionally engineered mechatronic modular systems that are currently built as sums of components. Advances in functionalities should be pursued together with the definition of new strategies and approaches, aiming to endow new robots with highly integrated sensory-motor architectures and morphologies exhibiting computational capabilities, with the ultimate goal of significantly reducing control complexity and simplifying the overall system design, with beneficial effects in terms of system efficiency and dependability, as well as safety for the user, and adaptive physical and behavioural human–robot interaction/collaboration.

6.3.2 Service Robotics

Future service robotics will be machines that will primarily help and assist elderly people in daily activities at home, in their workplace and in other environments. They will be able to perform a multitude of roles thanks to their capabilities to act and interact physically, emotionally, socially and safely with humans, providing for an improved quality of life.

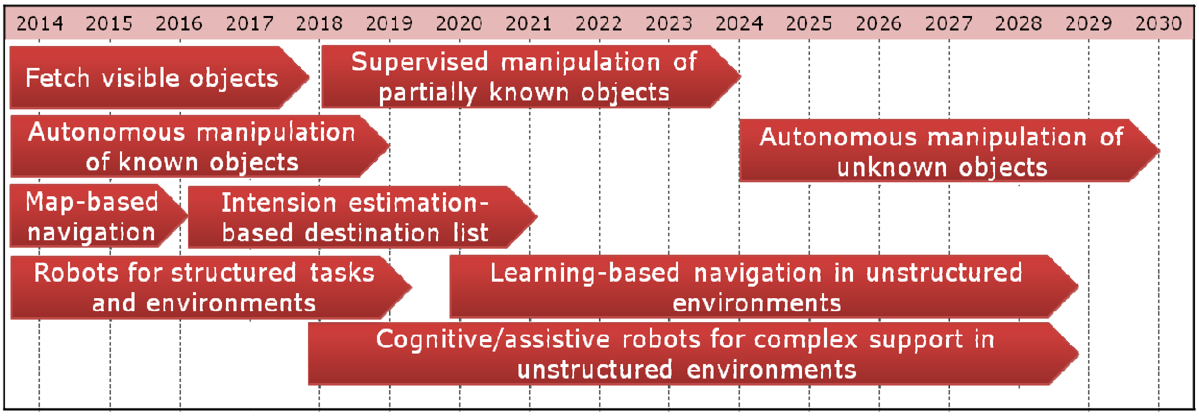
Manipulation – Manipulation makes service robots able to interact with and change the environment, for instance by grasping, manipulating and moving objects. In the future, service robots should be able to lift and transport heavy objects, assemble artefacts and manipulate different kinds of objects. Furthermore, dexterous manipulation will involve the ability to discover how to hold and move unknown objects, or the ability to match two objects together in specific ways. To be employed in AAL services, robots should be able to:

- transport objects, including heavy items, for long periods;
- reach impracticable sites in domestic and outdoor spaces;
- safely grasp and manipulate objects both knowing and ignoring their shape and weight;
- move safely with impedance and compliance control because of their presence in the environment and interacting with humans.

Navigation Indoors and Outdoors – Service robots should work with one or several persons in every context, they should be designed to move over unstructured and irregular ground (including wet or icy ground), go up/down hill, recognise obstacles present along the path and change their path in order to avoid them. They should be able to move both in indoor and outdoor environments and, for this reason, GPS components or other localisation services for dynamic environments should be installed in the robots. In this sense, the information exchange between the robot and the smart environment will be fundamental for navigation and mobility in every kind of environment, in order to give the robot awareness of its position with respect to the obstacle and other elements. Moreover, the smart environment should be able to perceive and recognise static and dynamic objects, in order to provide efficient planning and navigation status. Moreover, the implementation of motion-control strategies based on neuroscience models will enable robotic systems to behave like humans.

Perception – A robot system uses sensing and perception to gather information about its own state and the surrounding environment. The future challenges are: to manage a large amount of data, to improve perception algorithms to formalise sensor data for internal representation and to take into account the social affective aspects and emotions in the interaction process with human beings.

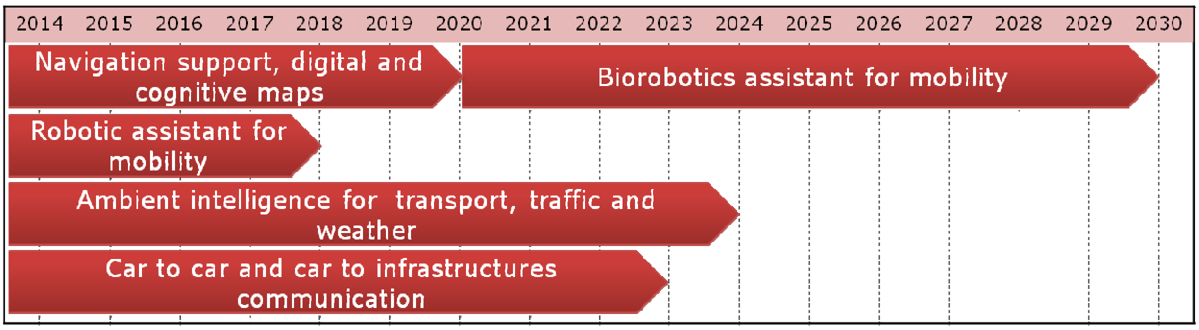
Roadmap 8: *Service Robotics*



6.3.3 Mobility

Smart mobility services enhance the independence of ageing persons by providing mobility support in terms of smart public transport, smart driving systems and portable devices with positioning and navigation assistance. Enabling technologies have to efficiently switch between indoor and outdoor localisation modes, in order to achieve a great level of personal localisation in the same devices. Public transport should be reorganised, both from the technological and organisational points of view, in order to become more alluring to and usable by end users, especially elderly and disable persons. A drive assistant should be able to assist during normal driving, preventing car crashes and reducing possible damage to passengers and other people. The prevention of car crashes could be pursued by alerting drivers in the event of critical conditions, such as reduced attention and abnormal motion variations; assistance during normal driving, instead, concerns automated parking, trip planning, facilitated control and car monitoring.

Roadmap 9: *Smart Mobility*



6.3.4 Smart Actuators

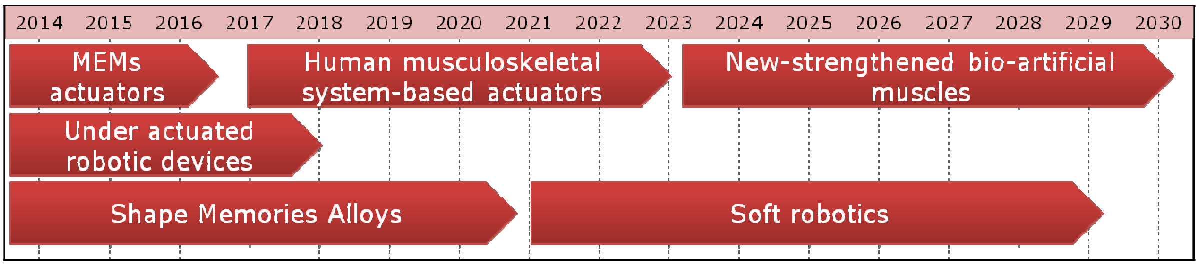
Smart actuators are techniques to generate force and torques. Future Robotic devices should have regenerating structures and a self-reassembly architecture.

MEMS – Micro electro mechanical systems (MEMS) are techniques for creating electromechanical devices with micro- and nanometre features, developed to exploit and adapt micro fabrication processes. In this way, in the future, there will be a positive emergence of applications in bio-actuators and smart biosensors with potentials in the fabrication of micro and efficient artificial muscles, fully integrated with bio-actuators and other micro and nano applications.

Shape Memory Alloys – In the future, actuators should be miniaturised and should reach high mechanical performance, comparable to traditional electric motors, in a limited space; to achieve this purpose, the main requirement is for actuators to be light and compact.

Soft Robotics – Soft robotics explores unconventional materials and their implementation in robotic agents and provides novel scientific concepts and contributes to understanding embodied intelligence. Furthermore, soft robotics will have a significant impact on robotic devices and on novel electronics, such as soft circuits and power supplies.

Roadmap 10: *Smart Actuators*



6.3.5 NeuroRobotics

NeuroRobotics develops technological solutions in which electrical signals produced by the brain could be connected to computers. In this way, neural signals could be used to directly control prosthesis and provide feedback to users.

Non-invasive techniques must improve in efficiency and wearability; invasive techniques should reduce the associated risks of surgery, develop biocompatible electrodes and record stable and durable signals in the long term. Furthermore, the size of the equipment should be reduced and communication improved to make the systems wireless and portable.

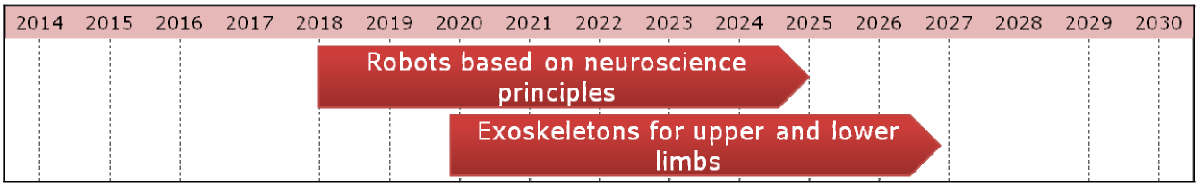
6.3.6 Wearable Robotics

Wearable robotics could replace or assist humans during ADL tasks. In general, they can be classified as offering services to the upper limbs, the lower limbs or all limbs.

They could be classified based on the nature of the service offered to the wearer: orthosis (exoskeleton), prosthesis or enhancing human capabilities.

In all these applications, robotic devices have to work closely with the human body. A number of challenges (Mohammed S. et al., 2012) still need to be solved and future studies will address issues such as safety, interaction between the wearer and the device, interaction between the device and high-level network architecture for continuous monitoring and cognitive control. In addition, health management control and energy storage are crucial technologies for successful portable wearable devices. New smart actuators will be engineered in order to fit a high number of actuators with high efficiency and low power consumption. Further, new algorithms for cognitive and behavioural control should be implemented.

Roadmap 11: *Wearable Robotics, Neurorobotics*



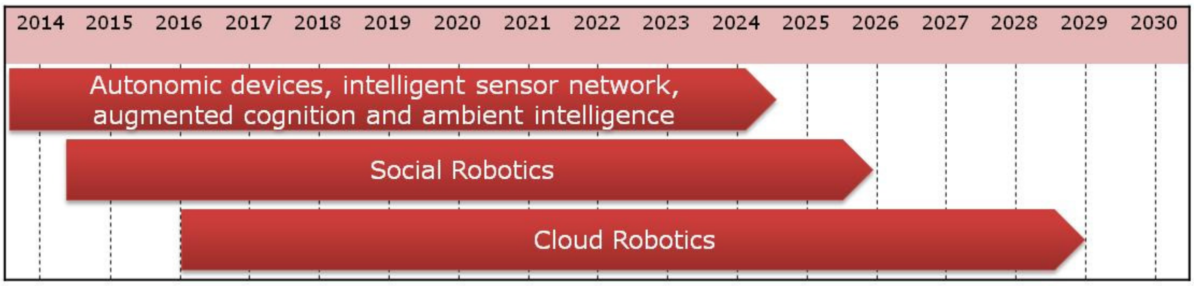
6.3.7 Smart environments and Ambient Intelligence

Future AAL service scenarios are strongly correlated with the concept of smart homes, smart environments and smart cities. According to this technological vision, sensors and actuators present inside private and urban environments should communicate among themselves and with other components set in the cloud in order to act efficiently, providing useful and accessible services also to older citizens. This coordination among devices can help also to optimise power consumption, a very important factor in energy sustainability and for the welfare of society (IEA, 2011), (TTC, 2012). For this reason, several industries developing electronic appliances are working strongly to innovate their products and make them more "smart" and able to communicate each other and cooperate to accomplish services. Furthermore, environmental automations should also evolve in order to be easily adaptable and installed inside existing environments, to manage power consumption efficiently and to also manage information from external components to improve and optimise services.

6.3.8 Cloud Robotics

Cloud robotics is the integration of different agents that allow efficient and improved cooperation between robots, smart environments and humans, to provide useful and high quality services to citizens. Cloud robotics will introduce some important benefits to robotic applications over traditional robotics (Ren F., 2011): offloading computation-intensive tasks to the cloud, accessing and sharing a vast amount of data, accessing and sharing knowledge, sharing of capabilities and information acquired, increasing storage, exploiting the capabilities of mobile robots to have a greater exchange of information with the environment and reducing the cost of a single robot. It allows the deployment of inexpensive robots with low computation power and memory requirements by leveraging on the communications network and the computing resources offered by the cloud infrastructure. Applications that can benefit from the cloud-robotics approach are myriad and include SLAM, grasping, navigation, monitoring, intrusion detection and surveillance. Cloud robotics has some technical challenges, related to the amount of data exchange, the delay deadline to complete the task, the allocation of the correct virtual machine in order to optimise the execution of the offloaded tasks and the decision to consider whether it is more advantageous to execute the task within the network or with a standalone robot (Hu G. et al., 2012). The communication challenges are also a key point of cloud robotics, because packet delivery failures and communication outages are inherent in any wireless communication system. Strategies and research have to focus their resources to develop faster and safer communication modalities in order to prevent the loss of important data and support the exchange of a large amount of data. It is clear how the use of standard protocols in this context has become a key point, allowing each robot to easily communicate with the cloud. Trust and security issues are major considerations in cloud robotics. A robot needs trust to launch task delegation on a public cloud, especially when the computation and network traffic incur monetary costs. The computing environments in the cloud should be verifiable by a user or a trusted party, e.g., to ensure there is no hidden or malicious code running besides the delegated tasks. Moreover, confidential data, logically private to clone devices, may be stored in the public cloud storage. Therefore, strong integrity and confidentiality protection are needed to secure application data.

Roadmap 12: *Smart Environments, AmI, Social and Cloud Robotics*



6.3.9 Social Robotics

The field of socially assistive robotics has recently became popular due to the potential to enhance the quality of life for broad populations of users, such as elderly, individual with physical impairments or in rehabilitation therapy, individuals with cognitive disabilities and social disorders. They are conceived to be employed at home, in residential structures, in town or city, in public spaces, etc. A social robot is an autonomous / semi-autonomous robot that interacts and communicates with humans or other autonomous physical agents by means of social behaviors and rules. The main feature of these robots is the social ability to "naturally" interact with humans with lifelike social behavior. The heart of the social robots' effectiveness is the physical embodiement and the capability to understand social signals from humans and appropriately respond. In future, social robots will act as companions that are able to interact with humans by adapting their conversational and behavioural duties in response to the signals that they detect on the part of the human. Furthermore, social robots will be also able to learn from and cooperate with humans not only for exchanging information each others, bur also for physical interaction.

6.4 Interacting

The term "interacting" concerns all kinds of means, both software and hardware, that allow the interaction process between the user and the service/machine. Generally, these tools are also called human–machine interfaces (HMIs). In AAL services, the interfacing technologies work as a bridge between the capabilities of the user and the AAL system accomplishing the services. In the last century, the progress in the ICT field also pushed the exponential growth in the interacting sector. Several complementary interfacing solutions were developed using different kinds of technologies and thinking for different methods of use.

This section discusses some of the main challenges of interacting and interaction technologies seen from the AAL perspective and also describes diverse technologies and interfaces, some existing on the market and also others, innovative prototypes, currently under research, that are considered important in the AAL context and fundamental to the success of AAL services on the market.

6.4.1 General issues for Interacting technologies

The main challenges related to this field are related both to technical and non-technical aspects. In particular, the important non-technological issues are: the design of the interaction; the usability and the possibility of personalising the interfaces; the multi-modality.

The design of the interaction is the process of identifying the strategies of communication between the user and the service; this means also the modelling of the exchange of input/commands and output/feedback between the user and the technological device accomplishing the service. Identifying the right approach for the user–machine interaction is a critical step in the design of an AAL service because developing the wrong interface can cause rejection and failure of the service, with the consequent economic damage for the service providers and companies, and, in some cases, can also induce accidents and physical damage tohumans (Gruhn, 2011), (Flaspöler, et al., 2009).

In order to find the most appropriate interaction approach for an AAL service, it is fundamental to study the motor and sensory capabilities of potential end-users (i.e. hearing, sight, arthritis, etc.), the context in which the service is provided (i.e. indoors, outdoors, the time of the day, silent/loud environments, etc.) and the structure of the service. Only on the basis of this information can AAL designers identify the most appropriate interface technologies that make this interaction easy and intuitive for the user. To develop effective interfaces for AAL services, designers should adopt one of the several existing theories and methodologies for designing technologies according to usability and acceptability criteria. An in-depth description of these design methods is reported in Section 7.3.

Furthermore, the interfaces should be developed respecting the usability and acceptability criteria (see also Section 7.3) and should be as multi-modal and as much able to be personalised as possible. In particular, these last aspects are very important because in most of the cases the users of the AAL services are people with different characteristics (i.e. older persons with hearing problems, others suffering from sight problems, or carers) so the service should possibly adopt different and complementary interfaces and interaction approaches, satisfying users with different necessities and abilities. Moreover these interfaces should also be able to be personalised in order to make them really easy and intuitive for the user.

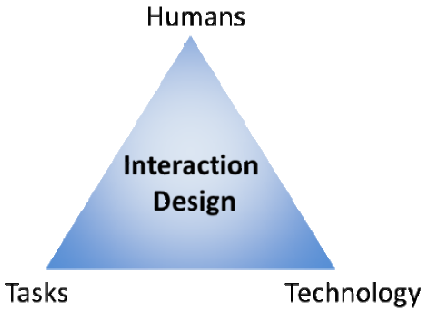


Figure 10 Scheme of the interaction design paradigm

6.4.2 Smart appliances, accessories and dresses

In recent years, ICT research has revolutionised human–human and human–machine interaction. In a few years smart appliances (e.g. computers, tablets, smartphones, etc.) and accessories (e.g. glasses, rings, watches, bracelets) have become very easy, cheap and effective tools used by people of all generations to communicate with each other, to exchange information and data, and to access useful services.

Smart appliances, multimedia and apps

Multimedia and smart appliances, like computers, tablets, smartphones, smart TVs and interactive whiteboards, are today common products present in our everyday life (see Figure 11). The success of these tools is due to the power elaboration, concentrated in short dimensions,cheap purchase price and the presence of software and apps that allow users to access, easily and everywhere, remote services and information located in other places. Moreover, apps help users to easily customise services making them highly usable. An example of these solutions is the new generation of apps for mobile health (m-Health) that, combined with wearable smart sensors, permit people to monitor their health at every moment of the day and everywhere (PWC, 2012).

Today,most older people use smart appliances and apps easily and daily, so AAL service developers should strongly take into account these devices as possible interfaces for providing AAL services and for facilitating the interaction between carers and elderly people.

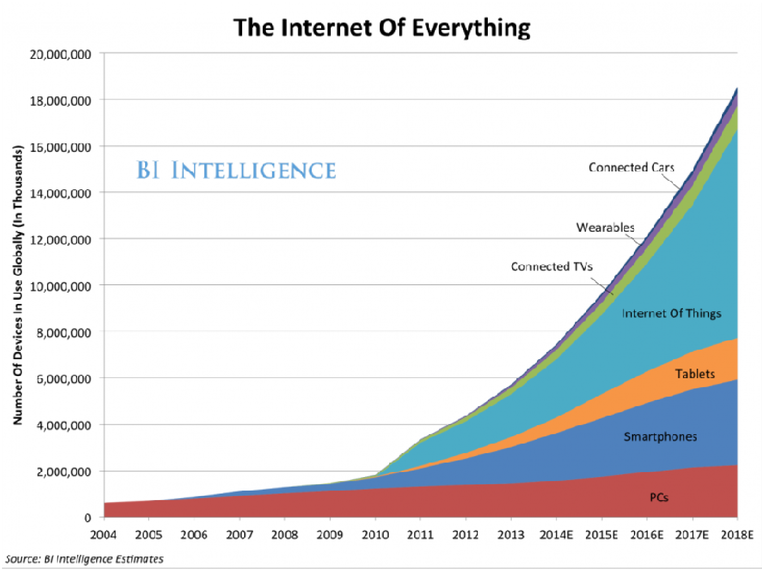


Figure 11 Estimations of global diffusion of multimedia devices and smart appliances (Source: BI Intelligence estimate)

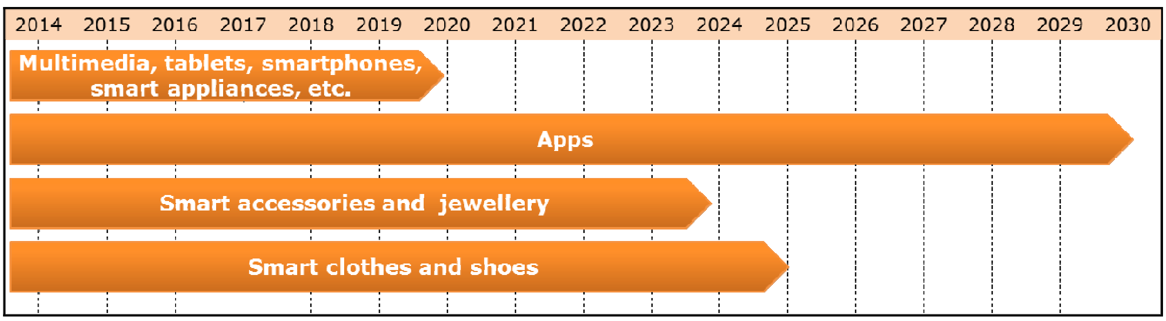
Smart wearable accessories

In recent years, ICT research has modified many accessories, like glasses, watches, bracelets, rings and earrings, to make them "smart" and useful to their users. In particular, they have become tools able to acquire information and to be an easy and natural interface between the person and the services. Famous examples that are becoming popular worldwide are the smart glasses "Google Glass" from Google[9], the watch "Galaxy Gear" from Samsung[10] and the smart ring "Ring" from Logbarinc[11]. Because of their high wearability, simplicity and invisibility, they represent an important resource for the interfaceof older persons with AAL services.

Smart dress

Another important challenge in the interacting field is the development of smart clothes and shoes to work also as wearable interfaces. These unobtrusive systems, having the shape, look and feel of normal garments, are enriched with embedded and integrated actuators in their texture, through which the user can both be monitored and also manage some external devices (such as TV, stereo, refrigerator, etc.) and access services set in the cloud (Berglin, 2013), (Minuto & Nijholt, 2013).

Roadmap 13: *Smart appliances, multimedia, apps, smart accessories and smart clothes*



[9]http://www.google.com/glass/start/
[10]http://www.samsung.com/it/consumer/mobile-devices/galaxy-gear/
[11]http://logbar.jp/ring/

6.4.3 Sensorial interfaces

Sensorial interfaces are technologies which create digital augmentations of physical objects through sensory perception.
Thanks to a**ugmented reality (AR)** the user can visualise an environment in which elements of virtual reality and real elements are combined. It is a live view of the real-world scenario whose elements are augmented by computer-generated information, such as sound, video and graphics. AR provides information so realistically and easily that in future it could be one of the most effective interfaces for elderly people to interact with and benefit from services, for example, to manage medical treatments and to train the physical and cognitive abilities of senior citizens (Singh & Singh, 2013).

Stereoscopic vision allows the user to perceive the depth of objects in a 2D image. It could be used in tele-rehabilitation allowing the physiotherapist to guide the elderly patient remotely, without being physically in the same place. The older person could also use special glasses to interact with devices through hand gestures, voice and head nodes, and thus use the glasses to answer video calls, check into places, execute voice searches and watch videos (Cardile et al., 2010).

Tactile feedback is related to skin perception of temperature and pressure. This type of interaction is provided using haptic interfaces. This technology complements the visual and audio channel of the subject and can be used as a user interface element that could transmit the feedback to, for example, the user's palm that is holding the device (Nishino et al., 2011).

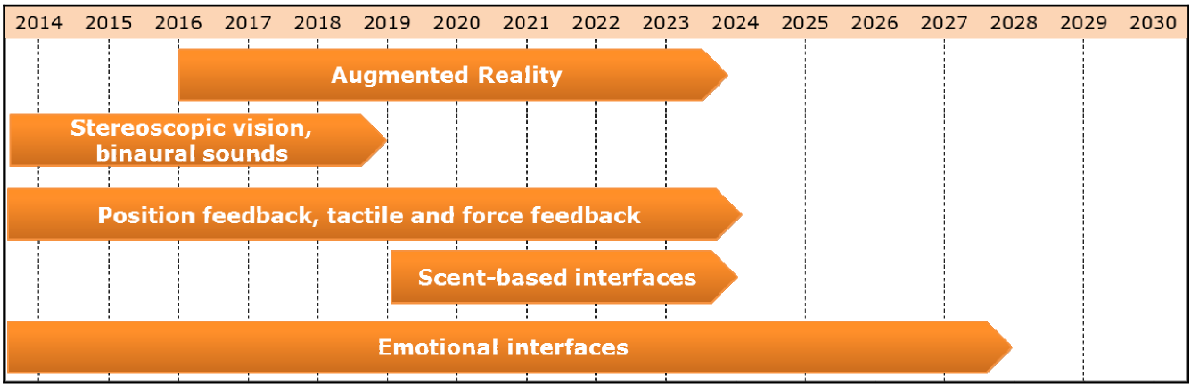
Force and positional feedback can be considered an evolution of haptic interfaces because beyond temperature and pressure they could also provide users with information on strength, weight, force, shape, etc. They can return forces and torsions to the user, depending on the position and the tactile properties of the virtual object he/she is touching (Koyanagi&Oshima, 2011). The interfaces based on this kind of feedback could be very important in AAL because they are a direct and natural form of interaction that could enrich and complete AAL services based on virtual and augmented reality.

Binaural sound, through sound-reproduction, allows the sound source in the 3D space to be located. It could be especially useful for persons with visual deficits because it can guide the user through sound and help him/her to move safely in unknown environments (Woodruff &DeLiang Wang, 2012).

Scent based interfaces are able to generate scents from a bank of available substances, increasing sensorial perception and adding more information useful for the user in recognising events and contexts (Czyzewski et al., 2013).

Emotional interfaces are the new generation of human-machine interaction. Inter-personal human communication includes not only spoken language, but also non-verbal cues, such as hand gestures, facial expressions and tone of voice, which are used to express feeling and give feedback. The first step toward an intelligent HCI having the abilities to sense and respond appropriately to the user's affective feedback is to detect and interpret affective states shown by the user in an automatic way (**emotional recognition**) (Parthasarathy&Xiaowen Fang, 2013). Being able to transfer affective information within interaction scenarios is of high importance for tailoring the content of interaction to the user's preferences and/or needs.

Roadmap 14: *Sensorial interfaces*



6.4.4 Spatial Interfaces

Spatial interfaces are systems which allow the user to manipulate and understand the states of entities through presented spatial models (3D or 2D).

Gesture based recognition is a technology, thanks to which the user can control devices and services with his hands, without touching them (Vyas et al., 2013). This can be one of the most natural and intuitive ways in which people and machines can communicate, since it closely mimics how humans interact with each other. Thus, elderly persons can use this interfacing approach to control devices, using only hand gestures, to navigate through menus and select actions.

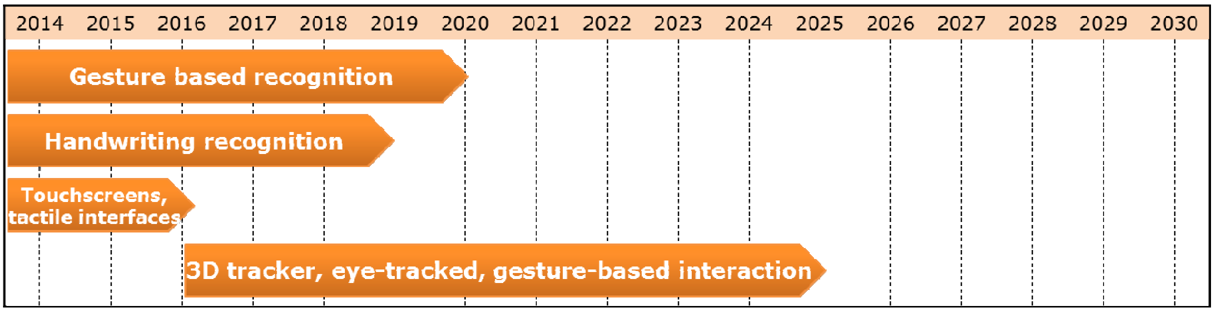
Tactile screen is a tool able to recognise which point of the area of the screen has been touched by a finger or a pointer. It simplifies the user interface, making it more intuitive, compact and robust.

Multi-touch screen concerns systems able to simultaneously recognise several points on a 2D screen. This technology can also identify different types of touch, such as by arm or the palm of the user's hand, or control devices depending on the distance of the body from the walls, the position and the point that is to be touched. In the future, this interface technology should evolve to arrive at optical displays projected directly onto the user's skin; this works like a classical screen on which the user can tap their fingertips and the system distinguishes which point of the forearm has been beaten and transfers the issued sound vibrations from the skin.

Eye tracker is the technique of recognising eye movements, measuring movements and rotations of the eyes (Iannizzotto& La Rosa, 2011). This information can be acquired in several ways using both systems attachable to the eyes, such as a special contact lens with an embedded mirror or magnetic field sensor, and contactless tools. This type of interface can help elderly persons suffering from a locomotion diseaseenormously, by enabling them to control devices simply by looking at them. For example the elderly person having problems with movinghis/her arms could use it to indicate to his/her assistant robot the point in the room that needs to be cleaned or reached.

3D Movement tracker is a system able to identify the 3D location and orientation of a device with respect to a reference point and to recognise its movements. For instance, in the AAL field, these computer vision systems offer a new solution for detecting a fall of an elderly person in a domestic environment (Stone &Skubic, 2014).

Roadmap 15: *Spatial interfaces*



6.4.5 Natural language interfaces

Vocal interaction is one of the most important and natural approaches that humans use to interact with each other. This aspect makes natural language interfaces very important in the AAL field.

In recent years, researchers in the ICT field have studied and developed several technological solutions which use linguistic entities, such as words or phrases, to control services and devices (Meng et al., 2012).

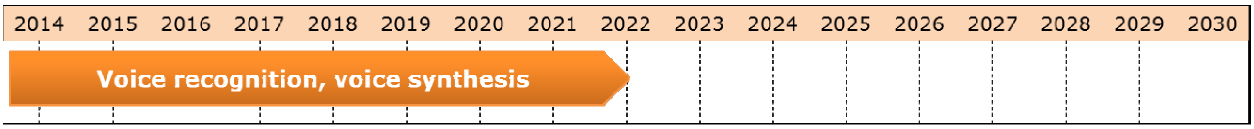
These technologies are able to comprehend natural language and to synthesise the voice.

Voice recognition and speech recognition are processes that elaborate spoken words, captured using microphones or telephones, to convert them into digitally stored words and to identify the person who is speaking from among different individuals. In the past, these tools were able to understand only prefixed words pronounced in a specific way but, today, vocal interfaces are able to comprehend words independently from the intonation and accent of the subject. Furthermore, also vocal synthesis, which at the beginning was very unnatural and machine-like, is becoming more and more realistic.

The big challenge in the field of vocal interaction is going beyond the recognition of pre-stored and modelled words and recognising the meaning of words and sentences.

The new generation of AAL services and systems will strongly benefit from these technologies.

Roadmap 16: *Natural language interfaces*



6.4.6 Multi-modal interfaces

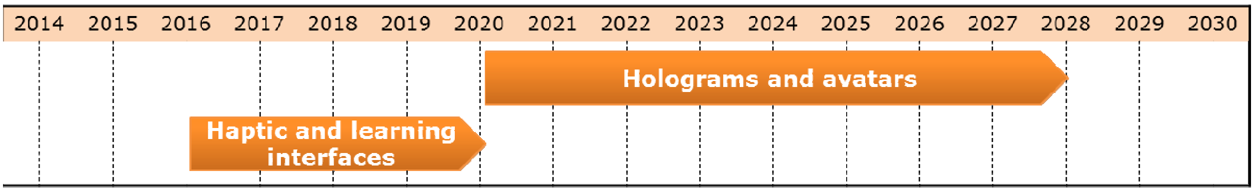
A multi-modal interface is characterised by the employment of multiple sensory channels and modalities for receiving and transmitting information. Its final objective is to enable the user to communicate with the machine using different actions (such as touching a screen, speaking or writing).

These interfaces are very important in AAL because they make AAL services flexible and easy to be used: indeed, users (older people and carers) can access and interact with the AAL services and solutions using the most appropriate interfacing strategy according to the context and their preferences. Examples of multi-modal interaction are the interfaces based on advanced holograms and haptic voice recognition.

Advanced holograms are interfaces that combine technologies for holograms (which enable the materialisation of three-dimensional images into the user workspace) with other types of interfaces (i.e. vocal, haptic, etc.). The holographic recording itself is not an image but consists of an apparently random structure ofvarying intensity, density or profile. These complex technologies, combined with tools for vocal interaction or haptic and forced feedback, are very natural and intuitive for the users. In AAL, for example, these solutions could be adopted to help older citizens alone to train their body and motor abilities (Onda& Arai, 2012), (Sonnino et al., 2013).

Another example of a multi-modal interface is **haptic voice recognition (HVR)**that combines speech and touch sensory inputs to perform voice recognition (Khe Chai Sim, 2010). Speech and gesture are two types of multi-modal input that can be used to facilitate and make human–machine interaction more natural in applications in which the traditional interfaces, such as keyboard and mouse, are inappropriate. This technology can be used to realise educational games, which are an efficient method of assisting elderly people to maintain an active mind and reasoning skills.

Roadmap 17: *Molti-modal interfaces*



6.4.7 Neural Interface and Brain Computer Interface

The term "brain computer interface" (BCI) includes all technologies that use online brain-signal processing to influence human interaction with computers, their environment and even other humans (Jebari, 2013). The target of BCI is to identify and predict behaviourally induced changes or "cognitive states" starting from the user's brain signals. In AAL,different applications of this technology can be used (Nicolas-Alonso & Gomez-Gil, 2012), (EPoSS, 2013)

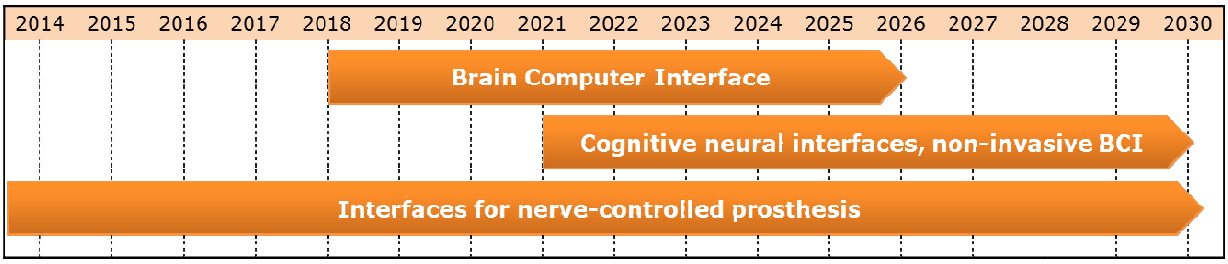
EEG-based BCI techniquesacquire, process and then translate signals from brain activity into machine codes or commands to provide a direct communication pathway between the brain and the external world.

Invasive BCIs use sensors inside the human brain to obtain high-quality brain activity signals or to send external signs to the brain. Any potential benefit based on increased signal quality must be balanced against the potential risks associated with both the surgery and the long-term implantation of these devices.

Non-invasive EEG-based BCIs, using electrodes placed along the skin of the scalp, can be used for devices controlled by the brain: such systems are those in which the user can interact with devices, using the brain's signals. Future devices will need to be less time consuming to set up and more comfortable to wear, because the current electrode caps and wet electrodes are not practical for everyday use.

Nerve controlled prosthesis are prosthetic devices that can substitute a damaged motor, sensory or cognitive modality and be controlled by using signals extracted from the human nerves (Micera et al., 2010).

Roadmap 18: *Neural interfaces and Brain Computer Interfaces (BCIs)*



6.5 Communicating

"Communicating" is the set of AAL enabling technologies related to machine–machine interfacing. This aspect is of prime importance because AAL services are typically implemented using distributed technological devices (such as sensors, actors and reasoning components) that cooperate together to provide the planned and desired service. Therefore, machine-to-machine communication strongly influences the effectiveness, efficiency and also exploitation of AAL services.

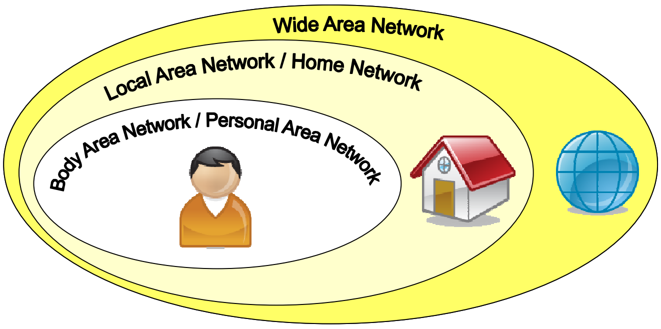


Figure 12. The spheres of communication.

6.5.1 Application Field of Communicating technologies

Wide area networks (WANs) are used whenever an AAL system needs to transmit information to the "outside world", e.g. to enable human communication, to raise/forward alarms, and to interact with system components located in the "Cloud". Today,for connections from the home environment, this is most often an Internet connection, where a number of different access technologies are offered by providers, based on the telephony cable infrastructure, TV cables, mobile phones or satellites. In addition to the price, the speed and reliability (availability) of the connection are the most important selection criteria. In general, available connection speeds are increasing (both for cabled and wireless connections) and prices are dropping, but broadband Internet access is still not available everywhere (in particular not in many rural areas in Europe), so solutions that can operate over classical telephony lines, which are available more or less everywhere, also have merit. It should be noted, however, that the general transition of the telecom providers from analogue telephony services to "voice over IP" can render systems designed to communicate over analogue telephone lines (such as classical tele-care products) unusable or unreliable. Finally, mobile-phone-based messaging services, such as SMS, should be mentioned, since they also have merit e.g. for reminder services.

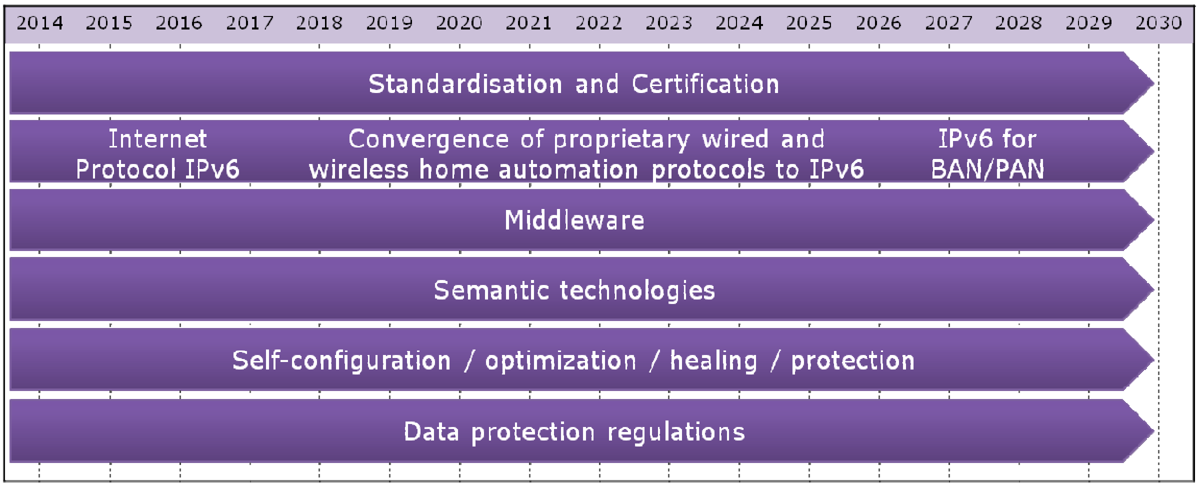
Issues concerning WANs include the question of availability of the network. If the WAN is used to transmit messages of great importance, such as a detected medical emergency, the transmission should not fail due to downtime of the Internet connection. Similarly, the use of mobile devices with outdoor networks (mobile telephony networks as well as wireless broadband networks) raises issues like availability of service, roaming and hand-over solutions, and prioritisation in the case of an emergency. In the home environment, the decreasing prices for communication may produce redundant networks, with a landline as the primary Internet connection and a mobile-phone-based connection as backup being viable. Another issue is the need for remote maintenance of complex AAL systems, which requires the ability of a system operator to dial "into" the home and check the status of devices behind the residential gateway, which at the same time increases the need for appropriate security of the system.

6.5.2 Generic aspects

Standardisation and certification: A large number of communication standards that are applicable to the domain of AAL are available today. Arguably, there is no lack of standards as "building blocks" for interoperable systems and services, but there is a lack of "blueprints" that demonstrate how standards can be combined to establish an interoperable "eco system" of devices and components that cover specific applications and cases of use.

There are, however, also some gaps in the standards landscape for AAL that are further described in the AALIANCE2 document D4.5 "Updated Report on Standards and Certification in AAL".
Transition to the "next generation" **Internet protocol (IPv6):** WANs will see a transition from the current Internet protocol (IPv4) to IPv6 relatively soon (short to mid-term) due to the exhaustion of the IPv4 address space. A migration or convergence of the proprietary wired and wireless home automation protocols towards IPv6 will take place in the long term; however, traditional home automation field buses and IPv6 networks will coexist for many years. Finally, increasingly, IPv6 will also be used in the body area network/personal area network (BAN/PAN) domain (Bluetooth with IPv6 addressing, 6LoWPAN – see the corresponding articles in the repository of standards.)
Middleware: The availability of mature middleware will simplify the integration of sensors, actors and services (application logic).
Semantic technologies: Communication between AAL system components will increasingly make use of semantic technology to describe sensor data, system components and context information (such as user preferences) in a machine-processable manner, thus enabling applications to better cope with the dynamic properties of the system.
Self-X: In the long term, advanced network protocols will enable dynamic networks with self-X properties: self-configuration (auto-configuration), self-optimisation, self-healing and self-protection.
Data protection regulations: Essentially,what is needed is a renewed data protection law that reflects the risks and opportunities of the "digital society" and is unified across the EU. This would clearly require a long-term process at the European level, initiated by the EC, with the broad involvement of "new" stakeholders (compared to the 1970s) such as industry and end-user organisations.

Roadmap 19: *General aspects of Comminicating*

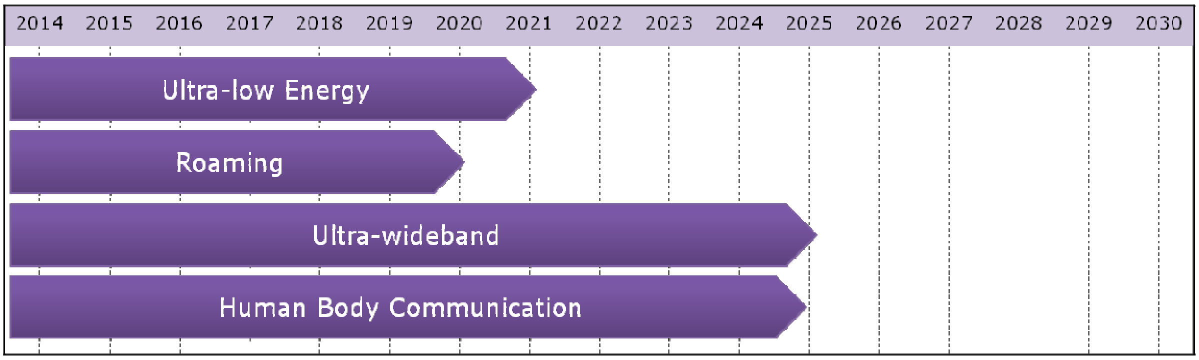


6.5.3 Body Area Network / Personal Area Network (BAN/PAN)

A BAN or a PAN integrates the system components (sensors, actors, IT components) that are worn by the user on the body, in the body, or integrated into clothing.
Ultra-low energy protocols will simplify the deployment of sensors by eliminating (if combined with energy harvesting) or reducing the need for regular battery replacements for sensors and actors with low intrinsic energy consumption.
Roaming: Systems will permit a dynamic hand-over (roaming) of personal area devices between different home networks, i.e. BAN/PAN components can be dynamically and automatically added or removed from a home network depending on their "visibility"; for example, a sensor noticing an emergency such as a cardiac event will be able to use the neighbour's home network to forward an alarm if the emergency happens during a visit to the neighbour.

Ultra-wideband: Radio applications based on ultra-wideband (UWB) technology will permit a simplified indoor location and ambient recording of presence and other vital parameters.
Human body communications: Implants and BAN components will use the human body as a communication medium with low energy consumption, verbosely enabling data transmission through a touch of the finger (to a sensor field).

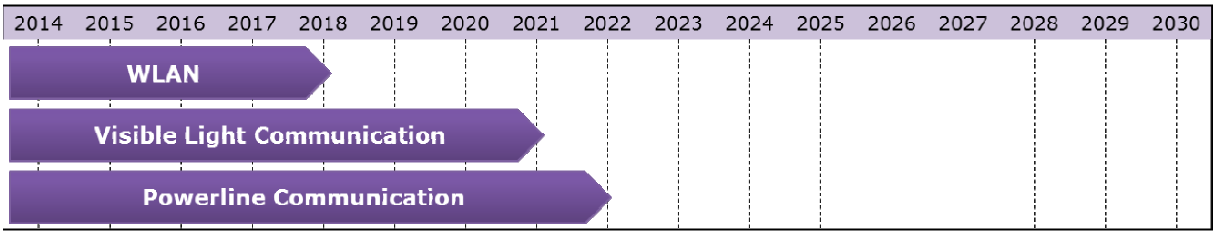
Roadmap 20: *Body/Personal Area Network (BAN/PAN)*



6.5.4 Local Area Network (LAN)/Home network

Home networks comprise different classes of network technology: on the one hand classical networks, such as cabled LANs, powerline communications (i.e., the use of the electrical installation for LAN communication) or wireless LAN (WLAN), and on the other hand the wired or wireless field buses used for home automation.
An important issue both for the LAN and for the home automation field bus is the ease of installation.
Visible light: There will be a use of visible light (e.g. based on LED modulation) for communication between sensors, actors and reasoning components of an AAL system in one room, with zero radiation exposure to the user.

Roadmap 21: *Local Area Network (LAN) / Home Network*



6.5.5 Wide Area Network (WAN)

Cloud services will be used for the "reasoning" components of AAL systems instead of local CPU power, increasing the bandwidth and availability requirements of the network.

Broadband: Bandwidth available to the home will increase with the availability of next generation mobile networks (up to 3 Gbit/s downstream with LTE Advanced) and the trend towards "fibre to the home" (i.e. the use of optical cables) for cable-based connections.

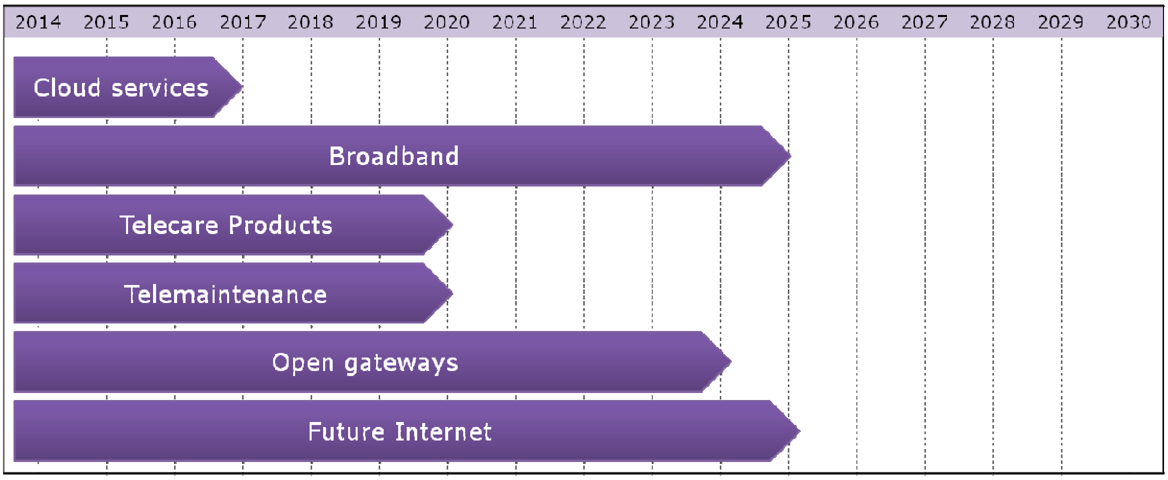
Tele-care products: The transition of telephony networks from analogue technology to voice over IP (VoIP) will force tele-care vendors to change the system architecture of their tele-care / social alarm systems, which are currently based on analogue telephony. It is likely that these products will then directly use TCP/IP networks instead of telephony services.

Tele maintenance: Future generations of residential gateways will permit the remote maintenance of devices (such as sensors and actors) in the home ("behind" the residential gateway), thus enabling telecom operators to offer remote maintenance services to AAL customers.

Open gateways: Future generations of residential gateways will permit a "partitioning" of the gateway such that multiple services can be offered over the same gateway without interference. This will open-up the residential gateway to third-party operators, one example being services for energy management in the context of smart energy grids, another one being AAL.

Future Internet: In the long term, new communication protocols developed by the various Future Internet projects might fundamentally change the way the Internet works, thus enabling new or better services related, for example, to quality of service, roaming of mobile devices, multi-homing, pooling, etc.

Roadmap 22: *Wide Area Network (WAN)*



7 Implementation Issues

Beyond service and technological challenges, other important implementation issues should be considered in order to really guarantee the deployment of AAL solutions within society and their success in the business market.

Some of the main aspects that should be considered are:

- the fulfilment of ethical issues, i.e. respecting autonomy, dignity and human rights;
- the involvement of users in the research and design of AAL technologies and services in order to increase the acceptability and usability of the proposed solutions;
- the definition of sustainable business models, support policies, certifications and standards suited to the introduction of AAL services and technologies in real care contexts and markets;
- the dependability of AAL devices, i.e. increasing acceptability by users.

7.1 Ethics

Developments in AAL technologies cannot be read without 'human rights' and 'ethics' lenses. At the interface between care and new technologies, AAL is a particularly relevant topic to focus on when dealing with ethics. Current international and European texts about human rights, as well as current EU legislation, can provide some relevant insights on how ethics is (and should be) considered within the AAL world, helping in this way the concrete implementation of AAL technologies in older persons' homes.

EU legislation has already addressed some challenges, for example on topics such as privacy and data protection,[12] as well as technology and safety.[13] In addition, the European

[12] http://ec.europa.eu/justice/data-protection
[13] http://europa.eu/rapid/press-release_IP-13-854_en.htm

Commission promotes several policies aiming to encourage such values in European and national legislation, including work on digital inclusion, the fight against social exclusion, eAccessibility, etc.

Applied to ageing-related policies at EU level, the values of autonomy, respect for dignity and, more recently, person-centredness, are increasingly considered as important. In addition, the result of the EUSTACEA project, the 'European Charter of the Rights and Responsibilities of Older People in Need of Long-Term Care and Assistance' provides some guidance on key values applied to care services (AGE Platform Europe, et al., 2010). However, concerning AAL technologies, there is still a lack of knowledge and evidence-based analysis on how individual dignity and autonomy are impacted, as well as the environment, social contexts and relationships, geographical situations, the health and social protection systems, individual skills, etc. Ethics in AAL is still a relatively new topic and few long-term trials have been developed dedicated specifically to this issue. One key project on that subject is the VALUEAgeing project,[14] which this chaptergained a lot of inspiration from.

Indeed, many issues need to be considered when looking at how to concretely implement the values and rights enshrined in international and European texts regarding AAL. This chapter will provide an overview of these aspects.

7.1.1 Main issues regarding ethics and AAL

Four main issues, identified as either risks or challenges, can be considered as key elements when analysing ethics regarding AAL. These are: social isolation, abuse, consent, and data protection and privacy.

Social isolation

While creating great potential for an increasing number of social interactions and contacts for everyone, the introduction of new technologies in home care raises some questions regarding how these actually impact the social networks of older persons in need of care. There is an existing fear that AAL may increase social isolation by reducing human contact. From the point of view of the older person in need of care, the introduction of new home care technologies could be seen as providing a great opportunity to live autonomously and reduce the number of hours carers need to spend at their home. On the other hand, one should not forget that older people are also a group particularly at risk of social exclusion (AGE Platform Europe, 2012), with increasingly reduced social networks and higher risks of mental health problems than other parts of the population. Geographical situations (urban/rural, proximity tofamily and/or close friends and neighbours), as well as the social context of the person are important yardsticks on whether a person is at risk of social isolation or not. AAL, while improving a person's autonomy and opportunities for social contact through ICT, could also in some situations be considered a risk for some older persons, due to reduction of the actual number of human contacts they would have, replaced by cold technologies and mechanical voices.

So what can be done? Implementing AAL cannot be successful without a prior analysis of the social context of a person and the risks it may represent toward social connectedness. It is clear that new technologies should not completely replace human contact. AAL should always be complementary to existing social contacts and caring activities, and never replace them.

Abuse and violation of rights

Older people in need of care are more vulnerable to abuse and violation of rights. As stated in the WHO Europe report on mistreatment of the elderly (WHO, 2011), "the prevalence of elder maltreatment in the community is high (about 3%) and may be as high as 25% for older people with high support needs". The international definition of elderly abuse is a "single, or repeated act, or lack of appropriate action, occurring within any relationship where there is an expectation of trust which causes harm or distress to an older person"

[14] http://www.valueageing.eu

(WHO - Elder abuse). Elderly abuse can take various forms such as physical and psychological or emotional, sexual and financial abuse. It can also be the result of intentional or unintentional neglect. The expectation of trust is key in abuse of the elderly, as it is higher when the older person is in need of care as she or he relies on others in daily or weekly activities. Implementing AAL in older persons' homes may lead to some abusive situations that need to be considered.

AAL is made up of complex technologies and services. The complexity of technologies could mean that companies selling AAL services and products could more easily abuse (for example, financially) older persons in need of care, i.e. as vulnerable consumers. The use of AAL at home, while reinforcing the person's capacity for self-care and reducing the need for care, may also lead to a reverse effect, i.e. more control from the family over the private life of the older person, leading to abusive situations. AAL may have both the impact of improving a person's safety with a complex system of sensors and alarms, but also affects an older person's freedom to move freely, to make decision on their own and to control their lives, for example due to an increasing number of alerts sent to the family.

So what can be done? Informed consent of the use of AAL products and services is a central consideration (see following paragraph). The impact of AAL should be measured and regular assessment of its implementation in older persons' homes carefully put in place. There should be a possibility for trial periods of AAL technologies, but also the opportunity to cease the use of these technologies at any time. Exit strategies and alternatives should already be planned at the moment when consent is given. Counselling and supporting services, especially from public services, are key in raising awareness and managing abusive situations; this includes the training of professionals and legal advice.

Consent

When, how, by whom…is consent given when participating in AAL research, and installing AAL technologies in a person's home? These are questions that need to be asked when AAL technologies are implemented in a home, which are linked to any basic contractual rule. This is especially challenging when the persons hosting AAL technologies in their homes are unable to give consent. AAL has an impact on an individual's environment and presents privacy and data protection risks, mainly due to the use of sensors, alarms and cameras, and the processing and storage of data. Consent is needed as a key element in respecting individual dignity and freedom. This is also key in terms of how AAL technologies can be accepted at home. It also applies to research in the field of AAL: how are subjects selected and how is their consent given? We strongly recommend reading the whole section dedicated to consent in the Value Ageing project report (VALUE Ageing Project, 2011), which provides key elements and aspects on the topic of consent.

How can consent be better taken into account? When using AAL technologies, there is always the need of a written form in aid of both the user and the professional. In addition, an interview with the user should be conducted at their home when an AAL system is installed. This should include a careful analysis of the person's status, and exit strategies should be planned in case the person uses and then rejects the AAL system. This is particularly important if the person is diagnosed with dementia.

Data protection and privacy

Where, how long, by whom …is the data processed and stored? These are some of the many questions to be clarified when AAL systems are installed. Managing and analysing data is a door to a person's privacy. AAL technologies may imply a lot of data storage and analyses linked to the different sensors and alerts put into place. But what if the person wants to change his or her habits, to hide some private activities, or to just do things differently? Will this result in an 'alert' by the AAL system? These are questions that should be asked when dealing with this complex network of new technologies in the private sphere of a person's home.

How can this be better taken into account? The EU Data Protection directive provides a useful minimum framework for data protection (European Commission, 2013). It highlights the need to use a transparent process when collecting and analysing data; this should be done for a legitimate purpose and follow the proportionality principle. Data minimisation – the objective to use the minimum amount of data possible and necessary – is a key element. All these elements should be included in the contracts and consent forms linked to the use of AAL technologies. There should be different options proposed and not a system of 'accepting data storage rules or not accepting the service'. In particular, there should be the possibility of personalising data protection according to a person's wishes.

7.1.2 Specific issues regarding ethics and AAL

Among all issues, we detected two specific ones to focus on. One is when a person is unable to give consent, such as during later stages of dementia. The other is a potentially new market: the introduction of robots, with all the new ethical issues that may therewith arise.

Dementia

According to the Organisation for Economic Co-operation and Development (OECD):

> Dementia is the most frequent form of degenerative condition in old people. It describes brain disorders that progressively lead to brain damage and the deterioration of an individual's functional capacity and social relations. Alzheimer's disease is the most common form, representing about 60% to 80% of cases (OECD, 2013).

This is an evolving disease, from diagnosis to the various stages of development, which depend on each person. There is currently no cure available. Individuals with dementia continue to possess human rights and freedom, which creates some challenges when they are unable to give consent, or provide contradictory information. The lack of treatment, and the need for acceptance of the disease as belonging to our societies, creates the need to reconsider how far we can go in delivering AAL services to people with dementia. The different level of competence a person may have as the disease is evolving also needs to be considered. The Value Ageing project dedicated a complete deliverable on that topic (VALUE Ageing project, D2.3, 2012).

AAL applied to persons with dementia can be helpful as well as detrimental; it can be confusing or can really help. That is why we need to be very careful when considering implementing AAL for persons with dementia, how technologies are tested on them and how consent is given.

What can be done? As the Value Ageing project has concluded, dignity, autonomy and person-centredness should be key drivers in ensuring that technology is developed in response to the needs and wishes of individuals with dementia. Regular assessment of a person's status and how AAL impacts his or her QoL are important. If existing, advance directives should be considered. More research is needed on this topic.

Robots and artificial intelligence

One could say that the artificial intelligence market has not developed far enough and that the robot most used in care conditions thus far is the Paro therapeutic robot (PARO Robots U.S., Inc., 2013). However, current developments may create some issues, especially when dealing with care activities.

AAL robotics for older people in need of care is also a topic of one of the deliverables of the Value Ageing project (VALUE Ageing Project, D2.4, 2012). The deliverable highlights several important issues. One concerns the reliability of AAL services and products as a key element in their acceptance. However, the use of artificial intelligence in robots leads to a situation of the unpredictability of their actions, which could potentially create problems of reliability. A related question, which is actually true for any use of new technologies in care activities, is: If there is a failure, who is responsible? In addition, the use of servant robots may be considered as contradictory to the objectives of providing autonomy and hope for more rehabilitative activities to reduce people's need for care. One could also question the capacity of a robot to 'care', and the need to complement the use of robotics at any time with human interventions and contact. Finally, the lack of long-term trials with robots, especially human-like robots, makes it difficult to assess concretely the impact of such technologies on older persons' environments and contexts, as well as their personal feelings.

What can be done? There is a need to develop more long-term trials to manage the novelty effect of robots. There is also a need to clarify standards and regulations over the use of robots, in particular in care activities. These regulations should aim to protect users and clarify responsibilities on the use of these kinds of new technologies, including risk management. Promotion of rehabilitative robotics is an option. Some voices consider that servant robots should not be used in care activities, and that more focus should be given to improving quality of care and quality of work for carers.

7.1.3 Tools to better implement ethical values in AAL

To concretely link the values introduced in this section to AAL, several tools could be considered:

- *Codes of conduct and principles for professionals:*
  Concrete applications of values for professionals apply both to the care sector and to the sector of new technologies at different levels (technical/care professionals, researchers, social workers, policy makers, etc.). At the EU level, some reference publications can be considered, including the following:
  - the 'European Quality Framework for Long-Term Care Services' (WeDO, 2012);
  - the ''European Charter of the Rights and Responsibilities of Older People in Need of Long-Term Care and Assistance' and its accompanying guide (AGE Platform Europe, et al., 2010);
  - other analyses conducted during other user-led projects, such as the Value Ageing project or others (VALUE Ageing Project).
- *Standardisation and regulation developments:*
  In order to develop concrete measures to apply values to AAL, standardisation and regulations based on codes of conduct and principles should be developed. They already exist or are coming into existence at the EU level (cf. accessibility, reliability, safety, protection of consumers rights, etc.[15][16]) They should protect end-users in particular and clarify responsibilities in case of failure (AALIANCE2 Summary of Standards, 2013).
- *Training:*
  Putting values into work and implementing these codes of conduct requires changing habits, which can be done by training and following up by leaders and managers. Training needs to be evidence-based, using current practices and testimonies.
- *Periodic assessment of impact:*
  To avoid errors and abuses after the provision of AAL services and technologies should be carried out periodic assessments and evaluations about the effectiveness of AAL solutions, their impact on the life of the user and his/her consent to use the tools (Delaney et al., 2011), (Zamora, 2012).
- *User involvement:*
  This ranges from participation in research trials to client involvement. User involvement enables the personalisation of products. It also provides the capacity to get a broader vision of how AAL services and products can be used, and gives more holistic analyses an impact on a wider range of variables in older people's environments. Finally, adequate user involvement helps to improve AAL acceptance and to make AAL developments closer to market reality. The AAL JP produced very relevant documents on this aspect.[17]

---

[15] http://ec.europa.eu/dgs/connect/en/content/active-ageing-and-independent-living
[16] http://ec.europa.eu/research/innovation-union/index_en.cfm?section=active-healthy-ageing
[17] http://www.aal-europe.eu/involving-end-users

Some overall challenges remain, including how AAL can be balanced between personalisation and mainstreaming, i.e. personal and collective expectations. Ethical issues are expected to evolve as AAL products are tested, enter the market and are used by an increasing number of individuals. Regular reviews of ethics in AAL are therefore needed, adapted to different situations (see Figure 13).

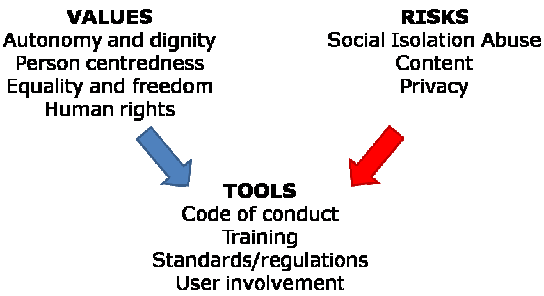


Figure 13. Ethics in the AAL field.

7.2 Legal Issues

AAL encompasses a very wide range of sectors, and therefore of legal areas. At cross roads between data management, privacy, consumer protection, patient safety, automatic decision making and artificial intelligence, and access to health and social services, eHealth and mHealth, digital access, working environments, Ambient Assisted Living is covering a multiplicity of regulations by gathering a wide variety of different sectors and stakeholders. Figure 14 shows this diversity applied to the field of eHealth on which AAL is based but not restricted to.

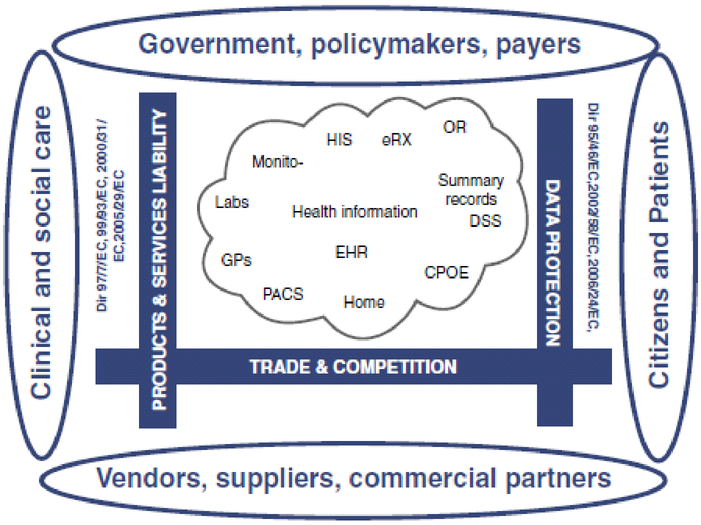


Figure 14. from (van Doosselaere et al., 2008)

This section aims at trying to guide the reader among the different legal aspects which should be taken on board when implementing AAL, and identifies some gaps in the current legislation which need to be looked upon. It should not be forgotten that all EU legislations should respect the principles enshrined in the EU Charter of fundamental rights[18] (European Commission, 2000).

7.2.1 Legal aspects of Ambient Assisted Living

This section is a short overview on different EU legislations applicable to AAL. A more in-depth explanation and clarification can be found in the European Commission document 'Legally Ehealth' released in 2008 and some updated information will be provided in this section[19].

[18] http://ec.europa.eu/justice/fundamental-rights/charter/index_en.htm
[19] http://fr.slideshare.net/denisesilber/legally-ehealth-report

Data protection regulation
Data protection is one of the key ethical challenges related to the use of AAL products and services. The user of AAL services interact with a number of databases including many personal information such as health but also daily activities, geographical position, monitoring of different life events.
The **European Data Protection Directive (95/46/EC)**[20] sets legally binding rules for the protection of individuals with regard to the processing of personal data. Through this regulation basic principles for processing personal data have been stipulated which have to be followed in all Member States:

- **Transparency**
  The data subject has the right to be informed when his or her personal data are being processed. The controller must provide his or her name and address, the purpose of processing, the recipients of the data and all other information required to ensure the processing is fair (art. 10 and 11). Data may be processed only under the following circumstances (art. 7). The data subject has the right to access all data processed about him or her. The data subject even has the right to demand the rectification, deletion or blocking of data that is incomplete, inaccurate or is not being processed in compliance with the data protection rules (art. 12).
- **Legitimate purpose**
  Personal data can only be processed for specified explicit and legitimate purposes and may not be processed further in a way incompatible with those purposes (art. 6 b).
- **Proportionality**
  (art. 6 and art. 8) Personal data may be processed only insofar as it is adequate, relevant and not excessive in relation to the purposes for which they are collected and/or further processed. The data must be accurate and, where necessary, kept up to date; every reasonable step must be taken to ensure that data which are inaccurate or incomplete, having regard to the purposes for which they were collected or for which they are further processed, are erased or rectified. The data should not be kept in a form which permits identification of data subjects for longer than is necessary for the purposes for which the data were collected or for which they are further processed.

The **ePrivacy Directive 2002/58/EC**[21] concerning the processing of personal data and the protection of privacy in the electronic communications sector also applies to AAL. It applies to all matters which are not specifically covered by the 1995 Directive. The main provision made in the 2002 Directive concerns the duty of electronic communication providers is to ensure security of services (art. 4).
The European Commission launched in January 2012 a proposal for a stronger legal basis, i.e. a **Regulation on the protection of individuals with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation**) (European Commission, 2012a). This new regulation aims to bring three new innovations[22]:

- *"One continent, one law:* The Regulation aims to establish a single, pan-European law for data protection, replacing the current inconsistent patchwork of national laws.
- *One-stop-shop*: The Regulation aims to establish a 'one-stop-shop' for businesses: companies will only have to deal with one single supervisory authority, not 28, making it simpler and cheaper for companies to do business in the EU.

[20] http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31995L0046
[21] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0058:en:HTML
[22] Text cited from: http://europa.eu/rapid/press-release_MEMO-14-186_fr.htm

- *The same rules for all companies* (regardless of their establishment): Today European companies have to adhere to stricter standards than their competitors established outside the EU but also doing business on our Single Market. With the reform, companies based outside of Europe will have to apply the same rules. European regulators will be equipped with strong powers to enforce this: data protection authorities will be able to fine companies who do not comply with EU rules with up to 2% of their global annual turnover. European companies with strong procedures for protecting personal data will have a competitive advantage on a global scale at a time when the issue is becoming increasingly sensitive.

The data protection reform aims also to strengthen citizens' rights. The new rules aim to put citizens back in control of their data, notably through:

- *A right to be forgotten*: When you no longer want your data to be processed and there are no legitimate grounds for retaining it, the data will be deleted. This is about empowering individuals, not about erasing past events or restricting freedom of the press.
- *Easier access to your own data*: A right to data portability will make it easier for you to transfer your personal data between service providers.
- *Putting you in control*: When your consent is required to process your data, you must be asked to give it explicitly. It cannot be assumed. Saying nothing is not the same thing as saying yes. Businesses and organisations will also need to inform you without undue delay about data breaches that could adversely affect you.
- *Data protection first, not an afterthought*: 'Privacy by design' and 'privacy by default' will also become essential principles in EU data protection rules – this means that data protection safeguards should be built into products and services from the earliest stage of development, and that privacy-friendly default settings should be the norm – for example on social networks.

Patient safety and Medical devices
Medical devices are also important components of some AAL solutions and services.
The legislation on medical devices can apply to some extent to some AAL products. This legislation is in fact three main EU directives[23], aiming at ensuring a high level of protection of human health and safety and the good functioning of the Single Market:

- *Directive 90/385/EEC regarding active implantable medical devices*
- *Directive 93/42/EEC regarding medical devices and*
- *Directive 98/79/EC regarding in vitro diagnostic medical devices.*

Some guidance on their implementation has been prepared by the European Commission[24].
This legal framework is also being revised at the moment. On 26 September 2012, the European Commission adopted a **Proposal for a Regulation on medical devices** and a Proposal for a Regulation on in vitro diagnostic medical devices which will, once adopted by the European Parliament and by the Council, replace the existing three medical devices directives. This revision aims to provide a wider, clearer scope for EU legislation on medical devices, a stronger supervision of independent assessment bodies by national authorities, more powers for assessment bodies to ensure thorough testing and regular checks on manufacturers, including unannounced factory inspections, clearer rights & responsibilities for manufacturers, importers and distributors, which would also apply to diagnostic services and internet sales, an extended Eudamed database on medical devices, and a better traceability of medical devices throughout the supply chain (European Commission, 2012b).

The European Parliament's vote in April 2014 "endorses a **stricter process involving pre-market assessments, together with post-market monitoring and vigilance" according to the European Public Health Alliance**[25]**.**

[23] http://ec.europa.eu/health/medical-devices/regulatory-framework/legislation/index_en.htm
[24] http://ec.europa.eu/health/medical-devices/documents/guidelines/index_en.htm

Consumer protection
AAL services and products involve a wide range of different types of consumers, including vulnerable consumers.
The EU developed several laws covering the consumers' rights when buying a product or service in the EU. EU legislation protects consumers from unfair treatment, ensures that products meet acceptable standards and enables redress in case of problems.
This is the **Consumer and marketing law**[26] which covers main areas crucial for protecting economic interests of consumers. The law is based on the notion that the asymmetry of information, where the seller knows more about the product or service than the consumer, is open to abuse. Several directives are included in this Consumer and marketing law, including for example consumers' rights, unfair commercial practices, misleading advertising, contracts laws, financial services, etc. Member States had until December 2013 to transpose the **Consumer Rights Directive** into their national laws. We refer the reader to the press release sent by the Commission on the adoption of the Directive where 10 main points were highlighted for consumers (see MEMO/11/450[27]).
Finally, the **Ecommerce Directive (2000/31/EC)** may apply to some extent to AAL devices and services. The Electronic Commerce Directive, adopted in 2000, sets up an Internal Market framework for electronic commerce, which provides legal certainty for business and consumers alike. It establishes harmonised rules on issues such as the transparency and information requirements for online service providers, commercial communications, electronic contracts and limitations of liability of intermediary service providers[28].

Area of Services
AAL will increasingly be considered as a service first, creating access to a wide range of different ICT, medical, or other supportive devices.
Public procurement rules may therefore apply, where the competition and internal market laws can apply[29]. A reform of these laws is going on from 2011 when the European Commission proposed the revision of Directives 2004/17/EC (procurement in the water, energy, transport and postal services sectors) and 2004/18/EC (public works, supply and service contracts), as well as the adoption of a directive on concession contracts. When AAL services are included as public provision, the rules may apply. The directives were voted by the European Parliament on 15 January 2014 and adopted by the Council on 11 February 2014. The Member States have until April 2016 to transpose the new rules into their national law. These laws aim to simplify the procurement processes and provide for example specific protection for some services, notably health, social and cultural services with a lighter service procurement rule and more flexible processes when working on a public service mission.

7.2.2 Identified gaps in legislation for AAL

AAL is a quite recent area and current legislation may not encompass all the challenges around the development, deployment and use of AAL services and products. Few ethical analyses encompassing the diversity of AAL services have been developed, and this is one of the first gaps. Then, several challenges are identified:

- **Broadband access**: AAL means interconnected devices themselves connected to Internet. Therefore access to Internet is essential, and it remains unclear how far access to Internet could become a right for all on a longer term. This is true

[25] http://www.epha.org/spip.php?article6008 and http://www.epha.org/spip.php?article5721
[26] http://ec.europa.eu/justice/consumer-marketing/law/index_en.htm
[27] http://europa.eu/rapid/press-release_MEMO-11-450_en.htm?locale=en
[28] http://ec.europa.eu/internal_market/e-commerce/directive/index_en.htm
[29] See: http://ec.europa.eu/internal_market/publicprocurement/index_en.htm

especially at the moment in remote areas where AAL could bring clear benefits but where broadband access is limited and/or expensive, but not only.

- **Data mining and automatic decision making:** the main challenge here remains the responsibility in case of wrong decision after automatic decision making, and/or decision making based on data mining. The new Regulation on Data protection replacing the former directives may at least partly help to solve the problem of wrong use of personal data with article 19 (right to object) and to be protected legally against this. In particular, article 20 mentions that *'Every natural person shall have the right not to be subject to a measure which produces legal effects concerning this natural person or significantly affects this natural person, and which is based solely on automated processing intended to evaluate certain personal aspects relating to this natural person or to analyse or predict in particular the natural person's performance at work, economic situation, location, health, personal preferences, reliability or behavior (European Commission, 2012a).'*
- **EHealth, including mHealth:** these are new areas where the European Commission is starting to work. In its Staff Working document on eHealth[30], it is stated that the aim of an upcoming eHealth action plan (2014-2020) will be to: achieving wider interoperability of eHealth services; supporting research, development and innovation in eHealth and wellbeing to address the availability of user-friendly tools and services; facilitating uptake and ensuring wider deployment; and promoting international cooperation. In addition, the European Commission launched a consultation for a Green paper on mHealth[31] inviting comments on the barriers and issues related to the use of mHealth. The objective of this consultation is to receive the views of a very wide range of stakeholders. The process is going but still no legislation is applied specifically to these fields.
- **New technologies applied to AAL** are increasing considerably, and they may not be included in current legislation which applies also to AAL. They include: robots, and especially servant/caring robots, biometrics, smart homes and nanotechnologies. Especially here the questions of testing and of the liability and responsibility in case of failure are essential aspects to be considered.
- **Accessibility:** the essential questions of accessible environments and services in Europe are still not solved at EU level. The European Commission announced the launch of a European Accessibility act but the text remains in the pipelines without official launch. The original EC idea[32] aimed at improving the functioning of the internal market, harmonizing accessibility requirements across Europe, stimulating innovation in the accessibility field, and improving the availability of accessible goods and services across Europe.
- **Quality services:** while an increasing number of services are delivered across the EU and cross-border, there is no common EU position on ensuring quality services. There is a voluntary framework for social services (SPC, 2010) which so far has not been used in EU legislation. However, this topic is essential in consumer protection and agreeing on common principles to guide quality monitoring of AAL across Europe. This is also related on how to ensure the users sufficient health, digital and financial literacy, transparency and access to information.

7.3 Acceptability and Usability

In general, one of the most important aspects that influence the success of technological solutions is the usability and the acceptability of these systems according to end-user perspectives.

This observation is especially valid in the AAL field for three main reasons:

[30] See: https://ec.europa.eu/digital-agenda/en/news/commission-staff-working-document-ehealth-action-plan-2012-2020-%E2%80%93-innovative-healthcare-21st
[31] See: http://ec.europa.eu/digital-agenda/en/news/green-paper-mobile-health-mhealth
[32] See: http://ec.europa.eu/smart-regulation/impact/planned_ia/docs/2012_just_025_european_accessibiliy_act_en.pdf

- the current field of socio-medical services is not used to adopting technological systems in supporting caregivers' work;
- most AAL solution end-users are individuals with a low affinity for technology (e.g. older persons, family members, informal caregivers, etc.);
- many technologies are not affordable or reliable for use by inexperienced users.

Up until the present, research in the AAL field has led to the development of a huge number of AAL services and technological devices. However, only a few of them are on the market and really purchased and used by older users, their caregivers and socio-medical experts.

There are several reasons related to the incomplete roll-out of AAL in the market; some of the most important are the following:

- many AAL solutions are not properly designed to take into consideration the true requirements, characteristics and contexts of use, thus they turn out to be inadequate and unusable by their real users;
- most concerned with the actual use of AAL services, not only older persons and caregivers but also politicians and socio-medical experts, are not aware about the potential benefits and the reliability of AAL solutions so they don't promote the introduction of these AAL solutions into current healthcare and service infrastructures.

Both of these aspects are really crucial for the exploitation of AAL systems.

In order to overcome these barriers, AAL developers and promoters should adopt some expedients and precautions during the design of AAL services and systems in order to favour their real usability and acceptability: proper design methodologies, involvement of real stakeholders, dependability, extensive validation, dissemination.

In particular, the basic idea is that designing a technological system is not sufficient in terms of awareness of the functions that the devices have to carry out; it is fundamental to know the user, his/her necessities and which factors influence their decisions to use the device. The usability and acceptability of technologies are aspects deeply studied in the computer and ICT fields from both psychological and engineering points of view and several theories have been developed to describe these features. Such theories can be used by designers and researchers to analyse end-user characteristics and needs. Only in this way is it possible to identify real requirements that will guide the design and validation of systems.

7.3.1 Theories and models on acceptability and usability of technologies

Among all developed theories, the most important ones, i.e. in the investigation of the social and personal factors influencing acceptance of technologies, are the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Usability Theory, described below. Starting from these, other interesting models have been developed to evaluate the acceptability and usability of technological devices.

The Technology Acceptance Model (TAM) (Davis, 1989) is derived from the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Theory of Planned Behaviour (Ajzen, 2002), mapping how users come to accept and use a technology. According to this theory, the intention to use a system is the result of subjective attitude, which in turn is strongly related to *perceived usefulness* (how much the system can improve user performance) and to *perceived ease of use* (the effort required to use the system). The extended version of this theory, known as TAM2, suggests also considering *subjective norms* (the degree to which people consider that others, who are important to them, think they should perform a behaviour; see Figure 15) (Venkatesh & Davis, 2000).

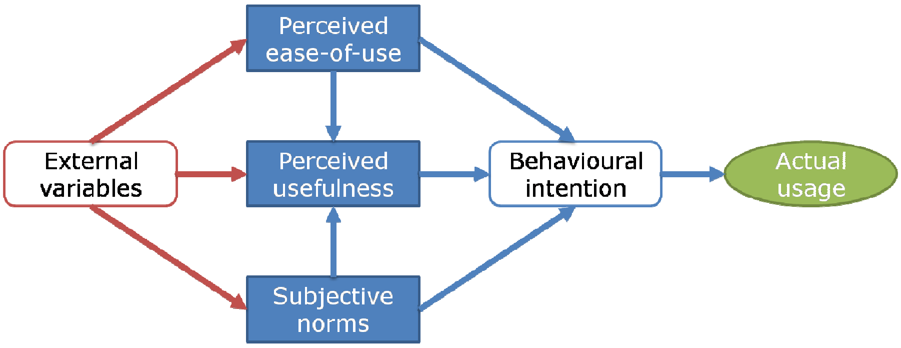


Figure 15. Scheme of the extended version of the Technology Acceptance Model (TAM2).

Another important theory on this topic is the UTAUT (Venkatesh, et al., 2003), developed to provide "a useful tool for managers needing to assess the likelihood of success for new technology introductions and help them understand the drivers of acceptance in order to proactively design interventions (including training, marketing, etc.) targeted at populations of users that may be less inclined to adopt and use new systems" (Venkatesh, et al., 2003). This theory asserts that performance expectancy, effort expectancy, social influence and facilitating conditions are the direct determinants of user acceptance and usage behaviour, whereas attitudes toward using technology, self-efficacy, and anxiety are not theorised as direct determinants of intention. According to this idea the key factors moderating the four direct determinants are gender, age, voluntariness of use, and experience (see Figure 16).

The Usability Theory (ISO, 1998) was created within the field of human–computer interaction. According to the International Organization for Standardization's (ISO) definition (9241, part 11), usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO, 1998).

Adopting this theory, the usability of a technological tool can be measured using a test which evaluates the following features:

- learnability;
- efficiency of use once the system has been learnt;
- ability of infrequent users to return to the system without having to relearn;
- frequency and seriousness of user errors;
- subjective user satisfaction.

Starting from these important theories, many models and solutions for the evaluation of the acceptability and usability of technologies have been developed.

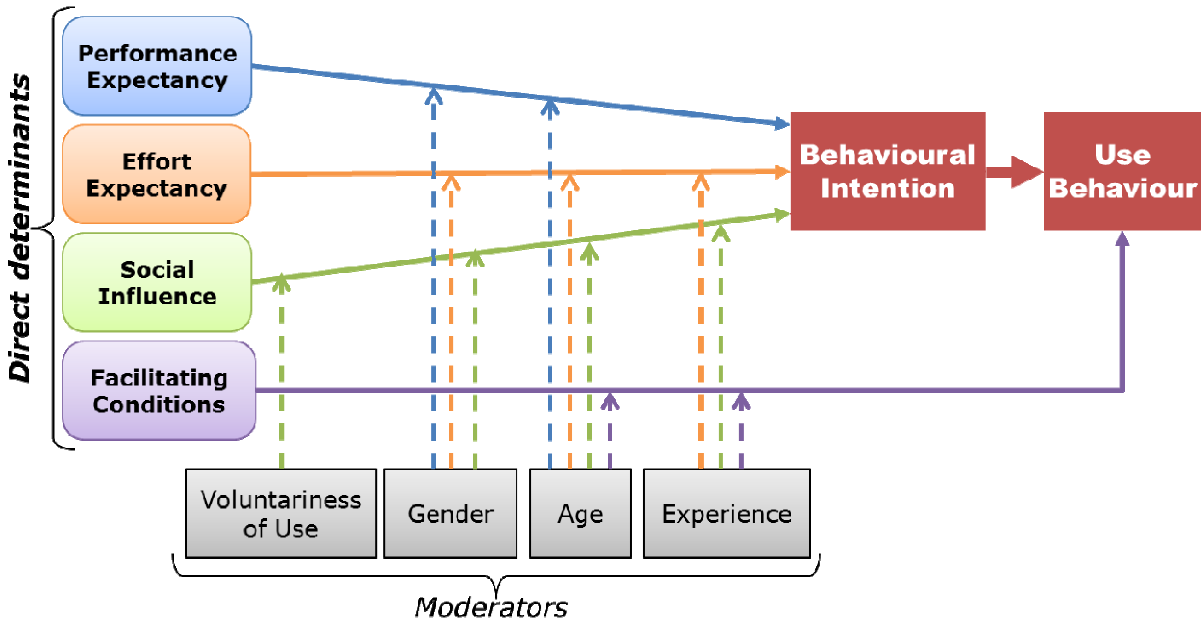


Figure 16. Scheme of the UTAUT (Venkatesh, et al., 2003)

Another interesting example is a model arising in the context of assistive technology that investigates not only psychological aspects but also technical features that influence the acceptability of assistive devices (Aquilano, et al., 2007). In particular, according to this research, acceptability is the result of user perceptions about the usability as well as other factors including utility, aesthetics, impact on daily habits, obtrusiveness, safety, portability and comfort (see Figure 17).

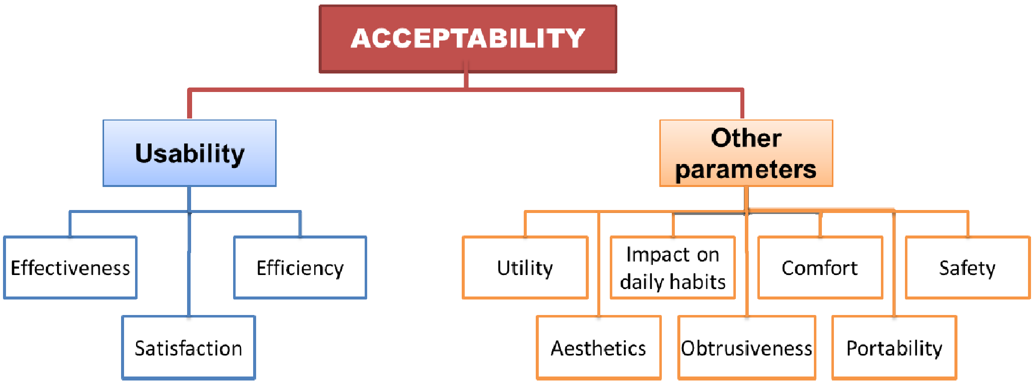


Figure 17. Scheme of components of acceptability (Aquilano, et al., 2007).

Other methodologies for the evaluation of the acceptability of technologies include the Psychosocial Impact of Assistive Devices Scale (Day & Jutai, 1996), which measures the impact of assistive technologies on the QoL of disabled users and investigates user competence, adaptability, and self-esteem; the Matching Person and Technology model (Scherer, 1998), which analyses psychosocial characteristics of users, environments of use and features of various technologies; and the Quebec User Evaluation of Satisfaction with Assistive Technology (Demers, et al., 1996), which evaluates parameters relative to user satisfaction in using a device and its services.

7.3.2 Methodologies for designing AAL devices

The topic of acceptance has inspired several research studies focusing on the development of the optimal design methodology of technological devices.

For example, the Usability Theory led to the Usability Engineering (UE) theory (Nielsen, 1992), a design approach created to guide researchers to develop systems based on perceived usefulness and ease to use. According to this design methodology, a technology should be designed following certain work stages (see Figure 18, left):

- *Knowledge of users:* To identify who end-users are, their characteristics, how they actually carry out tasks, which functions assists and how user characteristics can evolve.
- *Analysis of competitors:* To analyse existing products according to established usability guidelines and perform empirical user tests with these products.
- *Setting usability goals:* Starting from the main usability characteristics to identify specific goals and their weights.
- *Participatory design:* To involve users in the design process through regular meetings to assess user judgements and reactions about conceived ideas and solutions.
- *Coordinated design of the total system:* To design not only devices but also to conceive documentation on use, tutorials and help systems as well as to verify the consistency of designed solutions with international standards.
- *Guidelines & heuristic analysis:* To define the guidelines of the product and to perform a preliminary evaluation based on guidelines.
- *Prototyping:* To develop an initial prototype of the system.
- *Empirical testing:* To test, involving end-users and carrying out the tasks which the system is designed for to determine whether prototype features agree with guidelines and usability goals.
- *Interactive design:* To design the final version of the system.

- *Feedback from field of use:* To conduct follow-up studies of product use in the field to assess how real users use the system for naturally occurring tasks in their real-world working environments, leading to insights not readily available from laboratory studies.

Other important design methodologies that should be adopted in the AAL field are Universal Design, the Human-Activity-Assistive Technology model and the Human-Centred Design model.

Universal Design (Design, 1997) is a design approach created to develop systems, services or environments accessible to a wide range of people with different abilities and in various contexts. This method suggests taking into consideration the following seven aspects during the design phase (see Figure 18, right):

- *Equitable use:* The designed device should be usable by people with diverse abilities.
- *Flexibility in use:* The designed device should be personalisable according to individual preferences and abilities of possible users.
- *Simple and intuitive:* Users should easily understand the operating principle of the designed device independent of user experience, knowledge, language skills or current concentration levels.
- *Perceptible information:* The designed device should communicate necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- *Tolerance for errors:* The designed device should minimise hazards and the adverse consequences of accidental or unintended actions.
- *Low physical effort:* The designed device should be used efficiently and comfortably and with a minimum of fatigue.
- *Size and space for approach and use:* The designed device should have appropriate size and space for a correct approach, reach, manipulation and use regardless of user's body size, posture or mobility.

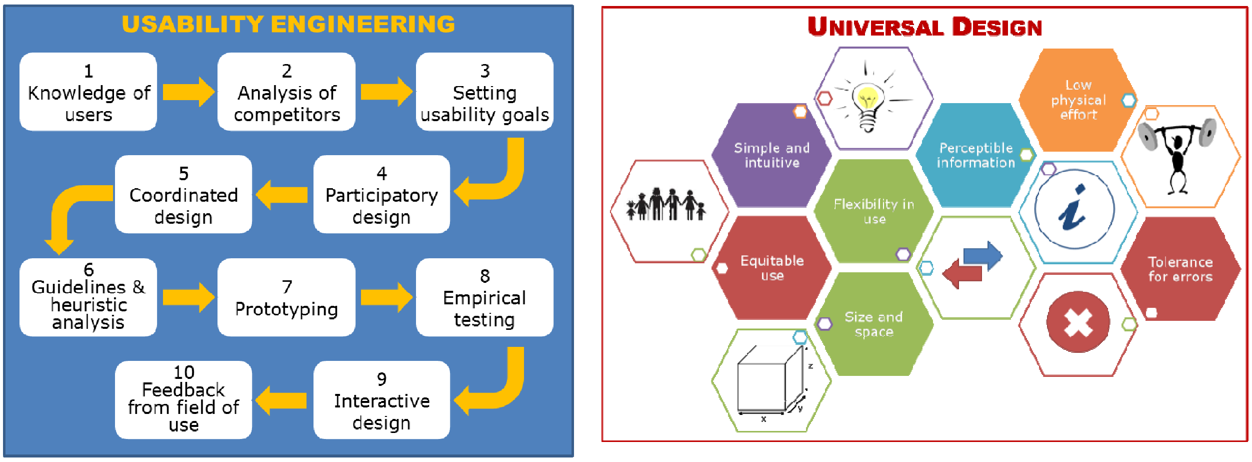


Figure 18. Schemes of Usability Engineering (left) and Universal Design (right).

Another important design approach is the Human-Activity-Assistive Technology (HAAT) model (Cook & Hussey, 1995), a method conceived of in the assistive technology field to avoid discontinuance problems. According to the HAAT model, the design of technologies should consider the combination of three factors: the human, activity and assistive technology factors applied in certain contexts (see Figure 19, left).

In particular, the human factor considers all individuals, with their specific sensory and motor abilities, who operate a device to carry out an activity. It includes disabled persons, relatives, assistants, clinicians and occupational therapists.

The activity factor considers the function that the device should support and assist. The term activity is related not only to a single action but to a set of tasks carried out in the following main areas: activities of daily living; work and productive activities; and play and leisure activities.

The assistive technology factor is the technological tool which assists and improves the user's abilities in the presence of disability. Important components of these devices are the human–machine and environmental interfaces that interact with a system processor in order to control and carry out tasks.

According to the HAAT model, these three factors should be evaluated, while also considering another important feature: the context. The term context includes different features, such as the setting (not only the location but also the environment with its rules, activities to carry out and the level of comfort); the social context (e.g. the presence of familiar peers, other familiar individuals, strangers or those who stay alone); the cultural context (the system of learned patterns of behaviour shared by members of the group that define the mechanism of interaction between group members and the environment); and the physical context (the physical environment, with its characteristics).

The Human-Centred Design cycle (Maguire, 2001) (Figure 19, right) is another important design methodology based mainly on four principles:

- *Active participation of users in the design:* In order to identify system requirements which are strongly related to end-user necessities and abilities and task characteristics.
- *Clear definition of functions between user and system:* Which parts of a task might be carried out by users and which executed by systems?.
- *Interactive design:* Continuous testing of conceived solutions with end-users.
- *A multidisciplinary design team:* Collaboration of figures and experts in different fields during all design stages ensuring the constant control of system features, seen from diverse points of view.

This design approach is described in detail in the ISO standard 13407 (ISO 13407, 1999) that specifies which activities may be carried out in the software design process in order to incorporate usability requirements. These activities are:

- planning the Human-Centred Design process;
- understanding and specifying the contexts of use;
- specifying user and organisational requirements;
- producing designs and prototypes;
- carrying out user-based assessments.

An important characteristic of this design method is that the sequence of design activities should be followed cyclically until the developed device satisfies the usability objective.

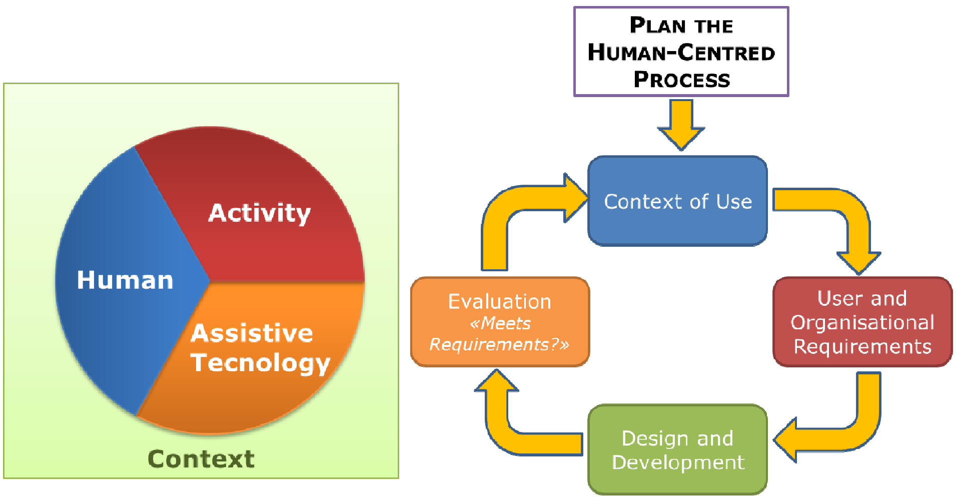


Figure 19. The Human-Activity-Assistive Technology model (left) and the Human-Centred Design cycle (ISO 13407) (right).

7.4 Sustainable Service Provisioning

To achieve sustainable AAL services using ICT solutions, the following aspects should be considered:

- proper development of services should be supported by AAL devices;
- AAL technologies have a low chance of being accepted and implemented in daily life if they are not properly integrated in a system of services designed to fulfil important values and the needs of older people and caregivers: in order to identify and address these necessities it is necessary to adopt proper methodologies to design new services and involve all stakeholders in the process;
- managing the change from 'classical' services to AAL services;
- the adoption of AAL services and solutions in real life requires the changing of people's and healthcare organisations' attitudes in care processes: to convince users about the effectiveness and benefits of new AAL services, it is important to carefully manage the introduction of new AAL solutions in the care process (the critical success factors at different levels – human, organisation, technology, financing, policy and legislation – have to be considered).

The next two subsections describe these elements for the design of sustainable services. The Appendix of this document reports an example of the implementation of these elements for the design of one AAL service scenario (proposed in Chapter 1).

7.4.1 Development of sustainable services supported by AAL devices

As shown in Chapter 3 of this document, each scenario should demonstrate its value for the different stakeholders and the improvement of the quality of care (formal and informal) provided to elderly people. Therefore it is necessary that:

- the use of AAL tools inside services really addresses the needs of people;
- the AAL services (and its devices) are integrated in the field of healthcare and social care.

A good approach to the development of a sustainable service is provided by the Service Design Thinking approach (Stickdorn & Schneider, 2010), also known as service innovation or social innovation. This method enables organisations to develop relevant services with an integral approach in co-creation with stakeholders. It is an intensive and interactive process in which needs and wishes are translated into ideas for new products or services. This method, already well known in the world of design and business, has only been applied to healthcare within the past few years (Brown, 2008), (Krijgsman, et al., 2013). It is an interdisciplinary approach that combines different methods and tools from various disciplines, which according to certain academics "helps to innovate (create new) or improve (existing) services to make them more useful, usable, desirable for clients and efficient as well as effective for organizations" (Stickdorn & Schneider, 2010).

Service Design Thinking has five principles:

- *User-centred:* Services should be experienced through the customer's eyes and the service provisioning with AAL devices must converge the user's needs.
- *Co-creative:* All stakeholders should be included in the service design process. The service provisioning with AAL devices must be developed by various stakeholders (users, front-line staff, back-office employees, managers, suppliers, providers and designers, etc.) because they add value to the service. The more users involved, the more likely loyalty and long-term engagement will increase and adoption and acceptance will advance.
- *Sequencing:* The services should be visualised as a sequence of interrelated actions and the service provisioning with AAL devices should be a dynamic movement (service moments).
- *Evidencing:* Intangible services should be visualised in terms of physical artefacts. Sometimes provisioning of AAL services can remain unnoticed, so it is important to provide evidence of work and effects to prolong service experiences beyond the

service itself, to increase user loyalty and appreciation and to stimulate them to recommend the service to others.
- *Holistic:* The entire environment of a service should be considered. The service provisioning with AAL devices does not stand alone, it should always be seen within a wider context (environment) and from various perspectives in which a service takes place.

Service Design Thinking is an iterative and nonlinear process, which means that at every stage it might be necessary to take a step back or even start again from scratch. Service Design Thinking consists of four stages, namely *exploration*, *creating*, *reflection* and *implementation*.

- *Exploration:* Aims to explore, find and define real problems from the point of view of users, gaining insights into behaviours and needs of current or potential users and translating them into values for each stakeholder. All the values together form the core, the base and the foundation of innovation and implementation. If these values are not realised, end-users will not change their behaviour and will not use the AAL devices. Furthermore, funding or financing parties will not provide fees or start investments when values are not evidently present.
- *Creation:* This stage is very close to the following, *reflection* stage, and aims at generating ideas from insight and values and transforming them into concepts. This stage is a very iterative one, because it is necessary to test and retest ideas and concepts, making mistakes and learning from them (Stickdorn & Schneider, 2010). From the concepts a 'prototype' of the service has to be developed in co-creation with end-users, ensuring at any time the connection with needs and values of current and potential users. It is therefore important to always demonstrate the value for the different stakeholders. Benefits of AAL devices have to be shown through the integration with welfare, social care and healthcare. When AAL devices become part of care, this entails a change in the work of (healthcare) professionals. E-health engages the entire care process: this means professionals provide care in a different way (Peeters, et al., 2013). Many healthcare professionals find it hard to apply technology as a part of their work because they consider care primarily as 'human work' and technology is not automatically part of this. If the value of technology is not immediately self-evident, care professionals will not be using it. They will only use technology if the quality of care may improve (Peeters, et al., 2013). The valuation by and value for the elderly is also crucial for successful implementation. Devices only make sense if the target groups recognise the added value of using them. In practice, once the elderly explore how QoL can be improved, they become very excited (Mulder, 2013).
- *Reflection:* The goal of this stage is to test prototypes with a few customers or experts and to gain feedback and consequently improve the prototypes and retest them until they match expectations and are ready to enter a pilot period. It is important that the prototypes of the service are as close as possible to reality in order to obtain valuable responses from the testers.
- *Implementation:* The goal of this final stage is to implement a new or renewed service on a larger scale. At the end of this stage it is no longer a pilot but an existing service available for the target group or population and has become a regular service of the providing organisation. Here the involvement of users is crucial, as well as the management of the change, explained in the next section.

7.4.2 Service with AAL devices: Managing the Change

In the Netherlands, many care organisations have gained a lot of experience with the implementation of technology in healthcare. However, technologies for elderly care do not have the scale of use that had been expected. Research has shown that implementation of technology depends on critical success factors, which are partly summarised in Table 2.

Table 2. Success factors of AAL tools integrated in healthcare and socio-medical services (Peeters, et al., 2013), (Broens, et al., 2007), (Scharft, 2010), (Bolder, 2011), (Dohmen, 2012), (Sponselee, 2013), (NEN Delft, 2011).

Level	Critical Success Factors
Human	• Adoption and acceptance by end-users (care users and caregivers) to make the service applicable (in healthcare) by and for humans.
Care providers	• Process innovation by the care provider. • Vision on applying technology and how to integrate technology in work and care processes. • Providing the right conditions through management of risks related to the application of technology in care processes. • A sound business model.
Technology	• Acceptability and usability. • Technological functionalities must fit needs. • Technology must function at all times and should be accessible, tailored to the situation and skills of the users. • The limitations and possible problems of the technology have to be communicated with users.
Policy and legislation	• Innovations in AAL technology healthcare often anticipate current and common policy and legislation. This can cause delays in the large-scale implementation of AAL technologies, especially if the innovation has to do with healthcare. This is a challenge for the EU since each member country is organised differently.

Human level – adoption and acceptance

As already described in Section 7.3 a lack of adoption and acceptance by end-users is one of the major causes of the reduced deployment of technology in home care (Peeters, et al., 2013). Adoption concerns the willingness of the users to take the innovation and embrace it (Rogers, 2003). Acceptance means the extent to which consumers are willing to integrate, i.e. to include the innovation in their daily work and life (Scharft, 2010). Research shows that adoption and acceptance among people determine the dissemination and implementation of innovations. The application of technology in the care process involves both care professionals and elderly people in need of care or support. Often the implementation of technology in these services creates resistance due to different factors, among which are fear of the unknown, lack of knowledge and/or skills, little trust in the added value of technology applied in the care of people, fear of the loss of work, or the idea that technology does not fit with the 'romantic' image that care professionals have about care/nursing (i.e. technology in care is 'cold care'). Besides the attitude of care professionals the role of older persons is essential: successful implementation depends on whether they want and are able to deal with the new technology (Peeters, et al., 2013). These are challenges which have to be taken into account for the implementation of services with AAL devices in healthcare.

Acceptance and use of technology in care: a change process

The implementation of services supported by AAL devices entails a huge change in care for elderly people. It requires knowledge and competence in the area of change management, where emotions play the main role, influencing behaviour. Only after people recognise and understand the need to change do changes in behaviour take place. Understanding starts with and through emotion, and if emotions are not seen or recognised, the change process will stagnate (Kotter & Cohen, 2002).

On the acceptance and use of ICT tools, several models and theories, like the UTAUT model, were developed to comprehend the aspects that influence the adoption of technologies. Some of these theories have been already described in Section 7.3.1.

Creating the change

As described previously, the introduction of technology in care entails a change for end-users and is often affected by the acceptance and use of technology. Two possible approaches to face and facilitate the process of change are Service Design Thinking (Stickdorn & Schneider, 2010) (described in Section 7.4.1) and Kotter's change process, described below (Kotter & Cohen, 2002).

By developing services according to Service Design Thinking, adoption and acceptance should already be encouraged, because users think of services together as related to AAL devices. It is also important that caregivers experience the added value of the AAL devices in order to deploy the technology solution themselves.

The Process for Leading Change, developed by Dr. John Kotter (Kotter & Cohen, 2002), defines eight steps for successful change. These steps provide handlebars to guide change in the right direction, entailing the implementation of services with AAL devices within health and social care. It is possible to walk through the steps in a linear fashion, but this is not required. Actually, the eight steps can also be seen as principles of the change process.

- *Step one:* The first step to start a successful large-scale change is to create a sense of urgency. Make sure there are enough people to 'go for it'. When people see and feel that a change is necessary they will join and influence other people to cooperate.
- *Step two:* The second step is to form a leading and guiding coalition. To lead the change it is important to bring together a few people convinced of the sense of urgency and with the right team spirit to lead the change, making others enthusiastic and cooperative. This group must have the right skills, leadership abilities and competencies, but also credibility and a network within the changing organisation.
- *Step three:* The third step is to create a vision. The leading coalition needs to guide the people to 'reach' the change, making clear what the vision, strategy and goals of the change are for the organisation. People will not cooperate when they do not know where things will lead to, i.e. which goals need to be reached.
- *Step four:* When the first three steps are completed it is time to communicate the vision behind the change (by the leading and guiding coalition). This is necessary to nurture understanding and create support in the organisation. The aim is to move as many people as possible: to make them contribute to realise the vision. Communication is often the step not given much attention to, most of the time because the former steps are not clear and executed well enough. Communication is a key factor for the success of the whole change process.
- *Step five:* This step involves empowering others to act to create large-scale support. This step is only possible when the first four steps are executed properly. Empowerment in this context means removing barriers or obstacles to obtaining change and to make people move.
- *Step six:* The sixth step is to make sure to create short-term wins to gain support of people who are already enthusiastic for the change; to cheer up the pessimistic ones and to disarm cynics; and to create a new impulse for the change process. Outcomes beneficial for all parties involve short-term wins early in the process, i.e. wins for as many people as possible; wins that break through the emotional defensive attitude; wins that have significance for others; and wins that are relatively cheap and easy to reach. And last but not least: wins that appeal to powerful fellow players, whose support is needed.
- *Step seven:* This step involves building on the change, setting goals to continue to build on what has been achieved and being aware that each success provides an opportunity to build on what went right and identify what can be improved.
- *Step eight:* The final step involves anchoring or incorporating the change into the culture. The change will only be reached when it is anchored in the organisation. The values behind the vision must be shown at any level in daily work. It is necessary to

make continuous efforts to ensure that the change is seen in every aspect of the organisation. This will help to give that change a solid place in the organisation's culture (Kotter & Cohen, 2002).

For adoption, acceptance and increasing the social impact (see UTAUT model) by care providers, the first two steps of this process are very important. To bring change in the way of giving care, service providers should feel a sense of urgency to the needs and opportunities provided by the AAL service. A guiding coalition that pulls the cart of implementation is also an important requirement. By including managers and care professionals (and perhaps people in need of care) in the guiding coalition, the social influence increases.

Regarding the construct of social influence for people needing care, the social environment (family, carers) should be informed and involved as much as possible in the implementation of AAL services. When they have to use AAL devices for the care of their relatives, it is important that they have the knowledge and skills regarding the related possibilities. They should also know what is expected from them. By involving the social environment in the development of the AAL services and technologies, assurance is provided that this new form of care will be 'theirs'.

Care providers
Chapter 2 of the roadmap described the main benefits of AAL solutions for formal caregivers, with the possibility to monitor older persons' conditions independently of time and location, and to contact them both through direct visits and remote calls (telecare), increasing their presence in the user's life. ICT devices enable them to more efficiently monitor elderly users and to assist them in daily life. Furthermore, AAL technologies could enable integration and coordination between all other home care actors (by creating a network among them).

To realise these benefits there should be:

- process innovation by the care provider;
- a vision on applying technology and how to integrate technology in work and care processes;
- provision of the right conditions through risk management related to the application of technology in care processes;
- a sound business model.

These factors secure the facilitating conditions (UTAUT model) for services with AAL devices for healthcare providers.

Process innovation
Introducing AAL devices into the services for the care of elderly people concerns a change for both informal and formal caregivers, providing them tools to give support and care in a different way. Informal caregivers will be given a greater role in the care process and for this reason both they and formal caregivers need to be involved in the process design. To make the implications of the service innovation tangible a service blueprint is a suitable tool. A service blueprint shows, in a schematic way, the service process between client and service provider. It also appoints all the necessary channels, components, and relationships between them (front and back activities, customers, personnel, environment, supporting processes, systems and resources). This makes the interactions between the different parts clear, including where each is placed and how these parts are related to each other.

Vision
It is important that an organisation (e.g. care provider) has or is developing a vision on how to apply and integrate technology in work and care processes. This vision has to link with the mission, vision, strategy and goals of the organisation. It will be the starting point and the mandate for the deployment and integration of technology in work and care processes. The vision has at least three aspects:

- the most important values and goals of the organisation in deploying AAL technology;
- the role of technology in the innovation strategy of the organisation;
- the target groups for whom the organisation wants to deploy AAL technology.

Technology and home automation can contribute to various values and goals that can be the core values and goals of the organisation or social developments the organisation wants to be a part of.

Making sure at the start of a project that there is a common image of values and goals to which technology has to contribute ensures a clear, common goal and better secures support for the project.

Management of risks

Finally, the end-users of AAL services will accept them only if the values of these new solutions match the expected value and reliability of the service provider. For example, if the end-users don't trust the reliability of the person who provides the service, the user will use the service less and less or will no longer want to purchase the service.

In the application of AAL devices in care processes, multiple actors are involved (manufacturers, suppliers, care providers, formal and informal caregivers) and each actor has a responsibility in the realisation of the expected value. There may be factors that have a disruptive effect on the reliability of AAL services. These should be analysed and, depending on the risk, measures should be taken (probability of damage occurring multiplied by impact of this damage). The Dutch NEN8028 standard, describing the quality of telemedicine, distinguishes risks (based upon ISO's standard 14971) using five themes, described below.

People:

- communication involves the physical distance between actors being bridged by information and communication technology;
- actors must be competent (able, knowledgeable, skilled and motivated) to deliver and receive care with telemedicine.

Processes and procedures:

- care provided via telemedicine is different from usual care: the guidelines/protocols/procedures are adjusted for the telemedicine-specific components and the tasks, competences and responsibilities are recorded in specific ways.

Information:

- information transfer indicates that despite physical distance the information is of sufficient quality to achieve the goals set;
- information quality (reliability, availability and confidentiality) must be sufficient to achieve the goals set.

Technology:

- software is available to adequately bridge the physical distance of telemedicine;
- equipment is available to adequately bridge the physical distance of telemedicine;
- technical infrastructure is in place for the proper functioning of software and equipment.

Finance:

- financing is available and costs are transparent, i.e. care providers and/or end-users can afford it financially or it is otherwise available through grants by governments or insurance companies (the payer knows exactly what is being paid for).

On the basis of these conditions, risks can be detected and controlled by taking appropriate countermeasures (Thompson, et al., 1991). Risk management will not only increase trust, it will also improve the quality of the application of technology (e.g. medical devices).

The business model

A business model can be helpful to illustrate how a new service can be transparent in a profitable marketing manner. A powerful tool to work out the business model is the Business Model Canvas[33]. This is a visual model in which the different business model components (target group, value propositions, resources, channels, activities, partners, costs, revenues) are shown in relation to each other.

In research stages, most of the costs are funded, but for a more wide-scale implementation a business case is needed where costs and benefits are weighed against each other. Costs associated with services and AAL device implementation are related to investments, maintenance and operational costs of the new systems. Because delivering AAL technology in social care and healthcare is rather new, governments and insurance companies have not yet developed proper financing structures. Insurance companies are reserved because there is a lack of cost-effectiveness. For that reason, it might be advisable to involve financiers in the development of AAL services and take their values and points of view in to account. During the stage of implementation it must be examined whether there are financing arrangements available to ensure care providers will have support for the costs associated with the services of AAL devices. Financial support is differently organised/controlled in the EU countries.

Benefits associated with services with AAL devices include contribution to the quality and efficiency of care. Benefits may also include innovation, contributing to the goals of the organisation or a social concern. The costs and benefits (economically and socially) can be summarised in a (socio-economic) business case together.

Technology

As described in Section 7.3, one of the most important aspects that influence the success of technological solutions is the usability and the acceptability of the AAL devices according to end-users' perspectives. This observation is valid especially in the AAL field for two main reasons: the current field of socio-medical services is not used to adopting technological systems for supporting caregivers' work, and most end-users of AAL devices are individuals with low technological affinity (e.g. older persons, family members, informal caregivers, etc.).

In Section 7.3 several design approaches are described to promote usability and acceptability. Each model lists factors which influence technology acceptance and use by end-users and have to be taken into account by developers of AAL technology. Keeping these factors in mind during the development of technology will minimise the risk of non-acceptance and non-use. The indicators of the construct of effort expectancy (UTUAT model), namely ease of use and complexity, will be secured if AAL devices are developed according to the principles of the design models. The 'participatory design' and 'interactive design' of some models are explicitly mentioned. These are principles which state that it is important to develop and test services with the people who should ultimately deliver and use the AAL technology.

7.5 Standards, Interoperability and Certification

As the section above shows, the vision and promise of AAL is more than 'a device and a service' – the vision is to provide an intelligent environment surrounding the user, an environment that monitors and 'understands' what the user is doing, or trying to do, an environment that offers support when needed, and remains largely invisible otherwise. It is clear that implementation of this vision requires many 'building blocks' or components (e.g. sensors, actors, networks, reasoning components, user interfaces); services (e.g. concierge services, meals on wheels, mobility support); and processes (e. g. nursing care, healthcare)

[33] http://www.businessmodelgeneration.com/canvas

that need to be integrated, working together, in order to provide the desired ambient support for users. This capability of working together seamlessly is denoted by the term interoperability. It can be argued that interoperability is a key requirement for the success of AAL systems on the market, for a number of reasons:

- *Variety of user requirements and preferences:* One characteristic property of older people as the main customer group for AAL systems is the very large variety of needs and preferences compared to younger people. This is on one hand due to the large number of possible physical or cognitive limitations and chronic diseases that may or may not be present, and on the other hand due to the individual experience with, and acceptance of, technical systems in general, and computers in particular. This means that a 'one size fits all' product will hardly be accepted on the market. Successful solutions will have to be modular and adaptable to individual user needs and preferences.
- *Need for 'future-proof' systems:* As a user's health status and individual limitations change over time, an AAL system will have to be extended or complemented with additional modules whenever a new need arises. It is unlikely that users will accept that in each of these cases a system needs to be completely exchanged with a different one (with possibly different user interfaces).
- *Integration with existing infrastructure:* AAL systems which make use of sensors or actors embedded in the environment need to be adapted for the layout of each individual house or apartment. Depending on the number of rooms, doors, electrical appliances, etc. the number and location of components will vary. Furthermore, in apartments where a home automation infrastructure (such as a KNX, LON or BACnet field bus) is already available, users will probably not accept that the complete network (including all cables in the walls) need to be exchanged because the AAL system only supports a different home automation network. Again, this requires a significant amount of modularity in product design.
- *Integration with local service providers:* AAL systems will most often have to integrate with local service providers delivering services such as nursing care, concierge services, meals on wheels, local transportation, etc. Therefore, in each city or region the system will have to interact with different providers.
- *No comprehensive product programme:* Unlike markets such as the medical device market, where a few 'big players' offer comprehensive product programmes covering all needs of a potential customer, the AAL sector is rather dominated by SMEs offering innovative products. It is unlikely that in this situation a single vendor will be able to offer a comprehensive product programme covering all needs of the customer base. This in turn makes it necessary to combine products from different vendors in order to address users' needs.

This is where standards come 'into play': if the interfaces between systems and system components can be defined precisely through vendor-independent standards, then it might be possible to simply connect systems and system components and achieve a seamless interoperability, so that from the user perspective the system seems to be a set– just as Lego building blocks can be combined in many different ways.

7.5.1 The role of standards

Standards play an important, although largely invisible, role in our daily lives. They define consistent interfaces enabling the interoperability and exchangeability of different components as well as safety requirements or permit service offerings to be compared. They are developed by expert committees such that they solve certain tasks in a way that does not favour any specific party (individual or organisation) – this vendor-neutral nature is a mandatory requirement for all official standards published, e.g. by standards bodies such as ISO, IEC, ITU, CEN, CENELEC or ETSI. Standard documents are voluntary, neutral recommendations that can be used by everyone – they become mandatory only if a law explicitly requires compliance with a certain standard or set of standards. An example of this is the medical device market, where the EU maintains an official list of 'harmonised standards' that must be complied with for every product placed on the EU market that falls within the scope of the EU Medical Device directive 93/42/EEC.

International and European standards reduce national trade barriers and open the international market to products and innovations. Due to adoption agreements, all European standards must be adopted in identical national standards by all members of CEN and CENELEC, i.e. the national standards bodies of the EU, EFTA and a few additional countries. Furthermore, all conflicting national standards must be updated whenever a European standard is published.

In addition to these official ('de jure') standards there are also 'industry standards', also called 'de facto standards', 'publicly available specifications', 'pre-standards' or 'application guides'. These documents are developed and published by a large variety of committees, including IEEE, IETF, OASIS and HL7. Compared to official standards, industry standards are often developed and published more quickly since the rules for public comment and voting may be simplified. Correspondingly, industry standards often play a major role in fields where technology changes very quickly, such as ICT.

Standards are obviously the most important 'building blocks' for enabling interoperability among AAL systems and system components, and as such of high relevance for the development of AAL products (as opposed to prototypes and feasibility studies, where interoperability is of limited importance). However, standards also play an important role in other aspects related to AAL:

- *Usability and accessibility:* As already explained in previous sections, both topics are important for AAL since AAL systems will be used by people with relatively limited experience with technology and by people with various disabilities and special needs. It is, therefore, important to consider these factors at the product design stage. A large number of standards exist that help system architects improve the usability of a system and achieve a 'design for all' that makes the system accessible to as many users as possible.
- *Safety and risk management:* The malfunction of an AAL system may pose a safety threat to the user. Therefore, both product safety (including electromagnetic compatibility) and risk management are relevant topics in AAL product design. Both topics are covered by standards, many of which (in the case of product safety) are legally required for all products brought to markets in the EU (recognisable by the CE mark on the product).
- *Security and data protection:* AAL systems often acquire personal data (in particular, health data) that requires protection under the EU Data Protection directive 95/46/EC. Furthermore, unauthorised interference with the system (such as abusing system actors to facilitate burglary) may pose security and safety risks. In addition to the standards on risk management, there are also standards covering the topics of data protection and system security, which may help system designers to appropriately address these issues.
- *Process and service level:* In addition to the technical aspects, the service level aspects and business processes of an AAL offering also need to be designed well. There are a number of specifications (in particular several German 'pre-standards') addressing requirements and quality criteria for AAL services.
- *Certification:* A certification or quality labelling programme is always based on a standard. A certificate is basically the confirmation of an independent third party that a product or service has been tested and found to be compliant with a certain set of requirements (standards), or, more precisely, that no deviations from the standard were found during the test.

7.5.2 Risks and challenges

While there are many advantages of standards-based solutions with open, well-defined interfaces, it needs to be clearly stated that the use of standards also poses a number of risks and challenges that may cause vendors to prefer closed, proprietary solutions over open standards-based ones:

- *Complexity:* Communication standards are often designed to support a wide range of possible use cases. This comes at a price, which is the greatly increased complexity of the specification. As an example, a blood pressure monitor is a device that essentially measures two or three values: systolic and diastolic blood pressure, and optionally the mean arterial pressure. Designing a proprietary communication protocol that delivers these three values over a communication link such as a serial cable or a Bluetooth emulation thereof is fairly trivial. However, the standard way of communicating such a measurement would be with reference to the ISO/IEEE standard 11073-10407 'Health informatics – Personal health device communication – Part 10407: Device specialization – Blood pressure monitor', which in turn is based on the ISO/IEEE standard 11073-20601 'Health informatics – Point-of-care medical device communication – Part 20601: Application profile – —Optimized exchange protocol'. Together, these two standards have a volume of about 260 pages (!), and define a highly complex communication protocol. It is understandable that many implementers shy away from such complexity, unless the additional flexibility of the standards-based interface (i.e. the possibility to simply exchange one blood pressure monitor with another one with the same interface) is absolutely needed.
- *Implementation costs:* Since implementing a standard is expensive, the final product may be more expensive than a comparable product with a simple, proprietary interface. This problem is exacerbated if an expensive external certification of standards compliance of the interface is needed – this may be one of the factors limiting the market uptake of Continua-based products.
- *Competition:* Vendor-independent, standard interfaces are a double-edged sword from the perspective of a vendor. On the one hand they may create new markets where products can be combined with the components of other vendors; on the other hand, it may permit the competition to produce compatible, but perhaps cheaper, alternatives that may threaten the market position of a product. This may be a danger especially for small enterprises producing high-quality, high-priced products, which fear being overwhelmed by cheap competitor products, mass-produced, e.g. in eastern Asia, if they 'open' their devices by standardising the interfaces. In such cases, 'vendor lock-in', while in general undesirable from the end-user perspective, is an integral part of the business model.
- *Interoperability problems:* Different developers may well read the same standard differently and produce incompatible implementations. Opening a product's interface to the competition makes it much more difficult for a vendor to guarantee to the customer that the product will always work as intended when combined with other products offering the same interface. Having a product portfolio that merely 'causes no trouble' may well be a reason for customers to prefer a proprietary product family.
- *Stifling innovation:* The preparation and publication of a standard takes time: in the case of international standards often three to five years. This means that a standard, once published, by definition will be somewhat outdated in technical fields that see rapid technological development. Furthermore, doing things 'the standard way' may prevent implementation of innovative ideas not (yet) supported by the standard. Innovative ideas such as the 'EnOcean' low-power wireless communication protocol that is optimised for energy harvesting necessarily start as incompatible alternatives to established standards (like wireless KNX in this example), although they may become standardised later (in this case, as ISO/IEC 14543-3-10).
- *Access:* One final, very simple reason not to use standards is a lack of knowledge about, and access to, standards. Especially in the research community there seems to be a significant lack of knowledge about available standards and the standardisation processes as such. Furthermore, most official standards are sold by standards bodies, i.e. unlike the IETF recommendations that govern the Internet, they are not freely available. While the costs of purchasing a standard will be negligible compared to the costs of implementing a standard, even the task of identifying which standards are of relevance for a certain task is difficult if the standards cannot be browsed – the abstract alone is often not sufficient.

Furthermore, the costs of purchasing a number of standards (like the complete family of ISO/IEEE 11073 specifications) can be an issue, especially for researchers with limited budgets.

7.5.3 Why standards are not enough

While the use of standards is a prerequisite for achieving interoperability, the use of standards in itself is not sufficient to guarantee interoperability, due to the following reasons:

- *Incompatible options:* As mentioned previously, communication standards are often designed to support a wide range of possible use cases. For this reason, standards often contain a multitude of options, because not every bit of information that can be transmitted with the standard is known or needed in every use case, and because it is possible to use the same standard in quite different ways. This means that despite implementing the same standard for two products they may still be incompatible if incompatible options are implemented.
- *Incompatible or incorrect implementations:* It is very difficult to write a standard so unambiguously that all implementers correctly understand all clauses as they were intended. Ambiguities are often found atlater stages, when two implementations of a standard prove to be incompatible; the reason being that the developers of the products interpreted the same standard differently. Furthermore, the implementation of any complex communication protocol may well contain errors (bugs), just like any other complex piece of software. Such bugs may also render devices incompatible.
- *Protocol stacks:* For each interface between devices, multiple standards typically need to be combined into a 'protocol stack' to cover all layers of the communication link: from the physical layer (connector and cable or radio link); over the network and transport layers defining how packets and bit-streams are exchanged; over the link; up to the application layer protocol defining messages, fields, and their meaning (semantics). In most cases it is necessary to combine several standards in order to define one protocol stack. Only if the same selection of standards is implemented for two products will they be interoperable without the use of an intermediate gateway ('translator').
- *Mapping of data between standards:* In more complex application scenarios there will be more than one interface, and often one piece of information will be transmitted using one standard for the first interface, and another standard will be used for the second interface. A good example is the monitoring of vital parameters for patients with chronic diseases: the sensor itself may transmit its measurements like blood pressure or the patient's weight using the ISO/IEEE 11073 standard to a gateway computer located in the patient's home (for example a set-top box, tablet computer or smart phone). This device will then forward the information over a long-distance connection in encrypted form to a telemedicine service centre. However, this transmission will not be ISO/IEEE 11073 standardised, which is not intended for this purpose; but perhaps another standard like HL7 may be used. In this situation a field of the 11073 message must be copied or translated to correspond with afield of the HL7 message. Such information cannot be found in either of these two standards, yet it is still a necessity in order to achieve interoperability for the overall use case.

A number of approaches have been devised over time to deal with these issues. It should be noted that all of these approaches only complement the use standards – they do not try to replace standards.

- *Application and integration profiles:* Many standards define so-called 'application profiles' that reduce the complexity and optionality of a standard by defining more precise requirements for specific use cases ('applications'). Here the goal is to ensure that two devices are interoperable if they implement the same application profile. Integration profiles go a step further by looking at complete use cases (application scenarios) and defining the complete protocol stack for each interface between systems or system components needed in the use case, plus a mapping between standards where needed. Integration profiles are defined by organisations such as

Integrating the Healthcare Enterprise, the Continua Health Alliance, or the Digital Living Network Alliance and complement the specifications of the standards themselves.

- *Conformance statements:* Some standards require that a vendor implementing the standard publishes a document for each product that describes which options of the standard are implemented, and how. Such conformance statements are intended to help customers select products that are interoperable. One problem with this approach, however, is that these document can be very complex (typically 50–60 pages in the case of the Digital Imaging and Communications in Medicine standard for medical imaging) and require an intimate understanding of the standard's details, which cannot (and perhaps should not) be expected from a customer.
- *Conformance testing:* This term denotes procedures that actively test whether a product is really compliant with a standard by performing a number of tests between the product ('system under test') and specific test software or hardware. Such conformance testing, when performed by an independent body, is most often the basis for certification programmes.
- *Cross-vendor testing:* This term denotes tests, where two or more products are connected, performed in order to validate whether or not the products are really interoperable. The advantages of cross-vendor testing are that complex use cases such as 'integration profiles' can be examined, and that the results are directly related to the customer's expectations of user-perceived interoperability. However, the problem of combinatorial 'explosion' prevents each possible combination of devices from being thoroughly tested in this manner, so that both conformance and cross-vendor testing must complement each other in practice.

7.5.4 The role of middleware

The term "middleware" describes a software layer between the operating system of a computer and an application program that provides reusable services in particular for communication tasks, such as connecting sensors and actors, and passing information between software modules. In AAL systems, middleware assists the development of applications by providing implementations of frequently used communication standards, and by offering reusable building blocks needed in many applications, e.g. persistent storage of sensor data, communications of alarms, multi-modal user interfaces etc. As such, middleware has an important role as an *enabling technology* for interoperability and standards-based communication. (Note: A more detailed coverage of this topic is available in the AALIANCE2 deliverable D4.3 '2nd workshop on Reference Designs for Integrated Applications').

AAL middleware can form the basis of an open platform, i. e. a combination of hardware and software components on which various applications implementing different assistive systems, developed by different authors, can be run. As such, AAL middleware has a fundamental influence on the business model chosen for individual products. One could compare an AAL platform with a smartphone: A smartphone is a hardware-software system that offers basic functionality (telephony, internet access etc.) and that can be extended with thousands of "apps" available in the app stores of the smart phone operating system vendors that execute on all (or most) smart phones sharing the same operating system. In a similar manner, an AAL residential gateway could serve as an execution platform for different kinds of assistive algorithms and connected to different sensors, depending on the needs of the individual customer. Since this would permit an AAL system to "grow" and "adapt" to the changing needs of the user, it addresses one very fundamental requirement of AAL systems explained in the outline to Section 7.6. In brief, *AAL middleware enables business models based on open, extensible platforms for integrated services*.

7.5.5 Trends and developments in standardization

Standardisation specific to the field of AAL has only started during the lifetime of the AALIANCE2 project, but has gained significant traction by now:

- The German standards body DKE has initiated a number of AAL working groups, and has in 2014 decided that the field is now sufficiently established to "move" these working groups from an incubator status to a more permant structure.
- IEC has decided to start an international Systems Committee on AAL, to be formally founded in fall 2014. Preparatory activities in the form of the IEC "Strategic Group 5" have been performed of the last 3 years.

Furthermore, there are a number of current trends and novel approaches that may influence the way standardisation "works" in the future:

- Ecosystems of established products based on industry have good opportunities today to convert their specifications into an official standard, e.g. by using the fast-track procedure offered by several standards bodies. This can be exemplified by the formal standardisation of former industry standards such as the Continua Design Guidelines (now ITU-T H.810) or the EnOcean protocol (now ISO/IEC 14543-3-10). This is an opportunity for ecosystems based on open AAL middleware platforms such as universAAL.
- While traditionally standardisation committees have looked only at individual interfaces, protocols, based on a single industrial sector, there is a trend towards a more systemic view addressing the overall needs of fields of applications such as AAL. For example, the new concept of a "Systems Committee" in IEC (over the traditional concept of a "Technical Committee") exactly mirrors this change in perspective. The big interest in the development of use-case based integration profiles (see next section) also reflects this trend towards looking at the "big picture".
- Another trend – at least in industry-driven standards bodies – is to complement standards by support tools enabling vendors to produce implementations that are really interoperable. This includes test tools, cross-vendor test events, and certification programs. Experience shows that the additional effort is worthwhile because it allows vendors to avoid many problems on prototype level, instead of fixing them in a potentially large based of installed products. Continua Health Alliance or Integrating the Healthcare Enterprise are examples for this approach. A "counterpart" for the AAL sector does, however, not yet exist – see the discussion in the following section.

7.5.6 Conclusions and recommendations

The following paragraphs summarse the 'lessons learnt' and derive recommendations related to standards and certification in AAL. More detailed explanations about the recommendations are available in the AALIANCE2 deliverable D4.5 'Updated Report on Standards and Certification in AAL'.

Standardisation watch initiative
One key problem for AAL researchers and developers is a lack of information about applicable standards. This is in part due to the difficulties, especially for researchers, in accessing the available body of standards, and in part due to the complex standards landscape that is indeed difficult to have an overview of, in particular in a field like AAL where many traditional industry domains come together. Therefore, we recommend the installation of a neutral and independent future-orientated standardisation watch initiative for AAL, e.g. as part of a European AAL technology platform, to provide the necessary impact power to enforce European leadership in this field. The tasks of this watch initiative would be to coordinate between the various bodies that develop standards relevant for AAL (CEN, CENELEC, ETSI, ISO, IEC, IEEE, W3C, etc.): to provide objective and vendor-neutral information about standards and specifications in the AAL community; to keep a knowledge base about standards in AAL (such as the AALIANCE2 repository of standards) that is continuously updated; and to promote the use of standards in the AAL community.

Preparatory action on an AAL reference architecture

We recommend that the European Commission support a preparatory action working towards a common understanding of the AAL domain, which may ultimately result in a commonly accepted reference model. In detail, such an action should develop a dictionary with definitions of terms for the AAL sector and harmonise it with the various existing developments (e.g. IEC electro-technical vocabulary, ISO/IEEE 11073 medical device nomenclature, and the German 'pre-standard' VDE-AR-E 2757-1: 'Ambient Assisted Living (AAL) – Terms and definitions'). Furthermore, the action should collect use cases (AAL application scenarios) and derive reference requirements. On-going work (IEC SG 5, IEC TC 100, AAL JP Action on Standards and Interoperability) should be taken into account. Finally, the action should analyse existing reference models from related domains (e.g. Internet of things, smart home) for their applicability and adaptability for the AAL domain. This work should take into account the human service level, since AAL systems are socio-technical systems combining technology with human service providers.

Development of integration profiles for AAL

As described in Section 7.5.3 'Why standards are not enough', the use of standards is a prerequisite for achieving interoperability among AAL systems and system components, and interoperability is a key requirement for a long-term success of AAL solutions on the market, due to customer needs. However, the use of standards in itself is not sufficient to guarantee interoperability. This goal can be reached, however, by making use of integration profiles, which are standards-based specifications that define all interfaces needed for all systems and system components for one specific use case or application scenario.

While many activities related to integration profiles for AAL are taking place at the moment, it should be noted that the maintenance of such profiles following the development of information technology standards, the development of test tools and the organisation of cross-vendor testing opportunities, requires time and proper organisation. IHE, which published more than 130 integration profiles for the eHealth sector, required about 15 years and several committees of domain experts to do so, and a similar timeframe must be expected for the AAL sector. The question whether any existing organisation is well-suited for this task, or whether a new organisation is needed, cannot be clearly answered today. Candidates for this task could be existing standards bodies (e.g. IEC, CENELEC, ETSI), the Continua Health Alliance (which is very interested in the AAL topic, but has certain issues with transparency, openness and consensus, as discussed in the eHealth European Interoperability Framework), or another body still to be founded. Long-term funding of such a body is a key issue, and both IHE and Continua demonstrate that such organisations can be sustainable without continued public funding.

In summary, the recommendation is to establish a European or international forum where all actors interested in AAL integration profiles can collaborate towards the establishment or commissioning of an organisation, taking over long-term responsibility for developing and maintaining integration profiles for AAL, together with the required accompanying measures such as the development of test tools and cross-vendor testing. Note that the coupling of a certification programme with such integration profiles suggests itself; therefore, the following paragraph should be viewed in conjunction with this topic.

Certification in AAL

Certificates give guidance to customers by informing them about specific product attributes, manufacturing conditions, compatibility with other products and compliance with legislation. An AAL certificate would facilitate market penetration because customers would be much more informed about AAL products. AAL vendors and service providers could promote their products and services with more success. It should be noted, though, that several types of certification are possible in the AAL sector: for instance technical certification testing the interoperability of a device; data privacy labels indicating that a product has been designed in compliance with European privacy regulations and data protection principles; or a certificate describing the infrastructure available in a building or apartment for the installation of AAL systems (such as broadband Internet access, a home automation infrastructure, etc.) For all these kinds of certificates, an organisation is needed to define criteria, testing procedures, term of validity and the designation of auditing authorities. The authors strongly recommend implementing an independent certification initiative at least at a European level, better yet at an international level. Whether or not an existing organisation (such as the Continua Health Alliance or Integrating the Healthcare Enterprise) could take over this role, or whether a new organisation is needed, still requires further study.

Study group on AAL and the EU Medical Device directive

In the EU member states, specific laws apply to 'medical devices', i.e. products intended for diagnostic or therapeutic purposes. Many vendors in the AAL field are concerned that the effort required to approve AAL systems as medical devices will increase the costs of the device such that a sustainable business case no longer exists. Furthermore, the organisational and regulatory effects of combining medical devices with non-medical devices in a complex AAL service setting are not well understood. This may very well be an important obstacle to the success of AAL on the market. Therefore, we recommend that a study group be established involving experts from the AAL domain and representatives of the medical device regulatory system (e.g. DG Health and Consumer, Directorate B, Unit B2 – Health Technology and Cosmetics, the European Association for Medical devices of Notified Bodies - TEAM-NB, and the International Medical Device Regulators Forum). The tasks of this study group should be twofold: 1) to examine how the service model of AAL systems can be mapped to the EU Medical Device regulatory system, and which modifications may be required; 2) to provide guidance to AAL system developers on the classification of AAL systems according to the EU Medical Device directive, and on the risk management for complex systems combining medical device components and non-medical components into a medical IT network, or using non-medical ambient sensors to derive diagnostically relevant information.

A data protection directive 'for the 21st century'

The current data protection laws in the EU member states, based on directive 95/46/EC, basically reflect 1970s' technology, when governments were seen as the primary risk to citizens' privacy, and 'processing of personal data' referred to mainframe computers. New technologies like the Internet, social media or smart appliances did not exist when current data protection laws were originally conceived. Furthermore, data protection laws in the EU are very fragmented among the member states and, within certain member states, even on a regional level. We recommend that the European Commission initiate consultations with the member states about a renewed data protection law that is adapted to the technology challenges and opportunities of the 21st century – an activity that certainly would require many years to complete, but could and should be started now (see Figure 20 for possible timelines).

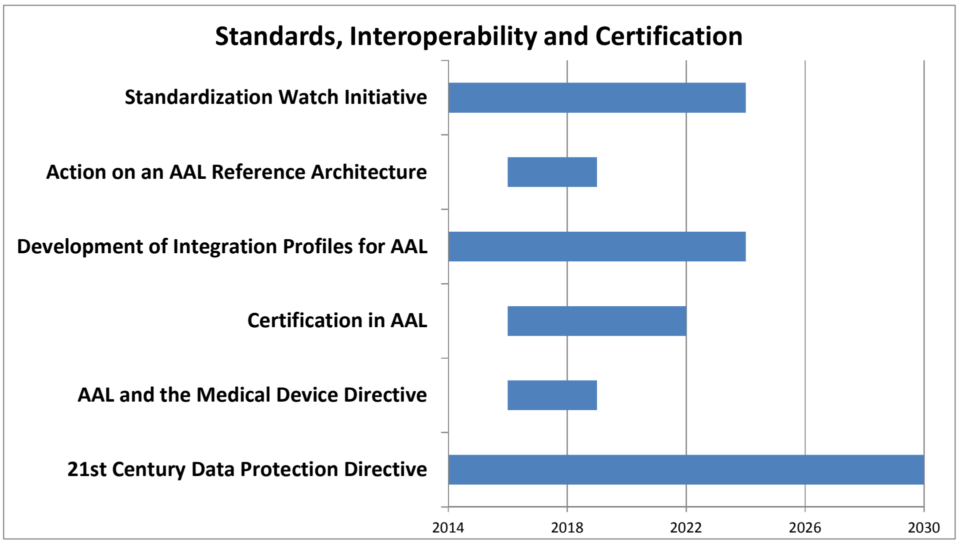


Figure 20. Possible timelines of the main aspects related to standardisation and certification in AAL.

7.6 Dependability

The acceptability and deployment of AAL technologies in real context depends strongly from an important aspect: the dependability of AAL devices. To be really used by common persons like elderly persons, family members and professional caregiver AAL systems should be designed to be safe, dependable and maintainable.

Dependability of AAL services and devices is a fundamental aspect for the success of AAL solutions in society and on the market. According to the IEC 60050-191, dependability is the term that describes "the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance" (IEC, 1990). This aspect strongly influences the success of new technological and service solutions and acceptability among end-users.

One of the most interesting analyses of the concept of dependability was carried out by Laprie, summarised by the below factors and in Figure 21 (Laprie, 1995).

Attributes:

- availability (readiness for correct service);
- reliability (continuity of correct service);
- safety (absence of catastrophic consequences for the user(s) and on the environment);
- integrity (absence of improper system alteration);
- maintainability (ability for a process to undergo modifications and repairs).

Threats:

- fault (defects in a system);
- error (discrepancy between the intended behaviour of a system and its actual behaviour inside the system boundary);
- failure (when a system displays behaviour that is contrary to its specification).

Means:

- prevention;
- removal;
- forecasting;
- tolerance.

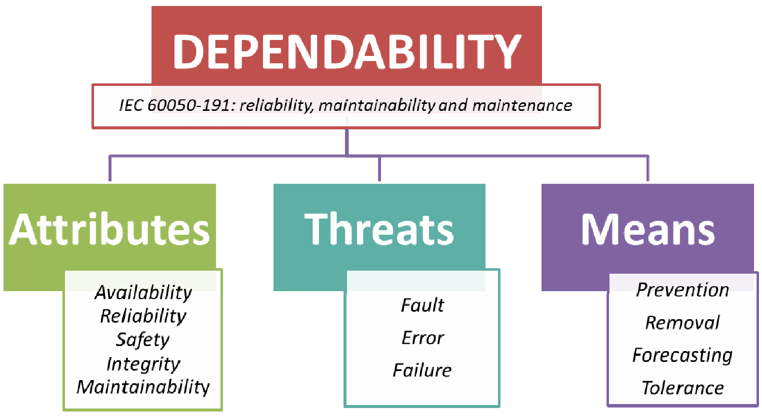


Figure 21. Scheme of dependability terms based on Laprie's study. (Laprie, 1995)

Among all technological sectors, the widest interest in this topic has been shown in systems engineering, automotive engineering and robotics.

According to the specific context and technology under analysis, properties are studied and analysed to identify the preventive aspects to be considered in the design and development phases of products and to also determine the metrics and benchmarks for evaluating the specific system before its production and commercialisation.

In systems engineering, the dependability of software, interfaces, databases and data processing has been subject to in-depth investigation; an example of these studies is the work carried out by Avižienis et al. (Avižienis, et al., 2001) which investigated the possible classes of faults and failures of computing systems and also the dependability means to take into consideration.

In robotics this property is very important because robots are complex devices that should interact with persons and so their safety and reliability are fundamental aspects to be guaranteed to their users. Several research groups are investigating these aspects (e.g. (Bicchi, et al., 2008), (Murphy & Schreckenghost, 2013)).

In reference to the AAL field, secondary and tertiary stakeholders designing and providing services and ICT solutions should take into account these aspects in the development of AAL solutions. In particular, some of the main factors that should be evaluated are:

- Who are the users of the AAL service/tool?
- How will the user interact with the AAL system?
- Is the system safe?
- Does the system manage and properly and safely transmit users' personal data?
- Which errors could users make when using the AAL system?
- Which errors could the AAL system make during the tasks?
- Which consequences could errors have on the service and for the users?
- Does the system recognise errors and malfunctions?
- What is the tolerance of the AAL system and service toward errors?
- How does the system inform users and service providers about errors?
- How can errors be prevented?
- What are the maintenance procedures?

These dependability issues strongly influence the reliability and acceptability of AAL services and devices for older persons and caregivers and thus their success in healthcare and socio-medical markets. For this reason the next generation of AAL tools should have the capacity to:

- recognize erroneous conditions;
- identify the malfunctioning aspects;
- alert both users and the expert repairers about it;
- adopt alternative strategies to guarantee the safety of the user and the environment and, if possible, the complete or partial execution of the services;
- in such case, to self-repair the damaged components (self-healing).

7.7 Green and Sustainable Technology

The increasing growth of environmental pollution (WHO, 2014) and of energy request is troubling phenomena that are attracting the attention of communities worldwide. In particular the huge consume of environmental and energetic resources is creating problems in satisfying this massive request and it is also causing severs environmental damages and also health problems for people of all ages, having negative effects also on the market (WHO, 2013).

For this reason all governments are promoting actions and policies devoted to the limitation of these destructive phenomena. In particular most of these strategies aim at both regulating the polluting emissions of industries and educating citizens to be responsible consumers and to adopt ecological habits and lifestyles that could reduce the negative impact on the environment. On the other side the communities are also pushing the scientific and technological research to study and identify new ecological solutions to manage efficiently the worldwide resources.

According to this view, international communities are considering ICT solutions as an opportunity to implement green strategies both inside industrial contexts and among common populations (Gordon, et al., 2009).

During the last few years there were several innovations in the technological field that induced the development of:

- new recyclable materials with a low impact on the environment (e.g. biodegradable materials, having the similar characteristics to plastic but less polluting than it (Petritz, et al., 2013), (Tsuzuki, et al., 2010), (Azlan & David, 2011), (Pool, 2009));
- novel power management strategies for the optimisation of energy consumption (e.g. (Yang, et al., 2011), (Niyato, et al., 2009), (Yamini, 2012));
- new solutions for the generation of green energy, like energy harvesting technologies (e.g. (Tahavori, 2010), (Kateeb, et al., 2011), (Benecke, et al., 2012)).

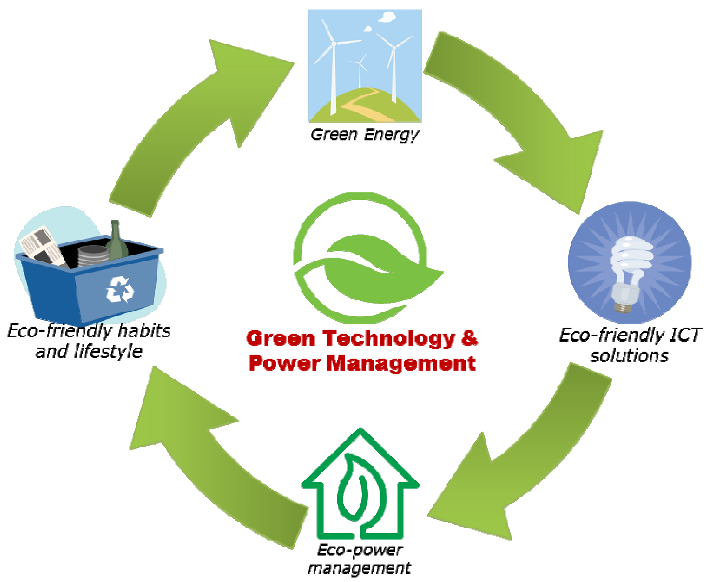
These solutions are very important and strongly related to AAL devices.

For example in Sensing fields, researches are studying a new generation of sensors able to efficiently manage, save, harvest and transmit energy. In order to achieve these results, improvements in the energy harvesting need to be made, such as developing more efficient power generation and data compression techniques for embedded system.

Many of AAL tools, like smart clothes, wearable sensors, and implantable devices, should embed technologies and circuits for automatically harvesting energy and storing it (Mitcheson, 2010).

So the new eco-friendly ICT solutions should be implemented in AAL services in order to provide services for older persons that satisfy each society's current and future green policies.

Furthermore, AAL solutions can help senior citizens to conduct an eco-friendly life. For example, smart environmental sensor networks can monitor the power consumption of electronic appliances and suggest to users the most appropriate strategies to reduce and optimise energy use (e.g. automatically switching off lights in absence of activity and users; regulating the air-conditioning of a single room in accordance with certain tasks, the user's presence and the user's needs) (Borean et al., 2012); and adopting eco-friendly habits (e.g. to help older persons to differentiate recyclable packaging after the use of goods).



8 Recommendations

During the project, five workshops specific to WP2 and three exhibitions at important AAL events were organised to involve AAL stakeholders' members in the project and collect their opinions about the main challenges, issues and recommendations for the future of AAL. Finally about 250 experts external to the Consortium were engaged.

This Section reports the summary of their considerations grouped in five areas.

8.1 Design

Needs of users

Many experts noticed that in the past, many AAL researches were "technology-driven" and so they did not properly take into account the users' needs. For this reason they reiterated the fact that the success of an AAL service and system depends on the proper analysis of the following:

- necessities of end-users (considering also their cultural background),
- structure and processes of local services, and also
- needs of the other stakeholders involved in the service.

Moreover in this process of analysis, it should also be taken in consideration to other important aspects: the evolution of the structure of the society (i. e. the change of the role of family into service provisions), the intergenerational relationships between the various actors of AAL services, and the prevention that should also be carried out before the age of 65 years old.

Fundamental requirements

Moreover many attendees underlined the fact that often AAL systems are very complex because they were designed trying to solve many problems together and to integrate several kinds of services but the results were often unusable to be effectively managed by the end-users. So they suggested to design AAL services starting from simpler solutions, even if less technological, and then to improve them considering the following requirements:

- acceptability,
- user-friendliness,
- accessibility for all,
- customisability,
- dependability, and
- avoiding isolation and loneliness.

For these reasons, they fostered the real cooperation between AAL experts and stakeholders (technicians, service providers, regional and national agencies, architect for smart house, municipality, etc.) in design.

Furthermore the design and development of an AAL solution should also take into account the ethical aspects related to the system and service and also the regulations and policies for the safety and privacy and the protection of critical data.

Knowledge of the AAL projects and products

Another interesting remark expressed by many experts is the redundancy of the AAL solutions caused by missing of knowledge about the previous projects and the existing products.

Carrying out an in-depth analysis of existing solutions allows us to identify devices and services that could be suited for personal purposes and to be integrated in the AAL service, optimising the design work.

Moreover knowing the previous projects, their success and their drawbacks, allows us to avoid repeating the same errors and so not to waste work and funds.

Proper experimentations
In order to verify the effectiveness of new AAL solutions in real life, a proper experimentation should be executed. In particular the validation should be carried out both at the beginning in small scale but also in large scale, and appropriate methodology should be adopted that has as much as possible standardized metrics and benchmarks that depict a homogeneous view of the AAL products and services and users' quality of life.

Duration of projects
Many experts remarked that the duration of the research and design is a critical aspect because often at the end of the project prototypes are obsolete for the market. For this reason they recommended people designing AAL solutions to plan properly and to optimise their work in order to avoid frustrating the research.

8.2 Exploitation

Dissemination of AAL culture
Most of the involved experts asserted that the success of AAL depends on the knowledge of AAL culture. Many elderly persons, caregivers, sociologists and service providers do not know about AAL solutions, or they underestimate potentialities and benefits of ICT devices and new services. For this reason in the next few years, all AAL stakeholders should work more to disseminate the AAL approach and the knowledge about the existing products and services as well as their potentialities. An important role in this dissemination process should be played by the older users and caregivers that are using AAL services and are satisfied with them. They are the best promoters of AAL culture among their friends and colleagues because they are the living example of the effectiveness of the AAL solutions.

Affordability of AAL solutions
Of course the use of AAL services depends on their affordability by private persons, and by public and private service providers. So companies developing AAL services should also conceive different levels of accessibility of its services based on the local organisation and financing of the community.

Exploitation capability of SMEs
However, many experts also noted that often SMEs working in AAL do not have adequate capabilities and resources for an effective exploitation of their services and products. Therefore it is necessary to overcome this issue with appropriate countermeasures to arrive on the market with adequate instruments.

Innovation
Furthermore, pre-existing companies in the socio-medical market should be stimulated to invest in research and development and to innovate their AAL products and services to make them effective and really usable in the market.

8.3 Market

Analysis of AAL market
Experts coming from the SMEs especially complained about the insufficient knowledge of the AAL market so they suggested putting more attention on the analysis of the AAL market to reinforce the utilisation of achieved research prototypes and to speed up their deployment into society.

Fragmentation of AAL market
Many persons working in the AAL sector remarked that the AAL market is strongly fragmented because each country has its own culture, organisation of services, and methods for financing. So in their opinion, the European Community should coordinate the national initiatives in the AAL field in order to avoid a fragmented market.

Entrepreneurship and disruptive business models
Many of the people interviewed noticed that there is a lack of entrepreneurship among subjects working in AAL research due to market risks. Therefore the stimulation of stakeholders to invest is crucial. Identifying innovative and sustainable AAL business models could convince stakeholders (healthcare sectors, insurances, privates, etc.) to invest in disruptive and effective AAL solutions.

Management of project funds
Sometimes projects are underestimated in terms of funds due to some unpredictable reasons that lead to weak developments of products and services. These errors slow down the process of launching these products and services into the market. So from one side, researchers and companies should properly estimate the feasibility of the AAL solution according to the budget, and from the other side, the creation of modular projects in terms of funds could help and favour products and services development and deployment.

8.4 Policies

Innovation and harmonisation of socio-medical care
Many suggestions were expressed about necessary policies in AAL. In particular, experts recommended developing policies, at the European, the national and also the regional levels, to rethink the organization of healthcare by renewing socio-medical services and by including new innovative services with the use of AAL technologies. Moreover they also suggested harmonising policies and rules related among different countries to the deployment of AAL products in order to make them "universal" and really implementable in all of Europe as well as worldwide.

Interoperability, standards and certification
The presence of AAL solutions in society and in the market depends also on missing rules for the standardisation, certification and interoperability of AAL products. It is important to regulate these aspects Therefore, in the next few years more attention should be placed on conceiving an adequate framework to guarantee the interoperability of these AAL platforms into real life and to identify existing or new standards to be implemented in the AAL solution development and the certification processes that AAL systems should satisfy.

Protection of personal information
Most AAL services require the transmission of personal and critical data; however, the existing policies on privacy to protect sensitive information are not sufficient. Policy makers should work in the next few years to regulate the transmission, elaboration, sharing and storing of health and personal data in order to guarantee the safety of their citizens.

Infrastructures
The use of the AAL solutions into society is also invalidated from the lack of adequate infrastructure (e. g. presence of architectural barriers and the lack of adequate WLAN infrastructure in the rural areas). Local and national administrations should work strongly to overcome these obstacles.

8.5 Other remarks

Two other important messages were expressed by experts.

- All older persons should be their own main care givers, so it is important to empower and to make senior people are aware of how they should take care of themselves.
- AAL technologies should be facilitators of AAL services for caregivers, so they should not replace the fundamental role of formal and informal caregivers. These tools should be designed to allow clinicians and care givers to more efficiently follow older people.

9 Conclusions

In conclusion, this document is the AALIANCE2 AAL Roadmap 2014 and identifies the main social, technological and legal issues and challenges of AAL that should be faced for the success of AAL services and technologies into the society and on the market.
The structure of the document reflects the research methodology adopted during the project.
The study started with the analysis of the main necessities and opportunities that AAL solutions can of all AAL stakeholders (older persons and informal carer, formal caregiver, service providers, industries, policy makers, etc.).
After this step, the main areas of services (Prevention, Compensation and Support, Independent and Active Ageing) to improve the QoL of older persons and the efficiency of cares were identified and then ten key AAL service scenarios were described (*Prevention of Early Degeneration of Cognitive Abilities, Healthy Living, Management of Chronic Diseases, Age-Friendly and Safe Environments, Fall Prevention, Management of Daily Activities and Keeping Control over Own Life, Keeping Social Contact and Having Fun, Outdoors Mobility, Avoiding Caregivers Isolation, Senior Citizens at Work*).

On the base of this information the main key technologies enabling the implementation for these services were analysed and described. These technological issues were categorised in five areas: Sensing, Acting, Reasoning, Interacting, and Communicating.

Moreover other important aspects for the real implementation and deployment of AAL solutions were faced. In particular the exanimated topics are the ethical aspects related to AAL, the acceptability of technologies, the strategies for the optimal design of AAL services (theories and concrete example), the AAL market in Europe, the issues related to standards, certification and interoperability in AAL, the dependability and reliability of AAL solutions and the green sustainability of AAL services and tools.
Finally, recommendations, challenges, and issues for the future of AAL, expressed by AAL experts involved in the AALIANCE Network, were collected and reported.

Appendix

From theory to practice: implementation of service design

The Section 7.4 described the elements necessary to establish effective AAL service. This appendix shows a practical example of how implementing the theories reported in Section 7.4 into practice and try to answer to the question '*which steps are needed to achieve sustainable AAL service?*' In addition, the different elements are integrated into four stages, and for each stage, the goals and steps are described. The starting point is one of the scenarios from this roadmap summarised as it follows:

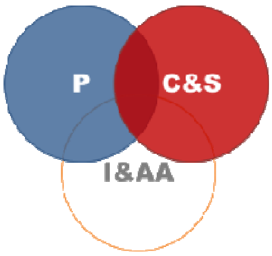
Scenario 3: MANAGEMENT OF CHRONIC DISEASES

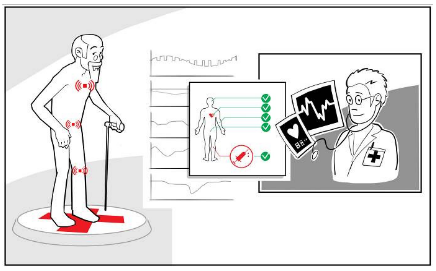
NEEDS & OPPORTUNITIES

Older persons:	- Support in managing their health and to avoid its deterioration. - Help in managing chronic diseases (therapies, taking drugs). - To live freely and independently.
Families, informal carers:	- To be always aware about the health status of the elderly persons. - To facilitate and improve the effectiveness of the assistance in managing their health status.
Service providers, formal caregivers:	- Awareness about the health status of their patients (also remotely). - To prescribe the right therapies for current health conditions.
Local community, society, healthcare systems:	- To maintain the good health of citizens and reduce frequent accessing of hospitals and house-to-house medical examinations. - To intervene promptly in cases of worsening of patients' health.

SERVICE AREAS

- Prevention
- **Compensation and Support**





POSSIBLE USE CASE

Maria is 80 years old and suffers from cardiovascular disease, diabetes and glaucoma. She lives in the countryside with her husband but her children live afar. She is not able to manage all therapies and drugs alone, so clinicians suggested some AAL solutions to her.
To monitor her health parameters, she uses wearable physiological sensors and a smart point-of-care instrument. These systems acquire her health information both on the demand of clinicians and automatically according to her current status, transmitting the data safely.
Clinicians can remotely monitor her health and follow the evolution of her diseases.
To manage use of drugs, Maria uses different types of smart drug dispensers, chosen according to her conditions (e.g. implantable collyrium dispenser for glaucoma, ingestible drug dispenser for insulin and stand-alone dispenser for cardiovascular disease). In case of doubt, she asks the AAL system to provide her the most appropriate indications, thanks to its advanced reasoning system and the remote intervention of her doctor.
Furthermore, every morning Maria carries out prescribed cardiovascular rehabilitation using a smart bike that works both outdoors and indoors. This tool is remotely programmed by clinicians with particular exercises which help Maria to carry out the right training. This system communicates with Maria through a touch display on the handlebars and a smart wireless earpiece. This device works together with wearable physiological sensors (to monitor Maria's health) and transmits acquired data safely to clinicians.
When the AAL system observes potentially dangerous conditions, it promptly alerts her children and

clinicians to get in contact with her and provide assistance.
KEY ENABLING TECHNOLOGIES - Easy-to-use point of care and wearable sensors for monitoring health everywhere - Smart stand-alone, wearable, ingestible and implantable drug dispensers - Smart bikes with touch displays and earpieces to execute indoor and outdoor rehabilitation - Advanced, reliable reasoning systems for data elaboration and recognition of health status - Secure management and transfer of health data and smart interfaces for clinicians

The scenario demonstrates the values for the different stakeholders. The scenario can contribute to the quality of care delivered to an older person, but this value won't be delivered simply by the presence of one (or more) AAL device(s) in the home of the elderly.

STAGE 1 EXPLORATION OF PROBLEMS AND NEEDS

In the first stage, it should be clear who the target group is, for whom the service has to be developed, and what the problems or needs are of the target group. In this way, it creates the necessary sense of urgency and thus the stakeholders feel the need for the development, implementation and application of the innovation. Understanding the target group and their problems or needs is the foundation to implementing a successful innovation concept.

Goal(s)	Definition of: • the target group(s) for whom the service has to be designed • the problems, needs, ambitions, doubts or desires of the target group(s) The values to be achieved are created. In this way the sense of urgency is defined or confirmed for the organization and an image of the values is created that must be realized for the target group(s).
Approach	During this stage, the following must be done: • Know who the target group is in order to define the problem from the point of view of end-users, . • Determine problems or needs of the target group(s). The following tools of Service Design are useful: - day in the life (a day in the life is a descriptive walkthrough of the daily activities of a user) - customer journey mapping (a customer journey provides a vivid but structured visualization of a service user's experience) - contextual interviews (contextual interviews are an ethnographic technique to observe and to probe the behaviours of (potential) users. Interviews are conducted in the environment, or in context, in which the service process of interest occurs). Focus groups can also be suitable. • Translate the problems or needs to realize values for the various target groups.

Starting from the service scenario (exploration stage) first of all, the target groups have to be defined: which particular group of elderly are we talking about? Which group care providers are we talking about? Care organizations? Care professionals? And who are the informal care givers in this scenario?

The second step is to investigate what the problems, needs, ambitions, desires or doubts are of the target group, regarding their management of daily activities and keeping control of their own life. Which supporting needs do the elderly have in this area? What needs are being met or are not, and what are the opportunities to improve the support?

Also what role other relevant stakeholders can play in the development of services with AAL devices should be considered (for example financers or policy makers) and what their interests are in developing services. This has to be taken into account when developing service concepts in the next stage.

STAGE 2 DEVELOPMENT SERVICE CONCEPTS WITH AAL DEVICES

In this phase, together with end-users and other relevant stakeholders, the insights and values discovered in the previous stage will be met with respect to the management of daily activities and of keeping control over one's own life. Doing this together prevents the arising of concepts that don't meet the needs of the targeted group for the service provisioning. Next, one or more concepts have to be developed to be tested in practice.

Goal(s)	• Development of one or more concepts of service provisioning (based upon insights and values found in the previous stage).
Approach	During this stage, the following must be done: • Development of one or more concepts of service provisioning, using AAL devices based upon ideas and insights found in the previous exploration stage.

Starting from a service scenario, there must be a reflection on how the service provisioning for the management of daily activities and keeping control over one's own life must look based upon the values and insights in the previous stage. In this scenario, family, professional caregivers and medical specialists are remotely informed with periodic reports and specific alerts about the status of the older persons.

This description is not concrete enough. Service designers have to search for the answers through the following questions:

- *Which information do AAL devices have to monitor to support the management of daily activities and keeping control over one's own life?* [Sensing]
- *What (part of) information has to be accessible or transferrable to informal caregivers?* [Communicating]
- *What (part of) information has to be accessible or transferrable to formal caregivers?* [Communicating]
- *When?* [Communicating]
- *In what way?* [Communicating]
- *What interventions should follow and based on what information?* [Reasoning]
- *Who has responsibilities and tasks in the intervention?* [Reasoning and Acting]

By answering these questions together, building blocks will arise to be tested in one or more concepts in practice

STAGE 3 PILOT

In Stage 3, concept(s) of service provisioning with AAL devices that arose in the previous stage will be made executable and tested. By piloting the service provision with AAL devices on a small scale, information is gathered on whether it meets the expectations of the earlier drawn business models. Also it creates the possibility of testing several solutions if needed, and insights are gathered on (un-)expected effects as well as information can be retrieved if reality meets the expected results. Experiences can be measured without investment. The pilot will bring insights into which activities and tasks should be performed for a large scale implementation of the service. It creates a stepping stone to make a decision about a large scale introduction of the service provisioning with AAL devices. In this stage, the following sub-stages should be followed:

1. Choice of Concept(s) and preparation of the pilot

In the previous stage one or more concepts of service provisioning with AAL devices were created. To judge which concept(s) are promising for testing in practice is called cresting a business model. It is important to create this model together with the relevant stakeholders. Doing this will create a sense of urgency among the stakeholders. A powerful tool to be used is the Business Model Canvas (described in a previous chapter). The use of the tool "Service Blueprint" can give a clear vision on what has to be organised and by whom. For each concept to be tested, a project plan has to be drawn. The results of both "Business Model Canvas" and "Service Blueprint" can be used as input for the plan. During the pilot, results are monitored.

Some of the tasks to be performed in the preparation phase can be the following (based on the project plan):

- compose an initial business case;
- create insights into the service to be provided by creating a service blue print;
- establish a suitable project organisation;
- compose functional and technical specifications--what requirements must be put on the applications of AAL devices?
- perform a risk analysis--which risks play a significant role with service provisioning to the target group?
- Accommodate (secure) the management of the AAL devices;
- compose all necessary protocols, procedures and agreements of use.;
- select end users that comply with the designated target group;
- train care providers (both formal and informal) and inform the end-users about the implications of the service provisioning with AAL devices;
- develop a research plan to monitor results and effects;
- develop a proper communication plan.

Testing the concept(s) a coalition is needed. This coalition is a partnership of initiators propelling the change that is needed. We refer to it as the guiding coalition. By accommodating tasks and responsibilities in the preparation stages, a natural feeling for ownership and enthusiasm will be established.

2. Execution stage (pilot)

During the execution stage, the following items will be important:

- A guiding coalition is needed. This can be established with a steering committee, a project manager, a project team and working groups.
- Stimulation of support and enthusiasm can be established by organising interim evaluation meetings. The presence and participation of the guiding coalition will enhance the effect intended
- While the pilot is being performed, signs will indicate that the innovation will be successful. Thus it is important to establish a broad baring ground for eventual up scaling. The guiding coalition will act as ambassadors to all stakeholders. Disseminating success internally to the intended target group during the pilot stage will reward the people involved in the hard-working pilot group. With all stakeholders internally and externally, it will create belief in the success of the innovative vision and strategy.
- Meanwhile intended benefits have to be constantly monitored. This will bring insights to the organisation on whether the expectation is in line with the actual results, especially in those cases when the financial resources are limited and a good balance between investments and benefits has to be established.

3. Evaluation

In the evaluation stage, the outcome of the pilot will become clear. The outcome can be compared with the initial targets defined in the project plan. Based on the results, decision making takes place about the next steps.

STAGE 4 IMPLEMENTATION

The goal of Stage 4 is to implement the new service or the renewed one but on a larger scale. At the end of this stage, the program is no longer a pilot but an existing service available for the target group or population. The goal of this stage is that the service with AAL devices becomes a regular, incorporated service of the providing organization. This goal makes it necessary to implement several supporting elements to make the service sustainable.

Sustainability goes hand in hand with adoption and acceptation. For adoption and acceptation, it is important that the perceived value delivered is in accordance with the existing users' needs. Service provided under wrong conditions can result in a decrease of the adoption and acceptation level, or even lead to stakeholders turning away from the service. In this stage, we will have a look into measurements, procedures, rules and regulations to compensate risk and to perform quality management of the user experience.

The following steps are recommended to achieve the goal described earlier:

1) *Risk management*

   Start with the stakeholders and the lessons learned and make an inventory of all the threads that influence the service level of the service. For each threat, estimate the probability that it will occur and the impact it will have. Calculate the risk from the occurrence and impact, and then sort form high to low. Define countermeasures. These countermeasures have to be implemented. In the actions implemented with Step 5, the efficiency of these countermeasures will be monitored and managed. Any risk missed in this step will also be covered in Step 5.

2) *Business Case: Are people still getting what they need/want to pay for?*

   Plain and simple. Redo your business case. Is it still valid, especially with the countermeasures defined in Step 1? This can be a point that the costs for countermeasures are too high for a positive business case. If so, a decision should be made to go on or to stop.

3) *Procedures, Protocols, Rules and Regulations (PPRR)*

   Using the tool "Service Blue Print", final insights will be established on all actions and tasks that have to be performed. It will give information on what to do when and who is responsible. It is important to involve a delegation of all internal stakeholders as well as all experts involved in the service provisioning. With the inventory of the tasks and actions discovered with the service blueprint, a list can be made of the important elements that have to be implemented.

4) *Implement the necessary changes*

   a) Organise the project with a steering group with the most important stakeholder, a project manager, project teams and working groups.
   b) Choose a method for project management. If you like, you can use Prince2 as a method. You should choose a method you are familiar with and feel comfortable using. It should contain at least the following items:
   c) A short and smart description of the purpose and goals you want to achieve. This will have to include the criteria by which this can be evaluated.
   d) A description of every task that has to be performed and which resources will be needed.
   e) A time plan that gives insights into when the resources are needed and which milestones are in the project.
   f) A communication plan
   g) A financial plan
   h) A risk management plan

i) An Evaluation plan

5) After the project has ended by achieving the goals intended the implementation is anchored in the organisation. The quality management of the service provisioning will be implemented by starting a plan, doing the work, checking the work, and acting. In this cycle, all intended and unintended effects will be monitored. Incidents will be registered and analysed. If needed, alterations to the service provisioning can be made, like additional countermeasures.

References

AAL - Ambient Assisted Living. (2012). Ambient Assisted Living Joint Programme - About. Retrieved from http://www.aal-europe.eu/about/

AALIANCE2 Summary of Standards. (2013). Retrieved from http://nero.offis.de/projects/aaliance2/start%2520

ABI Research. (2012, July 13). *Home Monitoring for Seniors Will Drive 36 Million Wearable Wireless Device Market*. Retrieved from http://www.abiresearch.com/press/home-monitoring-for-seniors-will-drive-36-million-.

AGE Platform Europe, et al. (2010, June). *European Charter European Charter of the rights and responsibilities of older people in need of long-term care and assistance*. Retrieved from http://www.age-platform.eu/images/stories/22204_AGE_charte_europeenne_EN_v4.pdf.

AGE Platform Europe. (2012). Older people also suffer because of the crisis.

Ajzen, I. (2002). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology*, 32, 665–683.

Aquilano, M., Salatino, C., & Carrozza, M. C. (2007). Assistive Technology: a New Approach to Evaluation. *IEEE International Conference onRehabilitation Robotics (ICORR 2007)* . Noordwijk.

Auerbach, D. I. (2012, July). Will the NP Workforce Grow in the Future?: New Forecasts and Implications for Healthcare Delivery. *Medical Care*, 7(7).

Avižienis, A., Laprie, J.-C., & Randell, B. (2001). Fundamental Concepts of Dependability. UCLA CSD .

Azlan, M., & David, N. (2011). Biodegradable material options for industrial and goods packaging. *IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*, (pp. 23-27). Penang.

Basu, S., Andrews, J., Kishore, S., Panjabi, R., & Stuckler, D. (2012, Jun). Comparative Performance of Private and Public Healthcare Systems in Low- and Middle-Income Countries: A Systematic Review. *PLOS Medicine*, 9(6).

Benecke, S., Ruckschloss, J., Nissen, N., & Lang, K.-D. (2012). Energy harvesting on its way to a reliable and green micro energy source. *Electronics Goes Green 2012+ (EGG)*, (pp. 1-8). Berlin.

Berglin, L. (2013). *Smart Textiles and Wearable Technology – A study of smart textiles in fashion and clothing*. A report within the Baltic Fashion Project, published by the Swedish School of Textiles, University of Borås. Retrieved from: http://www.hb.se/Global/THS/BalticFashion_rapport_Smarttextiles.pdf

Bicchi, A., Bavaro, M., Boccadamo, G., De Carli, D., Filippini, R., Grioli, G., Tonietti, G. (2008). Physical human-robot interaction: Dependability, safety, and performance. *IEEE International Workshop onAdvanced Motion Control (AMC '08)* , (pp. 9-14). Trento.

Bolder, S. (2011). Invoering van videocommunicatie door zorg aan huis leverende organisaties: een case study. . Universiteit Twente , Health Sciences, Twente.

Borean, C., Ricci, A., & Merlonghi, G. (2012). Energy@home: a "User-Centric" Energy Management System. Retrieved from http://www.energy-home.it/Documents/Others/110518Energy@Home_Whitepaper.pdf.

BRAID Project. (n.d.). Retrieved from http://www.braidproject.eu/

Braubach, M., & Power, A. (2011). Housing conditions and risk: reporting on a European study of housing quality and risk of accidents for older people. *Journal of Housing for the Elderly*, 25(3), 288-305.

Broens, H., Huis in 't Veld, M., Vollendroek-Hutten, M., Hermens, J., van Halteren, T., & Nieuwenhuis, J. (2007). Determinants of successful telemedicine implementations: a literature study*. Journal of Telemedicine and Telecare*, 13, 303-309.

Brown, T. (2008). Design Thinking. *Harvard Business Review*, 84-92.

Calhoun, P. S., Beckham, J. C., & Bosworth, H. B. (2002). Caregiver burden and psychological distress in partners of veterans with chronic posttraumatic stress disorder. *Journal of Traumatic Stress*, 15(3), pp. 205-212.

Camarinha-Matos, L. M., & Rosas, J. (2011). BRAID Project - D6.1 Interim Roadmap for ICT and Ageing. Retrieved from http://braidproject.eu/sites/default/files/BRAID-D6.1final.pdf

Cardile, F., Iannizzotto, G., & La Rosa, F. (2010). A vision-based system for elderly patients monitoring. *3rd Conference on Human System Interactions (HSI 2010)*. Rzeszow.

Cenderello, A., Galasso, G., Gargaro, F., Miele, M., Zamora Adames, D., Millard, J., Pedersen, K. (2013). TECHNOLAGE Project - Final Study Report (D8).

CEV - European Volunteer Centre. (2012). Volunteering Infrastructure in Europe.

Chang, C. (2012). Elderly Care and the Future of Social Innovation. *Stanford Social Innovation Review*. Retrieved from http://www.ssireview.org/blog/entry/elderly_care_and_the_future_of_social_innovation

Clarke, G. (2013). Microsoft brings back Windows watch after Apple seeks 'flexible' bod. *The Register*. Retrieved from http://www.theregister.co.uk/2013/04/16/microsoft_smart_watches/

Clemson, L., Fiatarone Singh, M. A., Bundy, A., Cumming, R.G., Manollaras, K., O'Loughlin, P., & Black, D. (2012). Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial. *BMJ 2012*;345:e4547

Cook, A., & Hussey, S. (1995). *Assistive technologies: principles and practice*. St. Louis: Mosby Year Book Inc.

Czyzewski, A., Dalka, P., Kosikowski, L., Kunka, B., Kupryjanow, A., Lech, M., & Odya, P. (2013). Multimodal human-computer interfaces based on advanced video and audio analysis. *International Conference on Human System Interaction (HSI 2013)*. Sopot.

D'Amico, A., & Di Natale, C. (2014). Beyond Human Senses: Technologies, Strategies, Opportunities, and New Responsibilities. *Lecture Notes in Electrical Engineering*, Volume 162, 2014, pp 3-7.

Daim, T.U., & Suntharasaj, P. (2010). *Technology Roadmap: Lab-on-a-Chip*. Rev. Adm. UFSM, Santa Maria, v. 3, n.1, p. 160-173.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 33(3), pp. 319–340.

Day, H., & Jutai, J. (1996). Measuring the psychosocial impact of assistive devices: the PIADS. *Canadian Journal of Rehabilitation*, 8, 159–168.

Dehghan, M., Mente, A., Teo, K.K., Gao, P., Sleight, P., Dagenais, G., Avezum, A., Probstfield, J.L., Dans, T., & Yusuf S. (2012). Relationship Between Healthy Diet and Risk of Cardiovascular Disease Among Patients on Drug Therapies for Secondary Prevention. *Circulation.* 126:2705-2712.

Delaney, S., Cullen, K., & Dolphin, C. (2011). *Deliverable 7.1 Evaluation plans for INDEPENDENT, WP7: Evaluation and progress assessment*. Retrieved from the INDEPENDENT Project http://independent-project.eu/fileadmin/INDEPENDENT/documents/INDEPENDENT_D7-1_public.pdf

Demers, L., Weiss-Lambrou, R., & Ska, B. (1996). Development of the quebec user evaluation of satisfaction with assistive technology (QUEST). *Assistive Technology*, 8(1), 3–13.

Design, C. o. (1997). *Principles of universal design*. Raleigh, NC: NC State University.

Dohmen, D. (2012). De 'e' van eHealth, Juiste energie voor optimale implementatie van moderne technologie in de zorg thuis. Universiteit Twente, Behavioural Sciences, Twente.

EIP-AHA European Innovation Partnership on Active and Healthy Ageing. (2011, November 17). Strategic Plan. Retrieved from http://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/steering-group/implementation_plan.pdf

EPoSS (2013). *Strategic Research Agenda of EPoSS - The European Technology Platform on Smart Systems Integration*. Pre-Print. Retrived from: http://www.smart-systems-integration.org/public/documents/publications/EPoSS%20SRA%20Pre-Print%20September%202013

European Citizens' Panel. (2007). Rural Europe: Definitions, Issues and Policies.

European Commission (2000). Charter of Fundamental Rights of the European Union, (2000/C 364/01), *Official Journal of the European Communities*. Retrieved from http://www.europarl.europa.eu/charter/pdf/text_en.pdf

European Commission, Committee of the Regions, & AGE Platform Europe (2011). How to promote active ageing in Europe - EU support to local and regional actors. Retrieved from http://ec.europa.eu/social/BlobServlet?docId=7005&langId=en

European Commission, Directorate-General for Economic and Financial Affairs (2012). The 2012 Ageing Report: Economic and budgetary projections for the EU27 Member States (2010-2060). European Economy. Retrieved from http://ec.europa.eu/economy_finance/publications/european_economy/2012/pdf/ee-2012-2_en.pdf

European Commission (2012) a. Proposal for a Regulation of the European Parliament and of the Council on the protection of individuals with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation). Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0011:FIN:EN:PDF

European Commission (2012) b. *Citizens' summary, EU proposals on medical devices*. Retrieved from http://ec.europa.eu/health/medical-devices/files/revision_docs/citizen_summary_20120926_en.pdf

European Commission (2013, November 25). Protection of personal data. Retrieved from http://ec.europa.eu/justice/data-protection/

Eurostat. (2010). Urban-rural typology. Retrieved from Eurostat: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Urban-rural_typology

Eurostat (2012). Mortality and life expectancy statistics. Retrieved from Eurostat: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Mortality_and_life_expectancy_statistics

Eurostat (2013) a. European social statistics - edition 2013. Retrieved from Eurostat: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-FP-13-001/EN/KS-FP-13-001-EN.PDF

Eurostat (2013) b. People at risk of poverty or social exclusion. Retrieved from Eurostat: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/People_at_risk_of_poverty_or_social_exclusion

Fillit, H. M., Gutterman, E. M., & Brooks, R. L. (2000). Impact of donepezil on caregiving burden for patients with Alzheimer's disease. *International Psychogeriatrics*, 12(3), pp. 389-401.

Finn, R., & Wright, D. (2010). Report on mechanisms for stakeholder co-ordination. London: BRAID Project - Bridging Research in Ageing and ICT Development.

Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.

Flaspöler, E., Hauke, A., Pappachan, P., Reinert, D., Bleyer, T., Henke, N., Kaluza, S., Schieder, A., Windel, A., Karwowski, W., Salminen, S., Blaise, J.C., Claudon, L., Ciccotelli, J., Eeckelaert, L., Verjans, M., Muylaert, K., Op de Beeck, R., Eder, B.C., Honings, C., Willems, F., Schaefer, M., Huelke, M., Lehtelä, J., Badiola, J., Nogareda, C., Ellwood, P., Thomson, I., & Shaw, T. (2009). *The human-machine interface as an emerging risk.* Published by: European Agency for Safety and Health at Work. Retrieved from: https://osha.europa.eu/en/publications/literature_reviews/HMI_emerging_risk

Frank R (2000). Understanding smart sensors. 2nd ed. Norwood, MA: Artech House, Inc.

Gasior, K., Huber, M., Lamura, G., Lelkes, O., Marin, B., Rodrigues, R., Zólyomi, E. (2012). *Facts and Figures on Healthy Ageing and Long-term Care - Europe and North America*. Wien: European Centre for Social Welfare Policy and Research.

Genet, N., Boerma, W., Kroneman, M., Hutchinson, A., & Saltman, R. B. (2012*). Home care across Europe: Current structure and future challenges*. World Health Organization.

GHO - Global Health Observatory (2013). *Urban population growth*. Retrieved from http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en/

Gordon, J., Skinner, A., & Button, A. (January 2009). Green Technology: Driving Economic and Environmental Benefits from ICT. World Economic Forum.

Gruhn, P. (2011). Human Machine Interface (HMI) Design: The Good, The Bad, and The Ugly (and what makes them so). *66th Annual Instrumentation Symposium for the Process Industries*.

Hoffmann, F., & Rodrigues, R. (2010, April). *Informal Carers: Who Takes Care of Them?* Retrieved from European Centre: http://www.euro.centre.org/data/1274190382_99603.pdf

Hooker, R. S., Cawley, J. F., & Everett, C. M. (2011, September). Predictive Modeling the Physician Assistant Supply: 2010–2025. *Public Health Reports*, 126, pp. 708-716.

Hu, G., Tay, W.P., & Wen, Y. (2012). Cloud Robotics: Architecture, Challenges and Applications. *IEEE Network*, 26:3, pp.21-28.

Huch, M. (2010). Identification and characterization of the main stakeholder groups for "ICT for Ageing" solutions. Deliverable D2, BRAID Project.

Iannizzotto, G., & La Rosa, F. (2011). Competitive Combination of Multiple Eye Detection and Tracking Techniques. *IEEE Transactions on Industrial Electronics*, 58(8), 3151–3159.

IEA International Energy Agency (2011). Technology Roadmap - Smart Grids. Retrieved from http://www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf

iNEMI Advancing manufacturing technology. (2013). iNEMI Technology Roadmap 2013.

Inmann, A., & Hodgins, D. (2014). *Implantable Sensor Systems for Medical Applications*. Woodhead Publishing Series in Biomaterials.

IEC - International Electrotechnical Commission (1990). *IEC 60050-191 Dependability and quality of service*.

ISO - International Organization for Standardization (1998). *ISO 9241-11 Guidance on Usability*.

ISO - International Organization for Standardization (1999). *ISO 13407 Human-centred design processes for interactive systems*.

Jebari, K. (2013). Brain Machine Interface and Human Enhancement – An Ethical Review. *Neuroethics,* 6 (3), 617-625.

Jianliang Meng, Junwei Zhang, & Haoquan Zhao (2012). Overview of the Speech Recognition Technology. *Fourth International Conference on Computational and Information Sciences (ICCIS 2012)*. Chongqing.

Karanikolos, M., Mladovsky, P., Cylus, J., Thomson, S., Basu, S., Stuckler, D., McKee, M. (2013, March 27). Financial crisis, austerity, and health in Europe. *The Lancet*.

Kateeb, I., Bikdash, M., & Chopade, P. (2011). Back to the future Renewable Energy Sources and green Smart Grid. *Proceedings of IEEE Southeastcon*, (pp. 147-152). Nashville, TN.

Khe Chai Sim (2010). Haptic Voice Recognition: Augmenting speech modality with touch events for efficient speech recognition. *IEEE Spoken Language Technology Workshop (SLT 2010)*.

Kim, D.H., Ghaffari, R., Lu, N., & Rodgers, J. (2012). Flexible and Stretchable Electronics for Biointegrated Devices. *Annual Review of Biomedical Engineering*, 113-128.

Kim, D.H., Lu, N., Ma, R., Kim, Y-S., Kim, R.H, Wang, S.,Wu, J., Won, S.M., Tao, H., Islam, A., Yu, K.J, Kim, T., Chowdhury, R., Ying, M., Xu, L., Li, M., Chung, H.J., Keum, H, McCormick, M., Liu, P., Zhang, Y.W., Omenetto, F.G., Huang, Y., Coleman, T., & Rogers, J.A. (2011). Epidermal Electronics. *Science*, 838-843.

Kotter, J., & Cohen, D. (2002). The Heart of Change. Principles of Leadership with organisational change. Den Haag: SDU Uitgeverij B.V.

Koyanagi, K., & Oshima, T. (2011). Force display touchpad: Prototype and pre-test. *37th Annual Conference on IEEE Industrial Electronics Society (IECON 2011)*. Melbourne, VIC.

Kramer A.F., Erickson K.I., Colcombe S.J., (2006). Exercise, cognition, and the aging brain. *Journal of Applied Physiology*, October 2006 vol. 101 no. 4 1237-1242

Krijgsman, J., de Bie, J., Burghouts, A., de Jong, J., Cath, G.-J., van Gennip, L., & Friele, R. (2013). eHealth, verder dan je denkt - eHealth-monitor 2013. Den Haag: Nictiz en het NIVEL.

Kubitschke L. and Cullen K. (2010). ICT and Ageing; European study on users, markets and technologies. European Commission Report.

Laprie, J. (1995). Dependable Computing: Concepts, Limits, Challenges. *IEEE International Symposium on Fault-Tolerant Computing*, (pp. 42-54). Pasadena, CA, USA.

Li, W., Lee, Y., Tsai, W., Xu, J., Son, Y., Park, J., & Moon, K. (2012). Service-oriented smart home applications: composition, code generation, deployment, and execution. *Service Oriented Computing and Applications*, Volume 6, Issue 1, pp 65-79.

Logan, B., Healey, J., Philipose, M., Tapia, E., & Intille, S. (2007). A long term evaluation of Sensing Modalities for Activity Recognition. *Proc. Of 2007 International Conference of ubiquitous Computing (UbiComp2007)*, 4717, 483-500.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies*, 55, 587–634.

Manyika, J., Chui, M., Bughin, J., Dobbs, R., Bisson, P., & Marrs, A. (2013). *Disruptive technologies: Advances that will transform life, business, and the global economy*. McKinsey Global Institute. Retrieved from http://www.mckinsey.com/~/media/McKinsey/dotcom/Insights%20and%20pubs/MGI/Research/Technology%20and%20Innovation/Disruptive%20technologies/MGI_Disruptive_technologies_Full_report_May2013.ashx

Markets and Markets. (2011) a. European Smart Homes and Assisted Living Market (2010 – 2015).

Markets and Markets. (2011) b. Global Smart Homes Market 2010 – 2015.

Micera, S., Citi, L., Rigosa, J., Carpaneto, J., Raspopovic, S., Di Pino, G., Rossini, L., Yoshida, K., Denaro, L., Dario, P., Rossini, P.M. (2010). Decoding Information From Neural Signals Recorded Using Intraneural Electrodes: Toward the Development of a Neurocontrolled Hand Prosthesis. *Proceedings of the IEEE*, 98(3), 407- 417.

Minuto, A., & Nijholt, A. (2013). Smart material interfaces as a methodology for interaction: a survey of SMIs' state of the art and development. *Proceedings of the second international workshop on Smart material interfaces: another step to a material future (SMI 2013)*. Sydney, NSW, Australia.

Mitcheson, P.D. (2010). Energy harvesting for human wearable and implantable bio-sensors. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. Buenos Aires.

Mohammed, S., Amirat, Y., & Rifai, H. (2012). Lower Limb movement Assistance trough wearable robotics: State of art and Challenges. *Advanced Robotics*, 26: 1-22.

Mulder, H. (2013, November). In voor zorg! Meta-analyse zorg op afstand. Resultaten en aanbevelingen In voor zorg-trajecten. Retrieved from http://www.invoorzorg.nl/docs/ivz/literatuur/Meta-analyse%20Zorg%20op%20afstand%20(2013).pdf

Mullaney, M. (2013, February 27). Student Innovator at Rensselaer Polytechnic Institute Aims To Personalize Medicine With Implantable Sensors. *RPI News*. Retrived from http://news.rpi.edu/luwakkey/3141

Murphy, R., & Schreckenghost, D. (2013). Survey of metrics for human-robot interaction. *ACM/IEEE International Conference on Human-Robot Interaction (HRI'13)*, (pp. 197-198). Tokyo.

National Public Health Partnership (2006). The Language of Prevention. Melbourne.

NCSL (2012). *Heart Disease and Stroke - An Overview of Our Nation's Leading Killers*. Retrieved from http://www.ncsl.org/issues-research/health/heart-disease-and-stroke-an-overview.aspx

NEN Delft (2011). NEN8028:2011 - Dutch standard for Quality management of Telemedicine. Delft.

Nicolas-Alonso, L.F., & Gomez-Gil, J. (2012). Brain Computer Interfaces, a Review. *Sensors*, 12, 1211-1279.

Nielsen, J. (1992). The usability engineering life cycle. *IEEE Computer*, 25(3), 12-22.

Nishino, H., Goto, R., Kagawa, T., Yoshida, K., Utsumiya, K., Hirooka, J., Osada, T., Nagatomo, N., & Aoki, E. (2011). A Touch Screen Interface Design with Tactile Feedback. *International Conference on Complex, Intelligent and Software Intensive Systems (CISIS 2011)*. Seoul.

Niyato, D., Chaisiri, S., & Lee Bu Sung. (2009). Optimal Power Management for Server Farm to Support Green Computing. *9th IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGRID '09)*, (pp. 84-91). Shanghai.

Nouchi, R., Taki, Y., Takeuchi, H., Hashizume, H., Akitsuki, Y., Shigemune, Y., Sekiguchi, A., Kotozaki, Y., Tsukiura, T., Yomogida, Y., Kawashima, R. (2012). Brain Training Game Improves Executive Functions and Processing Speed in the Elderly: A Randomized Controlled Trial, *PLoS ONE*, 7(1): e29676.

Noyce, A. J., Bestwick, J. P., Silveira-Moriyama, L., Hawkes, C. H., Knowles, C. H., Hardy, J., ... & Schrag, A. (2014). PREDICT-PD: Identifying risk of Parkinson's disease in the community: methods and baseline results. *Journal of Neurology, Neurosurgery & Psychiatry*, 85(1), 31-37.

NTT DATA (2014). *Trends in Telehealth. White Paper*. Retrived from www.nttdata.com/americas

OECD - The Organisation for Economic Co-operation and Development. (2013). Addressing Dementia: The OECD Response. Retrieved from http://www.oecd.org/sti/addressing-dementia-the-oecd-response.pdf

Onda, K., & Arai, F. (2012). Parallel Teleoperation of Holographic Optical Tweezers Using Multi-Touch User Interface. *IEEE International Conference on Robotics and Automation*.

Pálfalvi, J. (2011). Kinect Based Ambient Intelligence in AAL Applications, Budapest, Hungry.

PARO Robots U.S., Inc. (2013). PARO Therapeutic Robot. Retrieved from http://www.parorobots.com/

Parthasarathy, R., & Xiaowen Fang (2013). Introducing Emotional Interfaces to Healthcare Systems. *Human-Computer Interaction. Applications and Services. Lecture Notes in Computer Science*, 8005, 150-162.

Pavalko, E., & Woodbury, S. (2000). Social roles as process: Caregiving careers and women's health. *J Health Soc Behav*, 41(1), pp. 91-105.

Peeters, J., Wiegers, T., de Bie, J., & Friele, R. (2013). NIVEL Overzichtstudies: technologie in de zorg thuis. Nog een wereld te winnen! Retrieved from http://www.nivel.nl/sites/default/files/bestanden/Rapport-Technologie-in-de-zorg-thuis.pdf

Petritz, A., Wolfberger, A., Fian, A., Irimia-Vladu, M., Haase, A., Gold, H., Stadlober, B. (2013). Cellulose as biodegradable high-k dielectric layer in organic complementary inverters. *Applied Physics Letters*, 103(15), 153303--153303-5.

Pinquart, M., & Sörensen, S. (2003). Associations of stressors and uplifts of caregiving with caregiver burden and depressed mood: A meta-analysis. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences*, 58(2), pp. 112-128.

Point Topic. (2011). Broadband Coverage in Europe 2011. Research Report for the SMART 0027/2011 Project.

Polidori MC., Nelles G., Pientka L., (2010). Prevention of Dementia: Focus on Lifestyle. *International Journal of Alzheimer's Disease*, 2010: 393579

Pool, R. (2009). Racing greens - [engineering automotive]. *Engineering & Technology*, 4(10), 24-27.

Proteus Digital Health, (2012). Proteus Digital Health Announces FDA Clearance of Ingestible Sensor. Retrieved from http://proteusdigitalhealth.com/proteus-digital-health-announces-fda-clearance-of-ingestible-sensor/.

PWC (2012). *Emerging mHealth: Paths for growth*. Retrieved from PWC: http://www.pwc.com/en_GX/gx/healthcare/mhealth/assets/pwc-emerging-mhealth-full.pdf

Ranck, J. (2012). *The wearable computing market: a global analysis*. Connected Consumer, Gigaom.

Rechel, B., Doyle, Y., Grundy, E., & McKee, M. (2009). How can health systems respond to population ageing? Copenhagen: WHO Regional Office for Europe and European Observatory on Health Systems and Policies.

Reinhard, S. C., Given, B., Petlick, N. H., & Bemis, A. (2008). Supporting Family Caregivers in Providing Care - Chapter 14. In R. G. Hughes, *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US).

Ren, F., (2011). Robotics Cloud and Robotics School. *7th International Conference on Natural Language Processing and Knowledge Engineering (NLP-KE)*, 27-29 Nov. 2011, pp.1-8.

RISDOM, (2004-2006). Analisi del rischio di infortuni e prevenzione, monitoraggio e gestionedegliincidenti in ambientedomestico, RISDOM ASL 5

Rogers, E. (2003). The Diffusion of Innovations. New York: The Free Press.

Sahadi, J. (2004, Feb 13). CNN/Money.com, "Where the jobs will be Greatest employment growth is likely to be in service industries, according to new labor study.". Retrieved from http://money.cnn.com/2004/02/12/pf/jobs_blsprojection/

Savikko, N. (2008). Loneliness of Older People and Elements of an Intervention for its Alleviation. Turku: University of Turku.

Scharft, A. (2010). De toepassingen van telezorg-technologie binnen de COPD-zorg in Oost-Groningen. Een onderzoek naar de mogelijkheden en barrières. Universiteit Twente, Health Sciences, Twente. Retrieved from http://essay.utwente.nl/60614/1/MSc_Aafke_Scharft.pdf

Scherer, M. J. (1998). *The Matching Person & Technology (MPT) Model Manual*. Webster, NY: The Institute for Matching Person & Technology, Inc.

Schumacher, K., Dodd, M., & Paul, S. (1993). *The stress process in family caregivers of persons receiving chemotherapy*. Res Nurs Health, 16, pp. 395–404.

Singh, M., & Singh, M.P. (2013). Augmented Reality Interfaces. *IEEE Internet Computing*, 17(6), 66-70.

Sonnino, R., Matsumura, K.K., Bernardes Junior, J.L., Nakamura, R., & Tori, R. (2013). Fusion4D: 4D unencumbered direct manipulation and visualization. *XV Symposium on Virtual and Augmented Reality*.

Solis, P. and Carlaw, S. (2013). CONSUMER AND PERSONAL ROBOTICS; ABI research.SPC, The Social Protection Committee (2010). *A Voluntary European Quality Framework for Social Services*. Retrieved from http://ec.europa.eu/social/BlobServlet?docId=6140&langId=en

Sponselee, A. (2013). *Acceptance and Effectiveness of Telecare Services from the End-User Perspective*. Technische Universiteit Eindhoven, Eindhoven.

Stephens, M., Townsend, A., Martire, L., & Druley, J. (2001). Balancing parent care with other roles: Interrole conflict of adult daughter caregivers. *J Gerontol B Psychol Sci Soc Sci*, 56(1), pp. 24-34.

Stickdorn, M., & Schneider, J. (2010). This is Service Design Thinking. BIS Publishers.

Stone, E., & Skubic M. (2014). Fall Detection in Homes of Older Adults Using the Microsoft Kinect. *IEEE Journal of Biomedical and Health Informatics.*

Stula, S. (2012). Living in Old Age in Europe - Current Developments and Challenges. Observatory for Sociopolitical Developments in Europe.

Suntharalingam, V., Berger, R., Clark, S., Knecht, J., Messier, A. Newkomb, K., Rathman, D., Slattery, R., Soares, A., Stevenson, C., Warner, K., Young, D., Ang, L., Mansoorian, B., & Shaver, D. (2009). A 4-side Tileable Back-Illuminated 3D-Integrated Mpixel CMOS Image Sensor. *Proc. of 2009 IEEE International Solid-State Circuits Conference (ISSCC 2009)*, 38-39.

Tahavori, M. (2010). Portable green energy sources: Advancement and challenges. *International Conference on System Science and Engineering (ICSSE),* (pp. 599-604). Taipei.

Tarricone, R., & Tsouros, A. D. (2008). Home care in Europe. The solid facts.

The National Association for Home Care & Hospice. (2010). Basic statistics about home care.

Thompson, R., Higgins, C., & Howell, J. (1991). Personal Computing: Toward a Conceptual Model of Utilization. *MIS Quarterly*, 15(1), 125-143.

Trust for America's Health. (2009). Prevention for a Healthier America:. Washington, DC.

Tsuzuki, T., Zhang, L., Rana, R., Liu, Q., & Wang, X. (2010). Production of green nanomaterials. *International Conference on Nanoscience and Nanotechnology (ICONN)*, (pp. 150-153). Sydney, NSW.

TTC (2012). *Roadmap Smart Home: ICT-based solutions for the energy-efficient Smart Home*. Retrieved from http://www.dspvalley.com/userfiles/file/Roadmap%20Smart%20Home%20V1_0.pdf?PHPSESSID=c50202ad733662be76466f19262030f4

VALUE Ageing Project (2012, September 30). *D2.4 – Report on non-technological issues of assistive robot for elderly*. Retrieved from http://www.valueageing.eu/wp-content/uploads/2012/10/D2.4_Report_on_non_technological_issues_of_assistive_robos_for_elderly.pdf

VALUE Ageing Project. (2011, December 09). D2.2 WP2: ICT developments impacting on freedom and autonomy of older citizens - Discussion on the notion of consent of older citizens in situations of dependency. Retrieved from http://www.valueageing.eu/wp-content/uploads/2012/03/D2.2_FINAL.pdf

VALUE Ageing project. (2012, 04 16). D2.3 Ethical and Social Issues related to People with Dementia. Retrieved from http://www.valueageing.eu/wp-content/uploads/2012/04/07AGE03_D2.3_FINAL.pdf

VALUE Ageing Project. (n.d.). VALUE AGEING Incorporatin European Fundamental Values into ICT for Ageing: a vital political, ethical, technological, and industrial challenge. Retrieved from http://www.valueageing.eu/

Van Den Broek, G., Cavallo, F., & Wehrmann, C. (2010). *AALIANCE Ambient Assisted Living Roadmap*. IOS Press.

van Doosselaere, C., Herveg, J., Silber, D., & Wilson, P. (2008). *Legally eHealth - Putting eHealth in its European Legal Context.* Retrieved from European Commission https://webgate.ec.europa.eu/eipaha/library/index/download/id/200

Venkatesh, V., & Davis, F. (2000). A theoretical externsion of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2), 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27(3), 425-478.

Vyas, K.K., Pareek, A., & Vyas, S. (2013). Gesture Recognition and Control Part 1 - Basics, Literature Review & Different Techniques. *International Journal on Recent and Innovation Trends in Computing and Communication*, 1(7), 575–581.

Wang, C.-S. (2013). The Implementation of a Tele-Homecare System with Service Oriented Architecture and HL7 Message Transmission Standard. *American Journal of Public Health Research*, 1(1), pp. 18-26.

WeDO - For the Wellbeing and Dignity of Older people (2012). *European Quality Framework for long-term care services*. Retrieved from http://wedo.tttp.eu/system/files/24171_WeDo_brochure_A4_48p_EN_WEB.pdf

WHO – World Health Organization, Regional Office for Europe (2011). *European report on preventing elder maltreatment*. Retrieved from www.euro.who.int/__data/assets/pdf_file/0010/144676/e95110.pdf

WHO – World Health Organization, Regional Office for Europe () Elder abuse http://www.who.int/ageing/projects/elder_abuse/en/

WHO (2007). WHO Global Report on Falls Prevention in Older Age. Retrieved from http://www.who.int/ageing/publications/Falls_prevention7March.pdf

WHO (2013). Health effects of particulate matter. Policy implications for countries in eastern Europe, Caucasus and central Asia. Retrieved from WHO: http://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf?ua=1

WHO (2014). Ambient Air Pollution database - Update 2014. Retrieved from WHO: http://www.who.int/phe/health_topics/outdoorair/databases/AAP_database_results_2014.pdf?ua=1

WHO (n.d.). Ageing and life course - What is "active ageing"? Retrieved from http://www.who.int/ageing/active_ageing/en/

Wikipedia. (2013, July 02). Sheltered housing. (Wikipedia) Retrieved from http://en.wikipedia.org/wiki/Sheltered_housing

Woodruff, J., & DeLiang Wang (2012). Binaural Localization of Multiple Sources in Reverberant and Noisy Environments. *IEEE Transactions on Audio, Speech, and Language Processing*, 20(5), 1503-1512.

World Economic Forum (2014). Global Agenda Council on Robotics & Smart Devices 2012-2014. Retrieved from http://www.weforum.org/content/global-agenda-council-robotics-smart-devices-2012-2014.

World Economic outlook (2012). Coping with High Debt and Sluggish Growth. International Monetary Fund.

World Health Organization. (2007). Global Age-friendly Cities: A Guide.

Xu, X., & Zhong, M. (2014). Wireless Body Sensor Networks with Cloud Computing Capability for Pervasive Healthcare: Research Directions and Possible Solutions. *Lecture Notes in Electrical Engineering*, Volume 269, 2014, pp 979-988

Yamini, R. (2012). Power Management in Cloud Computing Using Green Algorithm. *IEEE International Conference On Advances In Engineering, Science And Management (ICAESM 2012)*, (pp. 128-133). Nagapattinam, Tamil Nadu.

Yang, C.-T., Wang, K.-C., Cheng, H.-Y., Kuo, C.-T., & Chu, W. (2011). Green Power Management with Dynamic Resource Allocation for Cloud Virtual Machines. *IEEE 13th International Conference on High Performance Computing and Communications (HPCC)*, (pp. 726-733). Banff, AB.

Zamora, B. (2012). Strategic Intelligence Monitor on Personal Health Systems, Phase 2 - Impact Assessment Final Report. *JRC Scientific and Policy Reports*. Retrieved from http://ftp.jrc.es/EURdoc/JRC71183.pdf.

List of Contributors

- Editors:

Michela Aquilano, *Scuola Superiore Sant'Anna, Italy*
Filippo Cavallo, *Scuola Superiore Sant'Anna, Italy*
Paolo Dario, *Scuola Superiore Sant'Anna, Italy*
Alessandra Moschetti, *Scuola Superiore Sant'Anna, Italy*

- Editorial Team:

Giorgia Acerbi*, Scuola Superiore Sant'Anna, Italy*
Laura Fiorini*, Scuola Superiore Sant'Anna, Italy*
Teresa Pagliai*, Scuola Superiore Sant'Anna, Italy*
Marco Eichelberg*, OFFIS, Germany*
Lars Rölker-Denker*, OFFIS, Germany*
John Barry, *Tunstall Healthcare, United Kingdom*
Cecilia Bufton, *Tunstall Healthcare, United Kingdom*
Joseph Tancredi, *Tunstall Healthcare, United Kingdom*
Michael Balasch, *Deutsche Telekom, Germany*
Harald Klaus, *Deutsche Telekom, Germany*
Michael Obach, *Fundatión Tecnalia, Spain*
Carmen Pastor Fernandez-Cuesta, *Fundatión Tecnalia, Spain*
Maude Luherne, *AGE Platform, Europe*
Corien Harder*, ZuidZorg, Netherlands*
Toon van de Looy, *Vanmorgen, Netherlands*
Gerard van Glabbeek, *Vanmorgen, Netherlands*

- Contributors:

Ann Ackaert, *iMINDS Future Internet, Belgium*
Hamid Aghajan, *Stanford University, USA*
Jan Alexandersson, *DFKI Gmbh, Germany*
Takeshi Ando, *Panasonic, Japan*
Alexey Andrushevich, *iHomeLab Lucerne University of Applied Science, Switzerland*
Jens-E. Appell, *Fraunhofer Institute for Digital Media Technology, Germany*
Takakashi Aramaki, *Panasonic, Japan*
Muhammad Asim, *Philips Electronics, Netherlands*
Arlene Astell, *CATCH, United Kingdom*
Johan E. Bengtsson, *Luleå University of Technology, Sweden*
Roberta Bevilacqua, *INRCA, Italy*
Henriette Bods, *DKE, Germany*
Manuele Bonaccorsi, *Scuola Superiore Sant'Anna, Italy*
Henriette Boos, *VDE, Germany*
Helen Campbell, *AGE Platform, Europe*
Juan Carlos Castro, *i2Cat Foundation, Spain*
Amedeo Cesta, *CNR-ISTI, Italy*
Angela Cluzel, *AGE Platform, Europe*
Laura Contin, *Telecom Italia, Italy*

Lorenzo D'Angelo, *TU München, Germany*
Aldo De Leonibus, *Inventya Ltd, United Kingdom*
Kemal Delic, *Hewlett-Packard Laboratories, France*
Giovanni Diraco, *CNR-IMM, Italy*
Ophelie Durand, *AGE Platform, Europe*
Birgid Eberhardt, *VDE, Germany*
Thomas Eichstädt-Engelen, *openHAB, Germany*
Gorka Epelde, *Vicomtech-IK4, Spain*
Raffaele Esposito, *Scuola Superiore Sant'Anna, Italy*
Raquel Fernandez Horcajada, *AAL Joint Programme, Belgium*
Don Fisher, *Stanford Hospital, USA*
Oliver Francke, *GENERATION DESIGN GmbH, Germany*
Masakatsu Fujie, *Waseda University, Japan*
Francesco Furfari, *CNR-ISTI, Italy*
Dolores Gallagher Thompson, *Stanford University School of Medicine, USA*
Sheila Garner, *Brookdale Senior Living, USA*
Marlene Gerneth, *Deutsche Telekom, Germany*
Kate Grant, *Nine Tiles Networks Ltd, United Kingdom*
Walter Greenleaf, SCL, USA
Lauren Grieco, *Stanford School of Medicine, USA*
Kai Hackbarth, *ProSyst Software GmbH, Germany*
Norihiro Hagita, *ATR Intelligent Robotics and Communication Laboratories, Japan*
Arar Han, *Alert-1, USA*
Corien Harder, *ZuidZorg, Netherlands*
Jan Havlik, *Technical University Prague, Czech Republic*
Adele Hayutin, *Stanford Center on Longevity, USA*
René Hempel, *IFAK, Germany*
Wilko Heuten, *OFFIS, Germany*
Walter Hlauschek, *CEIT, Austria*
Anja Hoethker, *Toyota Motor Europe, Belgium*
Anette Hoppe, *BTU Cottbus-Senftenberg, Germany*
Albert Hövel, *Deutsches Institut für Normung e.V., Germany*
Toru Irie, *Orix Living, Japan*
Hiroyuki Ishii, *Waseda University, Japan*
Yoshikazu Ishii, *Panasonic, Japan*
Martin Jaekel, *AAL Joint Programme, Belgium*
Stephen Johnston, *Aging 2.0, USA*
Jean-Claude Junquac, *Panasonic, USA*
Phil Kang, *Epson, USA*
Rolf Kistler, *iHomeLab Lucerne University of Applied Science, Switzerland*
Harald Klaus, *Deutsche Telekom, Germany*
Yo Kobayashi, *Waseda University, Japan*
Boris Koprivnikar, *Association of Social Institutions of Slovenia, Slovenia*
Slava Kozlov, *Summn, Netherlands*
Andreas Kraft, *Deutsche Telekom, Germany*
Kai Kreuzer, *openHAB, Germany*

Tom Kuczynski, *Science and Technology section of the EU delegation in Japan, Europe*
Antonio Kung, *Trialog, France*
Charles Laurey, *ZuidZorg, Netherlands*
Janina Laurila-Dürsch, *VDE, Germany*
Myriam Lipprandt, *OFFIS, Germany*
Ed Mahood, *DEKRA Akademie, Germany*
Fiorella Marcellini, *INRCA, Italy*
Corvin Meyer-Blankart, *Universität Hamburg, Germany*
Takahiro Miyashita, *ATR Social Media Laboratory Group, Japan*
Christoph Nedopil, *YOUSE, Germany*
Luca Odetti, *Tecnalia, Spain*
Roberto Orselli, *Smartex, Italy*
Christoph Ortner, *Universität Salzburg, Austria*
Jan Parchmann, *Universität Hamburg, Germany*
Martin Petzold, *Prosyst Software GmbH, Germany*
Nick Pompa, *Alert-1, USA*
Stefan Radomski, *TU Darmstadt, Germany*
Christian Reichelt, *FZI, Germany*
Antonio Remartinez, *IBERNEX, Spain*
Erika Rovini, *Scuola Superiore Sant'Anna, Italy*
Dirk Schnelle-Walka, *TU Darmstadt, Germany*
Salvatore Sessa, *Waseda Unioversity, Japan*
Naoko Shirota, *Home Care Assistance, USA*
Pietro Siciliano, *CNR-IMM, Italy*
Axel Sigmund, *VDI-VDE, Germany*
Ken Smith, *Stanford Center on Longevity, USA*
Martin Strehler, *Innovations manufaktur GmbH, Germany*
Jürgen Striebinger, *CIBEK GmbH, Germany*
Satheesh Sudarsan, *Samsung, USA*
Atsuo Takanishi, *Waseda University, Japan*
Mohammad-Reza "Saied" Tazari, *Fraunhofer IGD, Germany*
Uwe Tronnier, *FH Kaiserlautern, Germany*
Marian Tzuang, *Stanford University School of Medicine, USA*
Giovanni Ungaro, *Legrand, France*
Ger van den Broek, *Ger van den Broek Consultancy, Netherlands*
Fabrizio Vecchi, *Scuola Superiore Sant'Anna, Italy*
Stephen Von Rump, *Giraff Technologies AB, Sweden*
Markus Weber, DFKI, Germany
David Webster, *IDEO, USA*
Christian Wehrmann, *VDI-VDE, Germany*
Evan Welbourne, *Samsung, USA*
Ligia Whyte, *GAIA, Spain*
Reiner Wichert, *Fraunhofer-Allianz AAL, Germany*
Peter Wintlev-Jensen, *European Commission, Europe*
Kevin Wong, *Stanford University, USA*
Nozomu Yamazaki, *Waseda University, Japan*

Massimiliano Zecca, *Waseda University, Japan*

Gottfried Zimmermann, *Media Univerity Stuttgart, Germany*

- Acknowledgements:

The AALIANCE2 Consortium thanks the European Union for the support and all the AAL experts that participated to our surveys during the AAL Forum 2013 (Norrköping, Sweden), ForItAAL 2013 (Ancona, Italy) and ICT2013 (Vilnius, Lithuania).

AALIANCE2

European Next Generation
Ambient Assisted Living
Innovation Alliance