AALIANCE2

European Next Generation
Ambient Assisted Living
Innovation Alliance

Ambient Assisted Living Strategic Research Agenda

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/

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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 working in the Ambient Assisted Living field. The term Ambient Assisted Living (AAL) defines all services 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 Innovation platform (2008-2010). The main objectives of the AALIANCE2 Project were:

- Transformed 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
- Found 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 (incl. care and healthcare standards)
  - providing recommendations for a 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
- Supported 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:

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TUNSTALL Healthcare Ltd

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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 economic 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.

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Executive Summary

This document 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 strategic research agenda 2014. During the preparation of this document, 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 and AAL Strategic Research Agenda 2014 introduce several changes respect to the versions developed in 2010 by the AALIANCE Project. They go beyond the previous AAL application domains (AAL for Persons, AAL in the Community and AAL at work) and describe 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 six 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. In includes also an overview of the main needs and requirements of the AAL stakeholders (Chapter 1). The second section reports the main results of the studies about the current status of the AAL Market and its future business model perspectives carried out in the WP3 of this project (Chapter 2). The third part describes the three general AAL service areas and the main service scenarios identified during the project (Chapter 3). The fourth 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 4). The fift part describes briefly the main issues related to the implementation of AAL (Chapter 5). The sixth section reports the main recommendations for AAL stakeholders suggested by the members of the AALIANCE Network (Chapter 6).

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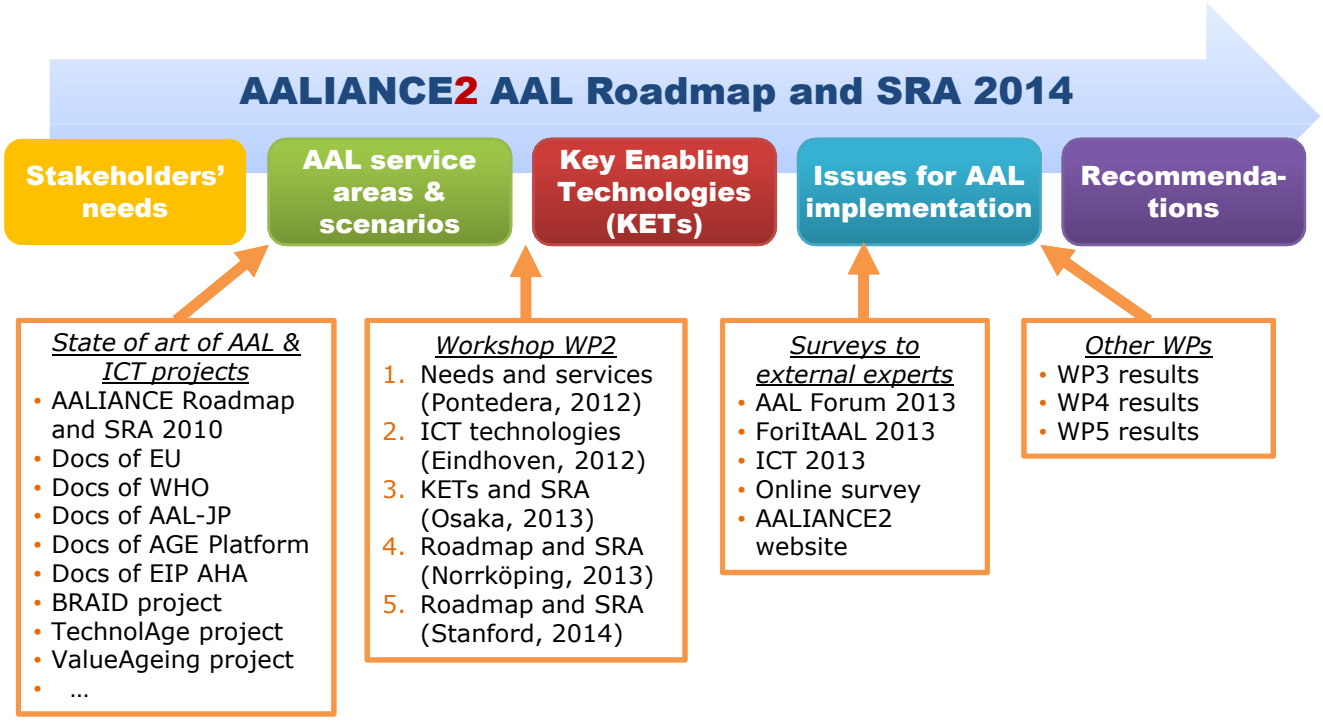
Roadmapping Methodology

The AALIANCE2 Roadmap and SRA 2014 are the results of the work carried out inside WP2 during the duration of AALIANCE2 Project.

From the conceptual point of view, the key contents of the documents are the analysis and identification of the main needs and challenges of AAL stakeholders, the consequent definition of the main areas of service and the key service scenarios and finally the current and future ICT technologies enabling the development of AAL services.

In parallel to these concepts, there were identified and described the social and technological issues necessary for the implementation of these AAL services and systems and also the recommendations coming from the experiences and opinions of AAL experts, both internal and external to the AALIANCE2 project, useful to support the real grow and exploitation of the AAL in our society.

From the practical point of view these documents are the results of two cycles of work during the information was extract by: the analysis of current state of art of ICT and AAL projects and products, and documents published by important agencies working in this sector (e.g. the European Union, the World Health Organization, the AAL Joint Programme, the AGE Platform Europe, etc.); the five Stakeholder Workshops organised on specific themes relative to WP2; the direct and indirect surveys with AAL experts involved in the AALIANCE2 Network; and the main results obtained in the other WPs of the AALIANCE2 Project.



1. Ageing Society: Needs and Challenges of AAL Stakeholders

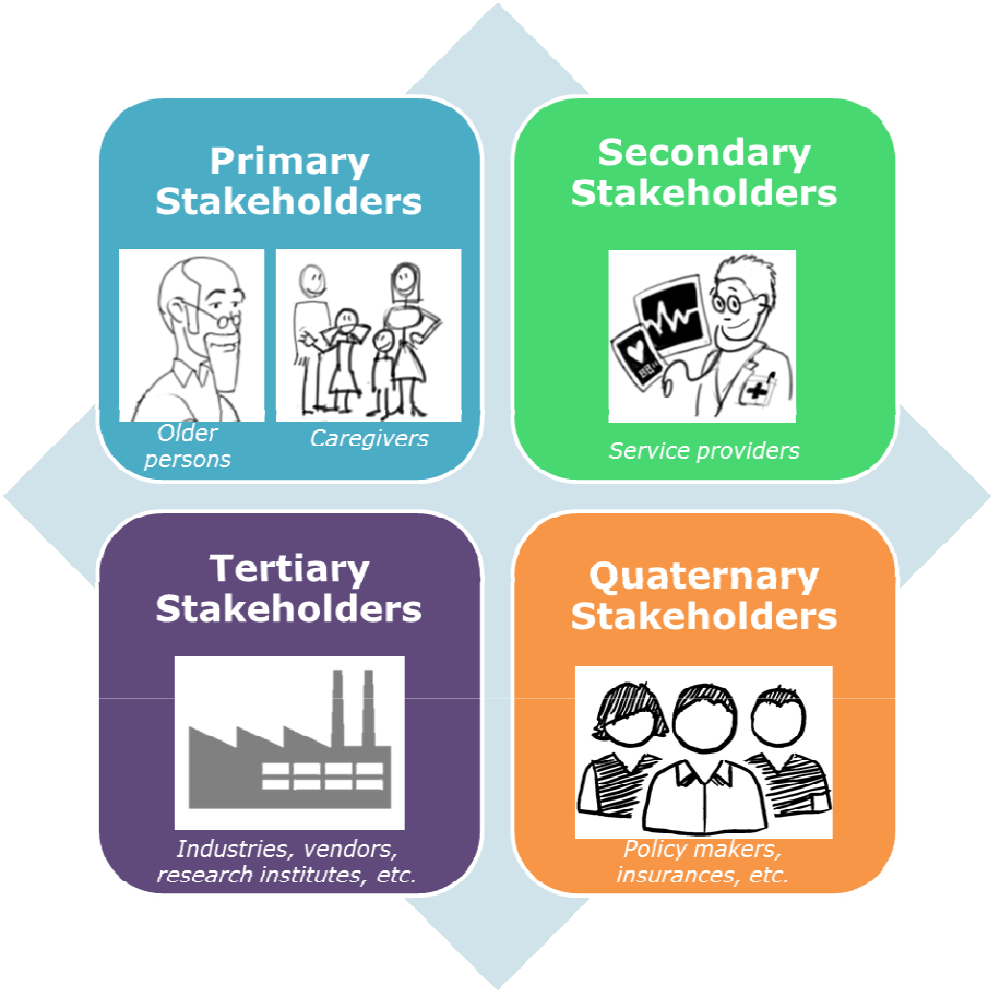


Figure 1. Scheme of the four stakeholders of AAL field

The field of AAL is really wide and complex and is characterized by various trends.
For developing a value Roadmap it is essential to analyse all needs and requirements of AAL stakeholders to design services and technological solutions that will effectively promote and support the idea of "ageing well" (Van Den Broek et al., 2010).
The main groups of AAL stakeholders identified were:

- *Primary stakeholders* (i.e. older persons, their families, informal caregivers)
- *Secondary stakeholders* (i.e. service providers)
- *Tertiary stakeholders* (organisations supplying goods for services like ICT devices)
- *Quaternary stakeholders* (i.e. policy makers, insurance companies, etc.).

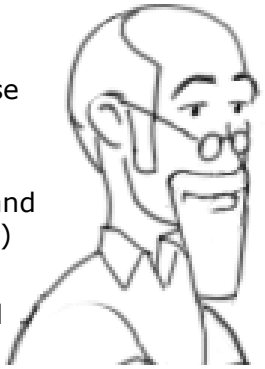
The following sections are aimed at giving an overview of the different perspectives of the primary, secondary and quaternary stakeholders, whereas the Chapter 2 reports the analysis of the current issues and the future challenges of the tertiary stakeholders.

Primary Stakeholders

Older Persons

Elderly persons face problems due decrease of motor, sensory and cognitive abilities related to the ageing process. AAL can help them in:

- Living independently without feelings of loneliness and vulnerability
- Reducing the risk of accidents, falls thanks to preventive exercise and smart domestic environment
- Helping them to easily manage chronic diseases
- Keeping elderly active able to enjoy their life, help their family and contribute to the society (both voluntary and remunerated work)
- Maintaining social contacts
- Facilitating their access to healthcare system and socio-medical care services
- Protecting elderly from maltreatments



Informal Caregivers (family, caretaker, etc.)

Informal caregivers enable many elderly persons to continue living at home, helping them in their daily tasks.

These persons cover almost an average 60% of care request, but often are not adequately supported by the formal care system.

The care-burden often influences negatively their physiological and psychological health and causes them also social problems.

For this reason new policies and healthcare organisation supporting more informal caregivers in their work are necessary.

Secondary Stakeholders

Formal Caregivers (service provider, nurse, volunteer, etc.)

Service providers supply home-care services, long-term care and other intermediate forms of care to older persons according to elderly people health, personal preference and financial situation.

- *Home-care services* → for older persons sufficiently independent, living at home, in good health conditions, that need help to manage some daily activities.
- *Long–term cares* → for older persons living with sever health condition, not independent, that should be followed 24 hours per day
- *Intermediate cares* → day care, night care and senior housing, etc.

Furthermore, also voluntary associations play a fundamental role in socio-medical care of older people. Volunteers usually support elderly persons by going with them to a visit or to have shopping, by keeping them company outside or at home.

The common problem of service providers and voluntary associations is the efficient management of huge requests of support.

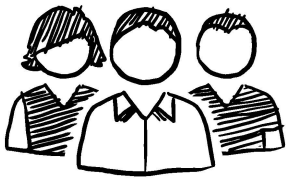
ICT devices can help formal caregiver facilitating their work. In particular AAL devices can execute less important ADL tasks for elderly people, recognise dangerous situations, also by monitoring health and environment condition, support in the performance of motor and cognitive rehabilitation exercises.

Quaternary Stakeholders

Policy makers, insurances, etc.

Efficient and financially sustainable healthcare and long-term care services

In order to face the request for healthcare and long-term care services, and the economic crisis, policy makers and economist should reorganise the services for old persons and optimise resources. AAL services could be part of this reorganization, but strategies for the integration of AAL services in health and social care are still missing.



To facilitate the access to services by all citizens (smart cities and infrastructures)

People are progressively moving to urban areas causing on one side that elderly people will have difficulties in accessing to the community services and on the other side people living in rural areas will be more isolated from the society. In both cases policy makers will have to provide more friendly services, also including ICT, to improve the QoL of citizens. Good infrastructures are therefore needed to connect citizens and improve the mobility and independence of people.

To have healthy and active citizens contributing to the welfare of the community

Governments should promote preventive actions for all the population, so that people could arrive to the elderly age in a healthier condition. In this way citizens can contribute to the community as worker or volunteer even in the old age.

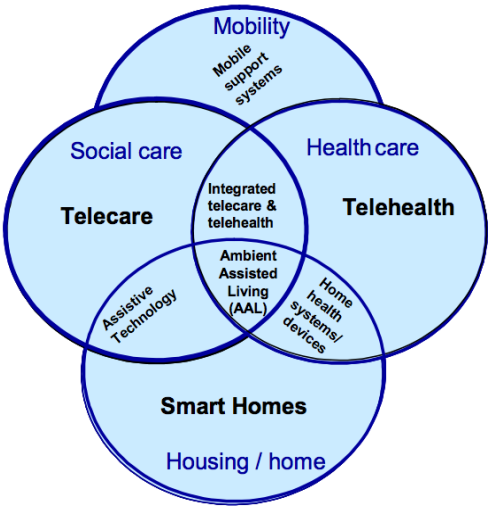
To revise regulations and funding instruments

Importance has to be given to security and privacy regulations and ethical considerations, in order to allow new services to be implemented. Moreover the available standards and certification tools need to be considered in order to regulate the development and use of the services.

2. AAL Market and Business Models

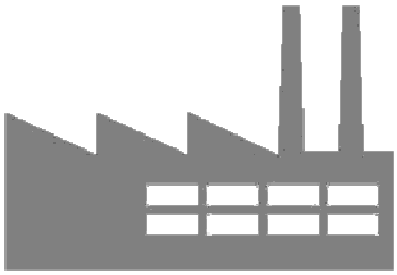
Definition of AAL Market

A segmentation of the ICT Market was proposed by Kubitschke & Cullen and included three main sectors: telecare, telehealth and smart homes. 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 "home automation" 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.



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. 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.

Business models



Ambient Assisted Living was defined as the overlap of telecare, telehealth and smart homes. This definition is clear in the diagram, but it is not so clear in practical use. Few solutions include components from all three domains, and most focus on the overlapping space of any two. This issue has had little impact on the ICT and Aging, as their approach was to look at the market state for each of the domains individually rather than to focus on the areas of overlap. In any event, this exhibit is widely used to explain the relationship between telecare, telehealth and smart homes and is the reference point for defining the AAL market.

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 (UK, Spain and Germany) 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 developments of these three major markets are described in details in the AALIANCE2 Roadmap 2014.

Proven Ambient Assisted Living business models that meet the criteria of delivering the benefits of telecare, telehealth and smart homes havenot been identified. What weidentified 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.

AAL Market trend

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 is leading to the need for better understanding of the technical challenges associated with medical electronics manufacturing. 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).

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 hindranceson its growth.

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).

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.

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.

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.

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 expectsthat 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).

Concerning mobile Health (mHealth), 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.

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.

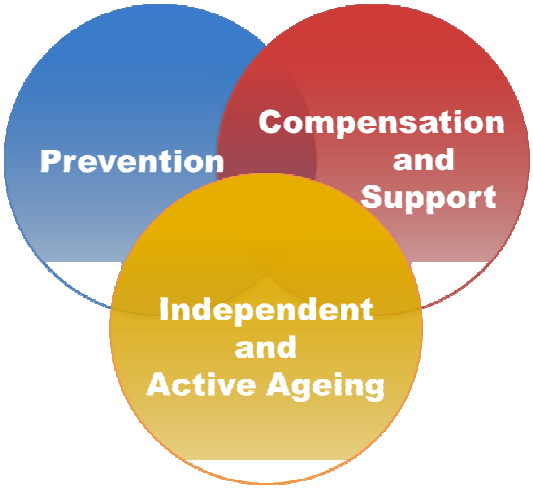
3. AAL Service Areas and Scenarios

In order to face needs and challenges of AAL stakeholders and to improve the quality of life of older persons and to help informal and formal caregivers in their work, new and renewed scenarios of AAL services were identified.

In AALIANCE2 these scenarios were grouped in three main service areas, called Prevention, Compensation and Support, and Independent and Active Ageing.

These three service areas represent the effects that services have on life of older people.

These areas are complementary and at the same time overlapping, because many services can produce benefits associable to two or all three of these aspects.



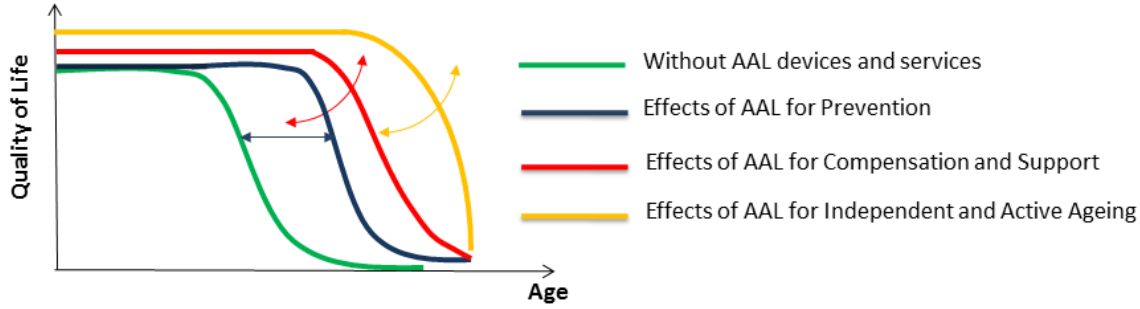
The services related to these areas help people staying healthy and be part of the society, guarantying them longer a good and adequate quality of life (QoL).

The **following figure** shows how the AALIANCE2 service areas could contribute to increase the perceived QoL:

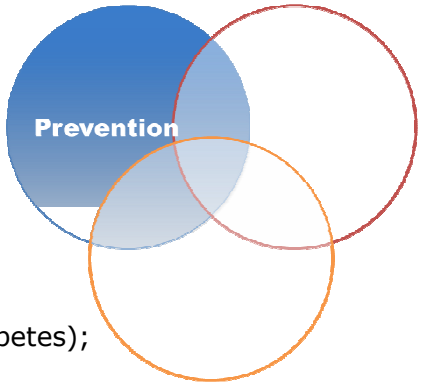
- the green line represents the standard QoL, which naturally decrease after a certain age due to morbidities and disabilities, as well as the reduction of social interactions;
- preventive actions, delaying or reducing morbidities, can also postpone the decreasing of QoL (see dark blue line);
- moreover, services compensating motor, sensing and cognitive deficits and supporting older persons in daily activities can induce a later worsening of the QoL (see red line);
- actions related to independent living and active ageing can have positive effects on older persons wellbeing and self-esteem and consequently can further maintain longer a good QoL (see yellow line).

Through these AAL service areas older people should be longer involved and active into society, improving their QoL and contributing longer to the community welfare.

All these actions can be efficiently supported by ICT technologies which can facilitate the accomplishment of these services.



Prevention



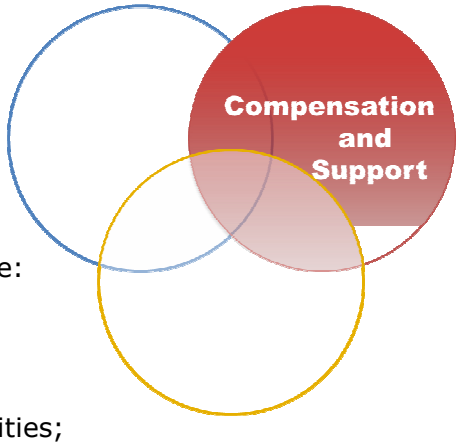
Prevention can be defined as the "action to reduce or eliminate the onset, causes, complications or recurrence of disease" *.
In the AALIANCE2, the Prevention area focuses mainly on actions to avoid or delay the onset of significant morbidity. The AAL technologies could have an important role in services for prevention because they could facilitate the implementation of these scenarios.
Examples of AAL preventive actions are:

- prevention of degeneration of cognitive diseases;
- chronic diseases (i.e. cardiovascular disease, COPD, diabetes);
- prevention of domestic accidents;
- prevention at work;
- falls prevention.

AAL solutions useful for these services are apps and interfaces for brain training, wearable sensors and smart interfaces to monitor and guide the execution of physical activity, smart electronic appliances helping to adopt an healthy and personalised diet.

** National Public Health Partnership, "The Language of Prevention," Melbourne, 2006.*

Compensation and Support

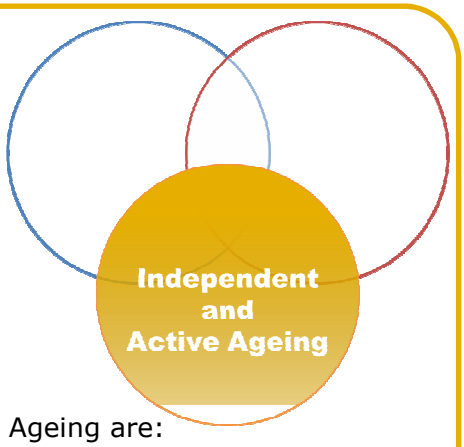


The Compensation and Support area includes the AAL services and devices that could help older persons in compensating some physical, sensory and cognitive limitations, derived from diseases and injuries, and in supporting them in daily life.
These solutions could be useful not only to maintain elderly persons more independent but to facilitate and optimise the work of caregivers.
Examples of AAL actions for Compensation and Support are:

- management of chronic diseases (monitoring, therapy, rehabilitation);
- management and care of the house;
- assistance in daily life activities;
- support for social interactions, hobbies and leisure activities;
- support for indoor and outdoor mobility;
- support at work.

AAL solutions useful for these services are point of care, smart sensors and tools for health monitoring, robotic systems (exoskeletons and assistive robots), facilitated interfaces, smart apps and cars for outdoor mobility, smart instruments for work and hobbies.

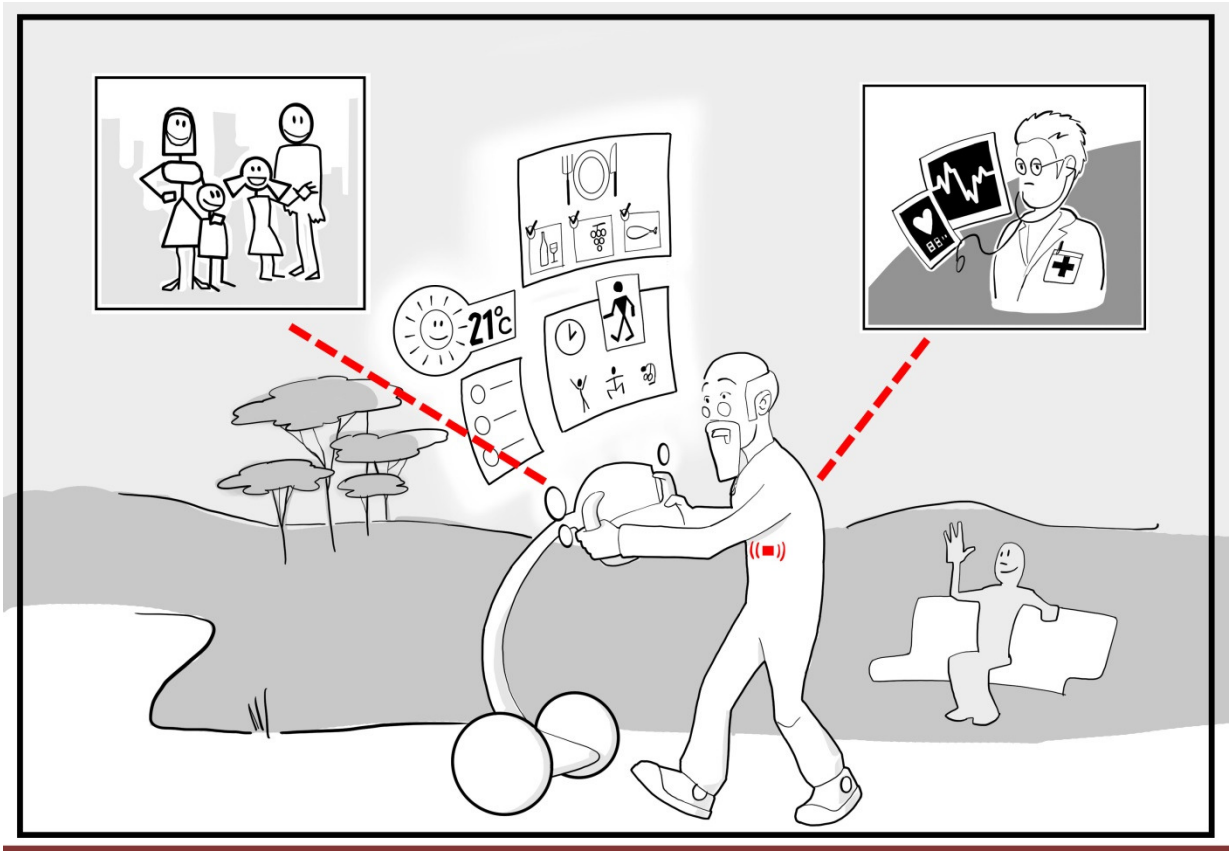
Independent and Active Ageing



This service area includes activities and services that allow older people to be longer independent, participate to the social activities and, when possible, work. In particular these scenarios should contribute to make elderly persons safer in their own place, able to manage their daily routine and more part of the community, helping them to be socially included. These AAL solutions may combine health, social care and smart living systems and 'age-friendly' environments.

Examples of AAL actions related to Independent and Active Ageing are:
- solutions to make safe and age-friendly domestic environment;
- facilitating social contacts and leisure activities;
- help for keeping control over life and decisions;
- support to be active in the community context and also at work.

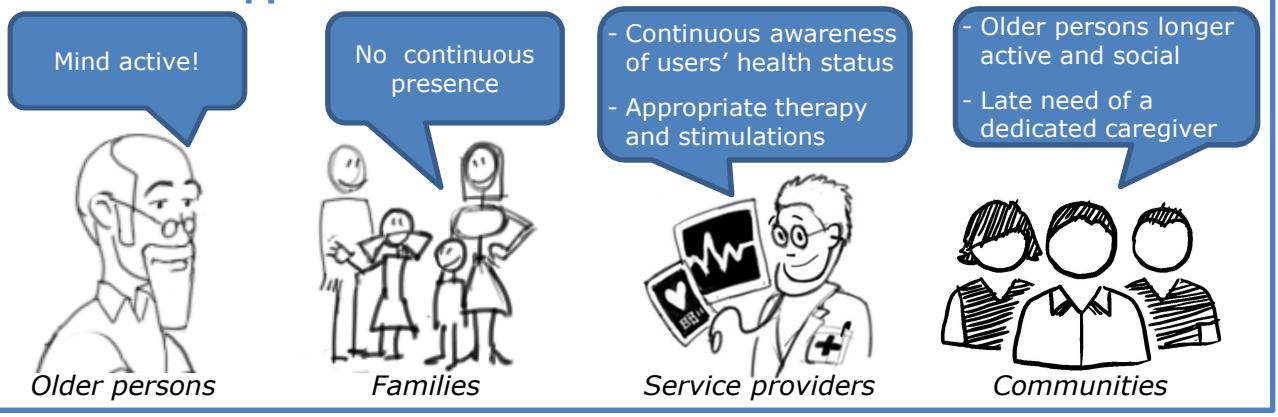
The use of ICT for independent living and active ageing is a key element to tackle current challenges of care and ageing, such as empowering people with age related dependencies or disabilities to live independently, delaying/avoiding institutionalization and staying active as much and as long as possible. Useful technological solutions are smart instruments for gaming, making hobbies and working, intuitive interfaces to have contact with family, friends and community, smart appliances and robots to manage easily daily tasks.



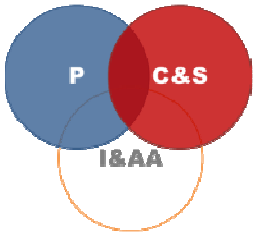
Scenario 1: Prevention of early degeneration of cognitive abilities

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. .

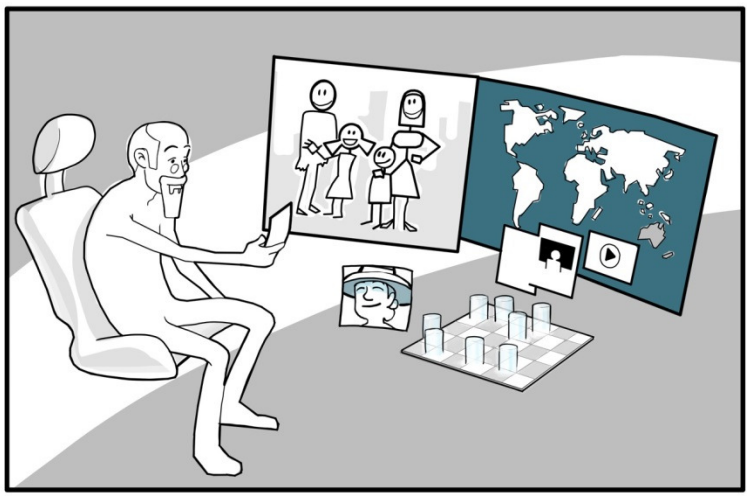
Needs & Opportunities



Stimulation of cognitive and motor abilities both alone and with therapists



Enabling Technologies



- Multimedia devices
- Sensorial, spatial and natural language interfaces
- Apps and smart games
- Smart interfaces for medical personnel
- Cloud

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

TIMELINE	*Task 1 Reminder and informer*	*Task 2 Cognitive gaming at community centres*	*Task 3 Cognitive gaming at home*	*Task 4 Remote control by clinicians*	
2014 **Short Term** 2018	▪ Multimedia appliances (e.g. smart TV) ▪ Personalisable apps to remind events and to provide news and information	▪ Multimedia appliances for group activities (e.g. interactive whiteboards) ▪ Natural language interfaces and spatial interfaces (e.g. tools for gesture recognition) ▪ Personalised gaming applications for the stimulation of cognitive abilities	▪ Multimedia appliances to be used alone (e.g. tablets, smartphones) ▪ Natural language interfaces and spatial interfaces (e.g. tools for gesture recognition) ▪ Personalised gaming applications for the stimulation of cognitive abilities	▪ Control interfaces for the caregivers and clinicians	**KETs**
2019 **Mid-Term** 2024	▪ 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	
2025 **Long Term** 2030		▪ 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		

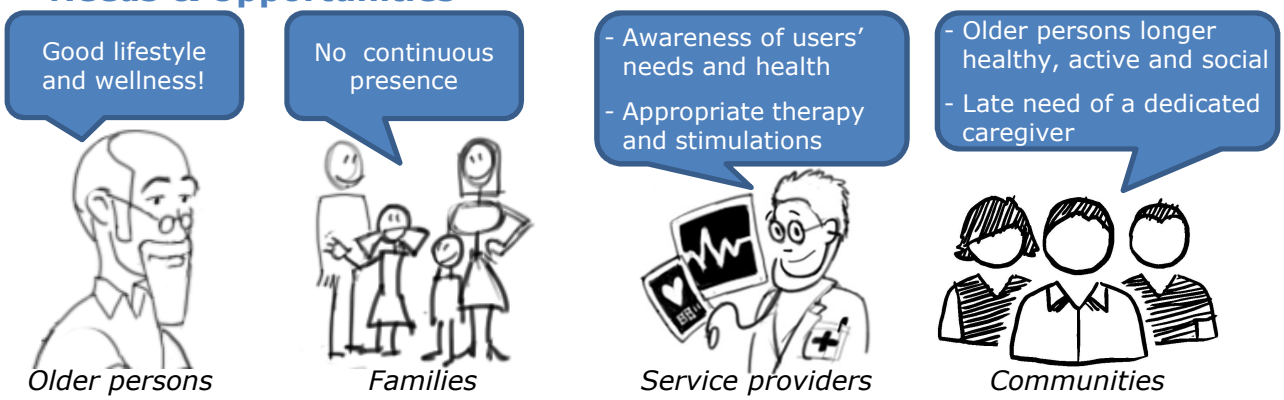
- ***Business perspectives of Scenario 1***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and interfaces - Gaming software and apps to stimulate cognitive capabilities - Service providers organising activities for elderly entertainment and stimulation	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

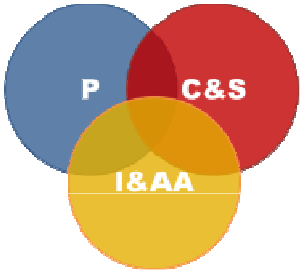
Scenario 2: Healthy Living

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.

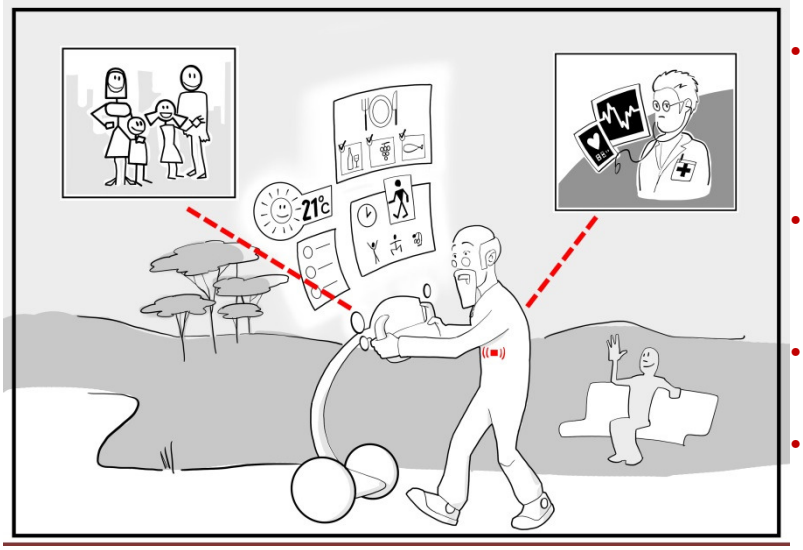
Needs & Opportunities



Healthy and improved life style: right diet and more physical activity



Enabling Technologies



- Smart wearable sensors to monitor health status during physical activity and correct movements
- Smart TV and augmented reality (avatar) to have some training at home
- Smart appliances helping to adopt healthy diet
- Remote control tools for caregiver

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

TIMELINE	*Task 1 Reminder of events and trainings*	*Task 2 Support for right diet*	*Task 3 Physical training*	*Task 4 Remote control by clinicians*	
2014 **Short Term** 2018	▪ Multimedia appliances ▪ Personalisable software and apps for reminding events and trainings	▪ Multimedia appliances ▪ Smart domestic appliances (refrigerator and hob) ▪ Personalisable software and apps providing advices for the right and healthy diet	▪ Multimedia appliances ▪ Smart accessories (glasses, watch, bracelet, etc.) ▪ Personalisable software and apps for sport ▪ On-body (wearable) sensors for health and motor monitoring ▪ Spatial interfaces for recognition of movements and gestures ▪ Reasoning tools to train, model, and recognise user's motor abilities	▪ Control interfaces for doctors and trainers	**KETs**
2019 2024 **Mid-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	
2025 **Long Term** 2030			▪ Advanced sensorial interfaces (e.g. virtual reality, holograms) ▪ Advanced intelligence for self-learning-modelling and automatic modification of motor training		

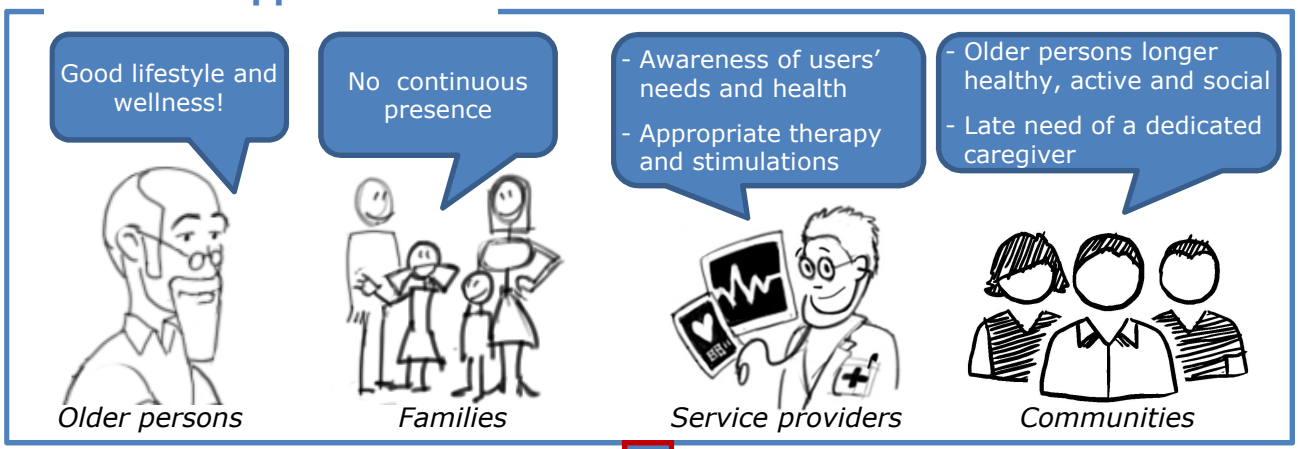
- ***Business perspectives of Scenario 2***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances, smart accessories and smart jewellery - Domestic appliances - On-body (wearable) sensors for health monitoring - Virtual reality - Software and apps for health, diet and motor activity - Service providers and sport groups	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.

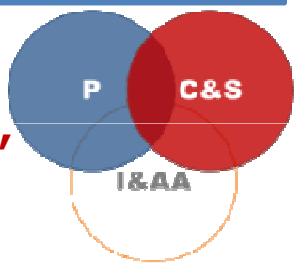
Scenario 3: Management of chronic diseases

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.

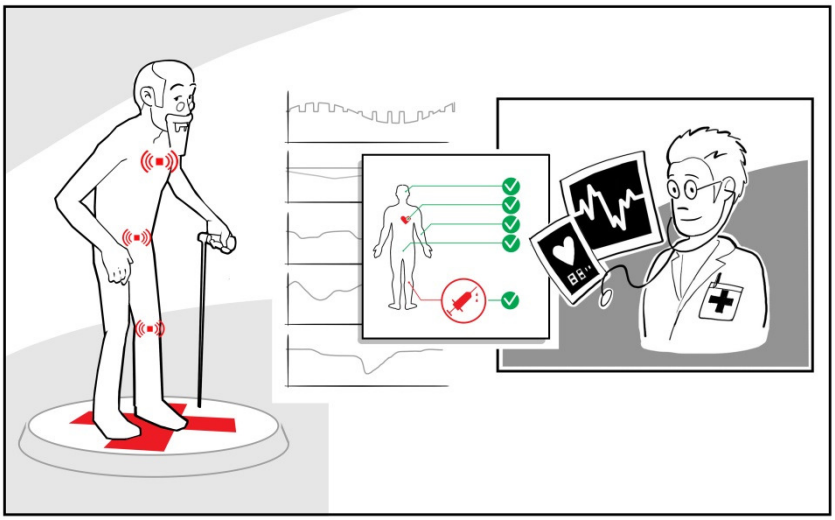
Needs & Opportunities



To monitor frequently health parameters, to help to manage drugs and to execute accurately and frequently rehabilitation



Enabling Technologies



- Smart rehabilitation for indoors and outdoors
- Tele-care
- Wearable sensors for physiological monitoring
- "Virtual" doctor for early support and education
- Smart interfaces to interact with caregiver and clinicians
- Point of care for health monitoring
- Smart dispensers of drugs
- Cloud

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

TIMELINE	*Task 1 Health monitoring*	*Task 2 Taking drugs*	*Task 3 Rehabilitation*	*Task 4 Remote control by clinicians*	
2014 **Short Term** 2018	▪ Standalone point of care ▪ Multimedia appliances and software applications for health monitoring ▪ On-body sensors for health and motor monitoring	▪ Standalone drug dispenser ▪ On-body (sticking plaster and wearable) drug dispenser	▪ Sensorised indoor rehabilitative devices ▪ Smart accessories for health monitoring ▪ Personalisable software and apps for rehabilitation ▪ Spatial interface for movements recognition ▪ 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	KETs
2019 **Mid-Term** 2024	▪ 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	
2025 **Long Term** 2030	▪ 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		

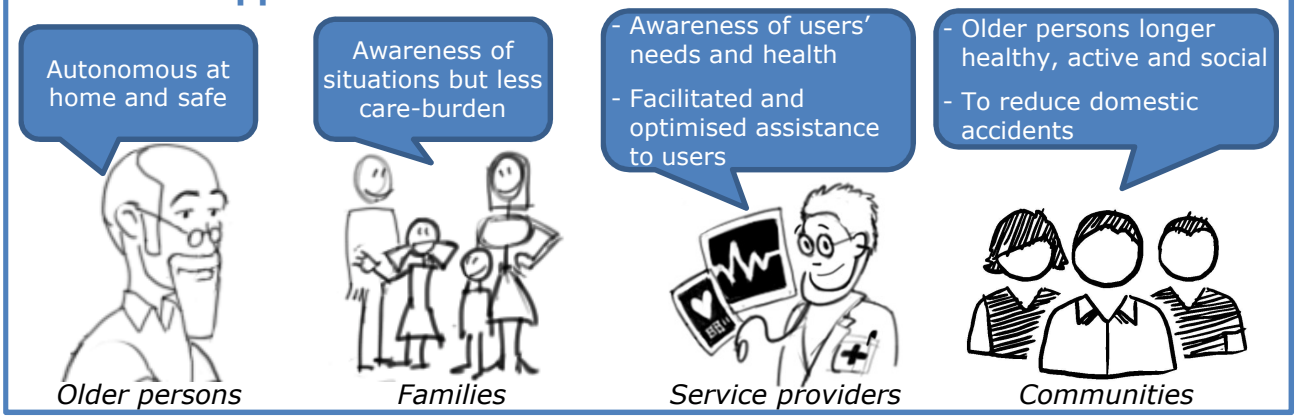
- ***Business perspectives of Scenario 3***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and smart accessories - In- and on-body drug dispensers - In- and on-body health sensors - Indoor and outdoor tools for rehabilitation - Virtual reality - Software and apps for health, drugs and rehabilitation - Service providers and clinical centres	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.

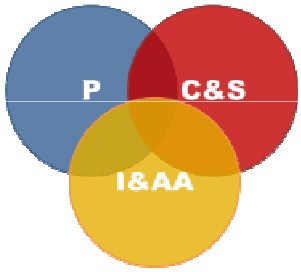
Scenario 4: Age-friendly and safe environments

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.

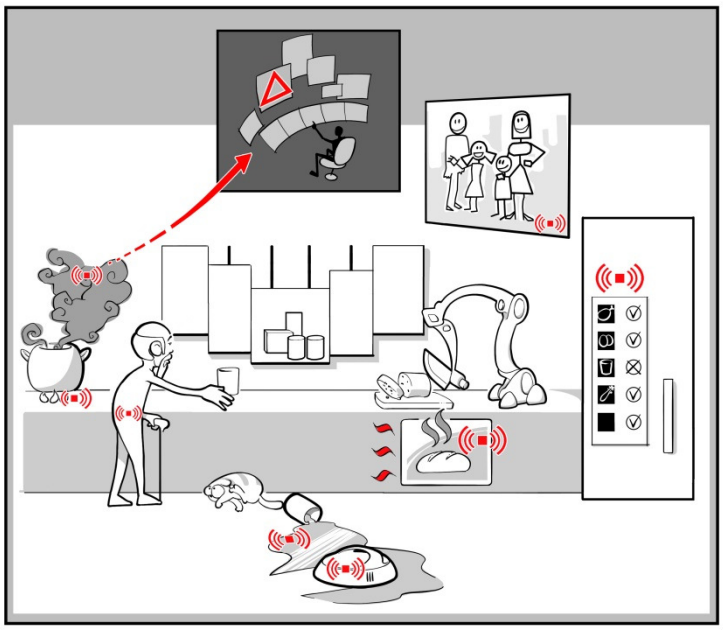
Needs & Opportunities



Automations and safety systems at home



Enabling Technologies



- Smart miniaturized environmental sensors
- Smart electronic appliances and automated furniture
- Service robots
- Smart apps for social inclusion
- Easy to use control interfaces
- Remote control tools for caregivers
- Cloud

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

TIMELINE	*Task 1 House safety*	*Task 2 House management*	*Task 3 Remote control by caregivers*	
2014 **Short Term** 2018	▪ 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**
2019 **Mid-Term** 2024	▪ 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	
2030 - 2025 **Long Term**		▪ Assistive robots		

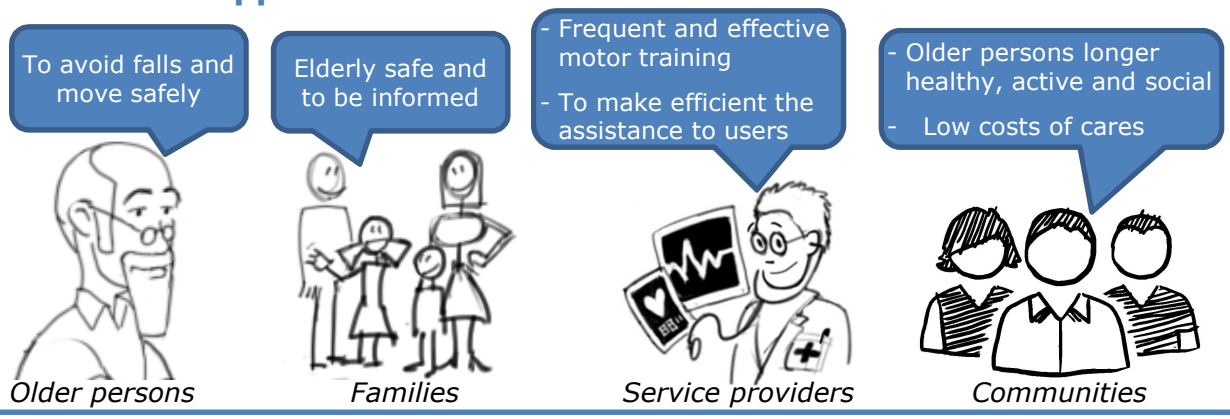
- ***Business perspectives of Scenario 4***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and smart accessories - Environmental sensors - House automations - Furnitures - Smart domestic appliances - Assistive robots for assistance at home	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.

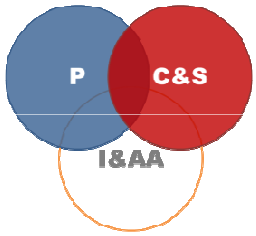
Scenario 5: Fall prevention

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.

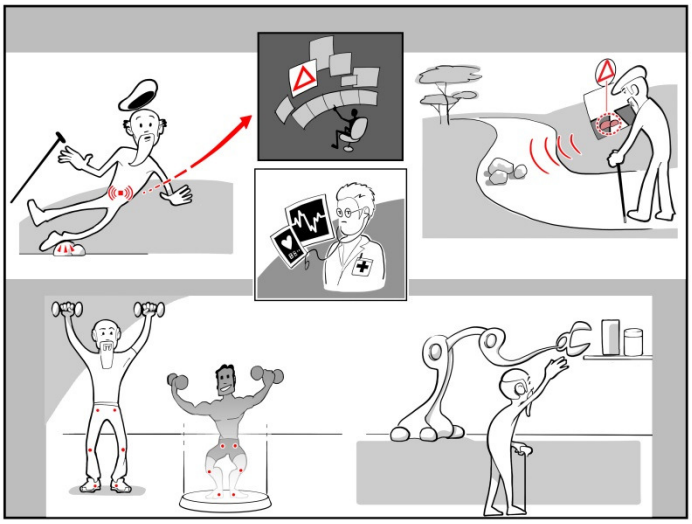
Needs & Opportunities



Safe indoor and outdoor environments and preventive actions to maintain motor and balance abilities



Enabling Technologies



- Smart stick for walking safely outdoors
- Wearable sensors for health and motion monitoring
- Smart TV, gymnastic tools and apps for motor training
- Smart miniaturized environmental sensors
- Service robots
- Cloud
- Interfaces for remote control

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

TIMELINE	*Task 1 Avoiding accidents at home*	*Task 2 Moving safely at home*	*Task 3 Moving safely outdoors*	*Task 4 Preventive motor training*	*Task 5 Alert for caregivers*	
2014 **Short Term** 2018	▪ 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, balance, motor abilities	▪ Interface for caregivers	**KETs**
2019 **Mid-Term** 2024			▪ Smart stick recognising obstacles ▪ Smart accessories and multimedia tools connected to the smart stick	▪ Smart gymnastic tools	▪ Data fusion ▪ Advanced processing system for recognition of dangerous situations	
2025 **Long Term** 2030	▪ Robotic arm for reaching inaccessible points and objects					

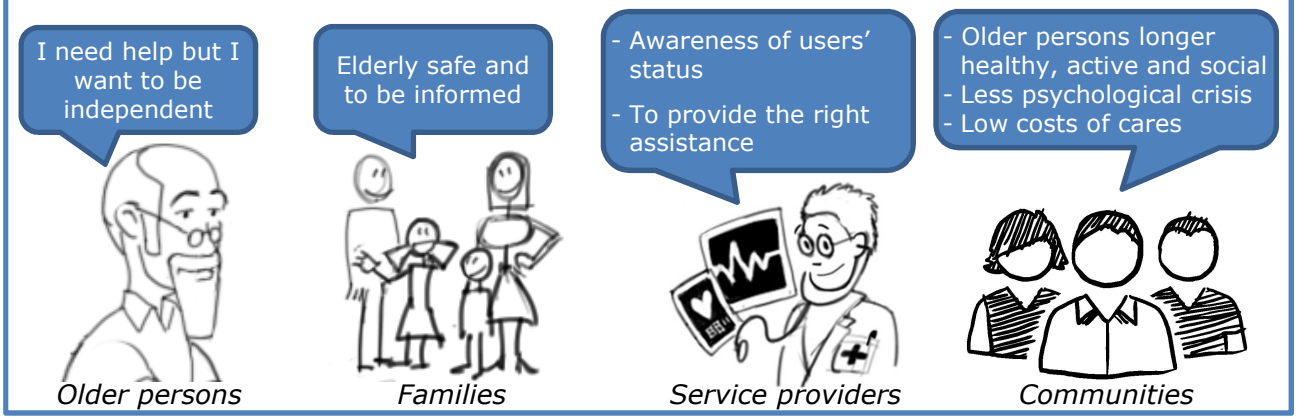
- ***Business perspectives of Scenario 5***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and smart accessories - Environmental sensors - House automations - Assistive devices for mobility - Assistive robots for assistance at home - Smart gymnastic tools for training	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

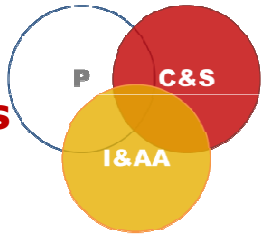
Scenario 6: Management of daily activities and keeping control over own life

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.

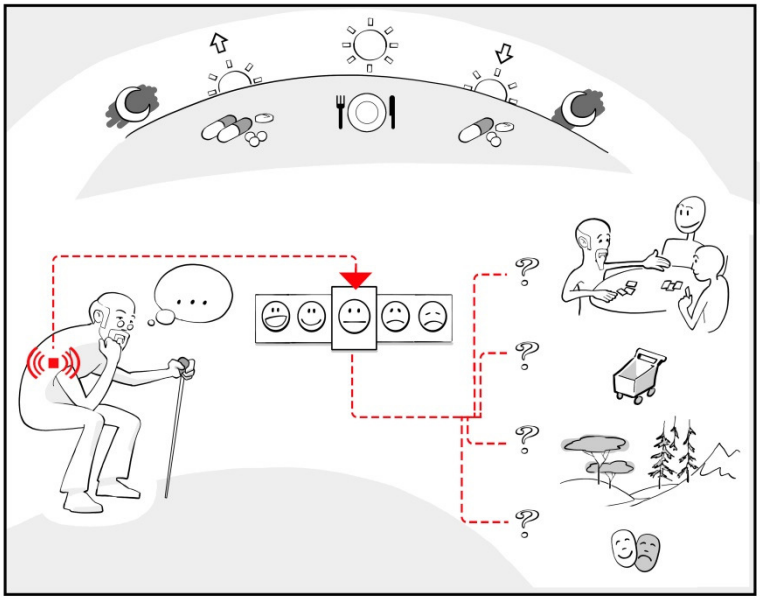
Needs & Opportunities



Support to manage house and daily activities
Psychological support and social inclusion



Enabling Technologies



- Smart miniaturized environmental sensors
- Smart electronic appliances and automated furniture
- Smart tools for hobbies at community centre
- Multimedia devices for social interaction
- Interfaces for user remote control
- Cloud

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

TIMELINE	Task 1 Monitoring of house	Task 2 Management of house	Task 3 Reminder of events	Task 4 Social activities	Task 5 Monitoring for caregiver	KETs
2014 **Short Term** 2018	▪ 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	
2019 **Mid-Term** 2024					▪ Ambient intelligence to recognise dangerous events and also user mood ▪ Safe data transfer	
2025 **Long Term** 2030		▪ Assistant robot				

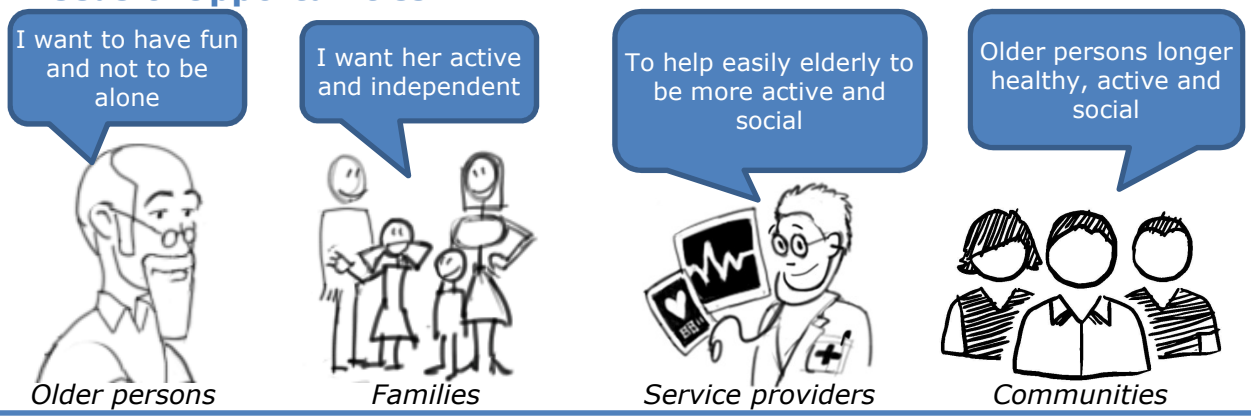
- ***Business perspectives of Scenario 6***

Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and related applications - Environmental sensors - Smart domestic appliances - Assistive robots for assistance at home - Tools for hobbies	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.

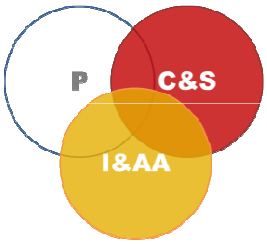
Scenario 7: Keeping social contact and having fun

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.

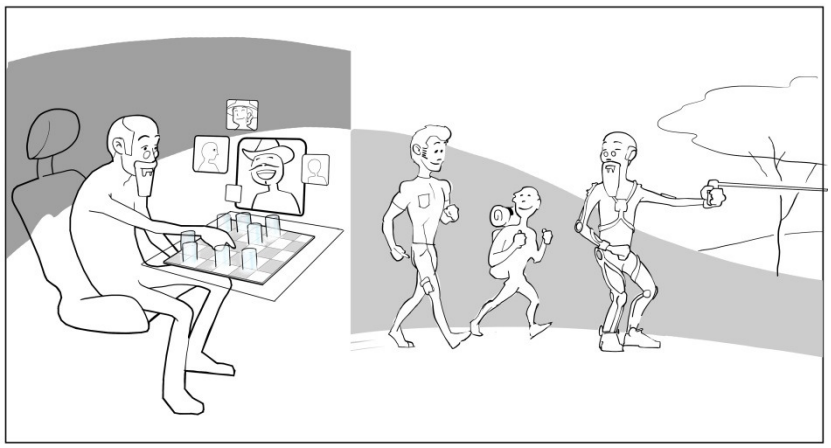
Needs & Opportunities



Support to practice hobbies and to have social contacts with family and friends



Enabling Technologies



- Smart applications to know events of the community
- Smart platforms for remote access to social activities
- Light and wearable robotic exoskeleton to compensate motor deficits
- Smart tools for practicing hobbies
- Tools for remote control
- Cloud

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

TIMELINE	*Task 1 Facilitating sport and hobbies*	*Task 2 Support for manual hobbies*	*Task 3 Playing cards*	*Task 4 Participation to social activities*	
2014 **Short Term** 2018		▪ 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**
2019 **Mid-Term** 2024	▪ 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	
2025 **Long Term** 2030	▪ Light exoskeletons for lower and upper limbs	▪ Light exoskeletons for arms and hands to facilitate fine movements			

- ***Business perspectives of Scenario 7***

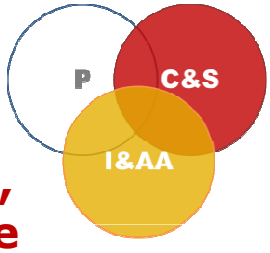
Business sectors	Market segment	Funding	Business Model
- Multimedia platform for remote participation to games and social events - Exosteletons - Smart accessories and assistive devices - Smart tools for hobbies	Limited but growing uptake regardless of country and segmentation (Comfortable+ or Less Affluent). 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

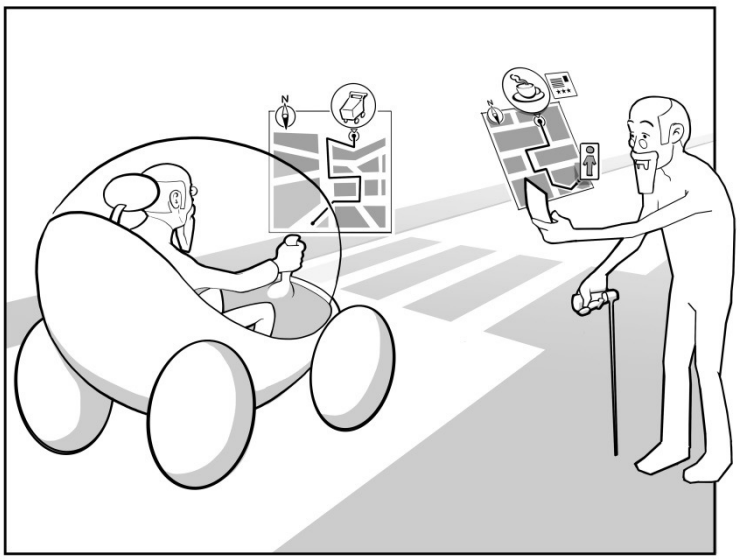
AAL technologies could develop interesting solutions useful to simplify the mobility of elderly people, like easy tools for pedestrians, smart cars helping user in driving, and accessible buses and public transports.

Needs & Opportunities

To help elderly to move safely inside the city, to have usable and accessible buses, trams, etc. to make safer the elderly drive



Enabling Technologies



- Multimedia devices and apps for path planning (pedestrian, public transport)
- Smart and accessible buses, trains, subways
- Smart cars and autonomous cars
- Smart sensors and tools for obstacle avoidance
- Cloud intelligence for traffic management
- Wearable sensors/ smartphone for localization and help in case of need
- Interface for remote control

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

TIMELINE	*Task 1 Public transportation*	*Task 2 Pedestrians*	*Task 3 Private transport*	
2014 **Short Term** 2018	▪ 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**
2019 **Mid-Term** 2024		▪ 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	
2025 **Long Term** 2030		▪ Wearable robotic solutions, i.e. prosthetics	▪ Autonomous cars (self-parking, no-pilot drive) ▪ Advanced infrastructure for transportation in smart cities and rural areas	

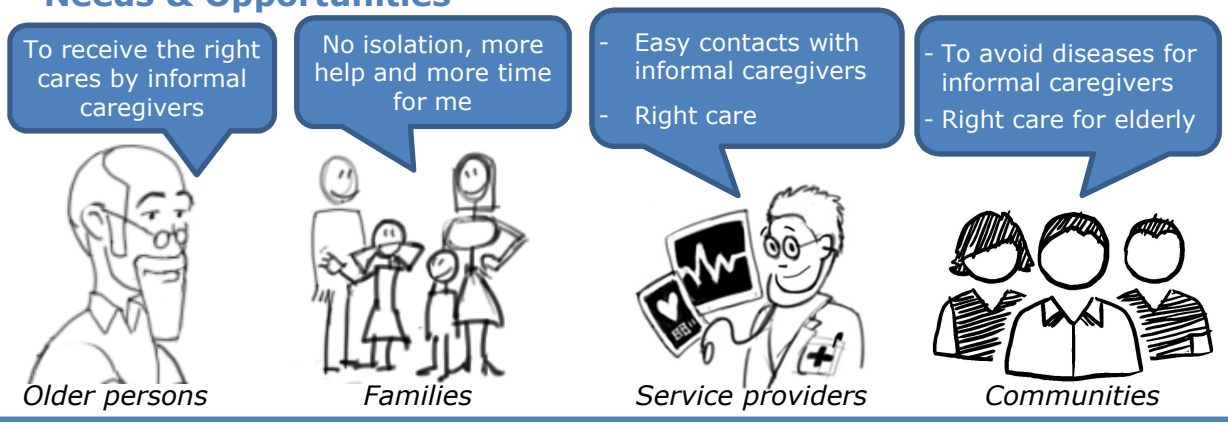
- ***Business perspectives of Scenario 8***

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

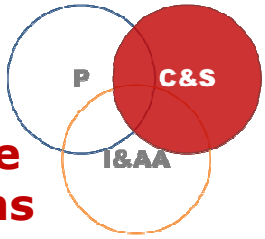
Scenario 9: Avoiding the isolation of caregivers

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.

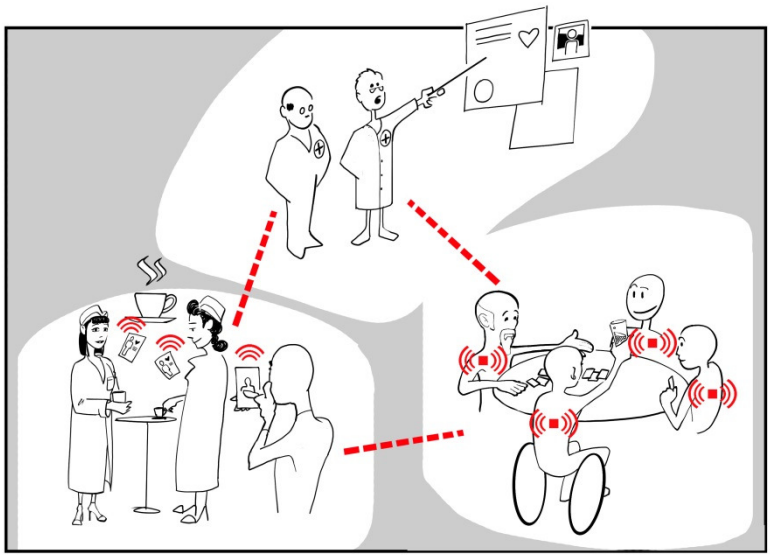
Needs & Opportunities



To facilitate informal caregiver to take care of elderly and to help them to take decisions



Enabling Technologies



- Facilitated interfaces for remote interaction with experts
- Assistive robots and smart appliances
- Smart applications to help decision making and to provide first help
- Smart sensor network for recognising events
- Hardware and software tools for the safe transfer and management of data
- Cloud
- Tools for remote control

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

TIMELINE	*Task 1 Remote consulting with experts*	*Task 2 Context awareness*	*Task 3 House management*	
2014 – 2018 **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**
2019 – 2024 **Mid-Term**		▪ Ambient intelligence for the recognition of anomalous behaviours ▪ Safe data transfer		
2025 – 2030 **Long Term**		▪ Big data management		

- ***Business perspectives of Scenario 9***

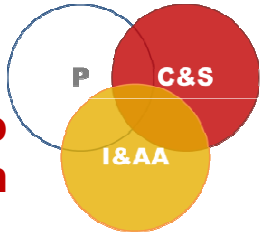
Business sectors	Market segment	Funding	Business Model
- Multimedia appliances and applications for remote control and consulting - Ambient Intelligence for context recognition and awareness of behaviour - Environmental sensors - Smart domestic appliances - Assistive robots for assistance at home	Limited 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

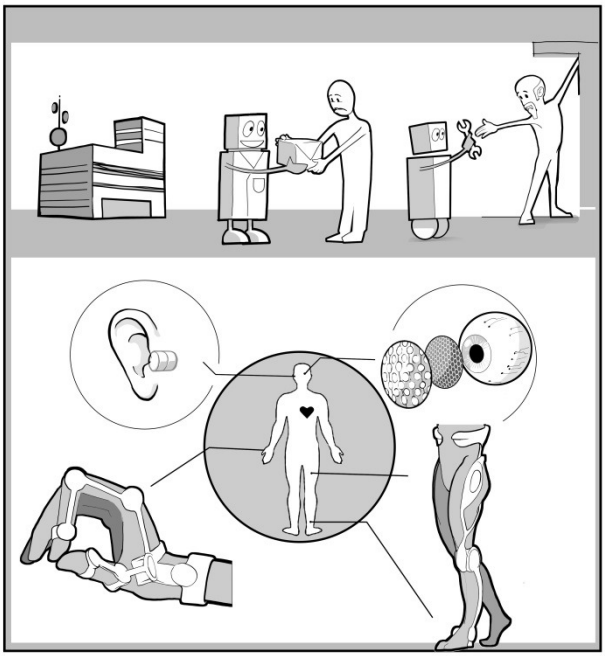
Senior working is a phenomenon which is becoming more and more common inside worldwide communities. AAL technologies can develop new working tools, like assistant robots and work equipment, able to facilitate work tasks of older persons. Moreover AAL devices can also be used to carry out preventive actions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

Needs & Opportunities

To facilitate work of older people and to carry out preventive actions to maintain good health conditions



Enabling Technologies



- Co-worker robot and smart work tools (e.g. smart glasses, etc.)
- Wearable sensors for health and motor data
- Exoskeletons
- Virtual trainer and smart gymnastic tools
- Cloud
- Tools for remote control

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

TIMELINE	*Task 1 Heavy work activities*	*Task 2 Precision work activities*	*Task 3 Preventive training*	
2014 **Short Term** 2018	▪ 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**
2019 **Mid-Term** 2024	▪ 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	
2025 **Long Term** 2030	▪ Advanced co-worker robots with high cognitive and physical interaction capabilities	▪ Exoskeletons	▪ Reasoning systems to manage work activities and prevent related risks	

- ***Business perspectives of Scenario 10***

Business sectors	Market segment	Funding	Business Model
- 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	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

4. KEY ENABLING TECHNOLOGIES IN AAL

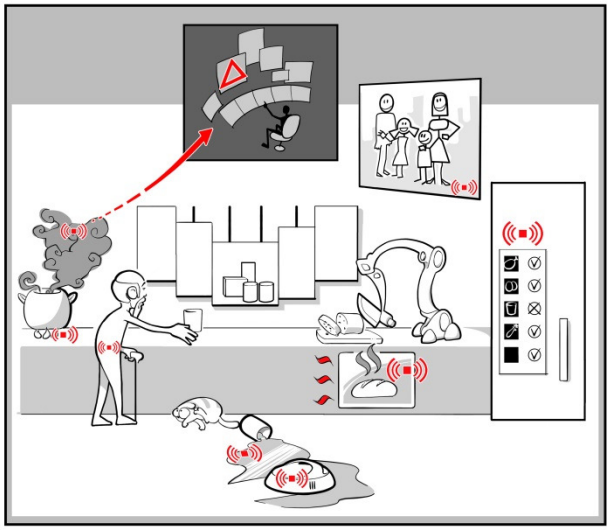
Key enabling technologies (KETs) are considered to be possible drivers in guiding EU policy for growth and attaining responsiveness to societal challenges, industrial leadership, sustainability and excellence in science.

They are the basis for the development of 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"***).

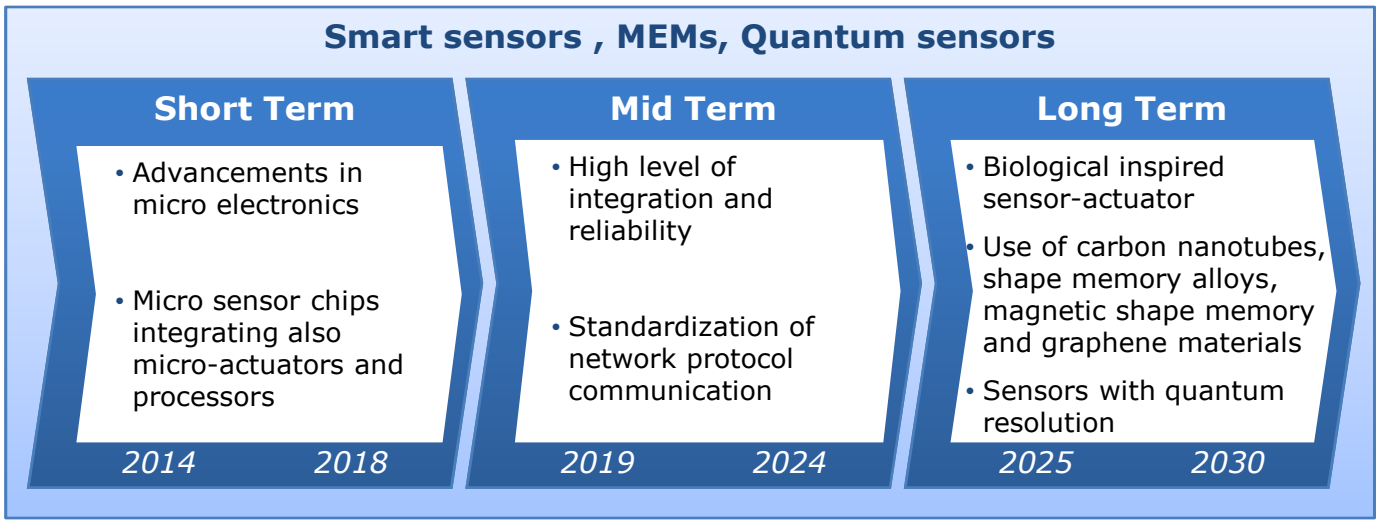
Obviously the different system components need to communicate with each other in order to provide the overall assistive service for which the system has been designed (***"Communicating"***).

Sensing

New sensing principles and technologies to measure physical, chemical, electrical, optical, etc. quantities of a phenomenon and to produce outputs usable to improve the AAL services

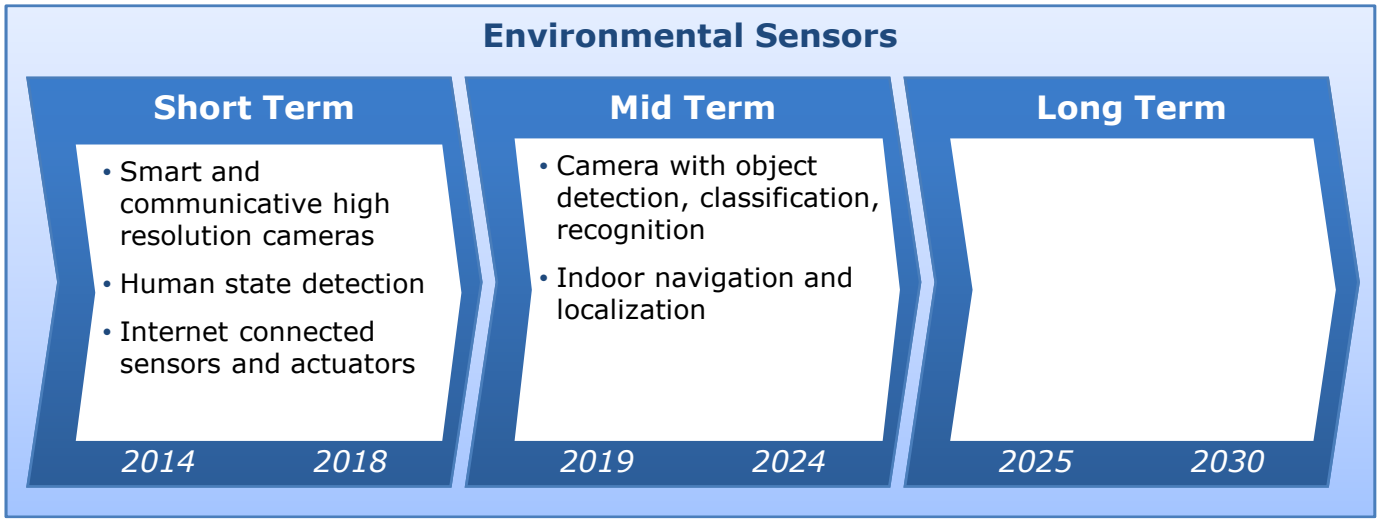


- **Micro-Electro-Mechanical System (MEMS)**
  micro system-based sensors for mechanical, optical, magnetic, and chemical measurements, produced thought the techniques of micro fabrication
- **Smart Sensors**
  intelligent systems-on-chip integrating the sensing element with an electronic circuit for on-board storage, computation and communication of data
- **Quantum Sensors**
  system based on quantum states with high resolution and sensitivity

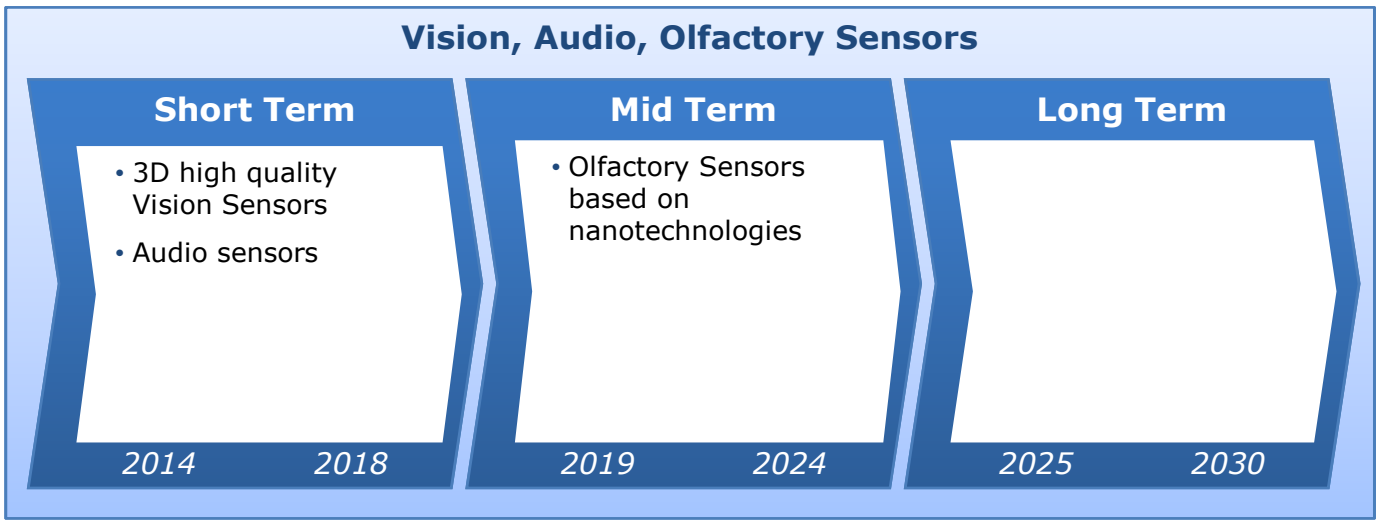


- **Environmental sensors**
  sensors for monitoring the surrounding environment and its condition

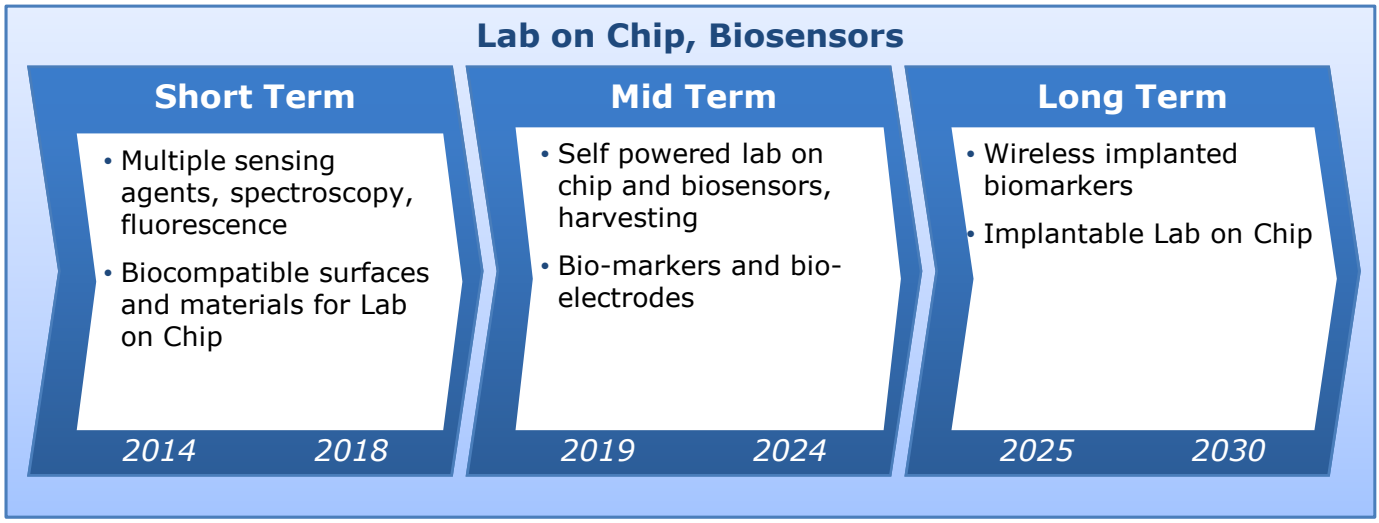
- **Pervasive Sensing & Smart Environments**
  network of sensors set in the environments able to merge information and recognise events and situations



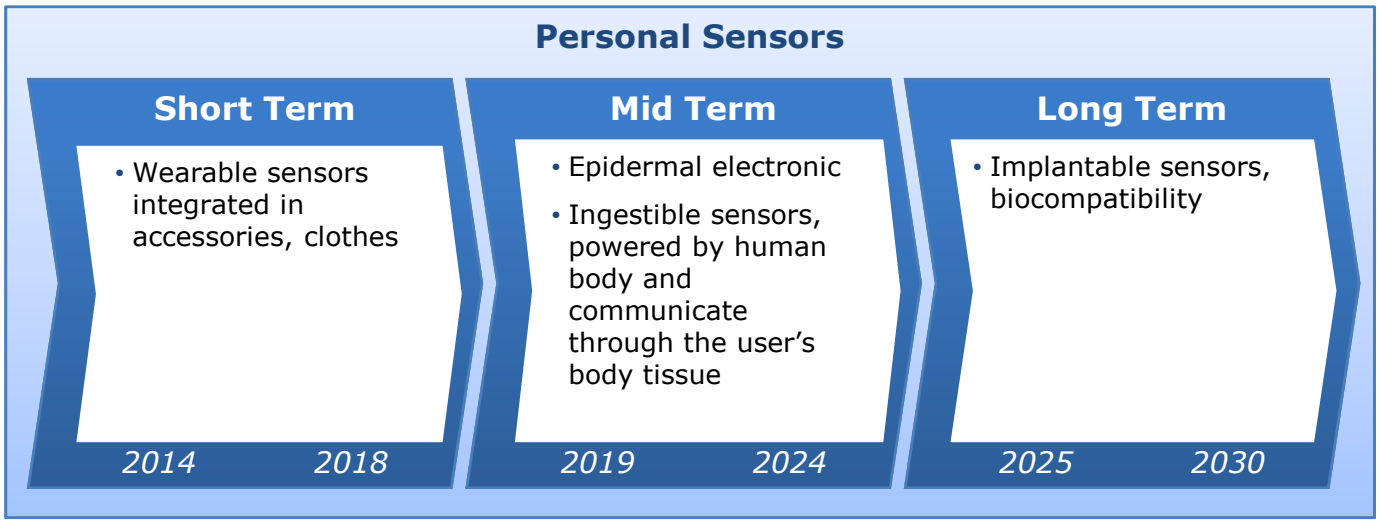
- **Vision Sensors**
  sensors able to extract useful information, like colour and depth, interpreting also 3D coordinate data
- **Acoustic Sensors**
  systems able to discriminate and distinguish sounds emitted from different sources used to recognise abnormal conditions
- **Olfactory Sensors**
  sensors able to recognise odours and to distinguish the sources



- **Biosensors**
  analytical devices composed of biological component and physiochemical detector used for the detection of specific analytes
- **Lab on Chip**
  chip integrating several laboratory functions in few squared centimetres

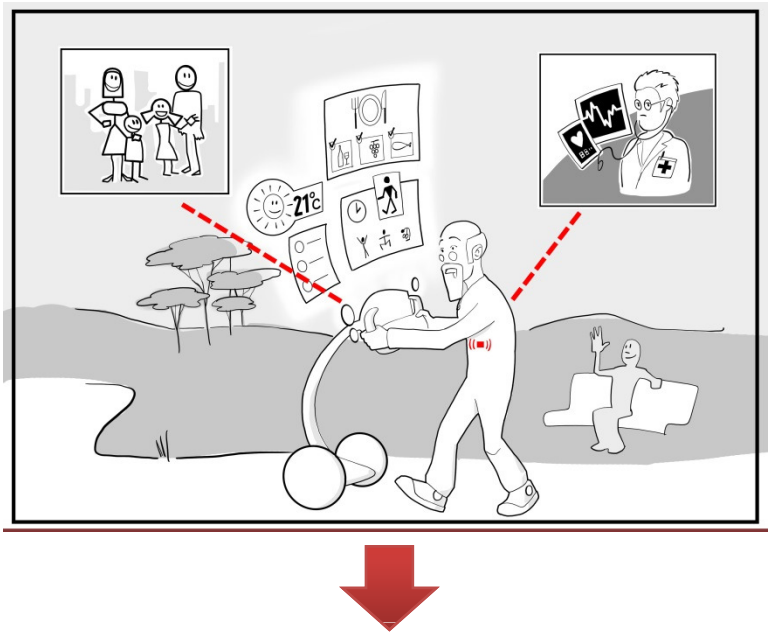


- **Personal (In- and On-Body) Sensors**
  smart sensors with different degree of invasiveness (wearable, ingestible and implantable), working in direct contact with users able to extract information about their health and status

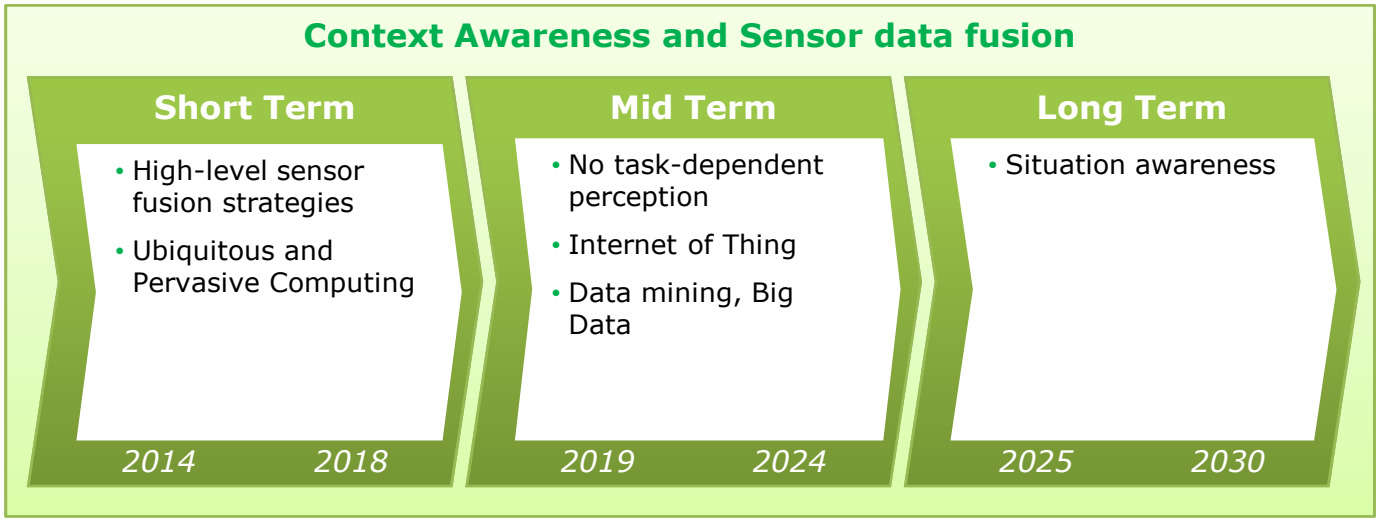


Reasoning

Intelligent systems with computational capabilities able to generate knowledge using logical techniques of deduction, induction or other forms of reasoning.

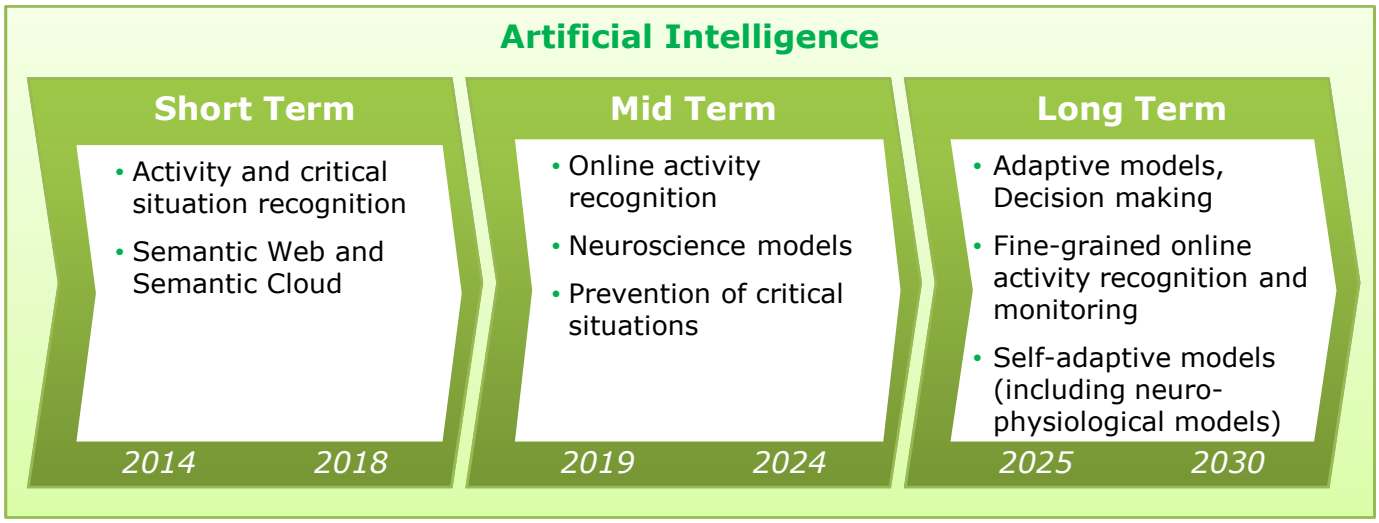


- **Context Awareness and Sensor data fusion**
  processing solutions able to merge data coming from different kinds of sensors and to extract information about context and current events (see technologies like Smart environments, Internet of Things, Ubiquitous and Pervasive Computing, Cloud computing)



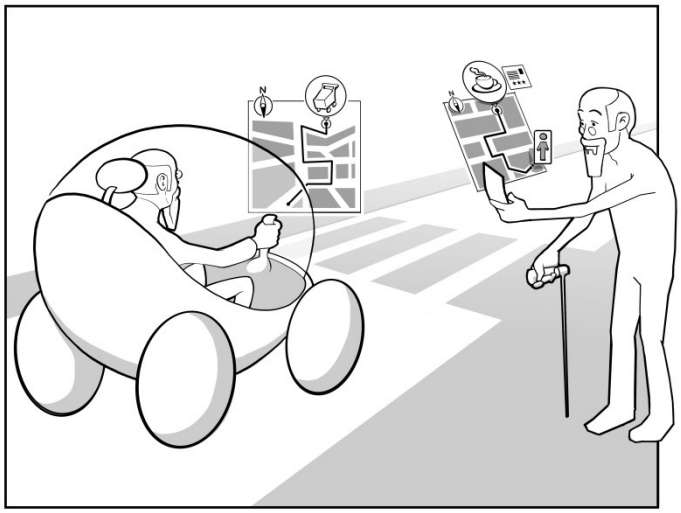
- ## Artificial Intelligence

tools able to recognize natural human inputs (e.g. voice and speech, images and body gestures, emotions), to create reliable models of the status and to self-learn how they evolve (e.g. data mining, context modelling, machine learning and e-learning, semantic web and semantic cloud), to predict events and to support caregivers in making decisions

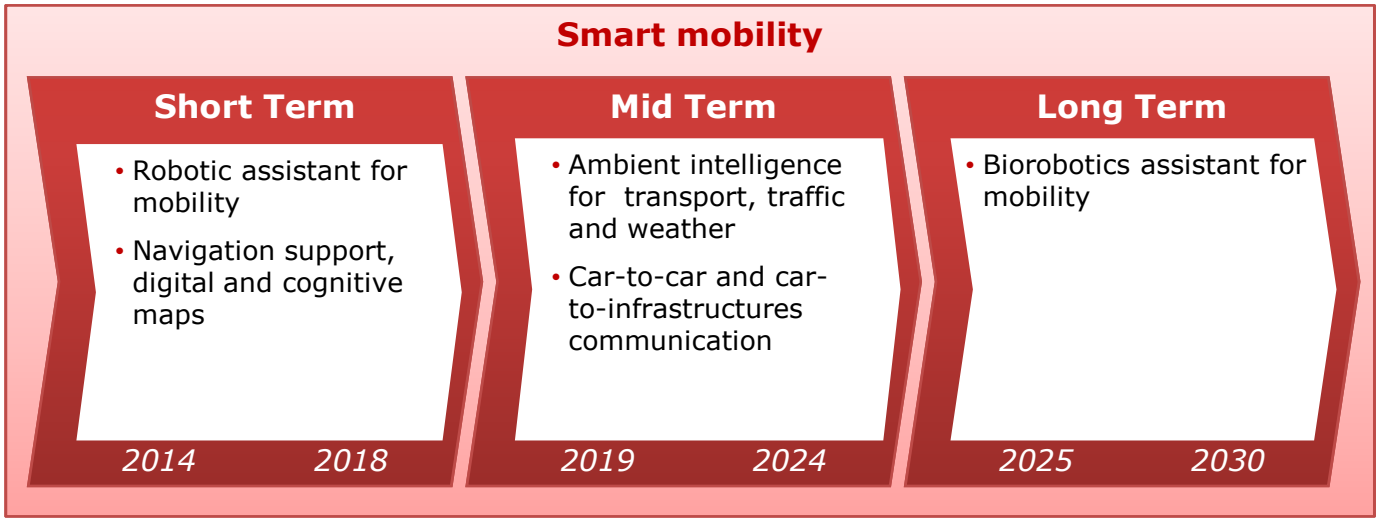


Acting

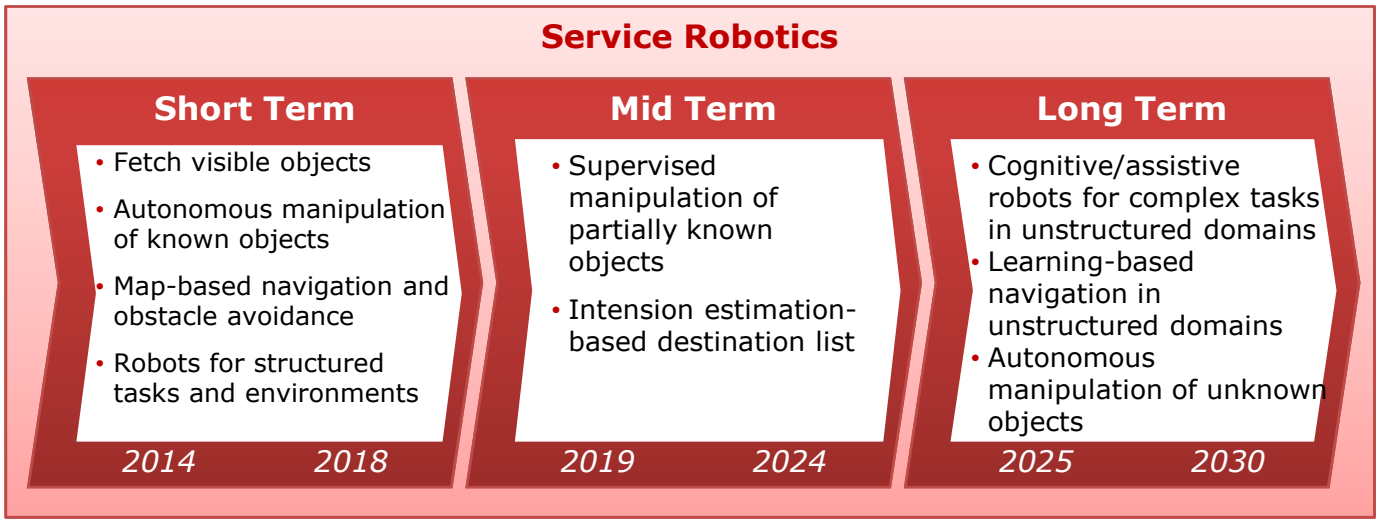
Automated systems and robotics, which proactively act for providing useful services, including physical and cognitive support.



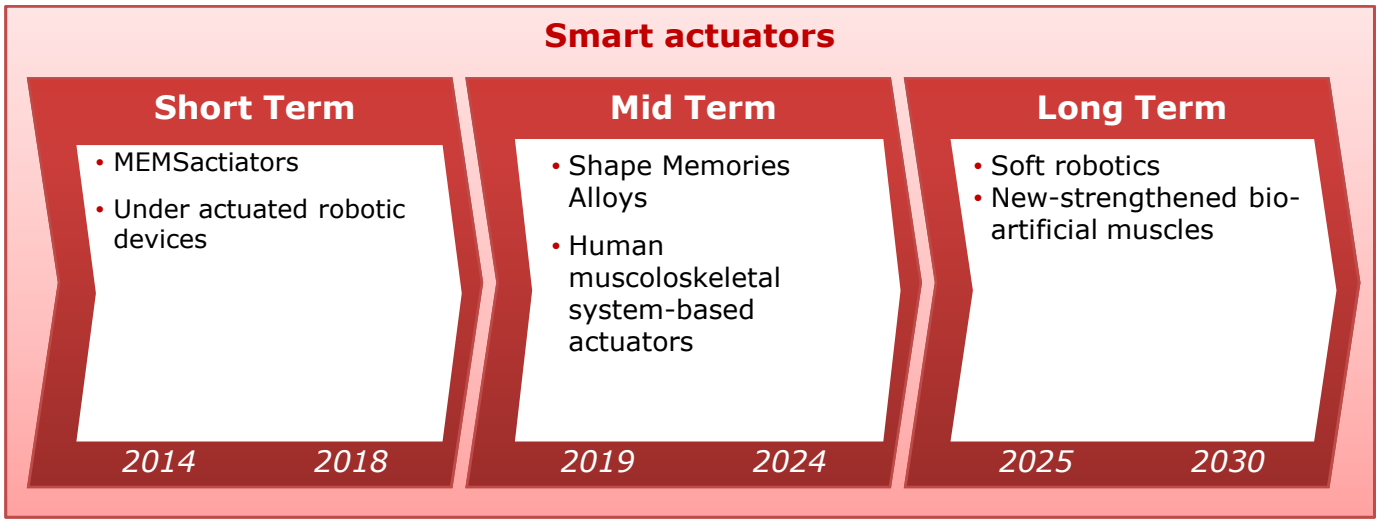
- **Smart mobility**
  technologies able to facilitate user mobility (e.g. smart public transport, smart drive system, portable devices with positioning and navigation assistance for pedestrians)



- **Service Robotics**
  reliable robots able to navigate and/or to manipulate objects that could provide dangerous or complicated services to users

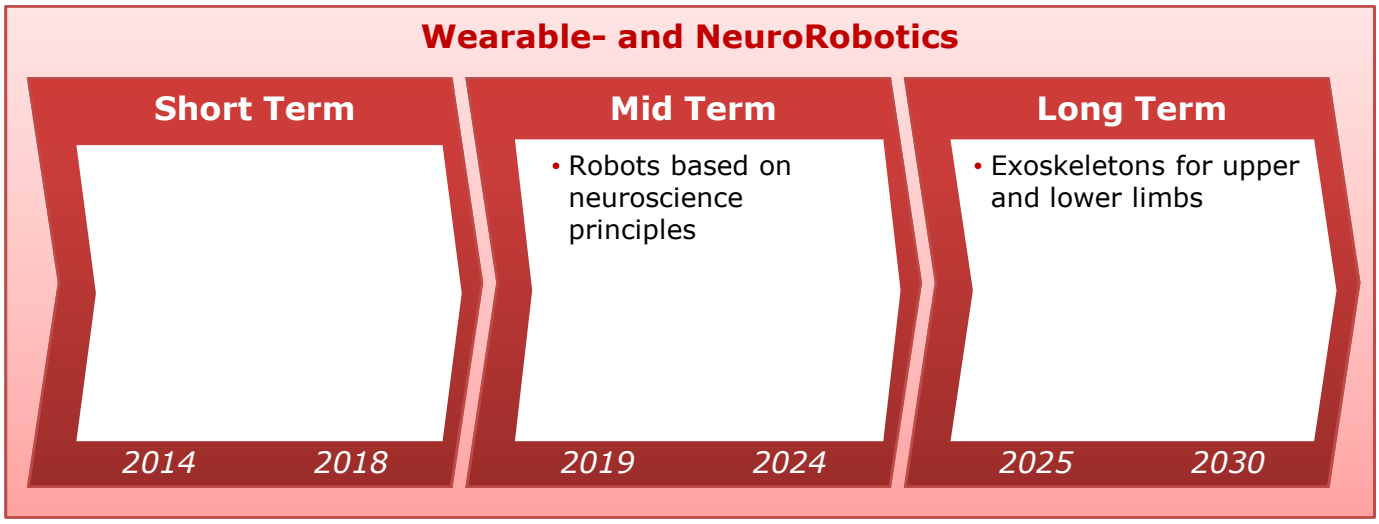


- **Smart Actuators**
  techniques to generate controlled force and torques able to quickly self-adapt according to surrounding conditions (e.g. MEMs, shape memories alloys, soft robotics)



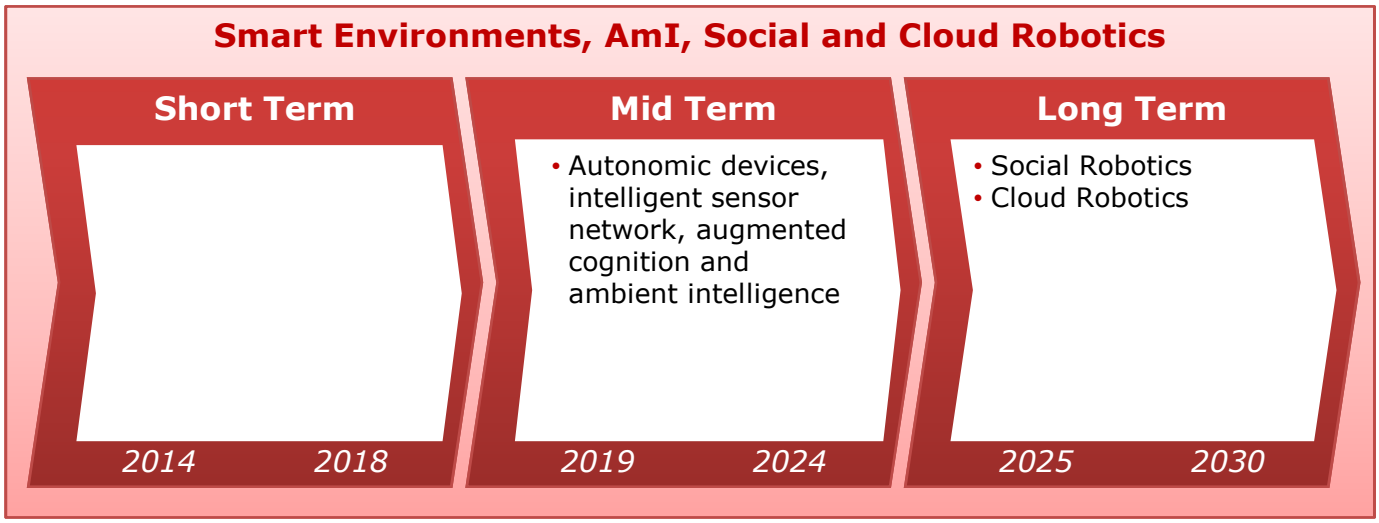
- **NeuroRobotics**
  in- and on-body solutions able to interact with human nervous system

- **Wearable Robotics**
  wearable exoskeleton able to compensate motor deficits and to support users in movements and in carrying out activities of daily life



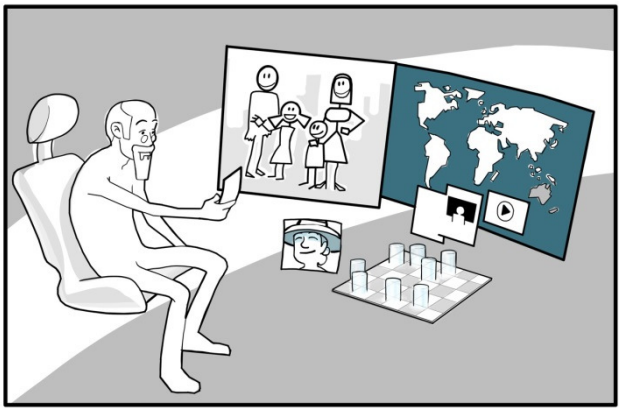
- **Smart environments and Ambient Intelligence**
  intelligent environmental components and automations able to communicate and cooperate for the efficient management of the services and power consumption

- **Cloud Robotics**
  integration of different agents that allow an efficient and improved cooperation between robots, smart environments and humans to provide useful and high quality services to citizens



Interacting

All kinds of means, both software and hardware, that allow interaction processes and bridge capabilities between users and service/machines.



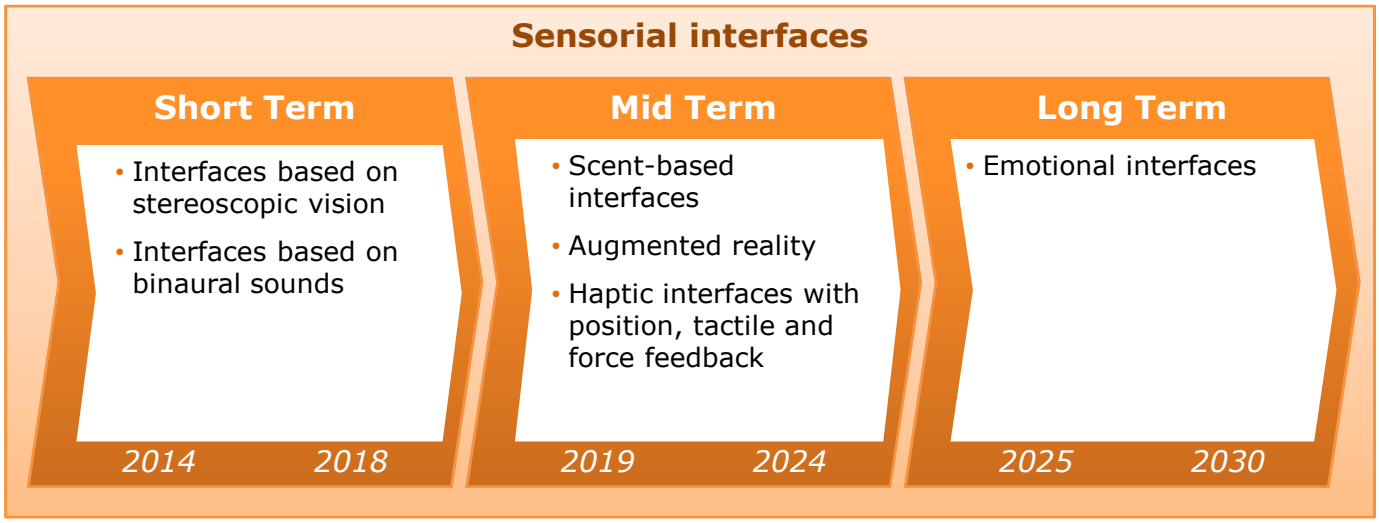
- **Smart multimedia appliances and apps**
  smart appliances, like computers, tablets, smartphones, smart TV and interactive whiteboards, that easily allow the exchange of information and data among people
- **Smart wearable accessories and jewellery**
  accessories, like glasses, watches, bracelets, rings and earrings, that are modified to allow user to access easily to data on internet and to exchange information with other persons
- **Smart clothes**
  comfortable cloths, like T-shirt, jacket, shoes, etc., integrating ICT components in their texture that allow user to receive information and to control easily external devices (e.g. house appliances)

Smart appliances, multimedia, apps, smart accessories and smart clothes

Short Term	Mid Term	Long Term
• Multimedia, tablets, smartphones, smart appliances, etc. • Apps	• Smart accessories and jewellery • Smart clothes and shoes	• Personalisable and self-learning apps
2014 – 2018	2019 – 2024	2025 – 2030

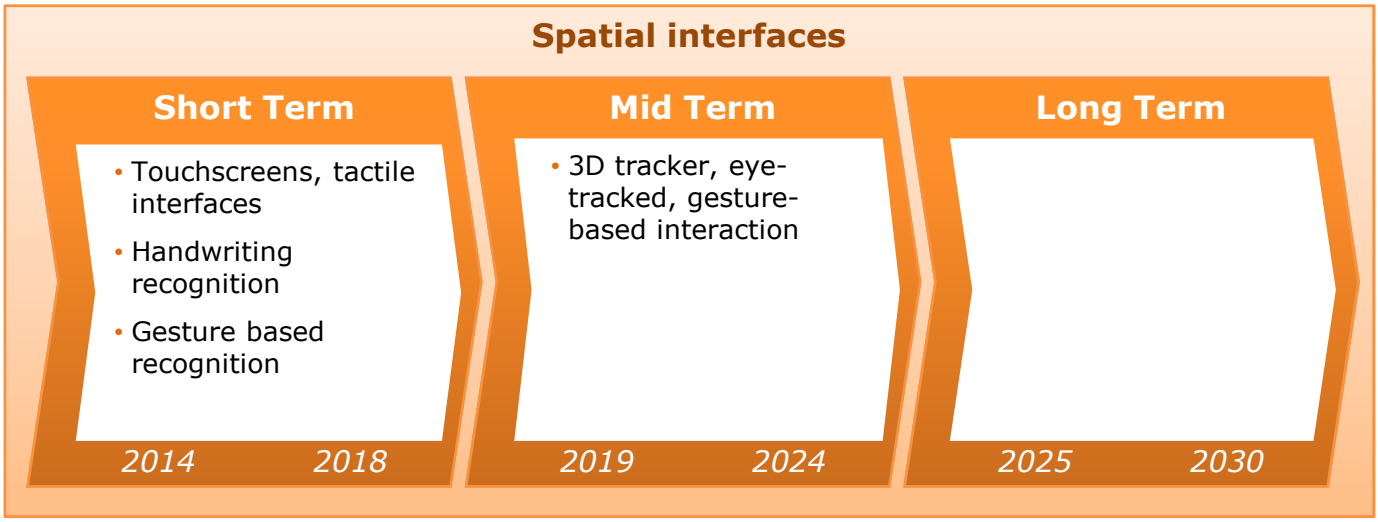
- **Sensorial interfaces**

  technologies which create digital augmentations of physical objects through sensory perception (e.g. augmented reality, stereoscopic vision, tactile and force feedback, binaural sound, scent based interfaces, intelligent clothes, emotional interfaces)

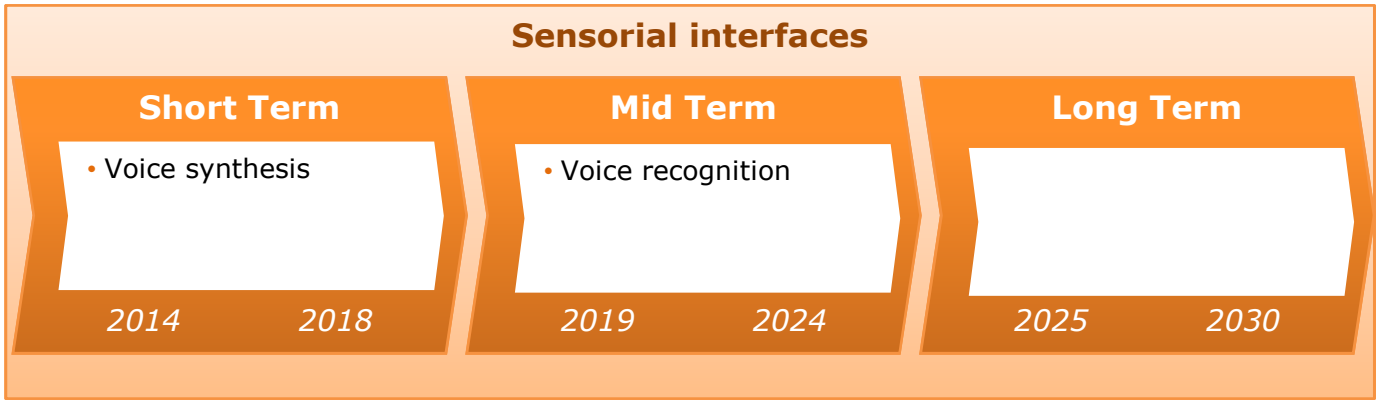


- **Spatial interfaces**

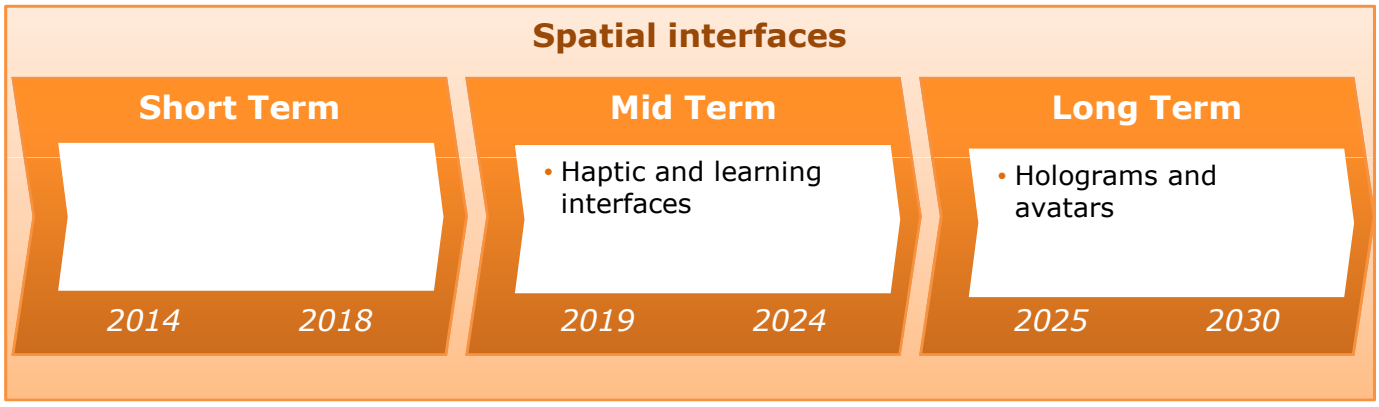
  systems which allow the user to manipulate and understand the states of the entities through presented 3D or 2D models (e.g. gesture based recognition, tactile and multi-touch screens, eye tracker, 3D Movement tracker)



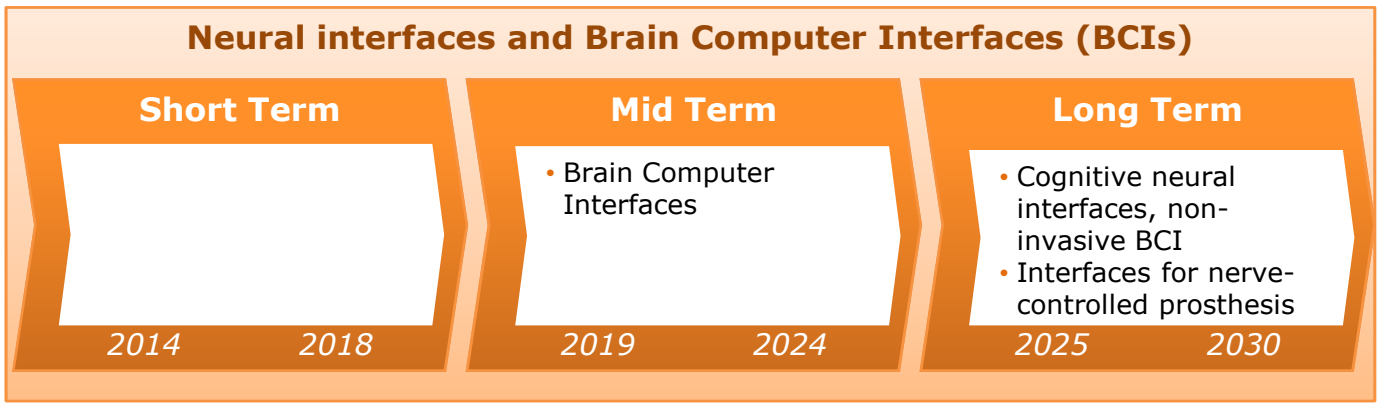
- **Natural language interfaces**
  technological solutions which use linguistic entities such as words or phrases to control services and devices (e.g. voice and speech recognition)



- **Multimodal interfaces**
  tools characterized by the employment of multiple sensory channels and modalities for receiving and transmitting information (e.g. advanced holograms, haptic voice recognition)



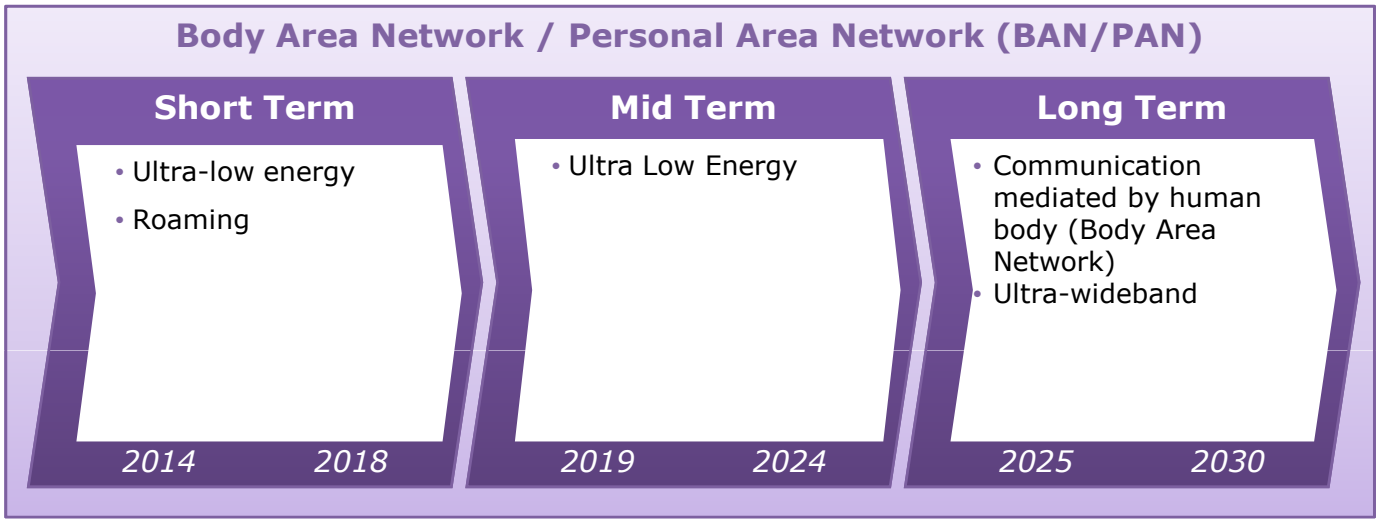
- **Neural interfaces and Brain Computer Interfaces (BCIs)**
  all technologies which use online brain-signal processing to influence human interaction with computers, their environment and even other humans (e.g. invasive BCIs, non-invasive EEG-based BCIs)



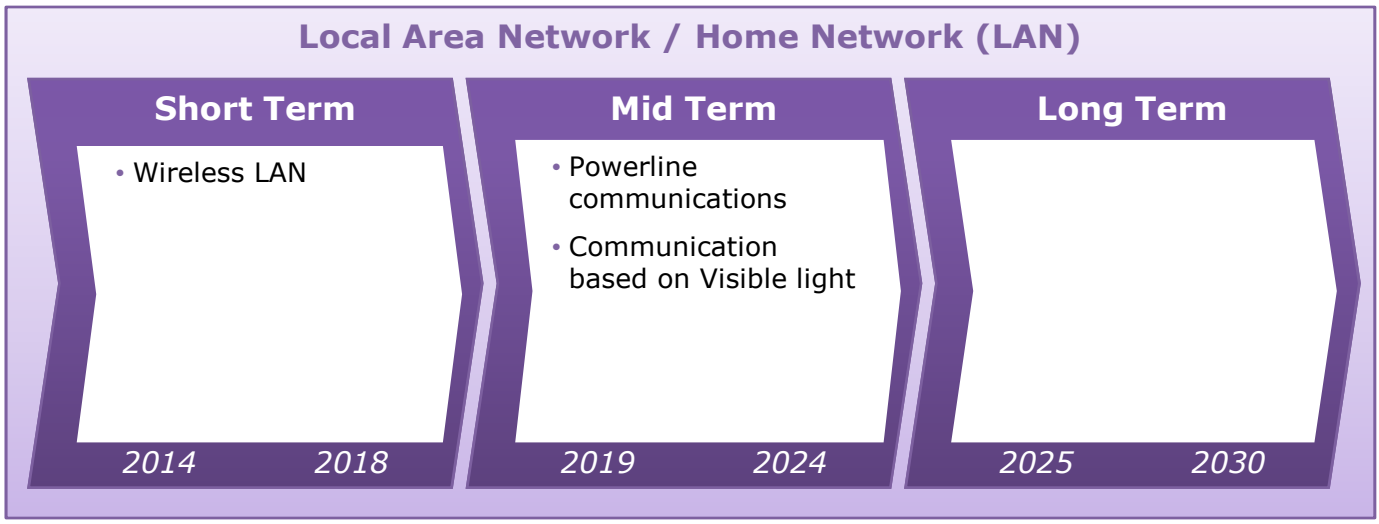
Communicating

Technologies related to machine to machine interfacing that allow devices to communicate and cooperate.

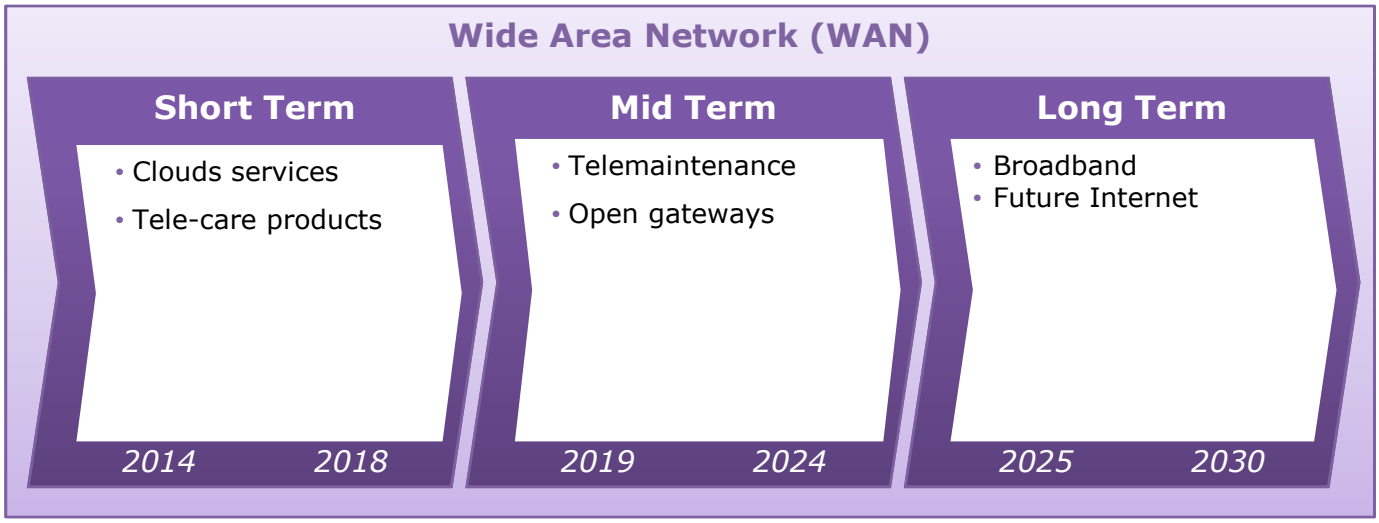
- **Body Area Network / Personal Area Network (BAN/PAN)**
  solutions for the communication among components worn by the user on the body, in the body, or integrated into the clothing (e.g. roaming, ultra-wide band, human body communication)



- **Local Area Network (LAN)/Home network**
  classical networks (e.g. cabled LAN, powerline communications, wireless LAN (WLAN), visible light), and wired or wireless field buses used for home automation



- **Wide Area Network (WAN)**
  advanced network (e.g. broadband) for cloud services, like tele-care products, tele-maintenance of devices and Future Internet



- **General aspects**

  - ***Standardisation and certification for AAL***
    standards and rules to guaranty safety of AAL devices and their interoperability with other tools and services

  - ***Internet protocol IPv6***
    new generation of internet protocol born to solve limitations of IPv4 and able to better carry the Internet traffic

  - ***New middleware solutions***
    middleware which simplify the integration of sensors, actors and services (application logic)

  - ***Semantic technologies***
    semantic tools able to describe sensor data, system components and context information in a machine-processable manner, thus enabling applications to better cope with the dynamic properties of the system

  - ***Self-X properties***
    self-configuration, self-optimization, self-healing and self-protection

  - ***Data protection regulations***
    renewed rules to protect personal data exchanged during AAL services

5. 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.

Ethics

Developments in AAL technologies cannot be read without 'human rights' and 'ethics' lenses. From an ethical perspective, the *value of autonomy*, the *respect for dignity* and the *person-centredness* are fundamental aspects which should be considered in the development of AAL services and solutions. 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. Moreover, other essential features that should be contemplated are: the *social isolation*, the *abuse and the rights violation*, the *consent*, the *data protection*.

SOCIAL ISOLATION

New AAL devices for home care are a great opportunity for elderly people to keep on living autonomously; at the same time they should not replace the human contacts and isolate older persons but means for favouring and improving social interactions.

CONSENT

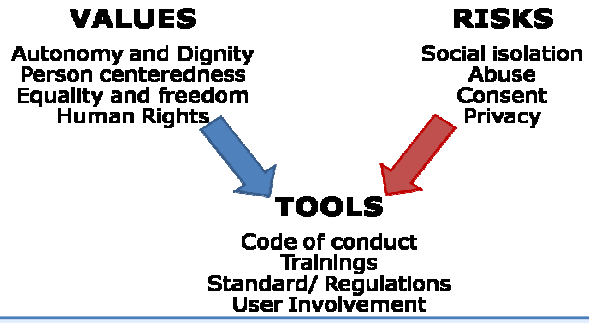
It is important that the persons using the AAL devices at home are able to understand what is going to be installed at his/her place, due to the impact over the person's environment and the risks over privacy and data protection. There is therefore the need of a written consensus form between the user and the professional, 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.

ABUSE AND VIOLATION OF RIGHTS

Elderly people in need of care are more at risk of abuse and violation of right. So AAL services should be developed avoiding abuse occasions (e.g. unmotivated and excessive control by caregivers, excessive costs of services and solutions, etc.). It is important to put attention in implementing these services in older persons' home and life and to regularly measure their impact.

DATA PROTECTION AND PRIVACY

AAL devices will store and manage a lot of data about elderly people who are using them. It is important in order to respect the privacy of the person to use a transparent process when connecting and analysing process. Key elements will be also to minimize the data collected and a strong legal aspect behind the use of the data in order to protect the privacy of the person.



TOOLS TO GARANTEE ETHICAL VALUES

Adopting the following precautions in AAL could ensure the respect of the ethical values :

- Codes of conduct and principles for professionals, both for the care sector and new technologies
- Definition of standards and regulations for AAL to protect end-users and clarify responsibilities in case of failure
- Trainings and continuous support for the adoption of AAL solution and the consequent change of life style and habits
- User involvement from the development of the product to research trials and market to enable the personalization of products.

Legal Issues

AAL encompasses a very wide range of sectors and stakeholders, and therefore of legal areas. Different regulations should be considered when implementing AAL in order to guarantee the rights of the users. 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.

ALREADY EXISTING LEGISLATIONS

In past the European Union dealt with the following legal aspects related also to AAL: *Data protection, Patient safety and medical devices, Consumer protection, Area of Services*.

Data Protection

Most of AAL products and services manipulate personal information such as health, daily activities, geographical position, etc. European legislation aims at guaranteeing the right use, elaboration and storing of personal data and also to preserve the user rights on them.

- *Existing Directives: 95/46/EC European Data Protection; 2002/58/EC E-Privacy*
- *Proposal: Jan. 2012 - General Data Protection Regulation* ('one continent, one law'; same rules for all companies; right to be forgotten and erasure; easier access to your own data; 'putting you in control')

Patient safety + Medical devices

In Europe there are three main directives on medical devices aiming at ensuring a high level of protection of human health and safety and the good functioning of the market. This legislation can be extended to some AAL products.

- *Existing Directives: 90/385/EEC Active implantable medical devices; 93/42/EEC Medical devices; 98/79/EC In vitro diagnostic medical devices.*
- *Proposal: Sep. 2012 - Regulation on medical devices and in-vitro devices* (wider and clearer scope, stronger supervision of independent assessment bodies, more powers for assessment bodies, clearer rights and responsibilities for manufacturers, importers and distributors, extended the database Eudamed, better traceability of medical products)

Consumer protection

The EU developed several laws covering the consumers' rights when buying a product or service in the EU and protecting consumers from unfair treatment, ensures that products meet acceptable standards and enables redress in case of problems. AAL services and products involve a wide range of different types of consumers, including vulnerable consumers.

- *Existing Directives: 2011/83/EC Consumer Rights; 1999/44/EC Consumer Sales and Guarantees; 93/13/EEC Unfair Contracts Terms; 2000/31/EC E-commerce Directive*

Area of Services

AAL services should also satisfy European and national legislations related to public procurement, competition and internal market. 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.

- *Existing Directives: 2014/25/EC Procurement in the water, energy, transport and postal services sectors; 2014/24/EC Contracts for public works, public supply and public service; 2014/23/EC Award of concession contracts*

IDENTIFIED GAPS IN AAL LEGISLATIONS

Being AAL quite a recent area, the current legislation mays not cover all challenges necessary for the development, deployment and use of AAL services and products. The main issues to be still faced from the European legislation are:

- ***Access to the broadband***
  In AAL the access to Internet is essential but it remains unclear how it could become a right for all citizens on a longer term, especially at the moment in remote areas where AAL could bring clear benefits but where broadband access is limited and/or expensive.
- ***Data mining and automatic decision making***
  These two aspects are issues very important in AAL but the responsibility in case of wrong decisions established from these processes is not defined. The new Regulation on Data protection may at least partly help to solve this problem.
- ***E-Health and m-Health***
  These types of services are healthcare solutions which are becoming more and more diffused in Europe. The European Commission is currently working to create legislation and standards necessary to protect citizens, guarantee a proper quality level and integrate them inside public and private healthcare system.
- ***New technologies applied to AAL***
  Many proposed AAL services are based on the use of several challenging technologies, like robotics, nanotechnologies, smart homes, etc. However before their employment in the real life it is necessary to define appropriate legislation for verifying the liability of these tools and responsibility in case of failure.
- ***Accessibility***
  The accessibility of environments and services is a problem still not solved in Europe. The European Commission developed the European Accessibility act, document not still officially launched which aims 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 of services***
  In spite of the increasing number of services delivered across Europe, the European Commission has not jet defined an appropriate legislation to ensure quality services. 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.

Acceptability & Usability

One of the key aspects influencing the success of a product or a service is its acceptability by consumers. The acceptability of a system is the result of the user perception about the usability and other factors of the proposed solution. Generally in ICT, and particularly in AAL field, it is very important to consider this feature during all the design stages of a solution in order to avoid failure on the market.

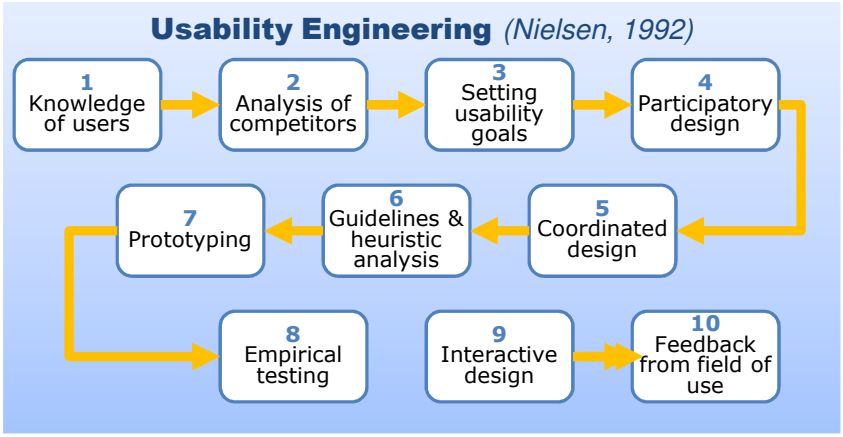
Critical aspects for acceptability and usability in AAL

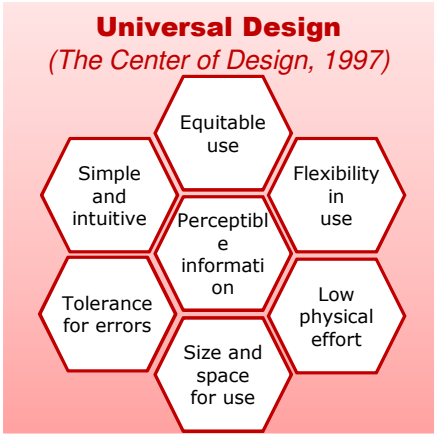
- most of end-user are persons with low technological affinity
- many technologies are not so affordable and reliable to be used by inexperienced users

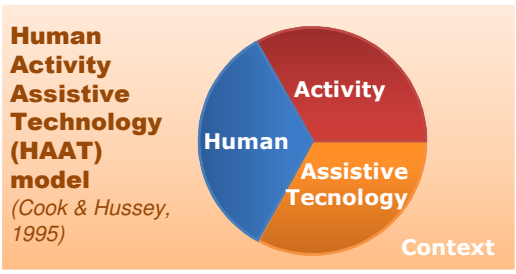
Many studies identified the psychological, social and technological factors influencing the acceptability of a system. A summary of this study is reported in the following table.

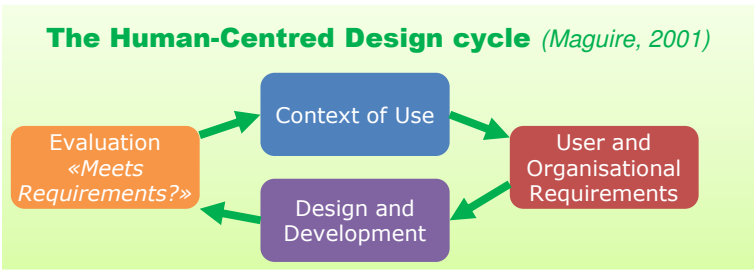
Theories on Usability and Acceptability of Technologies	*Key Aspects*
Technology Acceptance Model (TAM) (Davis, 1989)	Usefulness, ease of use, subjective norms
Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, et al., 2003)	performance expectancy, effort expectancy, social influence and facilitating conditions
Usability Theory (ISO 9241:1998)	effectiveness, efficiency, and satisfaction → usability
Model of Acceptability (Aquilano, et al., 2007)	Usability, utility, aesthetics, impact on daily habits, obtrusiveness, safety, portability, comfort

In order to avoid the failure of an AAL product on the market, it is recommended to adopt one or more design approaches and theories, like the Usability Engineering, the Universal Design, the Human-Activity-Assistive Technology model and the Human-Centred Design, helping to identify the real needs of the users and consequently the right requirements to be implemented on the system.









Suitable Service Provisioning

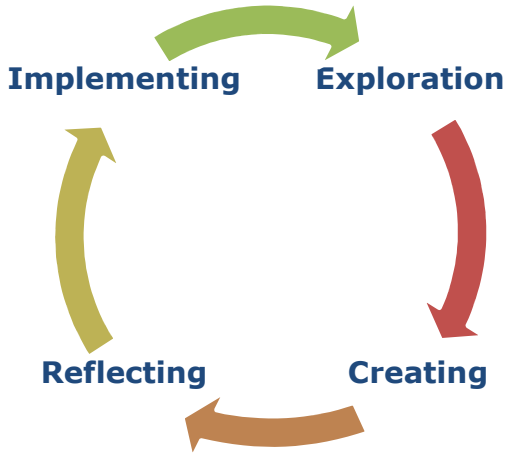
Key aspects for the achievement of a suitable AAL service are the implementation of a service that answers to real need and the real implementation in every day life going trough the acceptance and change in the mind of people and healthcare organizations that will use it.

SERVICE DESIGN THINKING

The service design thinking (STD) is a good approach for the development of a sustainable service with the cooperation of stakeholders. STD has five principles:

- *User-centered*
  the service have to answer to user-needs
- *Co-creative*
  all the stakeholders have to take part in the development of the design
- *Sequencing*
  the service should be seen as a sequence of action
- *Evidencing*
  the effect of the AAL service should be easily visible by end users
- *Holistic*
  the service has to be consider in the whole context and from various perspectives.

STD is a iterative and nonlinear process made of four stages: exploration, creating, reflection and implementation.



MANAGING THE CHANGE IN HEALTH- AND SOCIOMEDICAL-CARE SYSTEMS

There are different success factors for the integration of AAL services at different levels, as shown in the following table: .

Level	Critical Success Factors
Human	Adoption and acceptance of AAL services by the end users (both elderly persons and caregivers) is a key factor for the application of the service in everyday life.
Care Providers	• Caregivers should be involved in the process design and in the process innovation • Care providers must have the vision of the application of technologies and how to integrate them in work- and care processes • It is necessary to provide the right conditions through management of risks related to the application of technology in care process • A robust business model that illustrate how the new service can be transparent in a profitable marketing manner
Technology	Key factor for the success of technologies are acceptability and usability. In particular: • Technological solution must fit to needs • Technology must function at all times, moreover it should be accessible, tailored to the situation and skills of the users.
Policy and legislation	Innovations with (AAL) technology in healthcare often anticipate current and common policy and legislation. It can cause delays in large-scale implementation of (AAL) technology, especially if the innovation has to do with healthcare. This is a challenge for the EU since each EU-country is organized differently

Standards, Interoperability and Certification

The objective of AAL is not only to develop a device or a service per-se, but to provide an intelligent environment that monitors and recognises what the user is doing and provides support when needed. This smart environment is made of different "blocks" that should to work together in order to reach the common target. This capability is denoted by the term *Interoperability*. In AAL this feature is particularly important also because of:

- Variety of user requirements and preferences
- Need for "future proof" systems
- Integration with existing infrastructure
- Integration with local service providers
- No comprehensive product programme.

This is where *standards* come 'into play': they define consistent interfaces enabling the interoperability and exchangeability of different components as well as safety requirements or permit service offerings to be compared. However the implementation of standards entails both benefits and risks:

Benefits

- Interoperability
- Usability and accessibility
- Safety and risk management
- Security and data protection
- Process and service level
- Certification.

Risks

- Higher complexity of specifications
- Higher implementation costs
- More competition on the market
- Standard interpretations → Interoperability problems
- Stifling innovation because of standard timetable
- Access to standards with fee.

Role of the Middleware in AAL

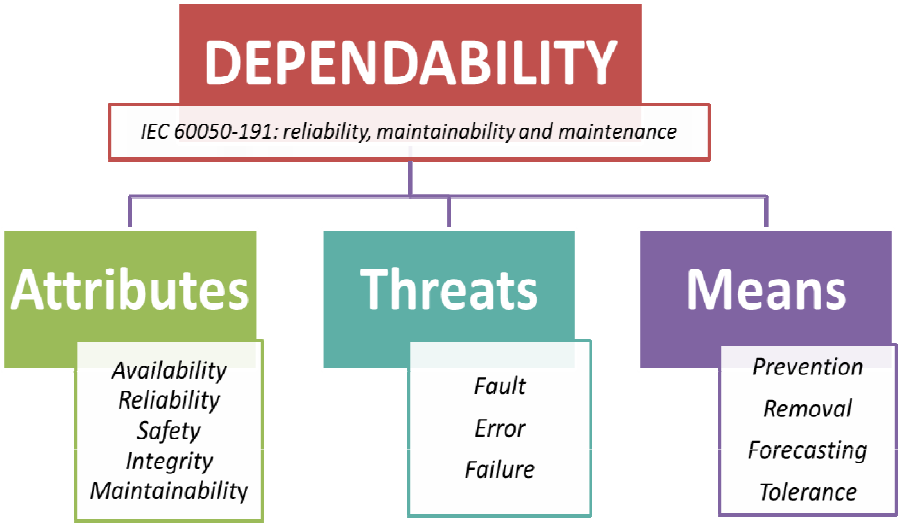
The "middleware" is a software layer between the operating system of a computer and an application program that provides reusable services in particular for communication tasks between different components. In AAL systems, middleware assists the development of applications by providing implementations of frequently used communication standards, and by offering reusable building blocks needed in many applications. As such, middleware has an important role as an enabling technology for interoperability and standards-based communication.

Recommendations for standards and certification in AAL

- ***Standardisation watch initiative:*** installation of a neutral and independent future-orientated standardisation watch initiative for AAL, to provide the necessary impact power to enforce European leadership in this field.
- ***Preparatory action on an AAL reference architecture:*** a preparatory action working towards a common understanding of the AAL domain, definitions and harmonisation of terms for the AAL sector and ultimately a commonly accepted reference model.
- ***Development of integration profiles for AAL:*** standards-based specifications that define all interfaces needed for all systems and system components for one specific use case or application scenario.
- ***Certification in AAL:*** implementation of an independent European or international certification initiative for AAL products to inform customers about specific attributes, manufacturing conditions, compatibility with other products and compliance with legislation and so to facilitate the market penetration.
- ***Study group on AAL and the EU Medical Device directive:*** a work team involving experts from the AAL domain and the medical device regulatory system to map the AAL service model into the EU Medical Device regulatory system, to classify AAL solutions according to the EU Medical Device directive, and to guide the risk management for complex systems combining medical and AAL device components.
- ***A data protection directive 'for the 21st century':*** a renewed data protection law that is adapted to the technology challenges and opportunities of the 21st century.

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.
According to the IEC 60050-191:1991, the term '*dependability*' can describes «the availability performance and its influencing factors : reliability performance, maintainability performance and maintenance support performance»
In 1995 Laprie analysed in-depth the concept of dependability and identified the attributes, the threats and the means related to this feature. The following scheme summarised the Laprie's results.



Dependability plays a fundamental role for the success of AAL solutions and aims at guaranteeing physical safety of devices that have to operate in human-inhabited environments and to fulfil their tasks with adequate performance and robustness in dynamic and unpredictable environments.

During the development of AAL services and technologies the secondary and tertiary stakeholders should take into account these aspects:

- *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?*

In particular the next generation of AAL technologies should have the capacity to:

- recognize erroneous conditions and identify the malfunctioning aspects;
- alert users, caregivers and specific repairers about the problem;
- adopt alternative strategies to guarantee the safety of the users and the environment and, if possible, execute part of the services;
- in such case, self-repair the damaged components (self-healing).

Green and Sustainable Technology

The worldwide increasing environmental pollution and energy request are phenomena which are attracting the attention of all governments. 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).

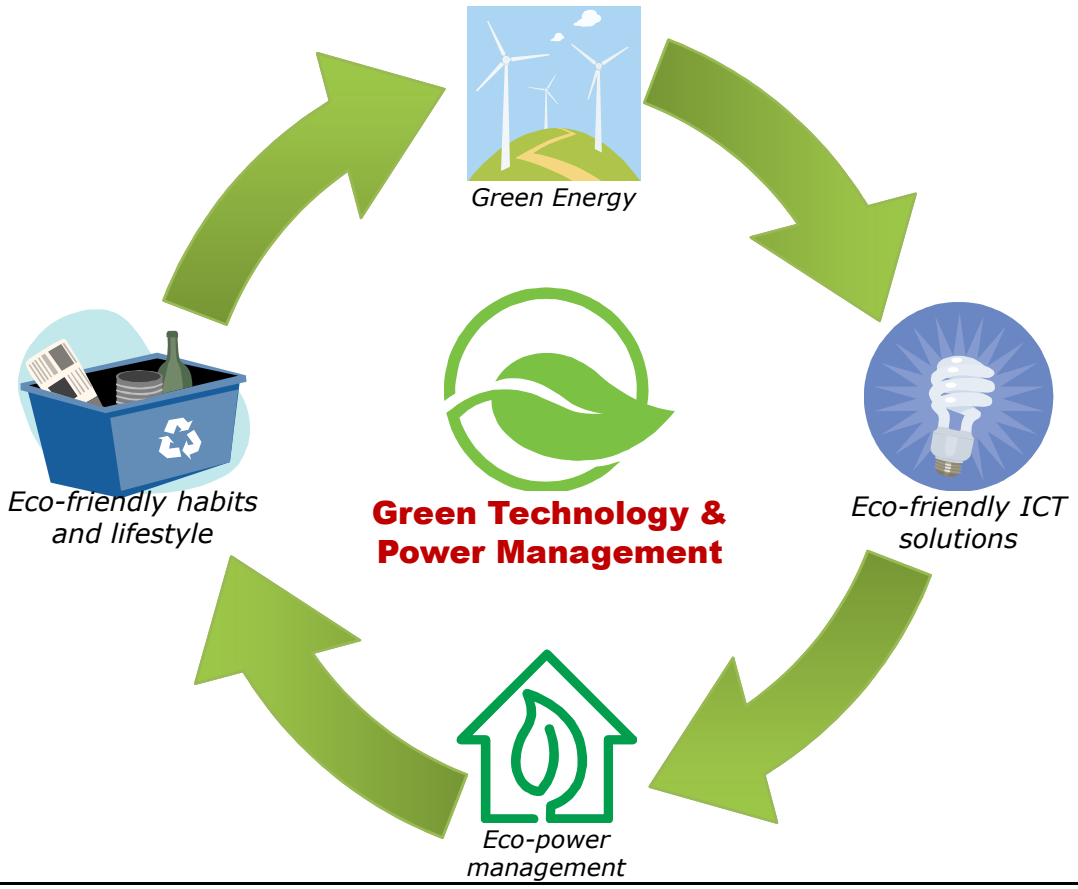
For these reasons all communities are promoting several different strategies in order to reduce these aspects, from the regulation of the polluting emissions of industries to the education of citizens to be responsible consumers and to adopt ecological habits and lifestyles. According to this view, international communities are considering ICT solutions as an opportunity to implement green strategies both inside industrial contexts and among common populations (Gordon, et al., 2009).

Some of these actions include:

- the development and use of new recyclable materials with low impact on the environment;
- novel power management strategies for the optimization of the energy consumption at both industrial and domestic levels;
- new solutions for the generation of green energy (e.g. energy harvesting technologies).

According to this idea also in AAL services new eco-friendly ICT solutions should be implemented also to help elderly people in:

- Power consumption management
- Adopting eco-friendly habits.



6. RECOMMENDATIONS

This section reports a summary of the opinions of more than 300 AAL experts, collected during the AALIANCE2 workshops and with questionnaires, interviews and internet surveys. These recommendations, representing the point of view of the four AAL stakeholders, were expressed on the base of the personal experience of the attendees in AAL field and were conceived as suggestions for improving the AAL systems and favouring the real exploitation of AAL solutions into the society and market.

Design

Needs of real users	The knowledge of real needs of all users and actors involved in the AAL services is the key aspect to design effective AAL solutions.
Design requirements	The design requirements, like acceptability, user-friendliness, accessibility for all, customisability, dependability, and avoiding isolation and loneliness, should be taken into account for favouring the pertinence and the success of AAL products and services.
Deployment requirements	During the design should be considered also the requirements related to the deployment of the AAL systems, like the evolving structure of the society, the intergenerational relationships among the various actors of AAL service, the ethical aspects, the regulations, and the policies for the safety and privacy.
Cooperation of all AAL stakeholders	From the beginning of the design all AAL stakeholders should be involved and they should cooperate till the real deployment of the AAL systems into the communities.
Knowledge of AAL products and projects	The knowledge of existing AAL projects and products and their deployment are task fundamental for guarantying the efficiency of the design process.
Proper experimentation	It is very important carrying out proper experimentation (both small and large scale; with real users and in the real contexts and environments) in order to verify the real value of the AAL solutions.
Project duration	The duration of project should be planned properly to avoid to develop obsolete solutions.

Exploitation

Dissemination of AAL culture	The success of AAL depends from the knowledge of AAL culture among elderly persons, caregivers, sociologists and service providers; for this reason it is important to disseminate properties and potentialities of the AAL products and services and also the success of case of study of AAL solutions.
Affordability of AAL solutions	Developers of AAL services and tools should also conceive different levels of accessibility of its services (private persons, public and private service providers) based on the local organisation and financing of the community.
Exploitation capability of SMEs	Companies and SMEs working in AAL should develop adequate capabilities and resources for effectively exploiting their services and products and arriving on the market with adequate instruments.
Innovation	Companies working in socio-medical field should invest more in research and development to innovate their AAL products and services to make them effective and really exploitable on the market..

Market

Analysis of AAL market	Currently there is an insufficient knowledge of the AAL market, so more attention should be put on it to reinforce the exploitation of achieved research prototype and speed up their deployment into society.
Fragmentation of AAL market	The current AAL market is strongly fragmented because each country has its own culture, organisation of services and methods for financing. So many companies have problem to develop AAL tools suited for different countries and regulations. In the future it is necessary to coordinate and harmonise the national initiatives in AAL field in order to reduce this fragmentation.
Entrepreneurship and disruptive business models	Many subjects working in AAL research lack of entrepreneurship. The AAL stakeholders (healthcare sectors, insurances, privates, etc.) should invest more on disruptive and effective AAL solutions, studying the most appropriate and sustainable AAL business models.
Management of project funds	For developing AAL solutions it is necessary a proper estimation of the feasibility of the idea, the time and the resources and management of funds in order to arrive efficiently to launch the products and services on the market.

Policies

Innovation and harmonisation of socio-medical care	The implementation of AAL solution inside the society depends strongly from the development of new European, national and regional policies, aiming to reorganise the healthcare system, to renew the socio-medical services and to include inside them innovative AAL technologies. Moreover there is also the necessity to harmonise policies and rules among different countries for facilitating the development and deployment of AAL products in all Europe and also worldwide.
Interoperability, standards and certification	It is important and necessary to fix rules for the standardisation, certification and interoperability of AAL products in order to guarantee the interoperability of these AAL platforms into real life and also the safety of the end-users.
Protection of personal information	Most of AAL services manage and transmit personal and critical data, so policy makers should develop policies regulating 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.

Other important messages

Role of older persons in AAL	Every older person should be the main carer of him/herself, so it is important to empower and make senior people aware about how they should take care of themselves.
AAL solutions as tools for caregivers	AAL technologies should be facilitator of AAL services for caregivers and so they should not replace the fundamental role of formal and informal caregivers. These tools should be designed to allow clinicians and carers to follow more efficiently older people.

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- Acknowledgements:

The AALIANCE2 Consortium thanks the European Union for the support and all the AAL experts that participated in the workshops:

- Needs and services (Pontedera, Italy, 14/02/2012)
- ICT technologies (Eindhoven, Netherlands, 27/09/2012)
- Standardisation and Certification for AAL (Frankfurt, Germany, 12/02/2013)
- Reference Architectures and AAL Middleware (Frankfurt, Germany, 11/06/2013)
- KETs & SRA (Osaka, Japan, 05/07/2013)
- Roadmap &SRA (Norrköping, Sweden, 24/09/2013)
- Roadmap&SRA (Stanford, USA, 18/03/2014)

and in our surveys during the AAL Forum 2013 (Norrköping, Sweden), ForItAAL 2013 (Ancona, Italy) and ICT2013 (Vilnius, Lithuania).

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