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AAL PROGRAMME

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AAL Market and Investment Report

A study prepared for the AAL Programme (Active and Assisted Living) by Technopolis Group

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1 Introduction

1.1 Objective and scope

The AAL Market and Investment Report was commissioned by the Ambient Assisted Living Association[1] and aims to provide a consolidated view of the existing market and investment information in Europe for the AAL domain. It covers data relevant for AAL and related technologies including current status, trends and future perspective for opportunities in the European Union (EU) and where possible link those to innovation in delivery of services.

The AAL domain broadly represents solutions (i.e. bundled products and services) that have an information and communication technology (ICT) component and are of direct value for older people, their families and carers to enhance their health, wellbeing and independence. Products and services may also benefit older people indirectly by increasing the efficiency and effectiveness of systems responsible for their wellbeing, health and care. The scope of this report is therefore largely limited to market developments that exclusively or predominantly focussed on ageing and the older people. The report also introduces the new and emerging business models that will shape the AAL market in the near future and provides an overview of the technologies that enabled the development of AAL solutions. While the primary goal of the report is to monitor the European market, relevant information on global markets is also included to provide context and indicate the potential for growth.

This report serves as a guide to investors, start-ups and small and medium enterprises (SMEs), mature companies, and policy makers that are interested in becoming more familiar with the market to support the independent living of older people:

- Investors – interested in exploring the AAL market and opportunities for investment, identifying investors that already invest in the AAL market and in the underlying technologies, and looking for examples of interesting start-ups working in the field.
- Start-ups and SMEs – interested in gaining information about the AAL market, its drivers and barriers and the focus on integrating different technological components, looking for tips on how to position their solutions in the AAL market, and looking for an overview of the other players in the market and their perspectives on the AAL market.
- Mature companies – looking to integrate AAL solutions as part of their wider range of products and solutions, seeking information about global and European market trends and developments, and looking for other players active in the area of AAL and new ideas and examples of start-ups with potential for growth.
- Policy makers – aiming to increase their understanding of the socio-political relevance of the AAL market as well as its economic potential, and for an overview of the key drivers and barriers in AAL.

The analytical framework for the market analysis is based on a review of the AAL domain definition set out in the TAALXONOMY[2] project supported by the Austrian Ministry for Transport, Innovation and Technology (BMVIT) and the Research Promotion Agency (FFG) between 2014-2015. An earlier relevant European project, the largely technology-driven AALIANCE2[3] project concluded in 2014.

[1] The Ambient Assisted Living Association was founded in 2007, following a decision by the European Parliament and the EU Council, with the aim to manage the AAL Programme. It received a first phase of funding of €150m during 2008-2013 and in a second phase €175m during 2014-2020 from the European Union. The AAL Programme leverages additional public and private investment. Among AAL project partners are SMEs, larger enterprises, end-user organisations, universities and research and technology development (RTD) organisations. It currently consists of 19 AAL Partner States, also including Israel and Canada from outside Europe.

[2] TAALXONOMY Project. Available at http://www.taalxonomy.eu/en/

[3] AALIANCE2 Project. Available at http://www.aaliance2.eu/

Definitions and categorisation of technology areas are based on the work of Borsella et al (2015)[4] and the roadmap developed as part of the AALIANCE2 project (2014)[5].

1.2 Definition of AAL sector

AAL is a concept that includes ICT solutions designed to help older people to live better independently and enable them to make improved health choices.[6] The idea is to use technology to deliver services that improve the quality of life, support independent and healthy living, whilst reducing pressures on health care systems. AAL[7] focuses on the need for:

- Support to access care, including emergency response, monitoring of medical parameters, and communication with medical professionals.
- Supervision of daily routine, including remote monitoring, while ensuring IT security.
- Support with daily routine, entertainment, and communication.

The AAL Association refers to a taxonomy of AAL which covers eight areas that describe how the older adults engage with the AAL market.[8] From a consumer point of view, there is a broad range of products and services that can contribute to longer independent living, from better solutions in Living and Building to enhanced Mobility and Transport for older people (for all categories, see Figure 1). In addition to categorising products and services relevant to independent living, the proposed taxonomy includes work supporting measures for job specific learning and training.

Figure 1 Areas of the AAL sector

The technology-driven AALIANCE project has defined the AAL market as the intersection of sectors related to smart home, telecare and telehealth. In this definition, the AAL solution is based on the

[4] Information and Communication Technologies for Health, Demographic Change and Wellbeing: A Survey of the Technological Scenario E. Borsella, E. Mantovani, A. Porcari Italian Association for Industrial Research (AIRI, Italy) April 2015

[5] AALIANCE2 Roadmap (2013) and AALIANCE2 Roadmap (2014) p58+ reference to the same categorisation and information on application areas

[6] See also Active and Assisted Living; Technologies and Applications (2017), Chapter 2 Current state of the art of smart environments and labs from an ambient assisted living point of view, Crandall and Cook, eds. Florez-Revuelta and Chaaraoui.

[7] Kurt Salmon and IDC (2014) Final Report: A Study concerning a Market Observatory in the Ambient Assisted Living field. Available at http://www.aal-europe.eu/wp-content/uploads/2016/03/Final-report-SA-Market-observatory.pdf

[8] TAALXONOMY Project. Available at http://www.taalxonomy.eu/en/

integration of components from these different sectors, where partnerships across these sectors are key to successful delivery. Following this concept, AAL solutions aim to enhance social care, health care and create suitable built (housing) environments for older people, which are considered prerequisites for longer healthy and independent living.

- Telecare is the term describing support and assistance provided remotely via the monitoring of users through communication technology and sensors. Telecare technologies support living independently at home for longer.
- Telehealth supports people living with long-term health conditions at home by enabling older people to monitor their health without having to (physically) visit their doctor. Telehealth is the remote exchange of data between a patient at home and their clinician(s) to assist in diagnosis and monitoring, it is typically used to support patients with long-term conditions.[9] Examples of telehealth include fixed or mobile home units to measure and monitor temperatures, blood pressure and other vital signs parameters for clinical review at a remote location using phone lines or wireless technology.
- Smart homes are a means of improving home care and the independence of older adults through the use of smart devices and technologies. Smart homes can be equipped with sensors, actuators, and/or biomedical monitors[10] to facilitate continuous mobility assistance and non-obtrusive disease prevention.[11]

In the development of suitable housing for older people, AAL also looks at opportunities in the smart (residential) homes sector and smart neighborhoods. Equally relevant, but not integral to this study, is the development of smart care homes and universal design in public spaces that support independency of the older adult. Closely related to this, but peripheral to the AAL market definition, are mobility support systems that enable personal mobility.

ICT is central to the AAL market. Borsella, et al. (2015) distinguish between:

- Assistive technologies – solutions developed at the interface of the health care sector and housing sector.
- Technologies for physical prevention – are solutions that are developed at the interface of social care and housing (in relation to independent living and smart home health systems).
- Technologies for rehabilitation – integrated care solutions that are developed at the interface of social care and health care.

A recent report[12] defined the Silver Economy as the part of the general economy that are relevant to the needs and demands of people aged 50 and over. Therefore, this market includes all economic activity (both public and private at the point of delivery) that serve the needs of older adults, including the products and services they purchase directly and the further economic activity this spending generates. This report estimated the size of the European Silver Economy based on the demand older adults represent in various sectors, including those relevant for AAL.

As can be seen from the above, the exact definitions given to the AAL sector and hence to the AAL market differ. Many of the definitions are overlapping but often overly restrictive or not covering all aspects of AAL. In this study, we will follow the broader definition of AAL as presented in Table 1. Nevertheless, it should be noted that data that were available for this study do not fully conform to this definition. Much

[9] "Telecare Services Association. What is Telehealth?" Available at: https://www.tsa-voice.org.uk/consumer-services/what-is-telehealth

[10] Smart homes — Current features and future perspectives (2009) Chan et al., Maturitas, 64, 90. Available at: https://doi.org/10.1016/j.maturitas.2009.07.014

[11] A review of smart homes—Present state and future challenges (2008) Chan et al. Computer Methods and Programs in Biomedicine, 91, 55. Available at: https://doi.org/10.1016/j.cmpb.2008.02.001

[12] The European Silver Economy (Technopolis) 2018. Available at: https://ec.europa.eu/digital-single-market/en/news/silver-economy-study-how-stimulate-economy-hundreds-millions-euros-year

of the historic data are linked to earlier, narrow definitions. In the following sections, we will note which aspect of the AAL market we present data for and reference those accordingly.

Table 1 Overview of AAL product and service categories and markets

AAL categories and definitions	
• Health & Care • Information & Communication	• Comprises of products and services which collect and manage medical data, which support therapy and care activities, as well as those assisting in nutrition and personal hygiene. • Comprises of products and services which one the one hand side present knowledge, offer advisory functions and on the other hand support and enable interpersonal communication and organization of daily living.
• Living & Building • Safety & Security	• Comprises of products and services for water and energy supply, light management, room climate as well as measures for design barrier-free rooms. Maintenance and access control are in this category, • Comprises of products and services, which prevent damage and burglary or which support the user in case of falls. Localisation and emergency management is part of this category.
Mobility & Transport	Comprises of products and services that on the one hand serve as transportation measures for persons and goods and, and on the other hand offers travel information, navigation and orientation solutions.
Vitality & Abilities	Comprises of products and services that support, train or enable basic physical, mental and social abilities, that are essential requirements for independent living.
Leisure & Culture	Comprises of products and services, which enrich or enable recreational activities in leisure time and cultural activities. Sports, media and games are covered as well as culture, religion and travelling.
Work & Training	It contains work supporting measures and products and services for job specific learning and training.

2 General market drivers and barriers

This chapter is relevant to policy makers, start-ups and SMEs looking to understand the market forces expressed as drivers and barriers that the AAL market is facing. Knowledge of these market drivers and barriers is key to understanding the market expectations, uptake of technologies and services and ultimately market trends which are presented in Chapter 5.

2.1 Drivers

2.1.1 Demographics

The ratio of people in the EU that are aged 65 or above compared to the people aged 15-64 is expected to increase from 28% in 2015 to 50% in 2060. On average, healthcare consumption increases with age, for example, individuals aged 50+ accounted for almost 70% of all in-patient hospital days in 2013, despite being only about 40% of the population. As a result, the number of people aged above 65 that will need (long-term) health care will increase substantially in the EU over the next few years and this puts direct pressure on the health care system. The social care sector is likewise put under pressure because with increasing age, people become more restricted in their movements and need additional support in daily tasks. Many older people need increasing assistance[13]. ICT based solutions may help older adults to live longer, independently in their own homes.

A specific challenge to old age is dementia and almost 6% of the EU population over 60 years of age suffer from dementia. Alzheimer's Disease is the most common disorder which causes dementia, accounting for about 65% of all cases.[14] It is estimated that the number of people with dementia will increase from 10m in 2015 to 13m in 2030 and 19m in 2050[15]. Prevalence of dementia increases exponentially with age, doubling with every 6-year increment in age, peaking among those aged 85+ in Europe[16]. Depending on the severity of their symptoms, individuals need varying levels of support. People with severe dementia symptoms can often not live on their own, as they may endanger themselves. In addition to affecting the person living with this disease, dementia also impacts the quality of life of family members who provide care.

2.1.2 Government incentives

There is a growing political awareness that the healthcare provision systems cannot continue to run as before. There is a need to optimise resources without jeopardising the quality of the services delivered, or even improving those. Therefore, there is an increased pressure on national health systems and a new push towards maximising 'efficiency' by exploiting available resources in the system, often through supporting independent living of older adults. Technology can help support the health and care services being delivered and, in particular, the Internet of Things (IoT) vision can contribute to connected healthcare. Digital healthcare strategies are defined by policy makers which represent a strong driver towards the adoption of AAL solutions. These solutions are adapted to different degrees and through different business models, depending on the particularities of each national health and care system. For example, the telecare market is largely driven by the public sector in the UK, Sweden, Spain, Germany and France; whereas in the Netherlands, the market is largely driven by private investment[17].

[13] Older Adults: Health and age-related changes. American Psychological Association. Available at: http://www.apa.org/pi/aging/resources/guides/older.aspx

[14] Alzheimer's disease. Alzheimer Europe. Available at: http://www.alzheimer-europe.org/Dementia/Alzheimer-s-disease

[15] Prince, M., Wimo, A., Guerchet, M., Ali, G. & Prina, M. (2015). World Alzheimer Report 2015, Alzheimer's Disease International, London

[16] Ibid.

[17] Coda Strategies (2017)

2.1.3 Consumer behaviour and interest

There has been increased interest in healthy ageing and in self health management. The availability of medical sensors embedded in consumer devices, primarily wearable devices, such as Fitbits and also some smartphones, has had positive effects by these devices enabling (amongst other) activity monitoring. The so-called Quantified Self movement – measuring individual vital data using everyday devices – has showed consumers how accessible technology can be used in a new way beyond voice, messaging, and Internet surfing. This movement has also enhanced consumer awareness about healthy behaviour and lifestyle. However, this effect is predominantly, at this moment in time, restricted to digitally-savvy individuals. These people, in turn, are sharing their understanding with others around them, including their friends, parents and grand-parents.

Some of these devices are not certified and for this reason there is scepticism about their accuracy, which would be crucial for reporting and analysing those parameters. The medical professional community has showed limited enthusiasm for endorsing technological solutions that can help manage healthy ageing However, some general practitioners and doctors do see wearable devices as a useful tool to engage with patients and talk about the importance of physical activity in general.

2.1.4 Penetration of technology

There is increasing acceptance of the benefits of new technologies in modern life if bundled appropriately in accessible services. The degree to which these new technologies are adopted however varies greatly geographically (urban versus rural areas) and demographically (younger versus older generations). There is also variation in the degree to which solutions have been introduced that can enable older people to stay longer at home and live independently.

- Internet usage amongst the older population is increasing rapidly. In 2007 only 16% of the 65-74-year-olds used the internet, whereas by 2016 this has increased to 49% (EU28, Eurostat).
- Smart phone penetration in Europe was close to 67%, however those aged over 55-74 lag behind and varies significantly across countries. Recent data from the US shows that the smart phone penetration is increasing fastest among older people.
- Older people are also becoming familiar with the use of smart TVs; in 2016, 3% of the 65-74-year-old population used a smart TV, and 5% of the 55-74-year-old used a smart TV (EU28, Eurostat). Similarly, usage of smart phones is also becoming more popular amongst the older population.
- Increased interest in wearable technology and monitoring health and wellbeing.
- Telecare penetration has increased amongst the older population; for example, in the UK about 32% of the 75+ are subscribed to telecare assistance (see Chapter 5).
- There is an increase in the use of ICT not only in private homes but also in the health and care system. For example, many general practitioners have adopted the use of electronic networks to exchange medical patient data with other healthcare providers and professionals and to transfer prescriptions to pharmacists. Finland uses Kanta to exchange electronic patient records, while Austria has introduced the ELGA system.

2.1.5 Technological and data developments

Generally, development in a variety of technology components is driving future progress in the AAL space. The combination of that with the decreasing cost of technologies is a strong driver for adoption. New AAL solutions are developed where technologies are bundled with service delivery. Sensing technology is an explanatory case and similar progress has been made in the field of data analytics, rapid software development and communications options. For example, remote patient monitoring is now possible using a range of connectivity options. Long Power Wide Area Network (LPWAN) can be applied in remote patient monitoring applications that do not require exchange of a large data set.

At the same time, interoperability – the ability to integrate and share data across devices – is a concern. The lack of interoperability and coexisting of solutions from different vendors is a serious barrier, particularly in smart home environments in which there are different communication protocols on

which devices are designed. There is a strong effort from the industry and standardisation bodies to bring formats and protocols together. UNIVERSAAL[18] is an example of an interoperable platform, however adoption of standardised protocols takes significant time for companies.

The lack of platforms based on open standards is regarded as one of the most significant market barriers within the ICT industry. Having common standards and interoperable solutions can bring new business models and market opportunities for cost-effective solutions that can not only enhance the quality of life but also open a new and potentially large market for solution and service providers. Issues of data protection/security, information governance and privacy will also need to be addressed. "These measures should specify in particular the necessary standards and terminologies for interoperability of relevant ICT systems to ensure safe, high-quality and efficient provision[19]" of services.

2.2 Barriers

2.2.1 Complex regulatory environment

The complexity of the regulatory environment, in combination with the need for interoperable solutions, common standards and data sharing, is one of the barriers in the AAL market[20]. For example, health and care falls under EU countries national jurisdiction and the EU has some policies, including in the field of telemedicine, that complement national law. EU legal instruments affecting, amongst other, telemedicine are[21]:

- The recent General Data Protection Regulation (GDPR) will require compliance from actors that process personal data concerning health, however consumers should benefit from more control over their personal data.
- Medical Device Directives, which harmonises the rules for the circulation of medical devices in the EU.
- The e-Commerce Directive.
- Directive on Distance Contracting.
- Directive on Electronic Signatures.
- Competition law.
- Directive on Professional Qualifications.
- Reimbursement.

At the national level, few countries have specific legal instruments dealing with telemedicine, and few have adopted "national regulations or professional and ethical guidelines concerning the provision of telemedicine services"[22], rules that set out patient privacy and confidentiality. Altogether, the lack of explicit legislation is thought to limit the uptake of telemedicine. From a commercial point of view, a key challenge is that an AAL device and solution needs to be certified per country as there is no overreaching EU legislation. This is a substantial overhead for companies, particularly start-ups. The large medical device manufacturer can absorb such costs, but, but smaller companies and start-ups struggle in this area.

[18] universAAL EU project (2014) Available at: http://universaal.sintef9013.com

[19] UNIversal solutions in Telemedicine. Deployment for European HEALTH care. Industry Report on Telemedicine Legal and Regulatory Framework (2015) Available at: http://united4health.eu/wp-content/uploads/2015/10/D5.5-v1.0-U4H-Industry-Report-on-Telemedicine-Legal-and-Regulatory-Framework.pdf

[20] See also AALIANCE2 (2014) Updated report on Standard and Certification in AAL

[21] United4Health (2015). D5.5 v1.0 U4H Industry Report on Telemedicine Legal and Regulatory Framework

[22] Ibid., P 15

2.2.1.1 Privacy and security concerns

Privacy protection is a key issue that needs to be managed for individual usage of ICT technologies by older adults as well as in institutional settings. On the one hand, consumer willingness to share data – in accordance with privacy regulations – should be encouraged. However, to increase user acceptance there needs to be a compromise between an improved and personalised service offering and privacy. Sharing data is key to drive innovation and improve health and care.

Nevertheless, individuals need to be aware of the importance of privacy protection. On average, across the EU28, 60% of individuals have provided personal information over the internet (e.g. name, date of birth, card number, location, information related to health and income).

There needs to be clear policy that outlines how data should be secured and integrated and AAL solutions should be secure by design. Service systems (hardware and software) need to meet the relevant health information standards and privacy and security provisions in standard operations. The European Commission, amongst other public bodies, is exploring which policy measures are most appropriate to secure citizens' access to 'electronic health records and the possibility to share these across borders'[23].

2.2.2 Technical skills

In 2016, on average across the EU, 56% of all individuals had basic or above basic digital skills. For the population age 55-75-year-old 32% had basic or above basic digital skills (a small increase from 2015, which was 31%) (Eurostat). This data suggests that across the EU there is already a tendency for the digital, but more can be done to encourage digital to become a preference. There is a need to build a digital culture oriented to services where things and objects being connected, exchange data, and analyse data in a different way. The interdependency of skills levels of older adults and their carers has a limiting impact on uptake of relevant solutions. In order to increase the number of skilled older adults, carers are needed to help with the integration of new technologies in people's lives. However, carers themselves are largely under skilled, forming a major barrier for the uptake of new technologies.

2.2.3 Interoperability

Limitations to interoperability with other platforms remain across Europe. Differing standards hinder the implementation of AAL solutions and limit their scaling up nationally and across the EU and to reach economies of scale. Greater interoperability across devices, services and systems will be needed to see the emergence of connected health care systems, which link providers with the wider population and particularly older people and their carers.

2.2.4 Market fragmentation

AAL solutions are offered across Europe by many small enterprises, creating a 'long tail' of fragmentation, hampering efforts to implement innovation at scale. This represents a barrier that needs to be overcome when entering into and expanding sales in European markets. These barriers include naturally occurring obstacles such as cultural diversity, language, market size and geographic location. In comparison, the US offers a more homogenous market than the diverse European environment. Therefore it is difficult to develop an AAL solution which is applicable to all areas of the EU, impacting marketability and investment prospects. Most experts suggest that an effective way to overcome such barriers is through partnerships formed across borders, be it with distributors or other intermediary organisations. Such organisations will offer services with connected technologies, lowering risk and enhancing access to consumers.

[23] https://ec.europa.eu/info/consultations/public-consultation-transformation-health-and-care-digital-single-market_en

3 Value chains and business models

This chapter is relevant to start-ups and SMEs looking to implement a business model canvas to help develop their company's vision and the opportunities to target their consumer segment.

Building a viable AAL business consist of a number of steps, including: identifying the key partners, activities and resources, turning the new solution to a value proposition to other businesses and customers, identifying relevant customer segments, a cost structure and revenue streams, and finally building customer relationships through effective channels of marketing and communication.

Developing a business model canvas can help identify the company vision and the way to achieve this vision. An outline of the AAL business model canvas is presented below in Table 2[24]. The business model canvas probes a business developer/strategist to answer a number of questions:

What do you do? To make an effective value proposition, it is key to understand the *current and potential* needs and wants of the target customer.

Who do you help? Targeting customer segments is important, since the population of older people covers a heterogeneous group, ranging from active at work and living well independently to frail people living with reduced mobility and/or physical and cognitive decline. The business model is designed with the end-user in mind and expectations around this will shape the value chain and business strategy. Examples of value propositions of successful organisation in the AAL market include, amongst other:

- Offering options for personalisation, e.g. solutions that allow people to understand better their health and wellbeing.
- Delivering a user-led-design/universal design – e.g. solutions that integrate the needs and wants of older people in the design and promoting adoption of the solution at an early stage.
- Facilitating communication – e.g. solutions that enable older people and organisations (e.g. care homes, doctors, family members) to interact easier and keep track of the wellbeing of patients, allowing for efficiency gains and improving quality of care.

Who will help you? Key partners to the AAL business model may include private technology providers, software developers, local and regional care providers, national health providers, service partners, system integrators, security enablers, solution and service providers. Technology providers include suppliers that provide different types of technological solutions that can be integrated into AAL solutions. A number of technologies that are particularly relevant to the AAL market are presented in Chapter 4, and comprise of sensing technology, reasoning technology, acting technology (including robotics), interacting technology and communicating technology.

How much will you make? Whilst investors help finance the development of technologies, it is expected that the technologies are used in products and services that generate revenue, e.g. from a smart home solution, thus making investments in the AAL market financially profitable. As such, it should be clear who is expected to pay for the solution: the older person and/or his family or other businesses (e.g. a care home or an electricity provider)?

Other questions asked by the business model canvas help clarify the key activities (how do you do it?), the key resources (what do you need?), the distribution channels (how do you reach the consumer?), the consumer relationships (how do you interact?), and the cost structure (what will it cost?).

[24] See also AALIANCE2 business model analysis for AAL and the H2020 –UNIFY – IoT Project, IoT Business models framework. Available at: http://www.internet-of-things-research.eu/pdf/D02_01_WP02_H2020_UNIFY-IoT_Final.pdf

Table 2 AAL business model canvas

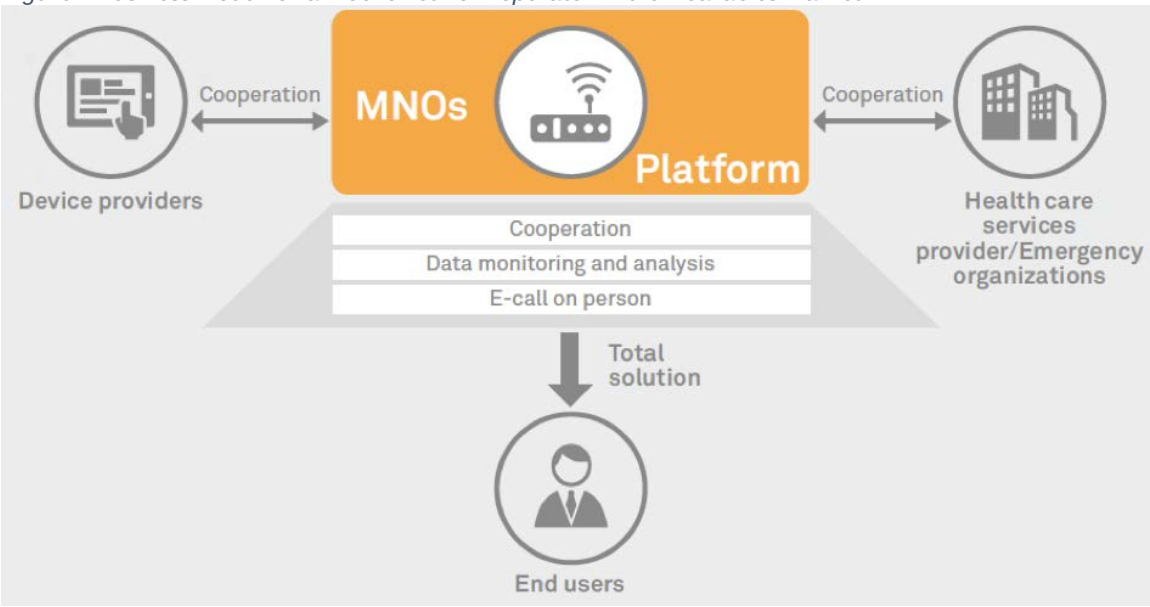
<table>
<tr>
<td rowspan="2">Key partners
Private technology providers, software developers, local, regional, national health and care providers, service partners, system integrators, security enablers, solution and service provider, user organisations</td>
<td>Key activities
Development of the product or service, customer development, logistics, market expansion</td>
<td rowspan="2">Value propositions
Likely includes options for personalisation, user-led-design/universal design, facilitate communication and coordination</td>
<td>Customer relationships
Personal assistance, automated services, self-service</td>
<td rowspan="2">Customer segments:
• Older people that are fit and independent; frail population, their families and informal caregivers
• Health and social care staff
• Service providers
• Businesses supplying AAL integrated solutions and services
• Insurers and commissioners</td>
</tr>
<tr>
<td>Key resources
Includes intellectual property and new ideas, financial resources, software</td>
<td>Distribution channels
Includes care organisations, online sales, etc.</td>
</tr>
<tr>
<td colspan="3">Cost structure
Product development and testing, ICT and personnel costs, logistics costs, marketing costs, installation and maintenance</td>
<td colspan="2">Revenue streams
Includes subscription fees, usage fee, product sale, or leasing</td>
</tr>
</table>

Some of the early solutions and services (e.g. telecare solutions, see CODA strategies) that are available on the market endorse traditional business models and linear value chains, for example moving from R&D inception, to the development of a platform, to the development of services, to the development of installation and maintenance, and finally to commercialisation. However, new business models are emerging where partners and collaborators are to a larger degree co-dependent over the entire product life cycle. In line with changes in related industries (such as IoT),[25] it is likely a that the AAL market will move away from a linear value chain to an umbrella market represented by a value network. In a value network, different actors of the system work more closely together to develop a common solution. The role of data and data analytics is key here as it provides the basics for a continuous feedback loop of the user experience to the improvement of the solution offered. For example, artificial intelligence offers huge improvements in accuracy e.g. in forecasting possible falls over time, and thus effectiveness. Furthermore, as a relatively new market it is difficult to sell directly to end-users, ideally a B2B2C consumer model is needed where an intermediary can facilitate access to an end user through avenues such as distribution or marketing networks. The ecosystem where the value network will thrive is innovative, open and transparent. It is clear that this is a complicated and challenging avenue, especially for solutions connected to markets that are largely nationalised, such as healthcare.

One example of a more open network is presented in Figure 2, which illustrates the business model of a mobile network operator (MNO) in the wearables market. The MNO offers the platform and connects organisations that provide devices and also connects with health care service organisations. The end-user buys an integrated solution that has the backing of the health care community and the technology of those providing the devices. Managing the consumer relationship and data analytics can be managed in-house or (partly) outsourced. The value proposition of this MNO consists of providing a secure connectivity service and a highly reliable network provision in emergency services.

[25] H2020 – UNIFY-IoT Project. Supporting Internet of Things Activities on Innovation Ecosystems. Available at http://www.internet-of-things-research.eu/pdf/D02_01_WP02_H2020_UNIFY-IoT_Final.pdf

Figure 2 Business model for a mobile network operator in the wearables market



Source: HUAWEI, A New Era in Connected Health Care

4 General digital technology and application developments

This chapter is relevant to start-ups and SMEs looking to understand the types of technologies that are relevant to the AAL market and the focus on integrating different technological components in AAL solutions. The chapter also provides an overview of the major innovators of technologies relevant to the AAL market and contrasts the performance of EU innovators to the global market performance.

4.1 Introduction to the framework

AAL solutions combine social, technological and business aspects, developed through a user-focussed design[26], to delivery effective services to older people. Borsella, et al. (2015) outline five enabling technologies that are part of the system that provides AAL solutions, including assistive technologies, technologies for physical prevention, and technologies for rehabilitation:

1. Sensor technology – provides electronic data for a wide range of AAL solutions.
2. Reasoning technology – aggregates, processes and analyses (sensor) data.
3. Acting technology – executes actions or operate components of the system, e.g. raises an alarm in cases of an emergency.
4. Interacting technology – facilitates human-machine interactions.
5. Communicating technology – enables different components of a system to exchange information.

The following sections outline the characteristics of these enabling technologies and application areas. An analysis of patent data (see Appendix A) is used to illustrate the activity level of EU and global businesses across different technology domains, providing an indication of innovation for potential integration into AAL solutions.

4.2 Sensing

4.2.1 Description and application areas

"A sensor is a device or system which measures a physical, chemical, electrical, or optical quantity of a phenomenon and produces an output related to that quantity" (Borsella, et al., 2015).

The most common type of sensor technology is wearable technology which includes accelerometers, gyroscopes and biometric sensors these are used as activity monitors, capturing movements and physiological parameters (e.g. heartbeat, temperature, pressure) and environmental context. "Wearable sensors detect abnormal or unforeseen situations by monitoring physiological parameters along with other parameters important for establishing context[27]". The data collected can be analysed and given to the end-user. The results of the AALIANCE project (Rodgers et al, 2017)[28] suggests that the tele-monitoring sensing technology roadmap will develop from (1.) the Fitbit type of technologies available on the market ca. 2015, to (2.0 external biomarkers in 2020 and (3.) wireless implanted biomarkers in 2025. Today, accelerometers are already fitted under the skin (for example to help prevent a heart attack).

[26] Guideline for user-friendly AAL design. Available at http://www.aal-europe.eu/wp-content/uploads/2015/02/AALA_Knowledge-Base_YOUSE_online.pdf

[27] Active and Assisted Living; Technologies and Applications (2017), Chapter 3 Ambient and wearable sensors for human health monitoring, Rodgers, Pai, and Conroy. P. 30/ Eds. Florez-Revuelta and Chaaraoui.

[28] Ambient Assisted Living Roadmap. Available at: http://www.aaliance2.eu/sites/default/files/RM2010.pdf

Another type of sensors, ambient sensors, are used to monitor motion, location, and environmental factors, e.g. for monitoring the whereabouts of older people in a residential home. This type of sensor can be used to detect falls and the degree of movement, for example, the time it takes for an individual to move between different rooms. Ambient sensors are able to detect precise/accurate data (and do not require the user to wear the technology) but there are various complexities, such as the range of the detection, and privacy concerns (Rodgers et al, 2017). The smart home concept is often described as having imbedded ambient sensors.

Sensor technology is not specifically developed for the AAL market but this type of technology is used in a wide range of AAL solutions. Key enablers to the sophistication and uptake of sensor technologies include the development in Microelectromechanical systems (MEMS) (also referred to as micro machines or micro systems technology). This type of solution is driving the mass production of wearable technology, automotive sensors and smart phones. The 2015 roadmap of INEMI, representing input from the private sector, public sector and academia suggests that MEMS is the most rapid growing technology area in the electronics industry.

"Recent developments in technology are increasing the availability and affordability of sensors[29]", amongst other developments, these changes are allowing AAL solutions to come to market at more affordable prices.

4.2.2 Technology roadmap

To proxy developments in sensing technology we look at the legal status of patent application across the world. Based on an analysis of patent data, Trappey et al. (2016)[30] identify patents classified under the technologies groups '*controlling systems'* and '*communication control protocols*' as most closely related to Cyber Physical Systems, which typically fall under sensor-based communication-abled autonomous systems, see appendix for an overview.

Global patent activity in 'sensing' technologies has been subject to periods of increase and decrease since 2000 (estimated using the number of patent applications filed). During this time, the patent activity of EU-28 countries (based on the location of the applicant) has, on average, decreased, falling by 35% between 2000 and 2014. Despite this decrease, the data provides evidence of continued research and development activity in this technology domain, see appendix A.

Due to this decline, and due to the rise in patent activity in other countries (e.g. China), the EU-28 share of the global patent activity has dropped by nearly 50% (from 28% in 2000 to 15% in 2014). When only considering granted patents, the performance of EU-28 countries fared considerably worse. As a share of all granted 'sensing' patent applications, the EU-28's relative performance fell by 75% between 2000 and 2014, from 28% of the global total to just 7%.

In 2000, over a quarter of global patents, both in the 'controlling systems' and the 'communication control protocol' technology areas, had applicants from one of the EU-28 countries (27% and 29% of patent applications filed respectively). However, between 2000 and 2014, the share of patent activity coming from EU-28 countries fell four times faster in 'communication control protocol' than it did for 'controlling systems' patents. Consequently, EU-28 countries witnessed a loss of 16% in share of global 'communication control protocol' patent applications, compared to a loss of just 9% in 'controlling systems' patents.

Germany are the top EU-28 country for all 'sensing' patent activity. Disaggregated, Germany maintain their top position for 'controlling systems' patent activity, but not for 'communication control protocol' where they are pipped to the post by France.

[29] Trappey et al (2016) A Review of Technology Standards and Patent Portfolios for Enabling Cyber-Physical Systems in Advanced Manufacturing, IEEE Access, v(4).

[30] Ibid.

Six of the top 30 companies globally in this technology area are from one of the EU-28 countries (see Appendix A).

4.3 Reasoning

4.3.1 Description and application areas

Reasoning technology components are able to aggregate, process and analyse, for example, sensor data and transform it into knowledge. Reasoning systems use algorithms to predict conditions and (emergency) situations or to classify information.

In the context of AAL, reasoning systems are identified to have thee functional layers[31]:

- Activity monitor layer – sensors deployed in the home environment and low-level data processing routines.
- Activity Modelling layer – obtaining the activity monitors that describe and capsulated meaningful information about activities such as location, duration or usage of AAL solutions, using a data driven or a knowledge driven approach, a hybrid data and knowledge driven approach, or *deep learning* (a class of machine learning algorithms).
- Activity interference layer – attempting at interfering the ongoing activities.

Machine learning models are components of Artificial Intelligence (AI) that can learn from data. These models can be applied to assistive technologies, telecare solutions and coaching applications, and decision support systems. These models can capture situations and behaviours[32] emergencies, activities of daily living, motion, psychosocial behaviour (communication), mental and psychical constitution (e.g. mood).

Activity monitoring technology can be implemented in ordinary houses or residential care homes, using RGB cameras and depth sensors. RGB cameras are applicable for human behaviour analysis, fall detection, tele-rehabilitation, gait analysis, and physiological monitoring. The technology involves image pre-processing, i.e. identifying the person of interest that is part of a wider image, and feature extraction and recognition[33].

Depth sensors do not process RGB colour images but instead measure (changes) in distance from the object to the sensor. This technology has been used in the Xbox console and can also be used for the collection of 3D data.[34] Depth images do not recognise the appearance of a person and for this reason protect a person privacy although the location of the sensor can be used for identification purposes. Because depth sensor technology is less invasive of a person's privacy this type of technology may be more adapt to AAL. Other relevant sensor data includes that gathered by accelerometers and audio sensors.

4.3.2 Technology roadmap

Based on a review of patent classifications, reasoning technologies is most closely linked to the following IPC technology groups: digital computing, data recognition, data processing, and image analysis (see Appendix A for an overview).

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[31] Active and Assisted Living; Technologies and Applications (2017), Chapter 7 Reasoning systems for AAL. Azkune, Ausín, and López-de-Ipiña. Eds. Florez-Revuelta and Chaaraoui.

[32] http://www.aaliance2.eu/sites/default/files/RM2010.pdf

[33] Active and Assisted Living; Technologies and Applications (2017), Chapter 4 Computer vision for active and assisted living, Planic, Chaaraoui, Kampel, and Florez-Revuelta. Eds. Florez-Revuelta and Chaaraoui.

[34] Using the Xbox Kinect sensor for positional data acquisition. American Journal of Physics 81, 71 (2013); Available at: doi: http://dx.doi.org/10.1119/1.4748853

Global patent activity (number of patent applications filed) in 'reasoning' technologies rose by over a third between 2000 and 2014. This growth was particularly strong in Asia, with growths in output of 1089%, 455%, and 139% being witnessed by China, Taiwan and South Korea respectively.

In comparison, the patent activity of EU-28 countries (based on the location of the applicant) was relatively subdued. Although some of the smaller players in the EU (e.g. Finland) increased their patent activity, a drop of around 25% in the activity of the biggest producers, Germany and France, meant the EU-28 witnessed an overall reduction of 8% in their patent activity between 2000 and 2014. Consequently, the EU-28 share of global patent activity (number of filed applications) fell by 6%, from 20% in 2000 to 14% in 2014.

As a share of all granted 'reasoning' patent applications, the EU-28's comparative performance fell from 20% of the global total in 2000 to just 8% in 2014.

The bulk of patent activity in this area was in the data recognition technology domain. EU-28 countries performed well in this field, as they did in digital computing and image analysis, accounting for nearly a fifth of patents in each of these fields between 2000 and 2014.

Although EU-28 patent activity in data recognition was not as impressive as the other technology groups, the EU's share of global patents (7%) was not below what one would expect given its population (7% of the global total in 2015[35]).

Two of the top 30 inventors/applicants filing 'reasoning' patent applications between 2000 and 2014 are located in one of the EU-28 countries. These are Philips Electronics (3rd globally) and Siemens AG (8th globally).

4.4 Acting

4.4.1 Description and application areas

Acting enabling technologies include robotics technologies and are implemented to support health and self-care and monitoring to support the independent living of older people. This technology group includes the production of robot companions, collaborative robots and exoskeletons as well as devices that enable changing settings and automating alerts but 'do not move'.

Research and developments in acting technologies focus on the development of smart actuators. Actuators are the components of a machine that are responsible for moving or controlling a mechanism or system. Some actuators incorporate in their design and production biological entities and processes (biomimicry), such as animal like features and behaviours (see the case study on Miro) and human muscles, e.g. mimicking the way a human hand moves.

Companion robots have integrated sensing technologies, reasoning technologies, interacting technologies and communicating technologies alongside acting technologies. A user-friendly-design is key, encouraging the end-user to interact physically, emotionally, socially with the technology, to the benefit of the older adult.

4.4.2 Technology roadmap

Based on a review of patent classifications, acting technologies is most closely linked to the IPC technology group robotic devices, which includes devices applicable to a wide range of sectors (see Appendix A for an overview).

Global patent activity (number of patent applications filled) in 'acting' technologies has risen by a fifth between 2000 and 2014. Whereas, the patent activity of EU-28 countries (based on the location of the

[35] The EU in the world – population. Eurostat. Available at http://ec.europa.eu/eurostat/statistics-explained/index.php/The_EU_in_the_world_-_population

applicant) in this area was steady with losses in some countries (e.g. Sweden and the UK) being offset by gains in others (e.g. Germany and France).

Despite growth being particularly strong in China and Canada, whose outputs grew by 956% and 512% respectively, the EU-28's share of global 'acting' patents remained stable at around a quarter between 2000 and 2014.

However, considering granted patents only, the performance of EU-28 countries was not as remarkable with their share reducing from 28% of the global total to just 10%.

Germany is the outstanding force in the European Union's 'acting' patent activity, filing triple the amount of applications between 2000 and 2014 as the next most active country (France).

Four of the global top 30 'acting' technology applicants / inventors reside in the European Union. These are: Kuka Roboter GMBH (7th globally – making industrial robots), ABB AB (10th), the French counterpart of Alternative Energies and Atomic Energy Commission or CEA (24th) and Siemens (28th).

4.5 Interacting

4.5.1 Description and application areas

Human-machine-interaction is a key aspect of AAL solutions, leveraging the accessibility and usefulness of the solution to the end-user. Interacting technologies can also be described as interface technologies and can be classified as[36]:

- Spatial – e.g. 3D movement trackers using accelerometers and optical sensors, gesture based interaction and touch screen interaction
- Sensorial – using digital augmentation of physical objects using sensory perception, e.g. temperature and pressure
- Natural language – voice recognition, map phenomes and handwritten recognition
- Multimodal – using two or more interaction modalities, depending on user preference

The development of Artificial Intelligence (AI), human-like ability of decision-making, speech recognition, etc., enables a system to recognize a sequence of words or actions of the user and to interpret the meaning of the situation or the intention of the user in the actual context.

The design of the interface in the context of AAL has to be a user centred design (UCD), tailored to the needs of people that are relatively more likely to experience loss of vision, hearing, touch sensation and cognitive and physical ability, losses that are associated with ageing[37].

4.5.2 Technology roadmap

Based on a review of patent classifications, interacting technologies is most closely linked to the following IPC technology groups: mice, joysticks, graphical user interfaces, speech recognition (see Appendix A for an overview).

Global patent activity (number of patent applications filed) in 'interacting' technologies peaked at just over 16,000 in 2010, before falling to below 10,000 in 2014. This is largely due to Japan and the US, the two most prolific countries in this field, both reducing their activity during this period – in Japan's case by more than half.

[36]See classification by Borsella, et al., 2015 – results from the AALIANCE2 project and further analysis in Active and Assisted Living; Technologies and Applications (2017), Chapter 8 Person-environment interaction, Caleb-Solly. Eds. Florez-Revuelta and Chaaraoui.

[37] Active and Assisted Living; Technologies and Applications (2017), Chapter 8 Person-environment interaction, Caleb-Solly. Eds. Florez-Revuelta and Chaaraoui.

The European Union has produced a consistent level of patent applications between 2000 and 2014, tailing off recently as with the global total. As with the other technological fields, Germany leads the rest of the EU producing almost double the amount of applications than the next most prolific country, the Netherlands.

The European Union is highly active in the speech recognition technology field filing over a fifth of global patents between 2000 and 2014. Although not as well, the EU also performs strongly in the other two 'interacting' technology groups (graphical user interfaces and mice, Joysticks) filing around 10% of global patent applications in each of these fields.

Four of the top 30 'interacting' technologies applicants / inventors are based in the European Union (see appendix). These are: Philips Electronics (6th globally), Nokia (8th), Fraunhofer Ges Forschung (11th), & Ericsson Telefon (27th).

4.6 Communicating

4.6.1 Description and application areas

Communication technology refer to between systems and system components machine-to-machine communication.

To enable AAL solutions to communicate common communication standards and protocols are key. Networks and systems have to be interoperable, usable, secure (protecting personal information), and reliable. Some of the different communication networks based on geographic location and level of security are:

- Personal Area Network (PAN) – is a network built around an individual person in a single building[38] and as such is usually categorised as communication between smart devices (i.e. communication between mobile phones, smartphones, for health and wellbeing monitoring).
  - An example is the IEEE 802.11 standard, combined with ZigBee can be used as a PAN.
- Local Area Network (LAN) - consist of a computer network at a single site, used for sharing information, that can be protected from unauthorized access.
- Wide Area Network (WAN) – a network which occupies a very large area such as the internet.
  - For example, via the internet the WAN can connect regional and national computers, to provide alarm notifications.

The transmission of data from sensors typically rely on a network architecture referred to as Body Area Networks (BANs)[39]. A BAN is a network of devices operating in or attached to the body. This can also be broken down to:

- Intra-BAN communications refer to communications between body sensors and/or between sensors and a central gateway.
- Inter-BAN communications include communicating data from personal devices such as smart phones to the access points.
- The beyond-BAN tier connects the access points to the internet and other networks, e.g. emergency services and care services.

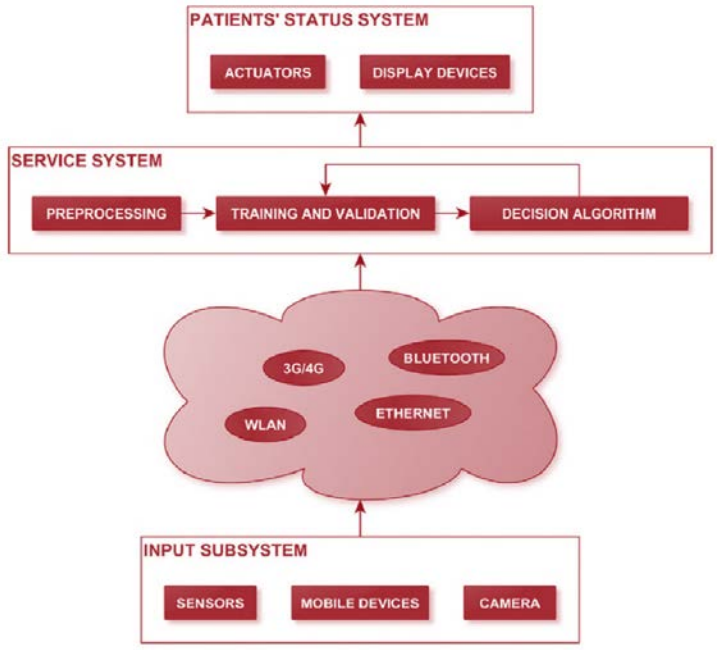
The ideal network structure is dependent on the intended purpose of the network. Chowdhury et al. (2017) outline a typical AAL system architecture, see below, which is a three-tier system where the patient's status system and the input subsystem are isolated. These are connected by the network that is

[38] Types of Networks. Available at http://study.com/academy/lesson/types-of-networks-lan-wan-wlan-man-san-pan-epn-vpn.html

[39] Borsella, et al., 2015

used for sharing information, which is represented by the cloud. The service system represents the data processing system.

Figure 3 Typical AAL system architecture



Source: Ambient Assisted Living and Enhanced Living Environments. (2017) Chapter 3 Energy Efficient Communication in Ambient Assisted Living, Chowdhury et al. Eds. Dobre et al. Elsevier.

Technological developments have increased the availability and affordability of computer networks[40] and, for example, low-power wireless protocols, enabling communication between AAL solutions, is enabling rapid AAL market growth.

4.6.2 Technology roadmap

Based on a review of patent classifications, communicating technologies is most closely linked to the following IPC technology groups: local, wide area networks and wireless communication networks (see Appendix A for an overview). Global patent activity (in terms of the number of patent applications filed) in 'communicating' technologies (see appendix) has grown considerably since 2000, increasing by nearly 70% between 2000 and 2014.

This growth has predominantly been seen in Asia. While some countries outside of Asia have seen growth in their patent activity, this bears no resemblance to the levels seen in China and India, who have both increased their patent activity by around 5000% between 2000 and 2014.

The EU led the world in 'communicating' technology patent activity (number of applications) at the start of the Millennium. However, as the EU-28 countries activity has since remained constant (falling slightly recently), and while the outputs of other countries have risen, the European Union's share has dropped from nearly a third of the global total in 2000 to just 13% in 2014. The US is now the most prolific producer of patent applications in this technological field.

[40] Trappey et al (2016) A Review of Technology Standards and Patent Portfolios for Enabling Cyber-Physical Systems in Advanced Manufacturing, IEEE Access, v(4).

Patent activity in wireless devices has fallen globally by 15% between 2000 and 2014. This fall has been more pronounced in EU countries, falling by 60% in the same period. As such, the EU's share of global patent activity in this technology has fallen from 29% in 2000 to 13% in 2014.

Five of the global top 30 'communicating' technologies applicants/inventors are based in the European Union. These are Ericsson Telefon (5th), Nokia (8th), Alcatel Lucent (16th), Siemens (20th), and Philips Electronics (26th).

5 Development and evolution of specific AAL solutions

This chapter is relevant to policy makers, start-ups and SMEs looking to understand how the AAL market is developing across broad classification of products and services, what characterises the different sectors and where the opportunities are now and in the future in the EU.

5.1 Introduction

This chapter describes the AAL products and services as categorised in the various AAL sectors. The objective of the classification according to a comprehensive and practical taxonomy is to improve comparability of AAL products and services.[41] Nevertheless, the mapping of a product and/or service into a singular category remains challenging. For example, some AAL products relevant for 'assistive and smart technologies' are available in a structured online catalogue[42] but many of the solutions are classified under multiple categories. The case study on Sensara illustrates the cross-cutting nature of AAL solutions, straddling across multiple standard categories, making it difficult to provide corresponding market estimations.

5.1.1 Case study of an integrated AAL solution: Sensara

Innovation (product/service/system)	Sensara HomeCare
Main end user (s)	Primary
Key words	Home, monitoring, alert
Organisation	Sensara
Organisation country	The Netherlands
	Self-learning sensors for safe home environment: • Sensara HomeCare is a platform which enables older adults to live independently and safely for longer. It is a producer of intelligent senior lifestyle monitoring with a focus on preventative care and personalised alarm systems. • Movement sensors coupled with self-learning algorithms empower the end-user, friends and family to provide care through quick responses and prevention as early detection of such risks is a proactive way to prevent more serious complications.[43]
	Market ready? • Investment by KPN has provided the company with the means to scale up production, development whilst widening its customer services and international outreach.[44] KPN Ventures is the venture capital investment arm of KPN the Netherland's leading telecom & ICT provider. Sensara Homecare sets are available in different packages for apartments, houses and a bed.[45]
	A unique technology? • Sensara prides itself on close cooperation between insurance companies, governments and users in order to create a platform that is supportive for the health sector.[46] The platform provides preventative care and personalised alarm services, using movement sensors and automated programmes that detect deviations from behaviour patterns. This

[41] https://www.taalxonomy.eu/project/

[42] https://www.aal-products.com/index.php/frontend/start?categorie=-1

[43] https://sensara.eu/en/

[44] http://www.eurocomms.com/industry-news/12237-kpn-continues-e-health-push-with-sensara-investment

[45] https://sensara.eu/product

[46] https://innovation-awards.nl/innovation/sensara-homecare-smart-life-monitoring-system/

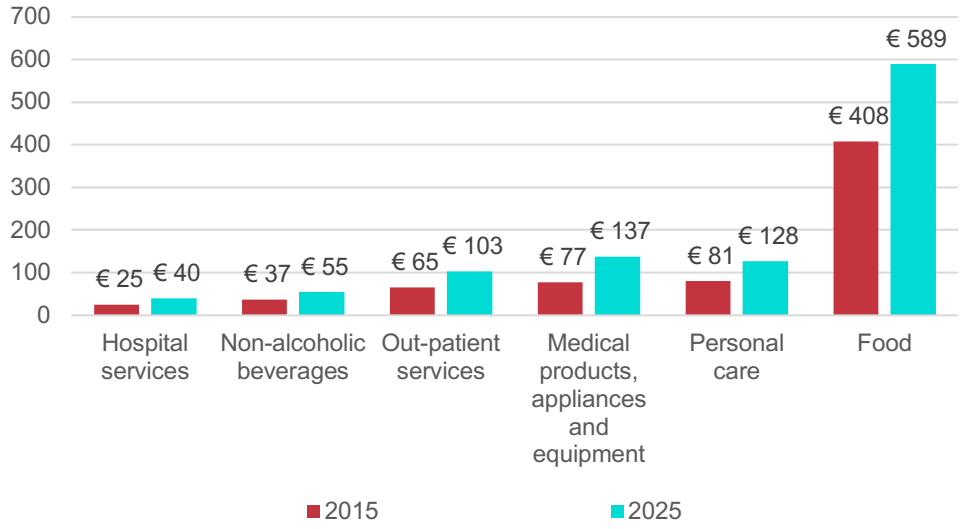
	can then provide status updates and alerts to caretakers through the app.[47] The software examines all the present and past signals detected from in house sensors and determines if certain profiles are occurring. Sensara uses specific profiles that are certified by the VU University Hospital in Amsterdam.
Future directions	Partnering into new avenues of development: • Sensara is currently working on a number of partnerships, extending its network as demand is increasing from elderly-care institutions, local governments and insurance companies for preventive healthcare and smart alarm services.[48]

5.2 Health & Care

In the EU, the 50+ spend €693b per year in relation to Health & Care, 46% of the total population's spend (Eurostat, 2015). The biggest component of spending is on food (€408b), followed by spending on personal care (€81b), see Figure 4.

The older population spend 57% of total spending on Medical products, appliances and equipment, see Table 3. By 2025 the 50+ population is expected to spend €1,052b per year (51% of total spending) on Health & Care.

Figure 4 Distribution of Health & Care 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 3 Older population consumption expenditure on Health & Care as a percentage of total private expenditure, 2015

	50-60	60+	50+
Hospital services	10%	35%	45%
Non-alcoholic beverages	16%	25%	41%
Out-patient services	15%	37%	51%
Medical products, appliances and equipment	14%	43%	57%

[47] http://www.eurocomms.com/industry-news/12237-kpn-continues-e-health-push-with-sensara-investment

[48] https://innovation-awards.nl/innovation/sensara-homecare-smart-life-monitoring-system/

	50-60	60+	50+
Personal care	15%	26%	41%
Food	16%	30%	46%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Health & Care compromises of products and services which collect and manage medical data, which support therapy and care activities, as well as those assisting in nutrition and personal hygiene. Application areas are:

- Health Care and Prevention
- Body and Vital Data
- Telecare and Telehealth
- Electronic Health Record
- Nutrition & Diet
- Personal Hygiene
- Therapy
- Drugs and Pharmaceuticals
- Care

Most of these application areas do not represent '*new sectors*'. The integration of technologies to help support independent living is leveraging market potential and is helping to reduce the cost of health care. It is estimated that the "introduction of ICT and telemedicine alone is expected to improve the efficiency of health care by 20%" (EC, 2016)[49]. Moreover, the experience of the Scottish Health Programme[50] suggests that the distribution of telecare services to 44,000 people reduced the number of emergency admissions to hospital of 8,700 patients and admissions to residential care of 3,800 patients. The telecare services also made it possible to speed up 2,500 hospital discharges.

ICT developments have allowed healthcare solution specialist providers and mobile network operators, amongst others, to provide remote monitoring solutions for older people. Generally, those include three main technological components: hardware (sensors and devices), connectivity, and the software side (middleware management layer, data analytics, and applications). Those solutions are provided through partnerships among different players providing different components.

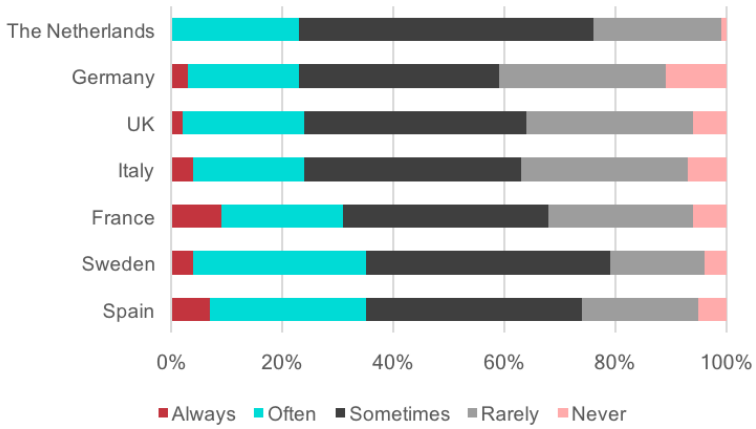
The health and care sector integrates all strands of technology: sensors, reasoning, acting, interacting and communicating. Various of the 23 products listed on the 'online catalogue for assistive and smart technologies' use sensor technology: e.g. SensFloor Med for gait analysis and CareMat Sensor Mates for fall prevention. Market estimations for Telecare and Telehealth are presented in Chapter 6. Additional primary research is needed to provide estimations for the other sub-categories.

Based on a survey of health care professionals, it is thought that in seven EU countries connected care devices are used often, at least, 20%-30% of the time when patients are living with serious or long-term medical conditions in their own homes – see figure below. In the Netherlands, Sweden and Spain, such devices are used at least sometimes in 70%-80% of cases.

[49] https://ec.europa.eu/digital-single-market/en/ehealth-and-ageing

[50] http://www.gov.scot/resource/0041/00411586.pdf

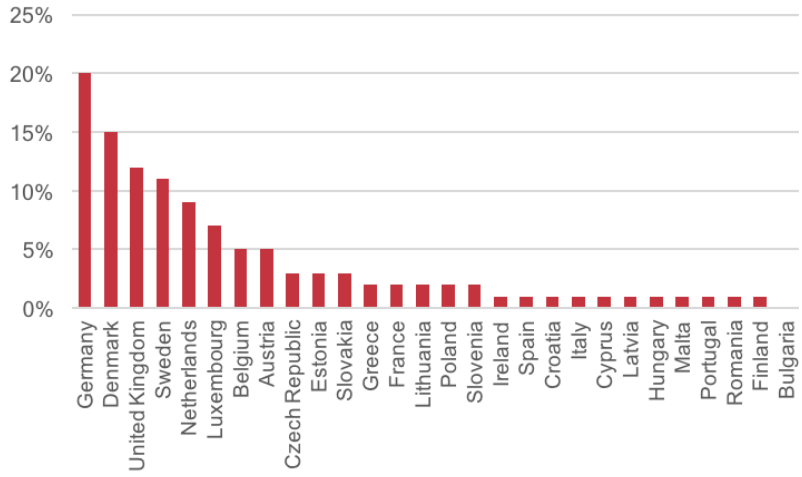
Figure 5 Frequency that connected care devices are used when patients are living with serious or long-term medical conditions in their own homes



Source: Future health index, 2017 https://www.futurehealthindex.com/data-tool/

It is likely that the consumer demand for the AAL market for Health and Care is at a relatively more mature level in countries where older people are also more likely to look for health and care solutions online. The figure below provides an overview of the degree to which older people purchase medicine online, e.g. ranging from 20% in Germany to 0% in Bulgaria.

Figure 6 Percentage of 55 to 74 years old that purchase medicine online



Source: Eurostat, 2017

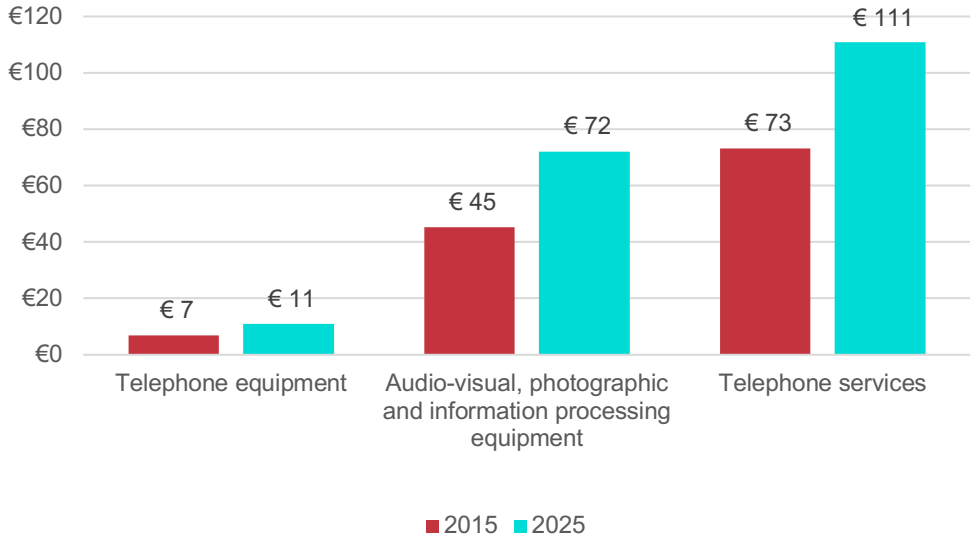
5.3 Information & Communication

In the EU, the 50+ spend €125b per year in relation to Telephone equipment, Telephone services, and Audio-visual, photographic and information processing equipment, 39% of the total population's spend (Eurostat, 2015).

The older population spend 40% of total spending on telephone services, see Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 4. By 2025 the 50+ population is expected to spend €194b per year (42% of total spending) on Information & Communication, see Figure 7.

Figure 7 Distribution of Information & Communication 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 4 Older population consumption expenditure on Information & Communication as a percentage of total private expenditure, 2015

	50-60	60+	50+
Telephone equipment	16%	20%	36%
Audio-visual, photographic and information processing equipment	17%	20%	37%
Telephone services	16%	24%	40%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Information & Communication comprises of products and services which present knowledge, offer advisory functions and on the other hand support and enable interpersonal communication and organization of daily living. Application areas are:

- Information and Knowledge
- Consulting, Coaching and Assistance
- Communication
- Organization

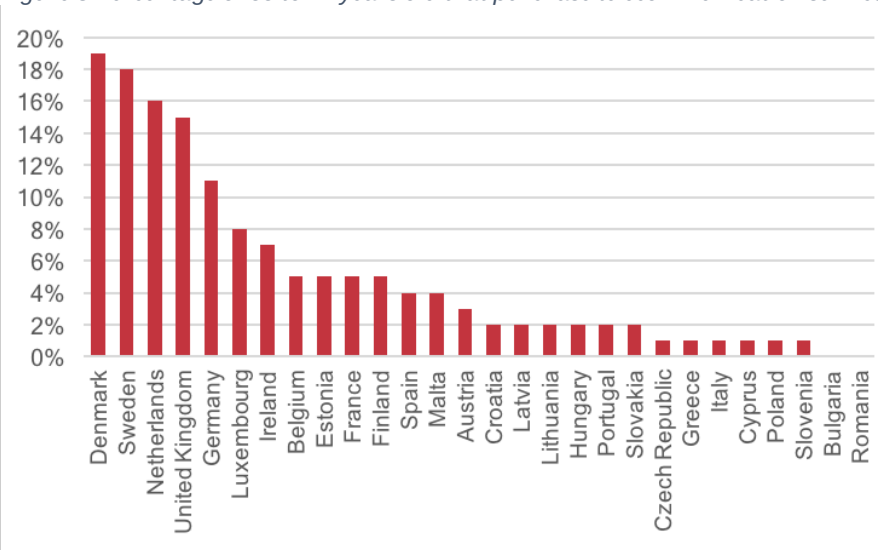
This category encompasses several applications supported by ICT. Various of the 23 products listed on the online Taalxonomy database use communication technology, e.g. the AAL Profiline emergency phone VarioTalk. Another example of a specific consumer product is 'Yooom', which is introduced in Chapter 7.

Market potential for this AAL category could be gauged via the study of market trends on mobile applications, although to the best of our knowledge such trends are not segmented by age group.

It is likely that the development of the AAL market for Information and Communication is at a relatively more mature level (i.e. demand for this type of products and services is higher) in countries where older people already purchase telecommunications online. As illustrated by means of the figure below, 19% of

the 55-74-year-old in Denmark already purchase telecommunications online – vs- 0% in Romania and Bulgaria.

Figure 8 Percentage of 55 to 74 years old that purchase telecommunication services online



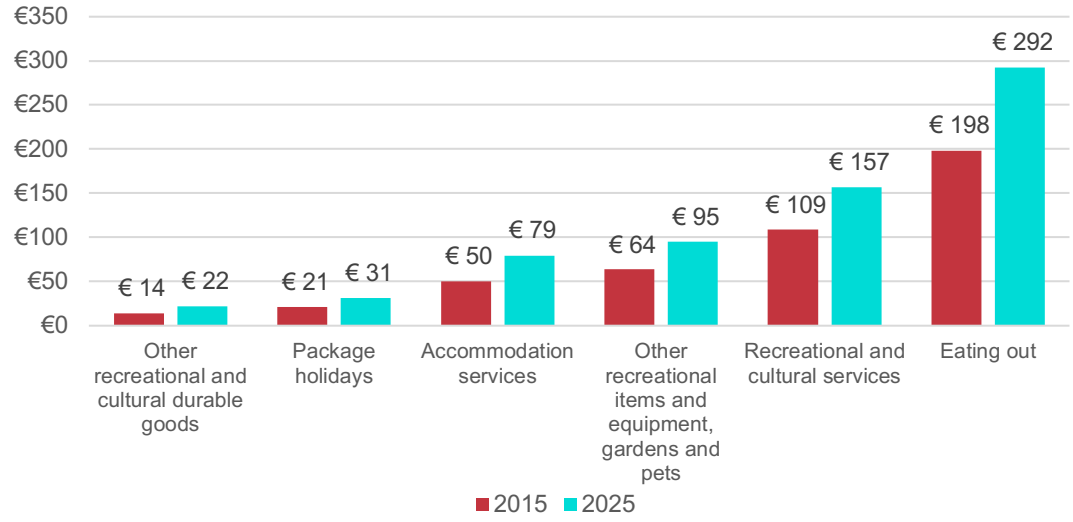
Source: Eurostat, 2017

5.4 Leisure & Culture

In the EU, the 50+ spend €455b per year in relation to Leisure & Culture, including eating out (€198b), recreational and cultural services (€109b) and accommodation services (€50b), 39% of the total population's spend (Eurostat, 2015). In 2015, the 50+ spend 45% of total consumption on package holidays, see Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 5. By 2025 the 50+ population is expected to spend €676b per year (42% of total spending) on Leisure and Culture.

Figure 9 Distribution of Leisure & Culture 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 5 Older population consumption expenditure on Leisure & Culture as a percentage of total private expenditure, 2015

	50-60	60+	50+
Other recreational and cultural durable goods	17%	23%	41%
Package holidays	17%	29%	45%
Accommodation services	18%	23%	41%
Other recreational items and equipment, gardens and pets	16%	24%	40%
Recreational and cultural services	16%	24%	41%
Eating out	16%	20%	36%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Leisure & Culture comprises of products and services, which enrich or enable recreational activities in leisure time and cultural activities. Application areas are:

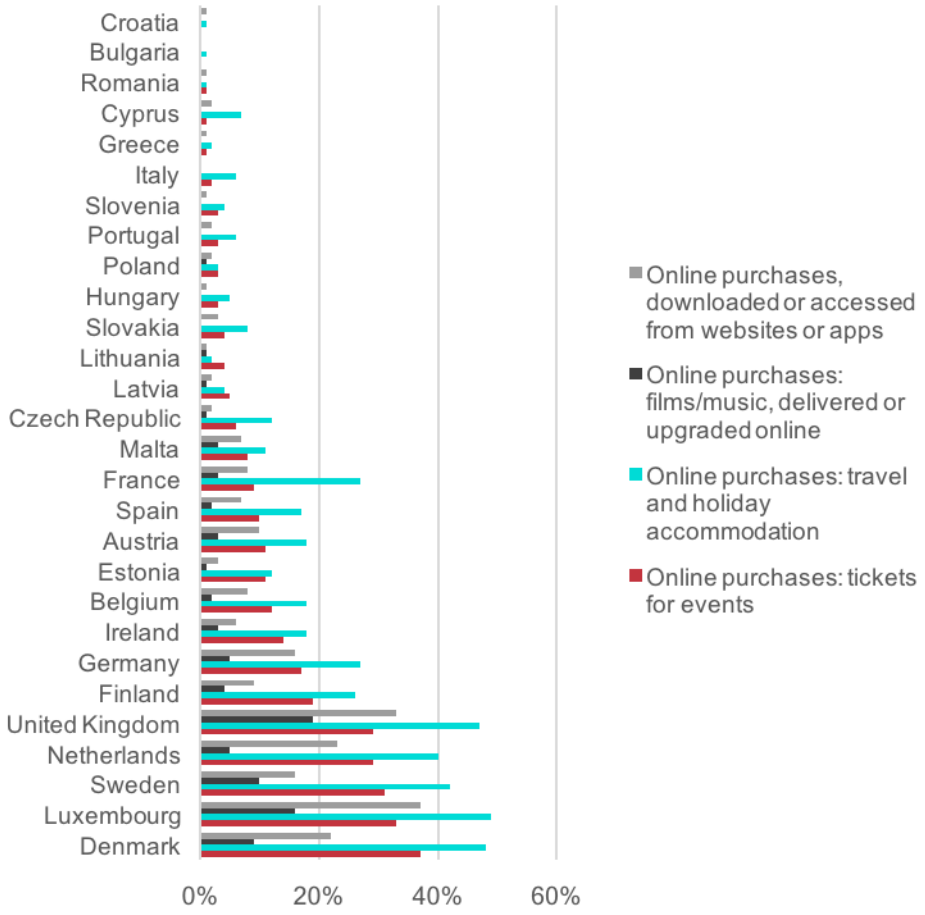
- Sports and Fitness
- Entertainment and Media
- Culture
- Traveling
- Religion and Faith
- Games
- Pets
- Other Activities

There is only a small number of products listed on the above mentioned 'online catalogue for assistive and smart technologies' in relation to the AAL leisure and culture sector. There are a number of mobile applications and platforms that aim at improving connectivity amongst other people. The emergence of these types of platforms is likely to trigger further market development.

In countries such as Denmark, Luxembourg and the Netherlands (in contrast to Croatia, Bulgaria and Romania), it is likely that there will be a stronger demand for the emergence of such platforms. In these countries, see figure below, today's 55-74-year-old consumer group already purchase leisure and culture services online, including: tickets for events, travel and holiday accommodation, and films/music, e-books, e-magazines/e-newspapers or computer software (incl. computer/video games, software upgrades).

The AAL leisure and culture market can extend well beyond the delivery of the abovementioned types of platforms. For example, ICT services (monitoring devices) that aid older people to take care of their pets are also part of this category of AAL solutions.

Figure 10 Percentage of 55 to 74 years old that purchased leisure and culture services online

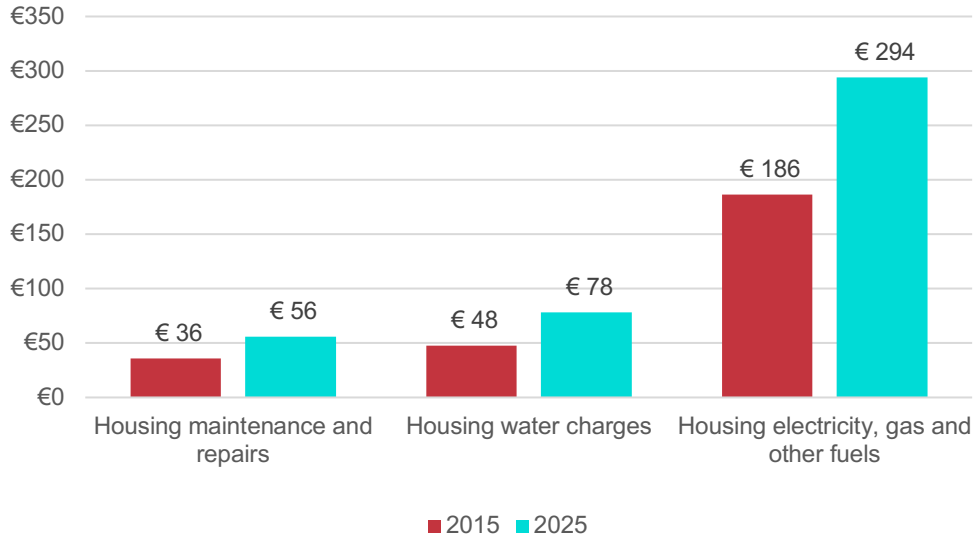


Source: Eurostat, 2017

5.5 Living & Building

In the EU, the 50+ spend €36b per year in relation to housing maintenance and repairs, 49% of the total population's spend (Eurostat, 2015). Total spending on Living & Building, including water charges and electricity, gas and other fuels of the 50+ is €270b, which is estimated to rise to €429b by 2025 – see Figure 11.

Figure 11 Distribution of Living & Building 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 6 Older population consumption expenditure on Living & Building as a percentage of total private expenditure, 2015

	50-60	60+	50+
Housing maintenance and repairs	16%	33%	49%
Housing water charges	11%	24%	35%
Housing electricity, gas and other fuels	16%	33%	49%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Living & Building comprises of products and services for water and energy supply, light management, room climate as well as measures for design barrier-free rooms. Application areas are:

- Accessible Housing
- Electricity
- Light
- Water
- Indoor Climate
- Entrance Control
- Environment
- Maintenance

One example of a relevant product that specifically target the older consumer group is KemuriSense smart power sockets, which contains passive sensors that continually measure temperature, humidity, electrical power usage, motion and power supply. The app screen of this product shows colour-coded changes to patterns of activity that could indicate the risk of hypothermia, dehydration, malnutrition, power loss and unattended falls[51]. Smart power sockets are fitted in kitchens of older people living alone

[51] http://www.kemurisense.com/

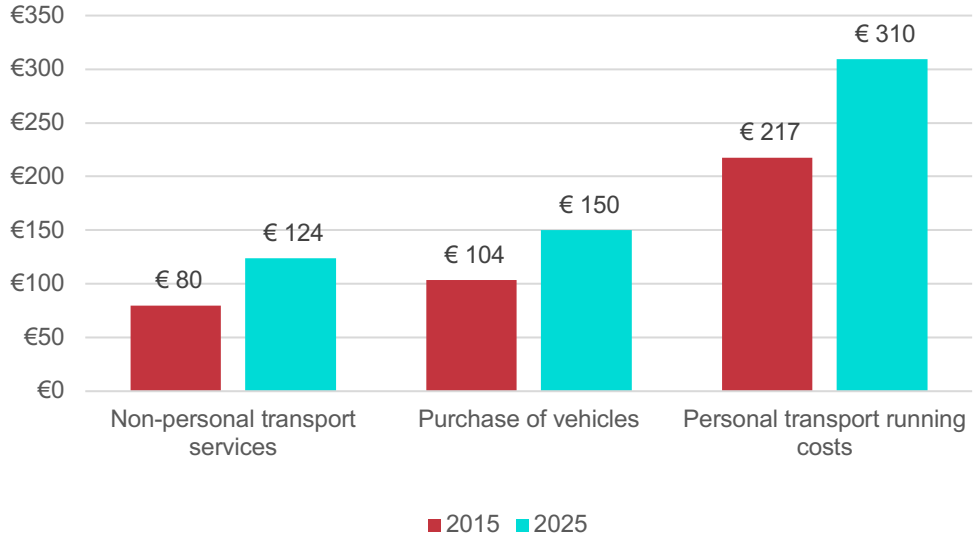
to measure ambient conditions and the use of kettles, microwaves or other electrical devices. The Wellbeing Monitor analyses the data every hour to identify unusual changes that could indicate a problem, possibly alerting families to take preventive action. If required, Kemuri sends SMS messages or alerts to vulnerable people's families or response centres. This type of product combines sensing and reasoning technology.

Smart home market estimations are presented in Chapter 6.

5.6 Mobility & Transport

In the EU, the 50+ spend €401b per year in relation to purchase of vehicles, personal transport running costs, and non-personal transport services, 38% of the total population's spend (Eurostat, 2015). By 2025, the 50+ spending on Mobility & Transport is expected to increase to €584b, 41% of total spending – see Figure 12.

Figure 12 Distribution of Mobility & Transport 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 7 Older population consumption expenditure on Mobility & Transport as a percentage of total private expenditure, 2015

	50-60	60+	50+
Non-personal transport services	18%	20%	37%
Purchase of vehicles	17%	20%	37%
Personal transport running costs	17%	22%	39%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Mobility & Transport compromises of products and services that serve as transportation measures for persons and goods and, and on the other hand offers travel information, navigation and orientation solutions. Application areas are the following sub-categories:

- Passenger Transport

- Transport and Supply of Goods
- Travel Information and Navigation
- Orientation

A number of products and services use acting technologies to aid the older adult when getting about. One of such examples is the 'Smart Cane', which can detect any unusual situation (fall detection, lower activity, etc.) and can alert caregivers and family if needed[52].

Other developments in the market include exoskeletons that are designed to help people with mobility disorders to be upright and mobile (e.g. PhoeniX Exoskeleton and Honda Walking Assist)[53].

Moreover, the move towards developing 'smart cities' is integrating technology, amongst other, in the public transport system, to the benefit of the mobility of the older adult.

5.7 Safety & Security

Safety & Security comprises of products and services, which prevent damage and burglary or which support the user in case of falls. Application areas are:

- Damages and Hazards
- Building Surveillance
- Falls
- Person Localization
- Emergency Management and Alarms

One element of this category is providing safety and security in home environments as well as potentially in care homes, such as door security systems.

Statista provides market estimations (see Chapter 6) on the broader living and buildings security market, however including older adults as well as younger people. Nevertheless, the data suggests that this (global) market is rapidly growing.

The AAL safety and security market specifically focuses on a range of products for fall prevention and this market is growing as carers in the formal and informal sector are looking for alternative ways to ensure that older people are safe. There are various estimations on the cost of falls and reducing fall and reducing the time between falls and hospitalisation can substantially decrease overall costs[54].

Sensor technology can be implemented as part of specific monitoring devices. For example, TeleGuard Bed Sensors are products that can be placed in bed under a mattress. A telephone call can be given to the care giver(s) as soon as the person lying in bed tries to stand up.

Fearless is an example of an intelligent, contactless fall sensor that not only detects falls, but also helps to prevent them, based on 3D sensors and smart behaviour modelling algorithms. Fearless is already in use in nursing homes, assisted living facilities, retirement homes and smart home facilities.

Another product example is Ubiquid[55], which transforms clothes and valuable objects of residents in retirement homes into connected objects. Thanks to RFID tags, Ubiquid allows every object to be identified and localised. Users benefit from peace of mind, knowing that their belongings will not be lost, stolen or damaged. Employees in retirement homes can sort, check or search objects at least 50%

[52] http://dring.io/en/

[53] http://www.suitx.com/phoenix and http://world.honda.com/Walking-Assist/

[54] http://www.who.int/mediacentre/factsheets/fs344/en/

[55] http://ubiquid.fr/offres

quicker than with any other solution and keep track of their work. Managers can follow the metrics through personalised, online dashboards improving their efficiency.

5.8 Vitality & Abilities

Vitality & Abilities compromises of products and services that support, train or enable basic physical, mental and social abilities that are essential requirements for independent living.

AAL products and services that are designed to help improve vitality and ability integrate a range of types of technology. Application areas and examples of products/services on the markets are:

- Physical Abilities – e.g. Pepper[56], a genuine humanoid companion created to communicate in a natural and intuitive way, through his body movements and his voice. Pepper is designed to interact, and can be used to dance, play, learn or even chat in another language. Pepper gradually memorises the users' personality traits and preferences and adapts himself to the users' tastes and habits.
- Cognitive Abilities – e.g. Memrica Prompt[57] a free software that emulates the way memory works to help older people living with memory problems make the most of each day. An app creates contextual records of shared history with family, friends and places to help users prepare for social events and journeys. It embeds images in reminders; clicking on images brings up relevant background information. A help function gives instant access to a supporter's telephone number, directions to chosen safe places and enhanced information about current location, including why the user is at that location. Just like memory, the user can search for anything in the system using normal language. A web dashboard is available for families, friends and carers to add images, content and reminders and see when they've been accessed. Analytics track user behaviour to send alerts if there's a change and collate summaries of weekly activity.
- Social Skills – e.g. Storyville Studios[58]. A platform for picture-based games strengthening social connections through storytelling.

The wearable device market is one of the bigger growing markets and equally relevant to 'Vitality and Abilities'. Wearable devices can be used for the following activities: wellness applications, sport and fitness applications, communications applications, and lifestyle applications. Market estimations for wearable devices are presented in Chapter 6.

5.9 Work & Training

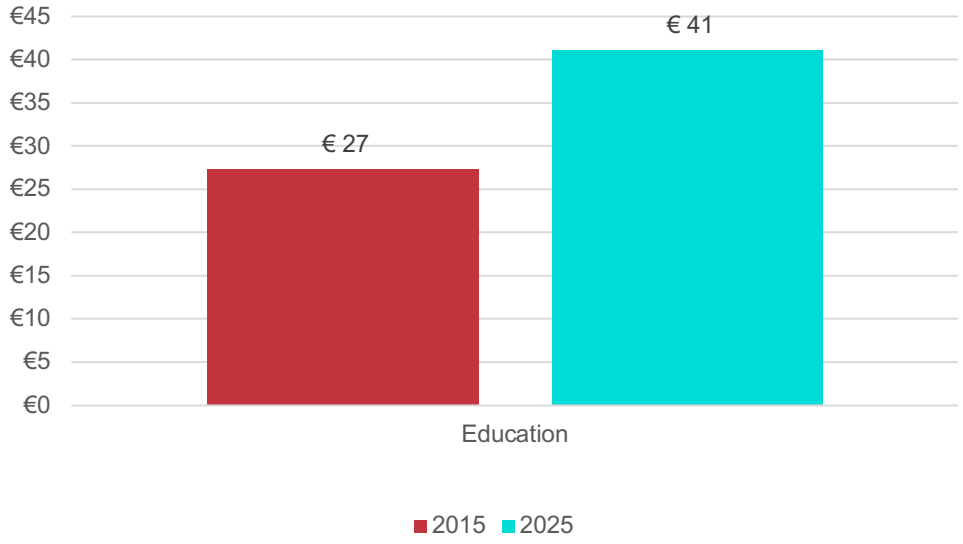
In the EU, the 50+ spend €27b per year in relation to education, 28% of the total population's spend (Eurostat, 2015). By 2025 it is estimated that the 50+ will spend €41b on education, 29% of total spending.

[56] https://www.ald.softbankrobotics.com/en/cool-robots/pepper

[57] http://memricaprompt.com/

[58] http://www.storyvillestudios.nl/

Figure 13 Distribution of Work & Training 50+ private consumption expenditure, in billions



Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

Table 8 Older population consumption expenditure on Work & Training as a percentage of total private expenditure, 2015

	50-60	60+	50+
Education	21%	6%	28%

Source: Data from Eurostat, 2015. Analysis by Technopolis and Oxford Economics, following the approach detailed in The Silver Economy Report (2017), supplementary material.

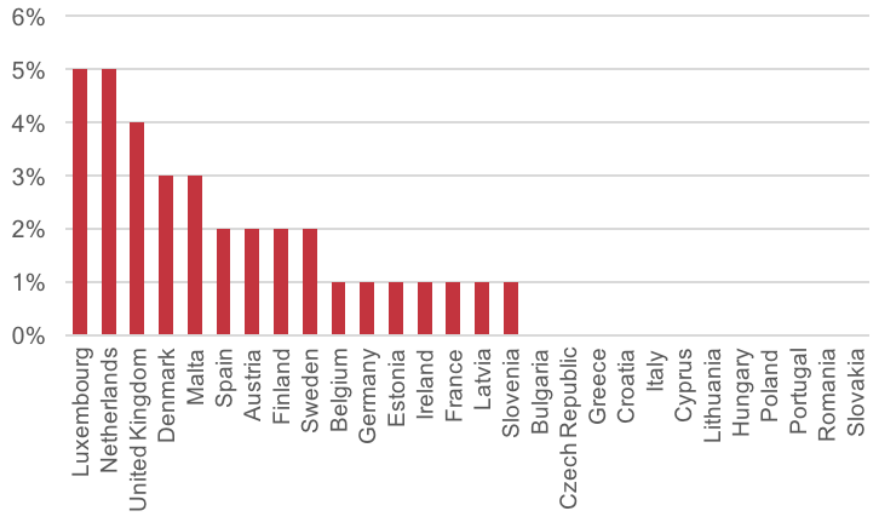
Work & Training consists of work supporting measures and products and services for job specific learning and training. The application areas are:

- Work Support
- Learning and Training

Work support services include series to help support posture and wellbeing at work.

The e-learning market in particular is a growing market, although it is developing more rapidly amongst the 30-50-year-old consumer segment. The figure below provides an indication of the percentage of older people that purchase e-learning material. This suggests that the e-learning market is relatively more developed in Luxembourg, the Netherlands, and the UK, where 4%-5% of the 55-74-year-old purchase e-learning materials online.

Figure 14 Percentage of 55 to 74 years old that purchase e-learning material



Source: Eurostat, 2017

6 Market and investment trends

6.1 Market trends

This section is relevant for investors and start-ups and SMEs interested in learning more about the current size of the AAL market and the growth potential. The chapter also provides data on market trends for sectors that are closely related to the AAL market but do not exclusively focus on the older people market segment.

This section presents an overview of the current and projected AAL market size and trends as well as the size of the related digital markets. An overview of the sector definitions is presented in Table 9. The analysis is based on secondary data, referenced throughout the text. Data from the Statista Digital Market Outlook is based on a stakeholder survey.

Table 9 Overview of AAL concepts and digital market definitions

Related concepts and key words	AAL market and related digital markets	Market definition	Excluded from market definition
Active and independent living, autonomy of older people	AAL market	Products and services for networked emergency alarms, accident detection, activity monitoring (by means of sensors) and comparable connected products that are aimed to support independent living for the elderly. This includes: • Pressure mats that detect whether a person has fallen and which can check whether he or she gets up again. • Emergency buttons that are either attached to walls or worn on the body and have a direct connection to emergency services. • Underlying services for the monitoring of older people and on-demand contacts.	Fitness trackers and wearables that are not directly connected to the household.

Related concepts and key words	AAL market and related digital markets	Market definition	Excluded from market definition
Telemedical services, Tele-assistance, Telemedicine, connected health, mHealth, prevention and management of chronic conditions, health monitoring	eHealth solutions	eHealth solutions market estimates are limited to the sectors "diabetes", "hypertension" and "heart failure". Included in the segments are the users of, and revenues generated from, pay-to-use apps (paid app downloads, premium versions and in-app purchases), for connected medical devices for use at home and for tele-medical services relating to remote patient monitoring.	• Hardware and software solutions for healthcare professionals • Advertising-funded apps
Wearable technologies, Sensors and activity trackers, management of daily life activities	Fitness – wearables and apps	• Wearables: devices that are explicitly intended for fitness. In particular, fitness wrist wear which is equipped with sensors and activity trackers that measure and analyse the physical activity and body functions of the wearer. Smart Clothes and Eyewear are included. • Apps: fitness and nutrition apps e.g. calorie counters, nutrition diaries and apps for detecting /tracking/ analyzing and sharing vitality and fitness achievements. The user base covers paying customers only i.e. users who pay for app downloads, premium/full versions and in-app purchases.	• Smartwatches • Apps that focus on specific diseases
Smart homes, assistive technology, assistive robotics, Internet of Things, home automation, integrated solutions, security	Smart home market	Smart home market estimates include: home automation, security, home entertainment, energy management, and the AAL market. The market covers the sale of networked devices and related services that enable home automation for private end users (through B2C or B2B2C). • Devices that are connected directly or indirectly via a so-called gateway to the Internet. Main purposes are controlling, monitoring and regulation of various functions in a private household. • Services which are necessary for maintenance or control of the household network e.g. subscription fees of control apps or external monitoring services.	• Devices whose primary function is not for the automation or remote control of household equipment, e.g. smartphones and tablets • Devices whose reason for purchase is only related to household connection and remote control to a limited extent, such as Smart-TVs, refrigerators, or ovens

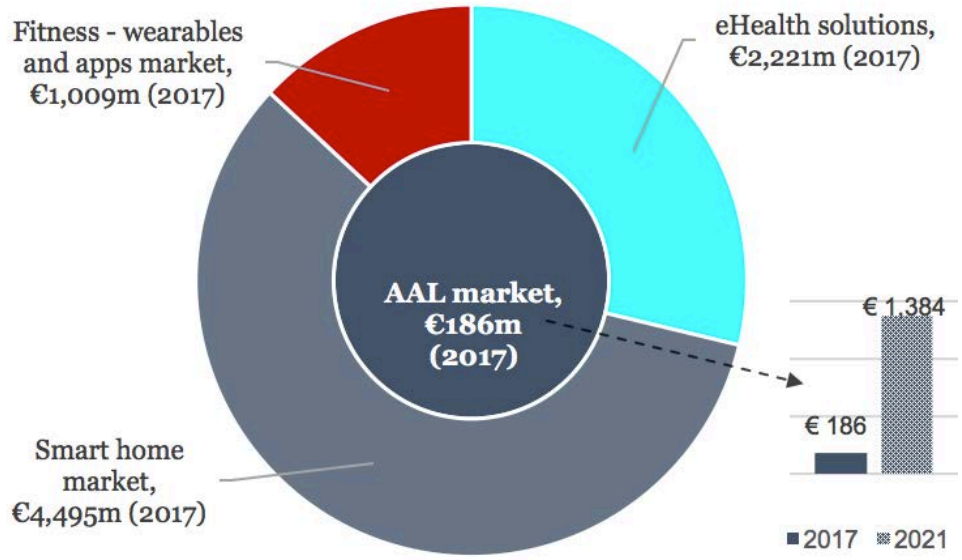
AAL market and related sector definitions from Statista Digital Market Outlook. For details on the AAL segment see also the Statista Digital Market Outlook report on Smart Home: Ambient Assisted Living (AAL)

Figure 15 presents an overview of the size of the EU AAL market[59] and related digital sectors. The AAL market in 2017 amounts to €186m and is expected to grow to €1,384m in 2021, representing a sevenfold increase in four years. In 2017, the EU market represents 21% of the global AAL market, and by 2021 the EU market size is expected to increase to 26% of the global market. The country with the largest market share is the US, accounting for 60% of total (€539m) in 2017 and an expected 40% of total (€2,132m) in 2021. As illustrated in Figure 16, the AAL market in Asia is also expected to grow rapidly from €111m in 2017 to €1,174m in 2021. Note that the AAL concept and definition should be broad, and where possible include fitness and wearables as part of the AAL market. However these markets were

[59] Data from Statista Digital Market Outlook. Data has been converted from US dollars to Euros using Oanda historical exchange rates from January 2017 – June 2017. For details on the AAL segment see also the Statista Digital Market Outlook report on Smart Home: Ambient Assisted Living (AAL). For all data from Statista, the EU market covers all EU countries excluding Cyprus, Greece, Luxembourg and Malta for which data is missing.

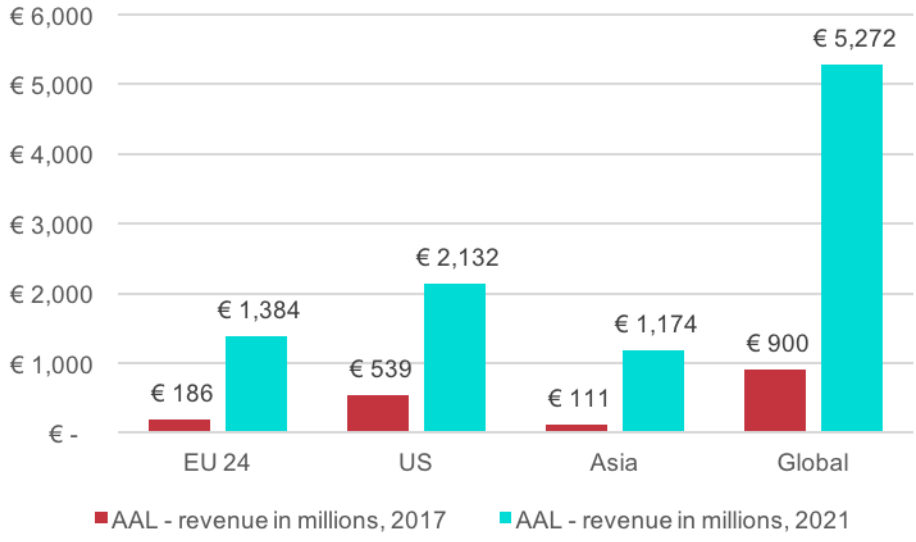
not segmented by age in Statista's database and hence we were unable to aggregate the relevant market segments into an overall EU AAL market size.

Figure 15 EU 24 AAL market and related sectors



Source: data from Statista Digital Market Outlook. Analysis by Technopolis. *The *eHealth market* estimate covers diabetes, hypertension and heart failure only. The *Fitness – wearables and apps market* is only a sub-set of the larger wearable technology market

Figure 16 AAL market size



Source: data from Statista, digital market outlook. Analysis by Technopolis

The largest AAL markets in the EU are forecasted to be Germany - 31% (€383m), the UK – 21% (€232m), France – 13% (€180m), and Italy, 6% (€139m) in 2021, which together represent 51% of the total EU market. AAL household penetration in these countries ranges from 0.2% in Italy to 0.5% in Germany in 2017 and market penetration is expected to increase to 1.6% in Italy and 3.1% on average by 2021. The EU country with the highest AAL household penetration is Estonia, with 0.7% in 2017 and an expected household penetration of 3.5% by 2021. The average AAL household penetration in 2017 is in line with

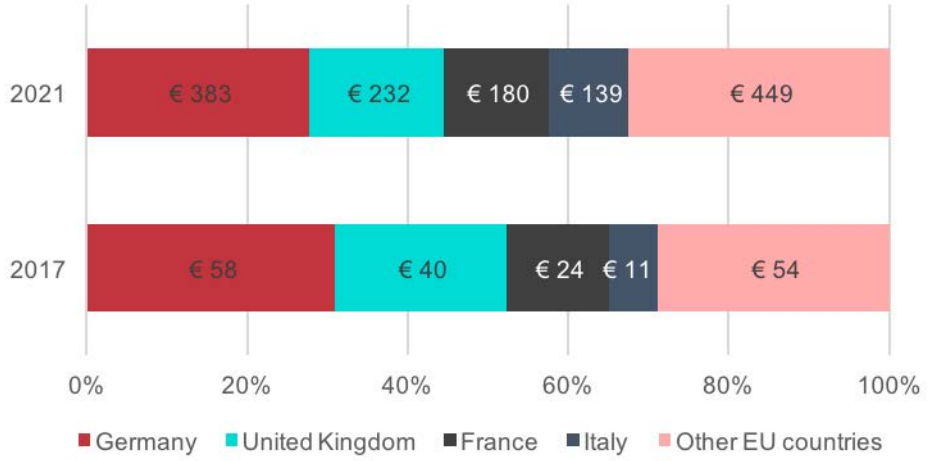
the global average – 0.3%, but average EU household penetration is expected to increase above the global average by 2021, 1.8% vs 1.3%.

Figure 18 illustrates that the average proportion of households in the EU with AAL devices and services will still fall substantially below that in the US, where it is predicted that by 2021, 5.3% of the households will have AAL devices. However, the rapid market penetration of smart home technology is expected to increase beyond 2020/2021, when a 'new' generation of older people, who are more tech-savvy then the previous generation, will grow older and be more inclined to invest in smart home solutions. Increased consumer awareness[60] and technological developments will likewise spur EU market developments in the field of AAL.

One of the technological developments closely associated with the AAL market is the field of assistive robotics progress in the field indicates that this market is likely to rapidly grow as well. IDC, a tech research company, forecasts global spending on robotics and related services to grow from more than $71 billion in 2015 to $135.4 billion in 2019.[61]

"In another sign of the expected boom, venture capital investments more than doubled last year to $587m, according to research firm CB Insights. Other investors are also piling in, says Manish Kothari of SRI International, a Silicon Valley research and development lab that has spun off robot companies. From private equity investors looking to build portfolios of robot investments, to new "incubators" such as Playground, started by former Google robotics chief Andy Rubin, the investment options have been proliferating rapidly."[62]

Figure 17 AAL market size in EU 24 countries



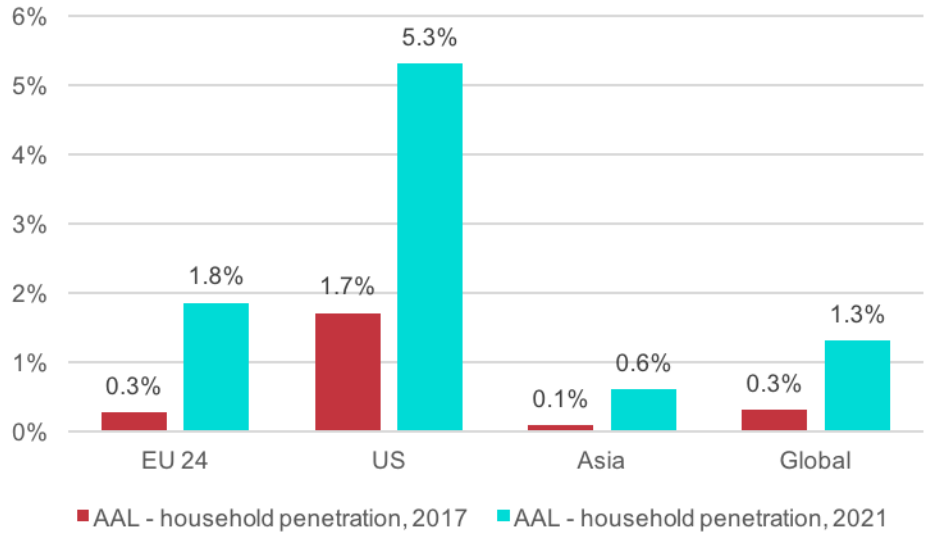
Source: data from Statista, digital market outlook. Analysis by Technopolis

[60] A Mapping of Smart Ageing Activity in Ireland and An Assessment of the Potential Smart Ageing Opportunity Areas (2015) Technopolis Group. Available at http://www.technopolis-group.com/?report=a-mapping-of-smart-ageing-activity-in-ireland-and-an-assessment-of-the-potential-smart-ageing-opportunity-areas

[61] IDC Press Release http://www.idc.com/getdoc.jsp?containerId=prUS41046916

[62] Rise of the robots is sparking an investment boom (2016) Financial Times. Available at https://www.ft.com/content/5a352264-0e26-11e6-ad80-67655613c2d6?mhq5j=e1

Figure 18 AAL market penetration



Source: data from Statista, digital market outlook. Analysis by Technopolis

Table 10 AAL and smart home market penetration

	AAL - household penetration, 2017	AAL - household penetration, 2021	Smart home - household penetration, 2017	Smart home - household penetration, 2021
Estonia	0.7%	3.5%	5.1%	32.4%
Austria	0.5%	3.3%	3.3%	28.8%
Sweden	0.4%	3.2%	3.4%	34.0%
Germany	0.5%	3.1%	4.7%	35.2%
Belgium	0.5%	2.9%	3.6%	25.9%
Netherlands	0.4%	2.5%	3.7%	30.5%
United Kingdom	0.5%	2.4%	5.3%	38.7%
Latvia	0.4%	2.3%	3.1%	24.1%
Finland	0.3%	2.2%	2.6%	33.8%
Denmark	0.3%	2.1%	3.7%	25.8%
France	0.3%	1.8%	2.1%	17.1%
Spain	0.2%	1.7%	1.3%	16.1%
Italy	0.2%	1.6%	1.0%	13.4%
Lithuania	0.2%	1.6%	1.6%	17.2%
Slovenia	0.2%	1.4%	1.2%	13.8%
Hungary	0.1%	1.3%	1.0%	12.5%
Czech Republic	0.1%	1.2%	1.0%	12.2%
Slovakia	0.1%	1.2%	0.8%	13.2%
Bulgaria	0.1%	1.1%	1.1%	12.0%

	AAL - household penetration, 2017	AAL - household penetration, 2021	Smart home - household penetration, 2017	Smart home - household penetration, 2021
Croatia	0.1%	1.1%	0.6%	9.3%
Ireland	0.1%	0.9%	0.7%	10.5%
Romania	0.1%	0.7%	0.6%	9.9%
Poland	0.1%	0.6%	0.5%	7.6%
Portugal	0.1%	0.6%	1.5%	16.7%
EU 24	0.3%	1.8%	2.2%	20.4%
US	1.7%	5.3%	14.9%	60.7%
Asia	0.1%	0.6%	0.9%	8.3%
Global	0.3%	1.3%	2.4%	15.6%

Source: data from Statista, digital market outlook. Analysis by Technopolis

6.1.1 Smart homes

Although a smaller proportion of households will adopt AAL devices by 2021, smart home technology is expected to be adopted by (on average) 20.4% of households in the EU by 2021, a steep increase from 2.2% in 2017. In the UK, Germany, Finland, Sweden, Estonia, and the Netherlands more than 30% of households are expected to have adopted smart home technology by 2021. Household adaptation of smart home technology in the US is expected to reach 60.7% by 2021. In relation, according to PWC, "53% of American consumers predict a singular remote that controls everything in the home will be the norm in the next 10 years."

The smart home market is one of the larger digital markets that are closely related to AAL but targets both younger and older consumers. According to estimations from Statista, global smart home market value (including AAL) is estimated to amount to more than €23b in 2017 and is expected to grow rapidly to more than €74b in 2021[63]. These estimates are roughly in line with estimates presented by PWC[64] that predict that the global smart homes market will amount to more than €55b by 2020. The rapid growth in the smart home market is currently based on growth in the delivery of energy management services and security and safety services. The success of the smart homes market can be seen as an early indication of potential growth in the AAL market because the market is underpinned by a comparable technological base and there is a lot of potential for the development of innovative solutions.

Strategy analytics present a higher estimate for the global smart home market, which is estimated to amount to €85b in 2017 and €149b in 2020 (including the value of hardware, installation and services) and estimate an even higher growth rate[65].

The rapid growth in the smart home market is currently based on growth in the delivery of energy management services and security and safety services.

[63] Statista presents new market estimations for the Smart Home market in 2018, i.e. the global smart home market is estimated to be €38b [$46b] in 20018 and €94b [$113b] in 2022. However, unlike the 2017 definition, this definition of 'smart homes' includes the following six sub-sectors: control and connectivity, comfort and lighting, security, home entertainment, energy management, and smart appliances and excludes AAL as a sub-sector.

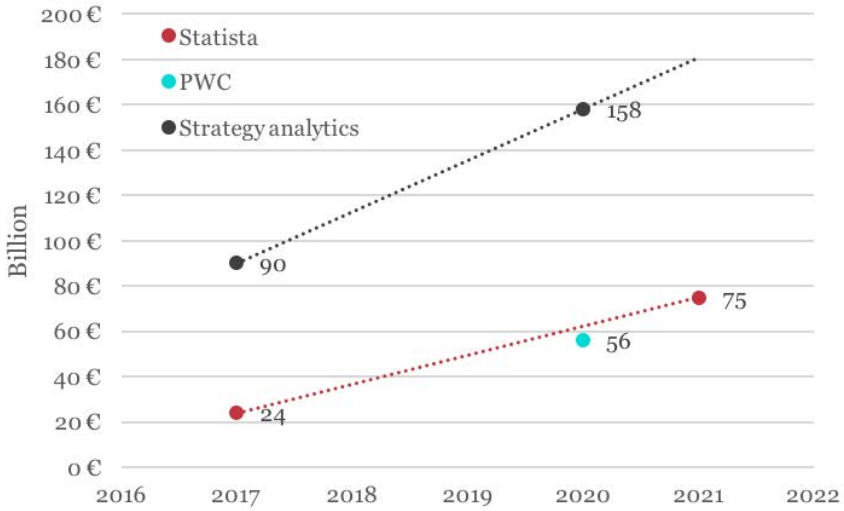
[64] http://pwcmegatrends.co.uk/mylifeconnected/home.html

[65] Strategy analytics, 2017. Data has been converted from US dollars to Euros using Oanda historical exchange rates from January 2017 – June 2017. https://www.strategyanalytics.com/strategy-analytics/news/strategy-analytics-press-releases/strategy-analytics-press-release/2017/02/28/global-consumer-smart-home-spending-to-grow-to-$158-billion-by-2022-up-from-$76-billion-in-2016#.WTkIh8m1tQa

Estimations for the global security market from Statista include (1.) digitally connected and controlled devices for burglar prevention and other security issues, (2.) motion sensors, door locks, security cameras, (3.) Surveillance services with connection to a broader smart home, and (4.) hazard prevention devices like water, smoke or gas sensors. It is estimated that in 2018 the global market is €8.2b [$10b] and that it will grow to €20b [$243b] in 2022. Household penetration is at 3.1 % in 2018.

The success of the smart homes market can be seen as an early indication of potential growth in the AAL market because the market is underpinned by a comparable technological base and there is potential for the development of innovative solutions. Indeed, there are indications that independent living solutions will in future be delivered through energy companies with smart energy solutions, such as Hive, from Centrica Connected Home.[66]

Figure 19 Size of the global smart home market

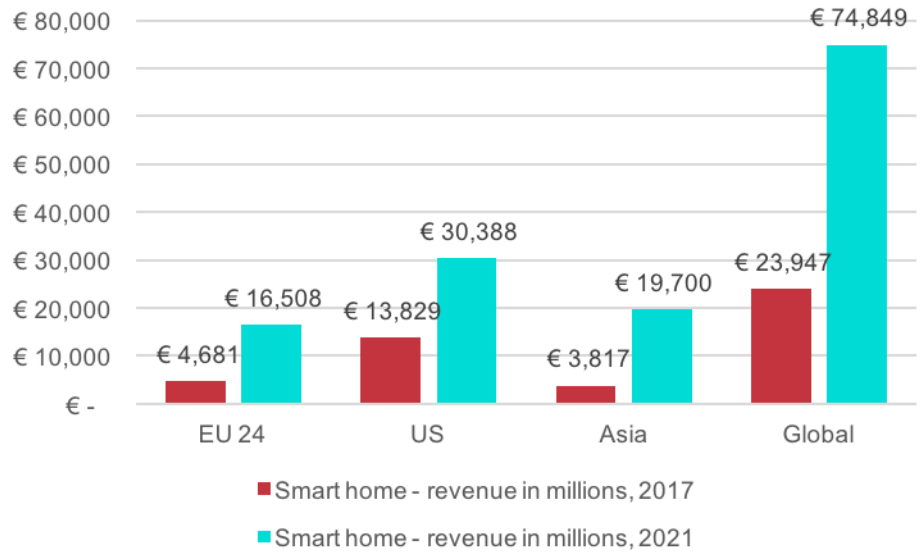


Source: data from Statista, digital market outlook, PWC Mega Trends, and Strategy analytics

The largest smart home market is the US, which is estimated at €13,290m for the year 2017 and is expected to amount to €28,256m by 2021, representing an estimated 41% of the global market in that year – see also Figure 20. In 2017, the EU smart home market is estimated at €4,495m and this market is expected to growth to €15,124m by 2021, 22% of the global market.

[66] Centrica Connected Home. Available at: https://www.hivehome.com

Figure 20 Smart home market size



Source: data from Statista, digital market outlook. Analysis by Technopolis

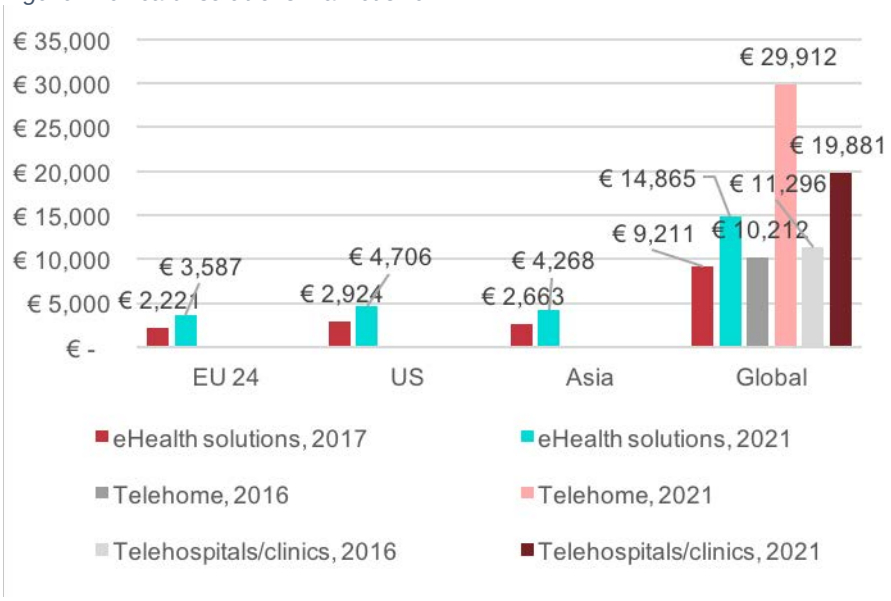
6.1.2 eHealth: telecare and telehealth

The eHealth market comprises of connected medical devices for use at home and for tele-medical services relating to remote patient monitoring. The EU market for selected eHealth solutions - covering diabetes, hypertension and heart failure - is expected to increase from €2,221m in 2017 to €3,587m in 2021, representing almost a quarter of the global market - see Figure 21. The country with the largest consumer base is the US, estimated at €2,924m in 2017. The countries with the largest consumer base in the EU are Germany, France, United Kingdom, Italy, and Spain. Because this estimate only covers selected sectors, it is possible that the entire eHealth market size is larger.

According to BBC research, the global tele-home market is expected to grow from around €10b in 2016 to close to €30b ($33.1b) by 2021 (BCC, 2016)[67] In addition to this, BBC research estimates that the global telehospitals/clinics market will grow from around €11b in 2016 to close to €20b in 2021. Thereby, largely exceeding estimates for the eHealth market in selected sectors, i.e. €9.2m, based on data from Statista.

[67] BBC Research, 2016 http://www.bccresearch.com/market-research/healthcare/telemedicine-technologies-global-markets-report-hlc014h.html. Data has been converted from US dollars to Euros using Oanda historical exchange rates from January 2016 – December 2016

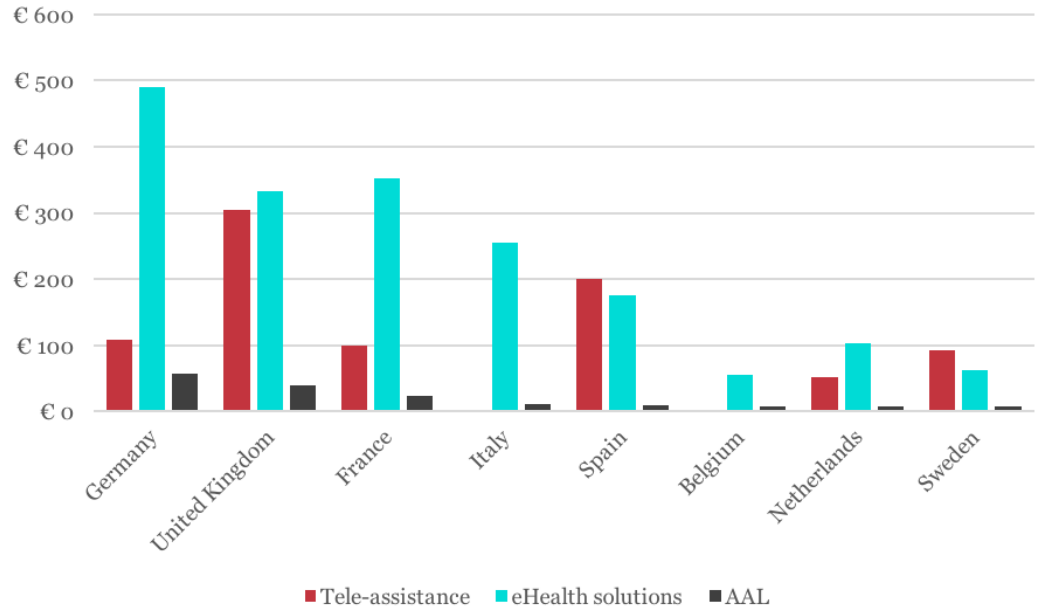
Figure 21 eHealth solutions market size



Source: data on ICT solutions for health care monitoring is from BBC (2016) and data on eHealth solutions is from Statista, digital market outlook

CODA Strategies estimates the tele-assistance market in France, as benchmarked with a select number of other EU countries, have the highest percentage of older people owning devices. CODA Strategies[68] reports that the country with the highest number of subscribers is the UK, with 1.7m subscribers and an estimated market value of €304m, which is close to the estimated value of eHealth in selected markets – see also Figure 22.

Figure 22 Overview of the size of the AAL market and related digital markets, by top 8 AAL market size in 2017



[68] CODA strategies (2017) L'avenir du marché de la téléassistance et des services associés, Pipame

Source: data on tele-assistance from CODA Strategies (2017) all other data from Statista, digital market outlook

As illustrated in the table below, the percentage subscribed to the tele-assistance market ranges from 3% in Germany to 15% in the UK amongst the 65+ and ranges from 6% in Germany to 32% in the UK for the 75+. According to the market analysis, in Central and Eastern Europe the percentage of subscribers is closer to 1%.

Table 11 Overview of the tele-assistance market

	UK	Sweden	Spain	Netherlands	France	Germany
Number subscribed	1,700,000	220,000	800,000	240,000	585,000	500,000
Percentage 65+ subscribed	15%	12%	10%	8%	5%	3%
Percentage 75+ subscribed	32%	26%	19%	19%	10%	6%

Source: data from CODA Strategies (2017), see also earlier analysis by Deloitte[69]

6.1.3 mHealth including wearable technologies

Closely related to the concept eHealth / digital health care sector is the concept connected health. PWC[70] predicts that by 2020 the size of the global connected health market will be close to €58.7b ($61b). This market comprises of:

- €1.9b ($2b) for the online prescriptions market.
- €13.5b ($14b) for the m Health devices market (blood glucose meter, BP monitors, pulse oximetry, neurological monitoring, cardiac monitors, apnoea and sleep monitor, wearable fitness sensor[71], heart rate monitor).
- €43.3b ($45b) for the m Health services market (prevention, diagnostic, monitoring, wellbeing, treatment),

The connected health market estimates from PWC party overlap with the digital 'fitness' – wearables and apps market estimate of Statista, digital market outlook. Figure 23 illustrates that this global market is estimated to grow from €5.3b in 2017 (€3.2b for the wearables market and €2.1b for the Apps market) to €9.1b in 2021. By 2021, the EU digital 'fitness' market is estimated to amount to almost €1.7b.

The wearable technologies market extends well beyond the 'fitness' component into AAL and eHealth, and the entertainment sector, including products such as Smartwatches, Fitness trackers, Smart eyewear, Smart clothing, Medical devices, and other infotainment devices, and some of these devices have health applications. CCS Insight estimates that the global market for wearable technologies will grow from €13.5b ($14b) in 2016 to €32.9 ($34.2b) in 2020[72]. IDTechEx produced bolder estimates and predicts that the wearable technology market will grow from €28.9b ($30b) in 2016 to over €38.5b ($40b) in 2018 to over €96.2b ($100b) by 2023 and €144.3b ($150b) by 2026[73]

[69] Deloitte (2015). Digital Health in the UK. An industry study for the office of life sciences

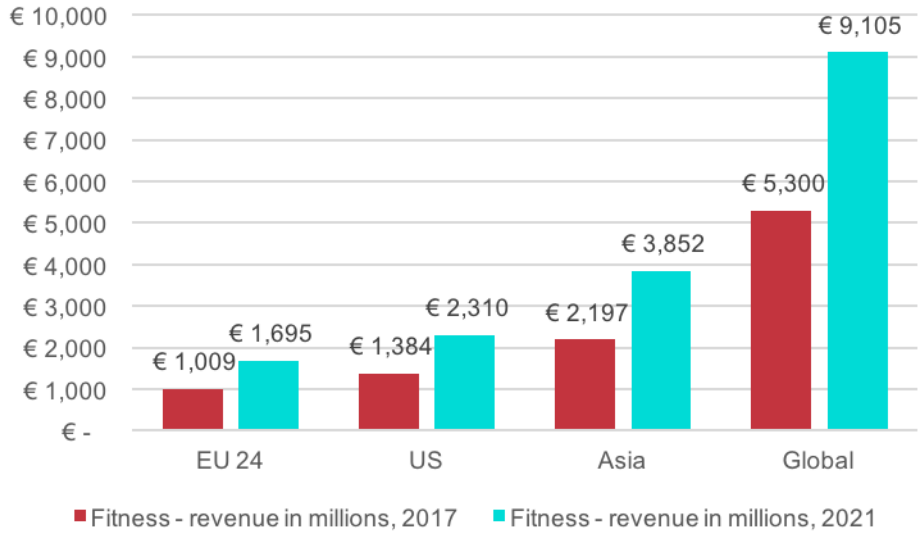
[70] http://pwcmegatrends.co.uk/mylifeconnected/health.html

[71] Wearable fitness sensors are also part of the business case on knowledge for an active and healthy lifestyle

[72] http://www.forbes.com/sites/paullamkin/2016/02/17/wearable-tech-market-to-be-worth-34-billion-by-2020/#600d12eb3fe3

[73] http://www.idtechex.com/research/reports/wearable-technology-2016-2026-000483.asp

Figure 23 Fitness – wearables and apps - market size



Source: data from statista, digital market outlook

6.2 Investors and key stakeholders

This section is relevant for investors and start-ups and SMEs interested in learning what players invest in the AAL market, their perspectives on the AAL market and investment behaviour. This section presents an overview of key investors in AAL technologies and solutions and other key players[74].

6.2.1 Big players

The AAL market includes key industrial players such, as Televic N.V. (Belgium), Vitaphone GmbH (Germany), Siemens AG (Germany), Schneider Electric S.E. (France), Legrand SA (France), Telbios (Italy), Philips N.V. (Netherlands), CareTech AB (Sweden) and ABB Group (Switzerland). Many of these larger companies actively patent AAL relevant technologies – see the Appendix A.

For example, Siemens is a German conglomerate company and is the largest engineering company in Europe. Siemens prides itself on being at the forefront of innovation to solve the social, economic and environmental challenges posed by modern society using the mantra: "progress in the service of man" as their vision.[75] The principal divisions of the company are Industry, Energy, Healthcare, and Infrastructure & Cities. It has filed more than 7,700 patents that are related to '*sensing*' technology in the past 15 years.

Royal Philips Electronics is a Dutch company and world leader in healthcare, lifestyle and lighting. Philips integrates technologies and design into people-centric solutions, based on fundamental customer insights and the brand promise of 'sense and simplicity'. Philips believe that the convergence of their consumer technologies and increasingly digitalised health systems will enable integrated solutions that will ease constraints on health systems but also create value for Philips stakeholders. [76] Philips runs a SimplyInnovate program to help innovators bring their new technologies to the market. Philips has a substantial portfolio of intellectual property. Philips is the world's largest patent applicant

[74] The analysis is based on desk research and the results of a selected number of interviews (see Appendix D).

[75] http://www.siemens-home.bsh-group.com/uk/discover-siemens/company/about-siemens

[76] http://www.philips.com/a-w/about/investor/philips-investment-proposition.html

at the European Patent Office.[77] Philips' IP portfolio currently consists of 79,000 patent rights, 49,000 trademarks, 86,000 design rights and 4,400 domain names.[78] Philips has filed more than 8,100 patents that are related to '*reasoning*' technology in the past 15 years.

Tunstall healthcare is seen as the European market leader for technology-enabled health care solutions, it has a dominant market position in the telecare market, delivering 'basic' telecare solutions across the EU. Tunstall Group Ltd. manufactures and distributes electronic products for healthcare services. Tunstall offers software and hardware for end-to-end solutions. Tele-health systems provide patients with the means to easily monitor their vital signs and symptoms at home, supporting the delivery of effective healthcare in the community.[79] Tunstall's philosophy focuses on providing efficient and effective healthcare solutions for older people and those with long term needs in doing so they hope to enable dignified and independent living.

Box 1 Tunstall

Tunstall provides technology enabled health and care solutions. They focus on four core areas these are: independent living, assisted living, remote patient monitoring and support and integrated nurse call systems.

Tunstall operates in more than 30 countries and employs over 1,2000 people.[80]

Tunstall was the first to develop alarm systems for older people, and remains at the forefront of telecare and telehealth developments.[81]

Over the last sixty years, Tunstall has helped support more than five million people and their families across the world.[82]

Other initiatives such as ZigBee are key to shaping the future market via setting wireless standards. ZigBee is a wireless language that allows everyday devices to connect with one another through the creation of personal area networks. In essence ZigBee is a low-power, low data rate wireless ad hoc network, one application of its use is for lifestyle monitoring and smart living bringing the benefits of IoT into the home.[83]

Box 2 ZigBee

ZigBee is a wireless standards and network organization offering IEEE 802.15 radio interface

"ZigBee Health Care offers a global standard for interoperable products enabling secure and reliable monitoring and management of non-critical, low-acuity healthcare services targeted at chronic disease, ageing independence and general health, wellness and fitness[84]".

[77] http://www.ip.philips.com/about

[78] http://www.ip.philips.com/about

[79] http://www.tunstall.co.uk/about

[80] http://www.tunstall.co.uk/

[81] http://uk.tunstall.com/Uploads/Documents/MST%20Tunstall%20digital%20journey%202025%20beyond.pdf

[82] http://www.tunstall.co.uk/about

[83] http://www.zigbee.org/what-is-zigbee/494-2/

[84] https://ec.europa.eu/eip/ageing/standards/healthcare/personal-autonomy/zigbee-health-care_en

ZigBee **Home Automation** helps "create smarter homes that enhance the comfort, convenience, security and energy management for the consumer"[85].

The ZigBee alliance, established in 2002, is **driving the future of IoT** by enabling connecting sensor or control devices, by establishing global standards. The ZigBee alliance includes 400+ companies, e.g. HUAWEI, Texas Instrument, IKEA, and EDF. The aim is that the devices produced by these companies are able to communicate.[86]

A number of larger companies also invest in SMEs, e.g. IBM, Google, KPN, etc. For example, KPN Ventures is the venture capital investment arm of KPN a leading telecom & ICT service provider in the Netherlands. They invest capital and enable access to KPN's infrastructure, security, connectivity and related technologies directly and indirectly in companies who have innovative products and business models.[87]

Box 3 KPN Ventures

KPN focuses on **early growth-stage investments** (series A/B) in European high growth companies. These companies will have focuses connected to KPN's core telecom and IT sectors including **connected homes, e-health and IoT**.[88]

"KPN is in a **market full of technological developments**, where much can be gained through collaboration with enterprising talent and investment in innovative companies".[89]

KPN was founded in 2015, it has a fund size of **€70 million**. Investment typically ranges from **€0.5 million - €2.5 million**.

KPN Ventures aims to create strategic **partnerships** with innovative technology companies.[90] KPN looks for minority stakes, building long-term partnerships and eventually external exits not acquisitions. [91]

6.2.2 Key investors

In addition to these types of private investors, there are a number of venture capital (VC) investors that have supported start-ups in the field of AAL.

One example out of many is Capricorn Venture Partners, an independent European manager of venture capital and equity funds, that specialises in technology focused innovative European companies. Belgium based, Capricorn invests in (Western) European companies via several different capital funds (in total the funds are approximately worth €400m) in areas related to biotechnology, big data, clean technology and digital health care these funds include – Capricorn Health-tech Fund and Capricorn ICT. The Capricorn ICT fund is roughly €30m, its portfolio focuses on digital health, big data and for many years has looked towards active ageing as a new line of investment. The firm prefers to acquire minority stakes in its portfolio companies and requires a seat on the company's board of directors. It seeks to exit investments between three and seven years through IPO and trade sale.[92] Capricorn acknowledges the

[85] http://www.zigbee.org/what-is-zigbee/

[86] http://www.zigbee.org/zigbeealliance/our-members/
http://www.webable.tv/Events/M_Enabling_Summit_2015/VideoId/1639/Kickoff-Presentation-On-The-Future-Of-The-Internet-Of-Things

[87] http://www.kpnventures.com/about/

[88] http://www.kpnventures.com/about/

[89] Herman Kienhuis (Director of KPN ventures), http://www.kpninnovatie.nl/kpn-ventures

[90] http://www.kpninnovatie.nl/kpn-ventures

[91] http://www.kpnventures.com/about/

[92] https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=97304

rising burden and cost associated with the Europe's demographic change and sees potential in smart, connected solutions to this pressure in healthcare. The mission is therefore to fund innovative companies and technologies that make a difference to the lives of people worldwide.[93]

Box 4 Capricorn Venture Partners

Capricorn Venture Partners NV was established in 1993 as a joint venture. Since December 1999, Capricorn Venture Partners is a fully partner-owned **independent investment advisory and management company**.[94]

Capricorn Venture Partners look to take minority stakes, with initial investments between **€0.5 – 5 million** in the first or second VC rounds.[95]

Capricorn Venture Partners look to invest in European companies that focus on large international markets, with defendable IP and a **proven technology base**.[96]

Capricorn's focus is predominantly on **early stage companies** typically requiring funding for **product or technology development**.[97]

Private banks and insurance providers also provide financial support to new and innovative companies in the AAL market. For example, the insurance company BUPA invests in retirement housing and assisted living properties.[98]

A number of start-ups are (partly) self-funded and some AAL start-ups have benefitted from crowd funding such as Kickstarter and Indiegogo. Such platforms facilitate global reward-based crowdfunding, a way to source funding without parting with equity. By asking a large number of backers to promise or pledge relatively small amounts of money, start-ups can gain capital from numerous backers in return for tangible rewards/and or experiences. Several examples of AAL technologies which have or are currently using such platforms for investment can be found below.

- Birdi – Birdi is a smart air monitor, not only is it a smoke detector, it also tracks air quality, every day health dangers, temperature, pollen, humidity and carbon monoxide. The user is kept connected through an app alerting them to the quality of air not only in their home but also in their neighbourhood. It can be controlled via smartphone or landline and alerts the user through the use of alarms, messages and lights. Although, their campaign has now ended 486 backers on Indiegogo.com saw $72,199 raised, more than 140% of Birdi's original $50,000 investment target.[99]
- Care hub – is a communication device that contains sensors to alert families to issues that could be affecting older adults relatives. It also provides a platform to enable a range of functions such as: two-way communication and reminder alerts. Care hub were looking for $25,000 to make their developed hardware prototype a reality. They stated that they had turned to Indiegogo.com in order to facilitate software development, certification and hardware tooling for mass production. The campaign raised $27,450 by February 12, 2016, with support from 61 backers.[100]

[93] http://www.capricorn.be/

[94] http://www.capricorn.be/en/team/history/

[95] http://www.capricorn.be/en/for-entrepreneurs/investment-criteria/

[96] http://www.capricorn.be/en/for-entrepreneurs/investment-criteria/

[97] http://www.capricorn.be/en/for-entrepreneurs/investment-criteria/

[98] http://www.englishcarevillages.com/news/bupa-enters-care-village-market, https://www.bupa.co.uk/care-services

[99] https://www.indiegogo.com/projects/birdi#/

[100] https://www.indiegogo.com/projects/the-carehub-communication-and-care-made-simple-camera-smart#/

- Ōura Ring – the Ōura Ring is a new wearable technology that provides sleep and activity tracking with "unparalleled precision".[101] The Ōura mobile app uses this information and synthesis it into daily knowledge empowering an individual to understand their state of mind and body. The Ōura Ring senses every action and inaction whilst using sensors to detect blood rate/volume, pulse, body temperature and sleep. It is designed to enable more restful sleep and therefore increase functionality and productivity. By 25 January 2018, there were over 2,383 backers on Kickstarter who in total have pledged $651,803 to the Finish company.[102]
- Check my temp – is a start-up that has developed an arm band that continuously monitors body temperature, movements and position in real-time. It also includes key features such as fall detection for older people. It can currently be pre-ordered on Indiegogo.com where 593 backers provided 179% of Check my temp's target fund by January 20, 2016.[103]

Across the EU there are a range of incubators and accelerators that support start-ups focused in digital (health) technologies. Such organisations can help stimulate investment by offering AAL companies guidance as well as tangible resources. The most distinct comparison between incubators and accelerators is the capital provided and the time lent. Accelerators are defined by their limited duration often only lasting between 3 – 4 months; such a finite duration reduces co-dependency and speeds up the venture process, quicker growth however can also result in quicker failure. Furthermore, accelerators often look to exchange equity for upfront capital. In comparison firms may stay with incubators from anywhere between 1 – 5 years, these programmes are often sponsored by private or public institutions with the intention of financially and technically supporting start-ups through the offering of services such as business management for a small fee.[104] As such incubators and accelerators can provide a succinct passage from the idea phase to its execution helping grow different ventures and fundamentally the economy.

A list of EU based incubators and accelerators interested in digital health is presented in Appendix C. XLHealth (Germany), Healthbox (UK), MOEBIO (Spain) are relevant examples. A global overview of the more active investors in the connected health and smart home sector is provided in Figure 24. These and other investors have provided start-up financing for an increasing number of companies over the years 2010-2015, see Figure 25. Under personal health management and health care services, the data includes the following companies: Sharecare in 2010, Yaofang in 2011, Oscar in 2012, Pillpack in 2013, Clover Health in 2014, NetMeds in 2015, and BlinkHealth in 2016[105]. In the smart home market, the data includes the following companies: Nest in 2010, Netamo in 2011, Canary in 2012, august in 2013, Rokid in 2014, Brava Home in 2015, and SAM (Smart Home Automation System and Monitoring Device) in 2016[106].

[101] https://ouraring.com/the-ring/

[102] https://www.kickstarter.com/projects/oura/oura-ring-improve-sleep-perform-better

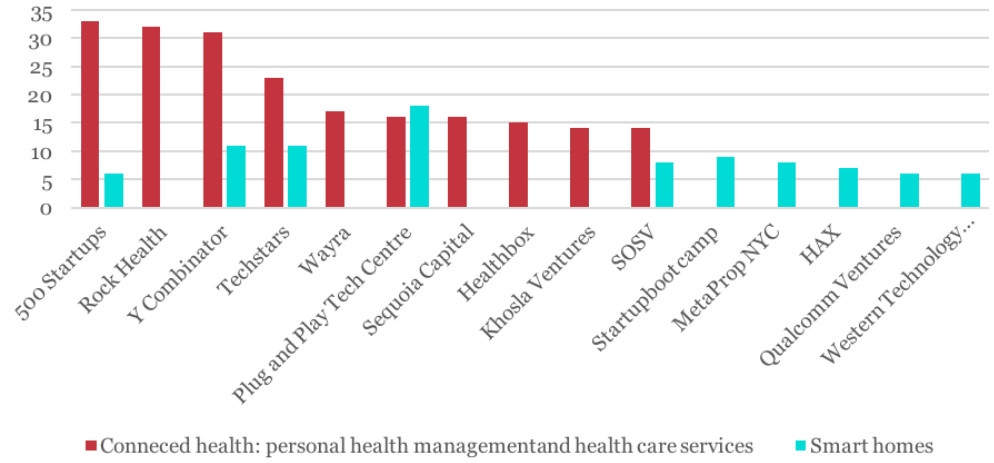
[103] https://www.indiegogo.com/projects/check-my-temp-more-than-a-wearable-thermometer-technology#/ and http://www.checkmytemp.com/

[104] http://www.mitpressjournals.org/doi/pdf/10.1162/INOV_a_00184

[105] Tracxn Technologies 2017, consumer health tech, July 2017

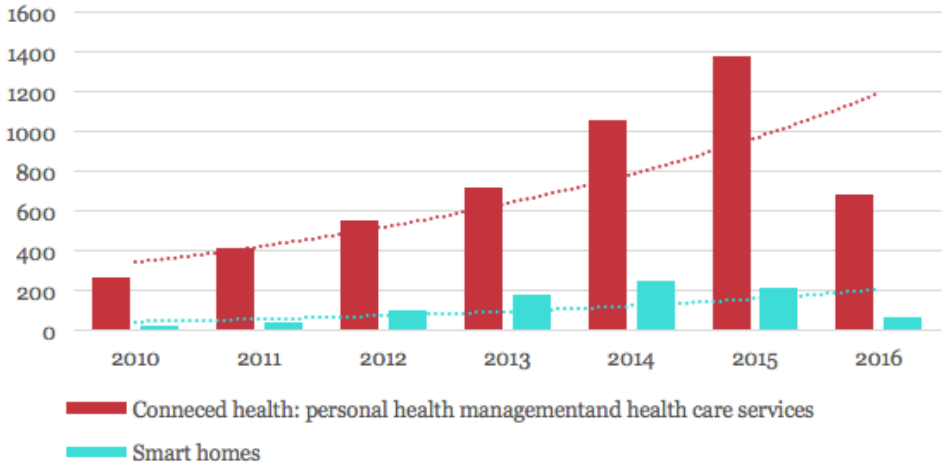
[106] Tracxn Technologies 2017, smart homes, May 2017

Figure 24 Most active investors - total number of companies invested in, by investor and sector



Source: based on data from Tracxn Technologies 2017 Note: blanks represent missing data.

Figure 25 Number of companies founded, by sector

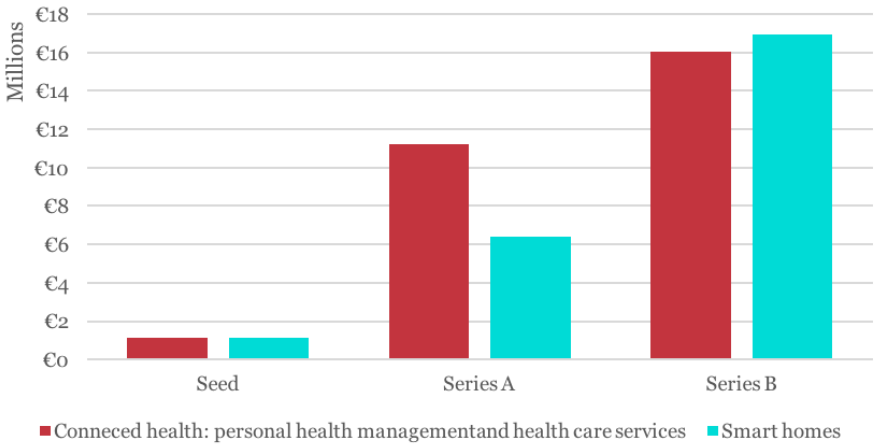


Source: based on data from Tracxn Technologies 2017

Considering the portfolio of investment made in 2016 in personal health management and health care services and smart homes (as tracked by Tracxn Technologies), average seed investment is just over €1m. Average Series A investment in personal health management and health care services was about €11m and Average Series A investment in the smart homes sector was just over €6m. Series B investment was around €16m. The vast majority of the funded companies are based in the US. Examples of a Series A companies relevant to the sector are Keecker (France)[107] – providing Smartphone controlled robot projector – and Sense (UK) - device to monitor appliances and track energy usage. In terms of series B investment, Netamo (France) is an interesting company that provides a thermostat, video monitoring and personal weather station and air quality sensor devices for use with Android and iOS apps.

[107] http://www.keecker.com/

Figure 26 Average start-up funding amount in 2016, by sector



Source: based on data from Tracxn Technologies 2017. Converted from US dollars to euros at 0.85 exchange rate.

One example of an organisation that supports business (more broadly than by providing financing) in this field is Happy Ageing. This Belgium organisation is part of LifeTechValley and offers a community of experts, which includes older people, care organizations, research institutes, and policy makers[108].

Box 5 Healthbox

Founded in 2011, Healthbox is a platform for healthcare innovation and entrepreneurship. Healthbox launched as one of the first healthcare-focused accelerator programs, with the goal of helping entrepreneurs navigate the complex industry and grow successful businesses.[109]

Healthbox works with leading healthcare organisations to advance an innovation strategy that supports a culture of idea generation, business creation, and entrepreneurial collaboration to foster sustainable impact.[110]

Healthbox has sourced over 2,500 early-stage companies from around the world and engaged closely with more than 160 companies.[111]

Healthbox has a portfolio of more than 50 active companies and strategic partnerships with more than 20 healthcare organisations.[112]

Box 6 Grants4app Accelerator

Grants4app accelerator is a mentoring program for digital health startups based in Berlin. Possible solutions they would invest in include smart watch apps, digital assistants, robots and remote monitoring and sensors. [113]

Grant4app looks for novel software, hardware, technologies, or processes that can be applied on particular areas contributing to improve health outcomes or pharmaceutical processes. [114]

[108] http://www.happyaging.be/nl

[109] https://www.healthbox.com/about-us

[110] https://www.healthbox.com/about-us

[111] https://www.healthbox.com/about-us

[112] https://www.grants4apps.com/#grants4apps

[113] https://masschallenge.org/our-approach

[114] https://www.grants4apps.com/#grants4apps

It offers to emerging entrepreneurs the guidance of Bayer experts, office space for 100 days and funding up to €50,000.[115]

Over the last two years more than 30 projects have been granted funds and assistance. These projects are predominantly based in Germany. [116]

6.2.3 Public platforms

There are also a number of public platforms that facilitate innovation in the AAL market[117]. There are specific policies steering initiatives towards smart ageing, for example, via the technology centre for connected health research (ARCH) in Ireland. The following are examples of public platforms used to drive innovation and investment in specific AAL markets in Europe and at a European-wide level.

- Austria started the National "benefit" initiative in 2008 supporting innovative and application-oriented projects in which businesses, research institutions and service providers cooperate. This programme is aimed at identifying technical solutions that enable older adults to continue living independently in their own homes. Technologies are developed jointly with older adults and their carers, ensuring that the projects also take into account ethical concerns and data protection requirements. Between 2008 and 2016, the programme funded 106 projects with over €21m.
- Applied Research for Connected Health (ARCH) – Applied Research for Connected Health (ARCH) is driven by policies laid out in Ireland's National Positive Ageing Strategy. Ireland is in a unique position to become a centre of excellence in regards to connected health solutions, ARCH is instrumental in this ambition. At the centre of Ireland's research and education infrastructure for connected health it allows the gathering, analysing and interpretation of data through the development of new knowledge and care models.[118]
- Assisted Living Innovation Platform (ALIP) – Assisted Living Innovation Platform (ALIP) was an innovation platform network launched in 2007 by Innovate UK's (the UK's innovation agency) predecessor of the Technology Strategy Board (TSB). It funded projects until 2012, with the intention to deliver an impact for many years beyond.[119] The innovation platform was hosted on _connect a networking platform that helps to facilitate innovation, where people can network, share information and knowledge securely.[120] In tandem with the Department of Health (DoH), Innovate UK has invested in solutions aimed at addressing the needs of an ever increasing older populations through the use of technologies and services that will enable individuals to receive support at home.[121]

Table 12 Examples of EU wide stakeholders

Stakeholder	Description
European Technology Platform on Smart Systems Integration (EPoSS)	• EPoSS brings together European private and public stakeholders in order to coordinate and to set-up sustainable structures for improving the competitiveness of European R&D on Smart Systems Technologies and their integration.

[115] https://digitalhealth.careers/10-most-important-digital-health-incubators-europe/

[116] https://masschallenge.org/our-approach

[117] An overview of public (and private) information portals in the field of AAL is summarised in a study commissioned by the AAL Association. http://www.aal-europe.eu/wp-content/uploads/2015/02/Information-Portal-in-the-field-of-AAL-Final-Report-public-version-2.pdf

[118] http://www.arch.ie/

[119] https://connect.innovateuk.org/web/assisted-living-innovation-platform-alip/who-we-are

[120] https://connect.innovateuk.org/documents/3301954/11214094/Health_KTN_LongTermCare_reports_KCL.pdf/5a31a1d9-8f16-4a4f-aeaf-91f9d1382ffa

[121] https://connect.innovateuk.org/web/assisted-living-innovation-platform-alip/who-we-are

	• The EPoSS network of stakeholders consists of organisations from more than 20 EU member states including universities, SMEs and large companies.[122]
Networked European Software and Services Initiative (NESSI)	• NESSI is the European Technology Platform dedicated to the digital information society. It promotes software, services and data as key resolves to European societal and economic challenges. • NESSI is wide in scope covering all sectors, both private and public, such as manufacturing, transportation, energy, and healthcare. • NESSI's first objective is to engage with European (ICT) Industry and to promote the need for dramatic changes due to new ICT eco-systems and innovations which are a pre-requisite for Europe to stay competitive globally.[123]
European Innovation Partnership on Active and Healthy Ageing (EIP on AHA)	• The EIP on AHA is a European Commission pilot initiative to foster innovation in the field of active and healthy ageing. It seeks to engage stakeholders at all levels (i.e. EU, national, regional and local) to contribute to and participate in the initiative. It also aims to gather further detailed information on existing national, regional and local initiatives. • Its overarching objective is to increase the average healthy lifespan of EU citizens by 2 years in 2020. • EIP on AHA also has a key focus on enhancing the competitiveness of EU industry through business and expansion in new markets whilst supporting social systems.[124]

Source: AALIANCE2 Report on relevant stakeholders in Europe (2012)

6.3 Trends in news media

This section is relevant for policy makers and start-ups and SMEs interested in learning how online news media coverage of AAL market has changed over time and what 'key-words' describing the AAL market were used relatively more frequently.

Figure 27 illustrates the online news media coverage of AAL markets in Europe between 2010 and 2016. News media coverage of the smart home market, in combination with key words describing the older population (ageing, elderly), shows a rapidly increasing trend for the period considered – a jump from less than 100 entries in 2010 to around 400 entries in 2016. The trends in news media coverage on the topic of eHealth is moderately increasing.

News media coverage on telecare and telehealth does not follow a strictly increasing trend for years covered. In the case of telecare, the keywords "older people" and "elderly" display several spikes of media coverage, notably in 2012, 2014, and 2015. Moreover, the keyword "elderly" returns the highest media coverage compared to other sectors in 2015, accounting for more than 700 entries. Nonetheless, the keywords "ageing" and "independent" remain relatively stable for the considered timeline. In the case of the sector of Telehealth, media coverage shows an increasing trend for the keyword "ageing" until 2014, before decreasing considerably until 2016. Finally, in the case of the sector of eHealth, the trend is stable for all keywords, with a slight overall decrease for the keyword "independent living".

Overall, the sectors of telecare and telehealth display the largest media coverage between 2010 and 2016, while the sector of smart homes and eHealth is relatively lower. Nonetheless, the sector of smart homes displays the most considerable increase for the considered timeline, this is related to the fact that the European smart home is at an early stage compared to the North American market in terms

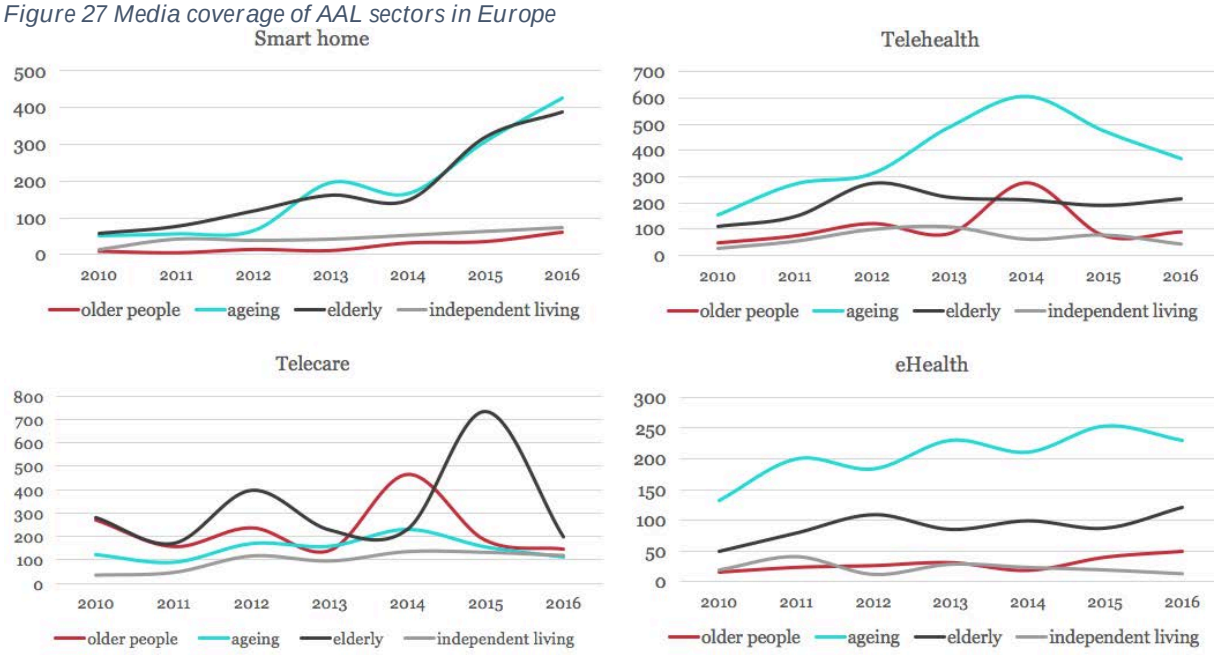
[122] http://www.smart-systems-integration.org/public/about/network-members/eposs-members

[123] http://www.nessi-europe.com/default.aspx?Page=about_us

[124] https://ec.europa.eu/eip/ageing/about-the-partnership_en

of penetration and market maturity[125]. In comparison, the telecare sector is am more mature segment of the care market[126], albeit with substantial potential for innovation.

Figure 27 Media coverage of AAL sectors in Europe



Source: Data from Meltwater, analysis by Technopolis

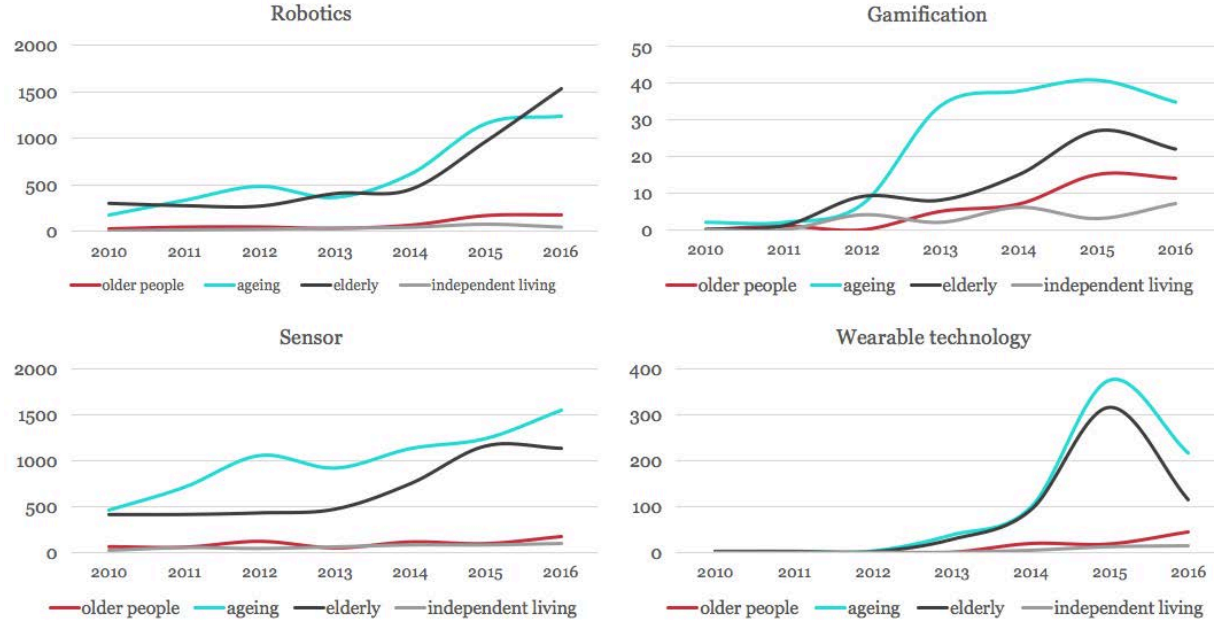
Figure 28 shows the media coverage of AAL technologies in Europe from 2010 to 2016. Media coverage of technologies such as robotics and sensors in relation to the older population show an increasing trend over the considered period, while gamification and wearable technologies show a sharp increase before decreasing in 2016. Robotics technologies show an increasing media coverage for the keywords "ageing" and "elderly" as opposed to the keywords "older people" and "independent living" that remain relatively stable for the considered period. The technology of sensors displays a similar pattern between 2010 and 2016. Nonetheless, the media coverage of gamification remains relatively low until 2012. The keyword "ageing" displays a considerable increase in media coverage as of 2013 compared to other keywords of the analysis. Nevertheless, "elderly", "older people", "independent living" display a stable increase for the same period. Finally, media coverage for wearable technology remains relatively low compared to the trends of other technologies until 2014. The analysis of the media coverage reveals that the keywords "elderly" and "ageing" display a considerable increase in 2015 before decreasing sharply in 2016. Moreover, the keywords "independent living" and "older people" remain stable over the timeline.

In general, media coverage of sensor and robotic technologies in relation to older people return considerably higher results than other technologies. Moreover, both technologies return the highest results of the media coverage analysis, even when compared to the sectoral analysis. This higher media coverage might be explained by the fact that such technologies have reached a higher level of maturity, as they have been developed much earlier. The unstable pattern of other sectors and technologies might be explained by the fact that they are still at earlier phases of development and application in the AAL sector.

[125] https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/berg_smart_homes.pdf, BERG Insight 2014

[126] https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/berg_integrated_care.pdf, BERG Insight 2013

Figure 28 Media coverage of AAL technologies in Europe



Source: Data from Meltwater, analysis by Technopolis

7 Market developments for AAL specific solutions

This chapter is relevant for investors and mature companies interested in new ideas and examples of start-ups with potential for growth. This chapter presents a selection of case studies about promising technological developments and AAL solutions. The examples comprise of disruptive innovations that are taking place and may influence related developments in the field[127].

7.1 Consumer markets

The following are a selection of solutions that target the private consumer markets with aspects such as wellbeing, lifestyle, independence, work, fun and comfort. The target consumer segments are the older adults and their families and social networks.

Innovation (product/service/system)	Sensara HomeCare
Main end user (s)	Primary
Key words	Home, monitoring, alert
Organisation	Sensara
Organisation country	The Netherlands
	Self-learning sensors for safe home environment: • Sensara HomeCare is a platform which enables older adults to live independently and safely for longer. It is a producer of intelligent senior lifestyle monitoring with a focus on preventative care and personalised alarm systems. In the context of older people wanting to live and remain independently in their homes for longer, Sensara facilitates this through the provision of innovative solutions. • Movement sensors coupled with self-learning algorithms empower the end-user, friends and family to provide care through quick responses and prevention as early detection of such risks is a proactive way to prevent more serious complications.[128] For example, analysing data disruption of daily bathroom routines could help pick up on risk of urinary tract infections before infection spreads to the bladder or kidneys. Sensara HomeCare also alerts individuals to potential health risks such as increased risk of falling or the possibility of dehydrating.
	Market ready? • Recent investment by KPN has provided the company with the means to scale up production, development whilst widening its customer services and international outreach.[129] KPN Ventures is the venture capital investment arm of KPN the Netherland's leading telecom & ICT provider. KPN said in a statement that the investment was "in line with KPN Ventures' strategy to invest in e-health and connected home services and KPN's conviction that innovative ICT solutions can contribute significantly to improving healthcare services and increasing people's autonomy even in the face of illness or old age."[130] • Sensara Homecare sets are available to be bought from the Sensara website. There are different packages available for different size spaces, currently Sensara provides packages for apartments, houses and a bed with prices ranging from €15.00 – €20.00 per month, with installation costs of approx. €100 for Dutch based homes.[131] Depending on the size and need of the end-user additional sensors may be purchased and installed separately.

[127] These exemplary case studies are based on desk research and interviews with key informants (see Appendix D).

[128] https://sensara.eu/en/

[129] http://www.eurocomms.com/industry-news/12237-kpn-continues-e-health-push-with-sensara-investment

[130] http://www.eurocomms.com/industry-news/12237-kpn-continues-e-health-push-with-sensara-investment

[131] https://sensara.eu/product

	A unique technology? • Sensara prides itself on close cooperation between insurance companies, governments and users in order to create a platform that is supportive for the health sector.[132] The platform provides preventative care and personalised alarm services, using movement sensors and automated programmes that detect deviations from behaviour patterns. This can then provide status updates and alerts to caretakers through the app.[133] The software examines all the present and past signals detected from in house sensors and determines if certain profiles are occurring. Sensara uses specific profiles that are certified by the VU University Hospital in Amsterdam. • If there is ever a change in routine an alert will be sent out to the app explaining the changes in the hopes of facilitating injury and illness prevention through active responses. By continuously receiving signals the software "learns" about the individual behaviour and automatically adjusts to changing patterns over time.[134]
Future directions	Partnering into new avenues of development: • Sensara is currently working on a number of partnerships, extending its ecosystem with other applications. Reinout Engelberts, CEO of Sensara, said: "There is a big demand from elderly-care institutions, local governments and insurance companies for preventive healthcare and smart alarm services that can support the professional caretakers and keep family informed as well."[135]

Innovation (product/service/system)	2PCS
Main end user (s)	Primary
Key words	Home, monitoring, alert
Organisation	2PCS
Organisation country	Austria
	Alerting and localising watch: 2PCS is a mobile safety watch for indoor and outdoor use. The 2PCS system is an alerting and locating system designed for the duties of professional care addressing the safety and independence of persons in care[136]. The solution and technology design of 2PCS allows the usage in various living and care settings, both in inpatient as well as ambulatory care[137] The 2PCS system can help same time and costs as well as unburden care givers and relatives of older adults wearing the device. The device is age friendly and dementia supportive and has a user-centred design.
	Market ready? 2PCS is looking for a distribution partner[138]
	A unique technology? 2PCs offers a state-of-the-art and interoperable technology[139]

Innovation (product/service/system)	Fearless
Main end user (s)	Primary, secondary, tertiary

[132] https://innovation-awards.nl/innovation/sensara-homecare-smart-life-monitoring-system/

[133] http://www.eurocomms.com/industry-news/12237-kpn-continues-e-health-push-with-sensara-investment

[134] https://innovation-awards.nl/innovation/sensara-homecare-smart-life-monitoring-system/

[135] https://innovation-awards.nl/innovation/sensara-homecare-smart-life-monitoring-system/

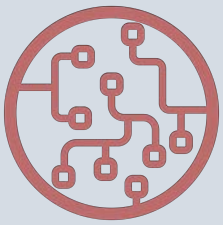
[136] https://www.2pcs-solutions.com/en/solutions/

[137] https://www.2pcs-solutions.com/en/solutions/

[138] https://www.2pcs-solutions.com/en/distributor/

[139] https://www.2pcs-solutions.com/en/solutions/

Key words	Home, monitoring, alert
Organisation	CogVis
Organisation country	Austria
	Fall prevention and fall detection: Fearless is the intelligent, contactless fall sensor that not only detects falls, but also helps to prevent them. Fearless is based on the latest 3D technology and simple to mount as a wall lamp. No need for wristwatch or special mat on the floor.[140]
	Market ready? Fearless is sold as B2B product to nursing homes, assisted living facilities, retirement homes and smart home facilities
	A unique technology? Behaviour modelling based on 3D sensors and evaluation conducted with end-users

Innovation (product/service/system)	Alcove Care System
Main end user (s)	Primary, secondary, tertiary
Key words	Home, wearable technology, monitoring, alert
Organisation	Alcove
Organisation country	UK
	IoT enabled independence: • Alcove is an IoT-powered adult social care system it provides software and hardware as a digital care service. It operates on a four pronged basis using: in-home sensors, wearable assistance devices, smartphone and tablet apps and digital tools to monitor activity. For example, a Falls Detection Package can be purchased for £27.99 a month it consists of a video calling tablet and button with a built in fall detector to raise an emergency call automatically when fall is detected or a call for help is made. At the moment, when abnormal behaviour is detected alerts are sent in escalation chains. However, many of these alerts could be better dealt with by the older adults themselves, rather than going directly to a family member or care worker. Data insights from IoT sensors trigger behavioural nudges sent to wearable or in-home devices, empowering people to best support themselves, through a nudge system data from in-home wireless sensors is processed and sends automated messages to either the Alcove Smartwatch or Alcove Connect, a wearable or in-home device depending on the users' preference. The alert is only escalated if the person does not respond or change their behaviour in accordance with the nudge.[141]
	Market ready? • Alcove was formed in 2014 with the aim to pioneer independent living for older and disabled adults. Currently on the market are a range of solutions that can be bought either as separate devices or as care specific packages. • Alcove is targeting the UK B2B telecare market, selling to local authorities, housing associations and domiciliary care providers as well as outsourcers serving those markets. Alcove also hopes to disrupt the tele-care market characterised by "big red buttons" and replace it with intelligent processing of data and preventative measures.[142] For the time being Alcove is focused on B2B tele-care rather than B2C tele-care or tele-health. This is predominantly because of the cost and the immaturity of the tele-health market.
	A unique technology?

[140] http://www.cogvis.at

[141] https://www.youralcove.com/

[142] https://www.youralcove.com/blogs/news/alcove-chosen-to-be-a-little-british-battler

	• Alcove uses a software-led approach, adapting commercially available hardware Alcove develops its own unique software. Data is analysed and displayed simply in a web-based application and used to send real-time personalized alerts to help keep older and disabled adults living independently in their own homes and out of residential care.[143] • Traditional alarm systems (e.g. pulling a cord/red pendant alarm) can often prove to be ineffective or cumbersome. Alcove is using an IoT powered solution to move away from contemporary reactive models of alert systems to data-driven, predictive and preventative model instead.[144] Through the processing of data Alcove is allowing people to remain in their own homes, adapting that home environment to meet their care needs and aspirations, by relying on real-time data instead of the triggering of an alarm Alcove is an automatic, seamless response. Wireless movement sensors stuck up around homes talk to the Alcove router which sends data securely to the cloud. This data (through the Alcove app) can then be viewed and alerts can be managed.[145]
Future directions	Data analytics and social care applications? • Currently Alcove is growing rapidly and some 50% of its revenue is recurring. Looking into the future, Alcove may consider an IPO in order to raise additional capital or, more likely, find itself acquired by a SITS company that is hoping to profit from the evolving UK telecare market. In the meantime, Alcove will be developing its offering further perhaps through the development of data analytics to enable dynamic care planning, or integrating with other social care applications.[146]

Innovation (product/service/system)	Activ84health
Main end user (s)	Primary, secondary
Key words	Exercise, connectivity, cognitive.
Organisation	Activ84health
Organisation country	Belgium
	Cycling to independence: • The Activ84Health platform (pronounced: Activate-for-health) opens up a window to the world for the older adults by bringing the joy and health benefits associated with cycling outdoors inside to a safe environment. Each user gets a personalised experience to fit their needs, motivations, and abilities. There is total freedom to explore urban and rural environments. Simply select a street on a map, and then get the visual experience of cycling through that location, all from a stationary bike. At each intersection, the user can choose which direction to go. The Activ84Health Explorer received the Smart Ageing Challenge 2016 prize from the European Commission's programme on Active and Assisted Living. [147]
	Market ready? • Activ84Health is on the market and commercially available, it currently operates across 40 platforms in both Belgium and the Netherlands. Activ84Health operates a B2B model there is no focus on individual customers, instead the platforms comprise of nursing homes, hospitals, psychiatric and rehabilitation centres. [148]
	A unique technology? • All the hardware that Activ84Health uses is commercially available and is purchased from standard commercial distributors. The software is completely custom built and has a user-centric designs. There is a strong focus on user-experience as it is vital to the success of the platform that the technology aligns with the needs of older adults. As such

[143] https://www.youralcove.com/blogs/news/alcove-chosen-to-be-a-little-british-battler

[144] https://www.tech4goodawards.com/finalist/alcove/

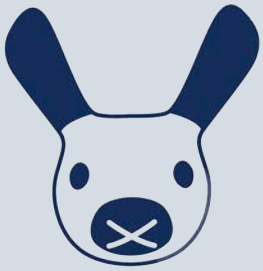
[145] https://www.youralcove.com/pages/how-it-works

[146] https://www.youralcove.com/blogs/news/alcove-chosen-to-be-a-little-british-battler

[147] http://www.activ84health.eu/blank-k7ayx

[148] Interview with Roel Smolders, CEO and co-founder of Activ84Health on 23/06/2017

	older adult focus groups and feedback from the different platforms has actively shaped the software. • According to Roel Smolders, Activ84Health's CEO and co-founder, it is not about the software, it is about creating a valuable user experience; their insight into the customer and end-user is what makes Activ84Health unique to the market.[149]
Future direction	European expansion: • First seed capital came from friends and family, however, after winning AAL's Smart Ageing Challenge award Activ84Health was contacted by a business angel who then further invested in the company. As such Activ84Health has begun to expand its commercial scope from Belgium to Europe. It has developed international business partners with current focuses on Sweden, the Netherlands and Austria with the hope to expand further. North America and the USA: • Activ84Health is in a comfortable position financially, money is no longer needed to survive, however, more investors would enable growth and expansion abroad. They are interested in moving towards the North American AAL market. As the technology is cloud based it does not matter where the customers are based and therefore seems like a viable and profitable avenue to pursue. However, Activ84Health would need a better understanding of the drivers behind the US AAL network in order to do this. [150]

Innovation (product/service/system)	MiRo
Main end user (s)	Primary
Key words	Robotics, monitoring, reasoning, navigating, sensing, companionship, interacting
Organisation	Consequential Robotics
Organisation country	UK
	A new generation of robots, a robotic alternative to live in care: • Consequential Robotics is a UK based start-up, it is a collaboration between Sebastian Conran's design studio (Sebastian Conran Associates) and the University of Sheffield. Their work centres on the development of a platform that facilitates independent living and care; the Care-Free Home system allows people the freedom to look after themselves through smart devices. Controlling your own private and intimate issues with devices as opposed to having to rely on external care is not only efficient and economic but also empowers individuals socially. At the centre of the Care-Free Home system is MiRo, an autonomous, fully programmable, companion biomimetic robot. The name MiRo is a nod towards "mimetic robot", designed as a hybrid of a puppy, rabbit and cow, MiRo is the approachable end-product of the world's first commercial biomimetic robot. • MiRo represents the next generation of personal and companion robots, the logic behind MiRo's pet like features was the belief that being animal-like rather than human-like will create a platform for people to engage in which aligns more readily with the capabilities of contemporary AI technologies.[151] MiRo looks to alleviate isolation and provide a platform in which individuals can more independently look after themselves. Market ready? • The development has been funded by a variety of investors. Seed capital has come from self-investment and both private and public external investment. The principal investment partner is IP Group a business, which focuses on the intellectual property commercialisation of innovative ideas.[152] MiRo has also received government funding towards its development.

[149] Interview with Roel Smolders, CEO and co-founder of Activ84Health on 23/06/2017,

[150] Interview with Roel Smolders, CEO and co-founder of Activ84Health on 23/06/2017

[151] http://consequentialrobotics.com/miro/

[152] http://www.ipgroupplc.com/

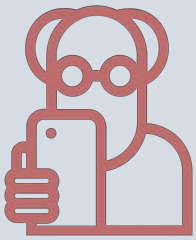
	• Although MiRo is currently shipping the product is only available to developers, with a limited number available this year. The cost for professional researchers is approximately £2,200 plus tax and shipping. It is being trialed on older adults groups by a number of institutions across the world including the University of Sheffield and Bristol Robotics.
	A unique technology? • Designed as a companion robot, MiRo does not provide physical assistance but does provide companionship and a monitoring function. MiRo works in conjunction with the Care-Free Home system for example, MiRo will respond to data collected by a wristband that monitors vital signs and contains a fall sensor whilst also receiving data from ceiling-mounted sensors which also measure environmental factors. MiRo can then use this data to address if you are OK or need extra assistance, most importantly MiRo and the Care-Free Home system can record the data leading up to the incident providing an easy way for care-givers or assistants to assess or review the events leading up to the situation. The ethos of MiRo is reflective of its capabilities, fitted with high-tech solutions MiRo addresses societal needs in a completely unique way. • MiRo combines a friendly, emotive exterior with a wide range of technologies; effectively a screen-less computer MiRo uses sensors, facial and voice recognition, light sensitive vision, navigation technology and precision sonar to facilitate its role as a companion robot. MiRo shows an extensive range of intelligence adapting to most situations with pin-point accuracy. MiRo is versatile due to its design built with a differential drive base and a three Degrees of Freedom (DoF) neck (lift, pitch, yaw).[153] Stereo cameras in the eyes and stereo microphones in the base of the ears are complemented by a sonar range-finder in the nose. In the body, four light level sensors are placed at each corner of the base, two infrared 'cliff' sensors point down from its front face, four capacitive sensors are arrayed along the inside of the body shell providing sensing of direct human touch. Internal sensors include twin accelerometers, a temperature sensor, and battery voltage monitoring.[154] • Running off Linux OS, MiRo's default control architecture is known as the Brain Based Biomimetic control system (3BCS) based on twenty years of research with three embedded ARM processors. Most products on the market are humanoid devices not animals but research on the animal brain and behaviour has allowed the creation of a platform that encompasses sophisticated processing, limbic systems and reptilian functions of the human brain uniquely the 3B Software IP is subject to copyright. MiRo is also unique due to its flexibility as a platform, if you prefer you can control MiRo directly from your favourite development environment. You can control MiRo remotely through WiFi or configure via Bluetooth and stream data or internal state. If you are a ROS programmer, MiRo can be easily configured as a ROS node.[155]
Future direction	Collaborating to commercialisation: • Consequential Robotics are currently partnering with developers to create further behavioural software for MiRo. Developers currently have the capability to design and implement new behaviours and programmes to operate on MiRo to suit their function and needs. It is hoped this freedom will accelerate research on animal-like robot companions and heighten MiRo's capabilities. Developers have a number of choices as to how they may go about this, one option is free simulation programme on the Consequential Robotics' webpage which allows developers an online platform to programme. Until the technology is proven it cannot be implemented, in particular on those who are frail or vulnerable users. It is planned that a £600 consumer version will go on sale in September 2018.

Innovation (product/service/system)	YoooM
Main end user (s)	Primary
Key words	Communication, networking
Organisation	ConnectedVitality
Organisation country	Netherlands

[153] http://consequentialrobotics.com/miro/

[154] http://consequentialrobotics.com/miro/

[155] http://consequentialrobotics.com/miro/

	Social connectivity through telepresence: • Older adults with mobility problems can have difficulties organising their social connections and lifestyle in the way they want, which puts them in a situation in which they are reliant on others. YoooM is an innovation that empowers these individuals through ICT solutions and telepresence technology. Through YoooM a network will be created that supports older people through three main platforms these platforms are: a platform for family contact and activities; a platform for care contacts and a support network; and access to a community of other older adults who have shared interests in hobbies, pastimes and personal experiences.[156] As such YoooM is a communication network that combats loneliness and promotes independence.
	Market ready? • Currently the YoooM standard is currently for sale with an recommended retail price of €120 it works by transforming a tablet into an arena for face-to-face contact. The asymmetric lens enlarges the image at the bottom of the screen allowing the body language (such as the arms and hands) and the activities to be added to the contact. The full YoooM platform has yet to be released onto the market.[157]
	A unique technology? • ConnectedVitality has developed a video communication network that enables immobile senior citizens to organise their social network.[158] The Connected Vitality Network consists of an encrypted network consisting of a WAN server and an unlimited number of clients, where senior citizens can log on to and connect with others CVN-listed members. Thanks to the new H.246 SVC video standard to de deployed in the CVN, for the first time up to 50 people can simultaneously participate in one group videoconference. At the home end of the subscriber a telepresence system is installed on which monitor, once switched on, other online CVN members are displayed in thumbnails. Through voice activation the speaker's image is centrally displayed until someone else takes over the conversation. YoooM has developed an ICT solution which empowers its end-users to engage in social and health interactions whilst allowing effective management of care. • Currently the full YoooM platform is not on the market only the low cost, standard version. It is however, detailed that on its release the full platform will have several features, which it promises will make it revolutionary in the world of telepresence, these will include: a double camera system, class room mode (for learning), club mode (for entertainment) and a touch interface that is designed specifically for older adults usage.
Future direction	YoooM and beyond? • The YoooM principle can be applied in many forms and for many different markets in and out of Europe and it is expected in the future collaborations with other platforms will enable this.[159]

7.2 Regulated markets

The following are a selection of solutions that target the tertiary markets and are intended to improve health and care of older people.

Innovation (product/service/system)	ICOVE
Main end user (s)	Tertiary
Key words	Automated monitoring system
Organisation	ZonMw the Dutch organisation for health research and healthcare innovation

156 http://www.aal-europe.eu/projects/cvn/

157 https://www.yooom.nl/

158 https://www.yooom.nl/

159 http://www.connectedvitality.eu/timeline.html

Organisation country	The Netherlands
	How it works[160] The ICOVE system sends general practitioners an alert during a consultation with tips and advice based on a selected collection of ACOVE quality indicators. The idea is that this system can improve the behaviour of healthcare professionals in good time. Clients and their families also have access to this information. The system is intended to monitor vulnerable older people with complex problems and their carers.
	The ICOVE project has resulted in an automated system to support clinical decisions by professionals. A website, ACOVE portal, makes the quality system accessible to older people and their families. Care providers can have specific guidelines supported with the technology. Results The main results of the ICOVE project include the following[161]: • Decision support system that automatically alerts and reminders to GPs about diagnostic and therapeutic options according to the applicable guidelines in the first line. The first results show that doctors' behaviour has improved for some quality indicators but not all. • Decision support system that automatically reminds internists at the internal outpatient clinics about sending letters of discharge to GPs in good time. The evaluation of this system showed a significant improvement. This project is still ongoing.

Innovation (product/service/system)	Cerner Millennium
Main end user (s)	Tertiary
Key words	Electronic patient records
Organisation	Cerner, UK
Organisation country	UK
	The Electronic Patient Record (EPR) The EPR is used as a primary reference for a patient's medical history and case notes. It is a system that is helping to make sense of busy, complex health services, analysing information in clever ways and helping to manage many every-day tasks[162] EPR goes beyond being a system for storing information. EPR is capable of analysing patient information and applying the knowledge, intelligence and experience of a much wider network[163]. EPR can help to manage the flow of patients through the health care system, helping respond to increases in demand by identifying where beds are available (or where they might be available tomorrow) and offering insights into how services are used and where they could be more efficient[164]. This system is already used by many healthcare organisations around the world. Cerner Millennium enables[165].: • Evidence-based decision making for clinicians • Reduced medication variances through streamlined administration and dispensing • Improving care for common high-risk conditions

[160] http://www.beteroud.nl/ouderen/zorg-icove-systeem-huisarts-2e-lijn.html

[161] http://www.beteroud.nl/ouderen/zorg-icove-onderzoek.html

[162] http://epr.this.nhs.uk/home/about-epr/

[163] http://epr.this.nhs.uk/home/about-epr/

[164] http://epr.this.nhs.uk/home/about-epr/

[165] http://www.cerner.com/About_Cerner/?langtype=2057

	• Increased staff efficiency and patient care with real-time bed management • Decreased turnaround time for results management and notes retrieval • Greater collaboration and handover of information • Enhanced care management through clinical real time clinical dashboards
	Market ready? Cerner UK have delivered *Cerner Millennium*® across 22 Trusts, supporting NHS providers in the delivery of high quality care to patients, safely and cost effectively. More than 66,700 active clinicians and staff within the NHS use *Cerner Millennium* solutions to help achieve key imperatives to deliver the highest quality of care[166].

[166] http://www.cerner.com/About_Cerner/?langtype=2057

8 Future prospects and concluding remarks

This chapter is relevant for investors, start-ups and SMEs, mature companies, and policy makers interested in a summary of the following:

- What is the AAL market?
- Is the AAL market an innovative market?
- How can the investor know the market is sufficiently large? – who is the customer?
- How can the investor know the consumer will like the product?
- Will consumer interest in AAL solutions grow?
- Who pays and will AAL solutions be affordable to consumers?
- Where are the opportunity areas?
- How does the EU AAL market compare with the global AAL market?

What is the AAL market?

The AAL market seeks to deliver solutions designed to help frailer and older people live better, independently and enable them to make better health choices[167]. The AAL consumer market is a growing market. The AAL market exists at the intersection of the smart home, telecare and telehealth market, and is also closely related to the eHealth and the wearable technology market.

Is the AAL market an innovative market?

A range of technologies are part of the ICT system that provides AAL solutions and recent technological developments have expanded the opportunities to integrate different types of these technologies in the smart home, telehealth and telecare market, driving the AAL market.

- Sensor technology such as wearable or ambient sensors are included in a wide range of AAL solutions. Sensor technology has become more readily availability and affordability which is positively influencing the affordability of AAL solutions.
- Reasoning technology is used to aggregate, process and analyse data, this includes machine learning models that are applied to telecare solutions and decision support systems.
- Acting technology and the development of smart actuators are responsible for moving or controlling a mechanism or system and have been integrated in various solutions such as companion robots.
- Interacting technology facilitate human-machine interactions (interface technology) and leverage the accessibility and usefulness of the solution to the end-user.
- Communicating technology enables different components of a system to exchange information.

How can the investor know the market is sufficiently large? – who is the customer?

As previously outlined, one of the first questions for an organisation/start-up is defining the target consumer segment; does the AAL solution directly target the older adult or e.g. residential care homes?

[167] See also Active and Assisted Living; Technologies and Applications (2017), Chapter 2 Current state of the art of smart environments and labs from an ambient assisted living point of view, Crandall and Cook, eds. Florez-Revuelta and Chaaraoui.

Consumer segments that are visibly large (e.g. solutions targeted to diabetics) appear more attractive to investors. The challenge is identifying the right consumer market segment for the AAL solutions. AAL solutions that are targeted to smaller consumer segments within the AAL market are seen as more difficult to scale-up. Larger upcoming sectors in the digital health sector include personalised healthcare, telemedicine, appointment booking, and personal health care management[168]. Large upcoming sectors in the smart home market include smart phone Apps, monitoring environment, and hubs[169]

> *Integrated care solutions should be built with a target consumer group of around 100,000-200,000* - Venture capital investor

Investors (e.g. start-ups investing in their own start-up capital, venture capital investors, banks, large companies) aim to make sufficiently large revenues and aim to grow these revenues over time. This means that the solution that is offered to the market needs to be targeted to a sizable consumer segment. Larger companies, such as telecom companies, that are looking to invest in start-ups to expand their own business look for larger revenue gains than some other types of investors.

> *Companies that are scalable have a solution that fits the needs of different end-users.* - Venture capital investor

At the same time, 'generic' solutions may not fit the needs of the customer. The older population is a diverse and heterogeneous group and includes people that are healthy and active, people that have some physical challenges, people with dementia, and people that are amongst the frailer in society and have multiple chronic disease. Solution that are more likely to be successful (can be personalised to) fit the needs/interests of a range of potential consumers.

Solutions that speak to a broader market segment integrate universal design. AAL solutions that integrate a universal design can speak to younger and older generations. For example, according to a venture capital investor, an integrated care solution can be used by the younger and active population. Additional features of the same platform can be activated for the older customer.

> *"Involving end users from the start in product development is a big plus"* - Venture capital investor

How can the investor know the consumer will like the product?

The AAL market is not seen as an easy market to distribute new solutions. For a start-up to get investors on-board they need to be provided with a demonstrator project or a tested solution. Measurable evidence on the impact of the proposed solution on the quality of life of older people can be a pre-requisite to convincing investors. A number of AAL solutions that are coming to market have been tested with older people in e.g. nursing homes, generating consumer feedback to further improve the product.

> *As an investor would like to see a few months of real world data to be sure that a proposed AAL solution works well* - Venture capital investor

Some researchers argue that research underlying proposed AAL solutions do not follow user requirements sufficiently.

Another key point is that the solution must have a unique selling point and the company must be able to articulate it to consumers. Some start-ups are able to demonstrate that their AAL solution can be integrated into everyday life, e.g. care homes, hospitals, and that end-users are willing to pay.

[168] Tracxn, 2017, Consumer health tech

[169] Tracxn, 2017 Smart homes

> *Demonstrating profitability can often help attract further investment* – Roel Smolders, CEO of Activ84Health

Will consumer interest in AAL solutions grow?

There is a political awareness that the healthcare provision systems can integrate technology to help improve the efficiency of services delivered, without compromising on quality. AAL is being adapted to different degrees and with different models in mind, dependent on the national health and care system. For example, in the UK, Sweden, Spain, Germany and France the telecare market is largely driven by the public sector (whereas in the Netherlands, the market is largely driven by private investment)[170]. This demonstrates that the public sector can influence the overall market penetration of AAL solutions. While public sector can kick start the procurement of new services, it may reduce end-users' incentive to purchase AAL services themselves. It is likely that insurers and health authorities would invest more in the future, recognising the need to encourage longer independent living. The demonstration of economic/efficiency gains will further increase interest from this consumer group.

Moreover, there has been some increased interest in healthy ageing and in self-health management, which is encouraging. Internet usage amongst the older population is increasing and older people are seeing the benefit of connecting with friends and family by means of technology.

Who pays and will AAL solutions be affordable to consumers?

Some of the basic questions around product distribution are who pays, how much and for what? And who are the distributors?

In some countries, older people and family members are more reluctant to pay for types of AAL solutions than in other countries with people believing that these types of products and services should be provided by national/regional governments. This is more typically the case for solutions that are related to telehealth and eHealth. There will be less space for private led initiative if there is little complementarity between public and private solutions.

In some countries (e.g. Switzerland), experts do see that people are willing to invest some private money on their personal health.

There also is an increasing interest in the application of robotics to support independent living (as is demonstrated by the increased interest from news media on robotics and ageing), however, questions about the affordability of robots has arisen. In comparison with some other solutions that are subscription based, robots might be sold as one-off investment, making these solutions appear, at first, as more unaffordable. There also is a question of positioning. For example, Consequential Robotics is planning the launch of a pet robot – Miro with a price tag of £600, which is comparable or less than the annual cost of looking after a living pet.

> *There are many factors that need to come together until an AAL system finds its way to the market and is accepted by the end-users. Technology must be reliable and easy to use, end-users must see a value in the provided services and finally the system should be broadly available and affordable.* - Rolf Kistler, Head of Ambient Assisted Living Research at the Lucerne University of Applied Sciences and Arts

[170] Coda Strategies (2017)

There is a degree of uncertainty about the future price and take-up of AAL solutions, which depends on how the solutions will be introduced to the market, their degree of interoperability, the availability of technology, and the distribution platform.

Where are the opportunity areas?

Opportunity areas in the AAL market exists in combining different types of technologies into new and innovative solutions that support independent living of older people. According to some academic experts, AAL solutions that integrate simpler sensors, e.g. wristbands, and data processing technologies, and artificial intelligence are more likely to have market potential.

According to Rolf Kistler, Head of Ambient Assisted Living Research at the Lucerne University of Applied Sciences and Arts, opportunity areas include: "Smart emergency calling systems, personal assistants (at home and outside), intelligent monitoring systems, simple communication services, information platforms that make information and elderly care-services easily available for informal carers and gives them the support to organise themselves, platforms that help building up and supporting caring communities".

Moreover, there is increased interest in identifying solutions that keep people active and healthy, rather than focussing on treatment. Gamification is part of this area (see case on Activ84Health). However, to some degree, investors have yet to be convinced of investing further astray from the health and (basic) care sector, which is characterised by a need. This means that there are limited financial resources available in this space because investment is often directed towards cure and rehabilitation solutions, and not towards care (the difference between "need to have" and "nice to have").

> *Technology in the active and healthy ageing market is often viewed as 'a nice to have technology, not a need to have technology.' It was challenging to find investors as medical solutions often take precedent with venture capitalists whilst Activ84Health focuses on wellbeing, creating a valuable user experience and improving the quality of life for older adults.*– Roel Smolders, CEO of Activ84Health

According to Rolf Kistler, there is an interest in platforms where services can be integrated. For example, a platform that tries to connect informal carers to care specialists to help release the care burden.

In order to further expand opportunities, some experts argue that there is a need for a new business model, a type of value network, that can integrate multiple solutions.

How does the EU AAL market compare with the global AAL market?

As described in Chapter 5, in 2017, the EU market represents 21% of the global AAL market, and by 2021 the EU market size is expected to increase to 26% of the global market. The country with the largest market share is the US, accounting for 60% of total (€539m) in 2017 and an expected 40% of total (€2,132m) in 2021.

The penetration of AAL technologies in the US is substantially higher than it is across the EU. In comparison to the US market, the EU market is relatively diverse. EU countries have different health systems, policy systems and legal rules and a wider range of consumer expectation and cultural differences. This means that expanding internationally is more challenging in the EU and the is a need to find local distribution partners.

> *It is difficult to gain international exposure – going from a small scale local market to an international one can be very hard. There are very different socio-cultural*

> *expectations towards technology across Europe and more needs to be done to find international partners for AAL businesses. Focus in this area needs to be sensitive to cultural experience whilst actively finding distributors and intermediary customers internationally.*— Roel Smolders, CEO of Activ84Health

Some EU countries (i.e. Denmark, Estonia, Iceland, Finland, Norway, Sweden and also the Netherlands and Spain) a larger proportion of GPs have adopted such electronic networks, making eHealth/telehealth systems more accessible to the relevant consumer groups. AAL market penetration in some EU countries has potential to rapidly reach the level of market penetration in the US.

Appendix A Patent data approach

A.1 Data and approach

This patent analysis draws on data in the European Patent Office Worldwide Patent Statistical Database (PATSTAT) – one of the most comprehensive patent databases in the world. It contains over 70 million records of patent applications (as well as utility models and design rights) filed in 170 IP offices around the world as far back as 1844. It comprises detailed information on each of these applications including application year, characteristics of applicants and inventors (geography, type of organisation), application authority, technological area, status (granted, pending).

Patent data is classified using the 'International Patent Classification' (IPC) system, splitting patents and utility models into a range of detailed technology categories. Patent applications are classified under eight top classes (e.g. Human Necessities, Mechanical Engineering) and further classified into 600 or so subclasses.

This analysis focuses on an international perspective and is based on patent applications made by applicants and inventors based worldwide. Since a patent can be submitted by applicants / inventors from different countries we have applied fractional counting (see box below).

> **Box 1: How does fractional counting work?**
>
> Fractional counting accounts for the fact that more than one inventor (or applicant) can file a patent. In those cases, a count of the number of inventors listed in a patent is made and a proportional share of their participation is assigned to each inventor. For example, if four inventors are listed in a patent, each inventor gets assigned 0.25 patents.

A.2 Definition for patent analysis

Our patent analysis of technologies utilises the IPC classification codes listed in the tables below.

Table 13 IPC classifications used for 'sensing' technologies patent analysis

Technology group	Relevant IPC classification
Controlling systems	• G05B – control or regulating systems in general; functional elements of such systems; monitoring or testing arrangements for such systems or elements. Sub-categories include: - G05B 1/00 – Comparing elements, i.e. elements for effecting comparison directly or indirectly between a desired value and existing or anticipated values - G05B 6/00 – Internal feedback arrangements for obtaining particular characteristics, e.g. proportional, integral, differential
Communication control protocol	• H04L 29/06 – Arrangements, apparatus, circuits or systems characterised by a protocol

Table 14 IPC classifications used for 'reasoning' technologies patent analysis

Technology group	Relevant IPC classification
Digital computing	• G06F 19/00 – digital computing or data processing equipment or methods Sub-categories include: - G06F 19/10 – bioinformatics

Technology group	Relevant IPC classification
	- G06F 19/22 – machine learning, data mining or biostatistics, e.g. pattern finding, knowledge discovery, rule extraction, correlation, clustering or classification - G06F 19/28 – programming tools or database systems, e.g. ontologies, heterogeneous data integration, data warehousing or computing architectures
Data recognition	• G06K – recognition of data; presentation of data; record carriers; handling record carriers
Data processing	• G06Q 50/22 – data processing systems specially adapted for Health care, e.g. hospitals; Social work • G06Q 50/24 – data processing systems specially adapted for patient record management
Image analysis	• G06T 7/00 – image analysis

Table 15 IPC classifications used for 'acting' technologies patent analysis

Technology group	Relevant IPC classification
Robotic devices	• B25J – manipulators (e.g. handling tools, devices, or machines having a gripping or work head capable of bodily movement in space and of change of orientation). Sub-categories include: - B25J 1/00 – manipulators positioned in space by hand - B25J 3/00 – manipulator of master-slave type, i.e. both controlling unit and controlled unit perform corresponding spatial movements - B25J 9/00 – Programme-controlled manipulators

Table 16 IPC classifications used for 'interacting' technologies patent analysis

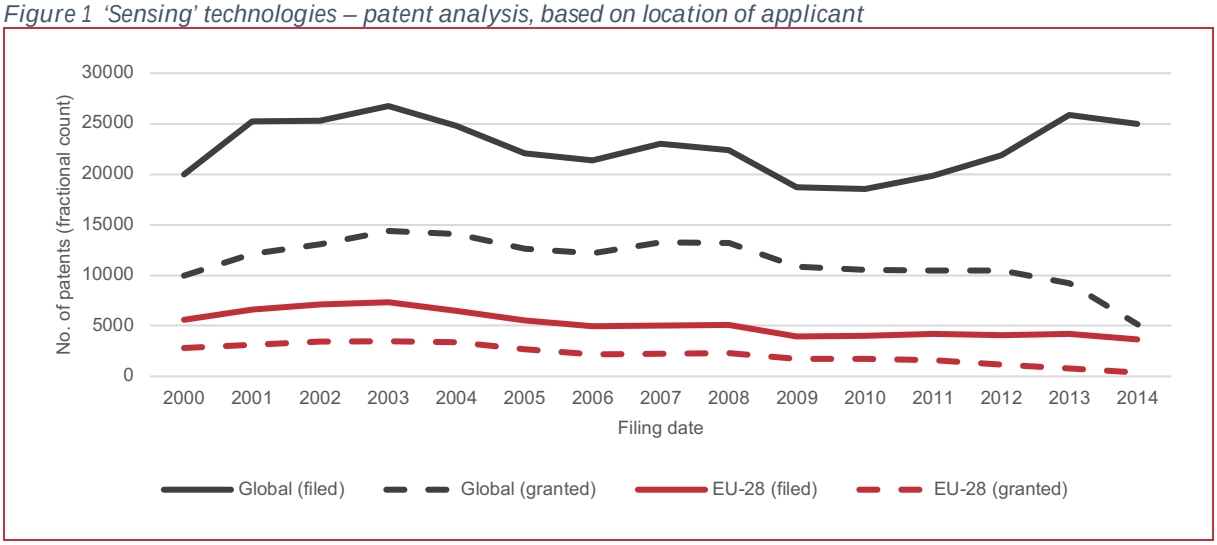
Technology group	Relevant IPC classification
Mice, joysticks	• G06F 3/033 – Pointing devices displaced or positioned by the user for transferring data to be processed into a form capable of being handled by the computer
Graphical user interfaces	• G06F 3/048 – Interaction techniques based on graphical user interfaces [GUIs] for transferring data to be processed into a form capable of being handled by the computer
Speech recognition	• G10L – Speech analysis or synthesis; speech recognition; speech or voice processing; speech or audio coding or decoding

Table 17 IPC classifications used for communicating patent analysis

Technology group	Relevant IPC classification
Local, wide area networks	• H04L 12/28 – data switching networks characterised by path configuration, e.g. LAN [Local Area Networks] or WAN [Wide Area Networks]
Wireless communication networks	• H04W – Wireless communication networks Sub-categories include: • H04W 88/00 – Devices specially adapted for wireless communication networks

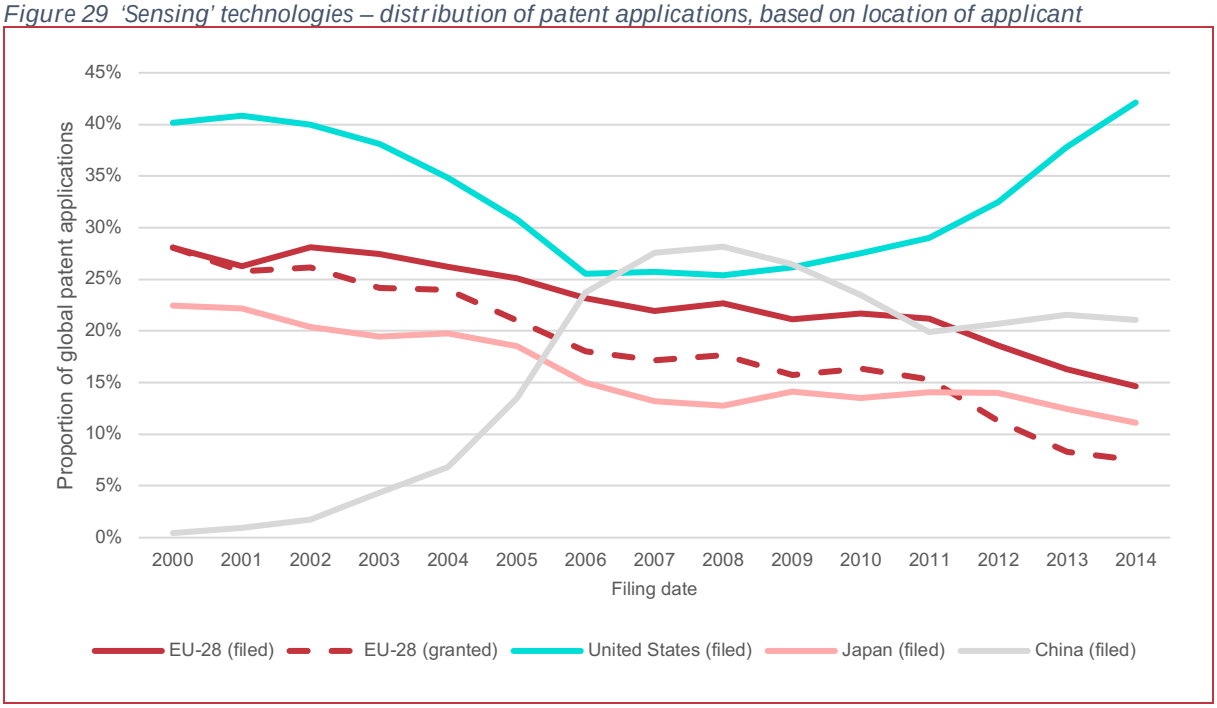
A.3 Results from the patent analysis

Figure 1 'Sensing' technologies – patent analysis, based on location of applicant



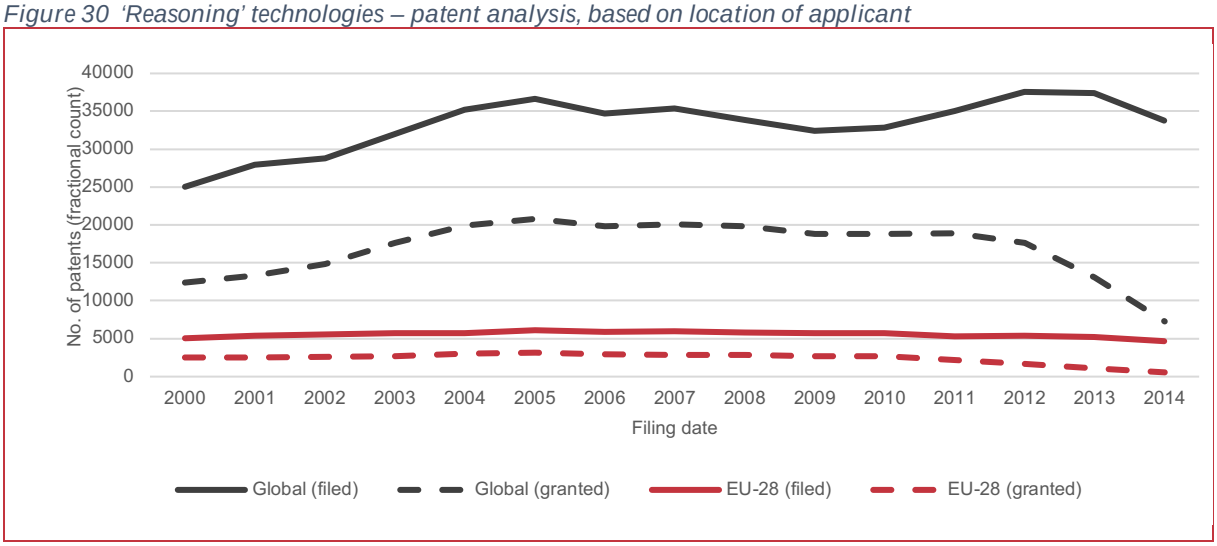
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 29 'Sensing' technologies – distribution of patent applications, based on location of applicant



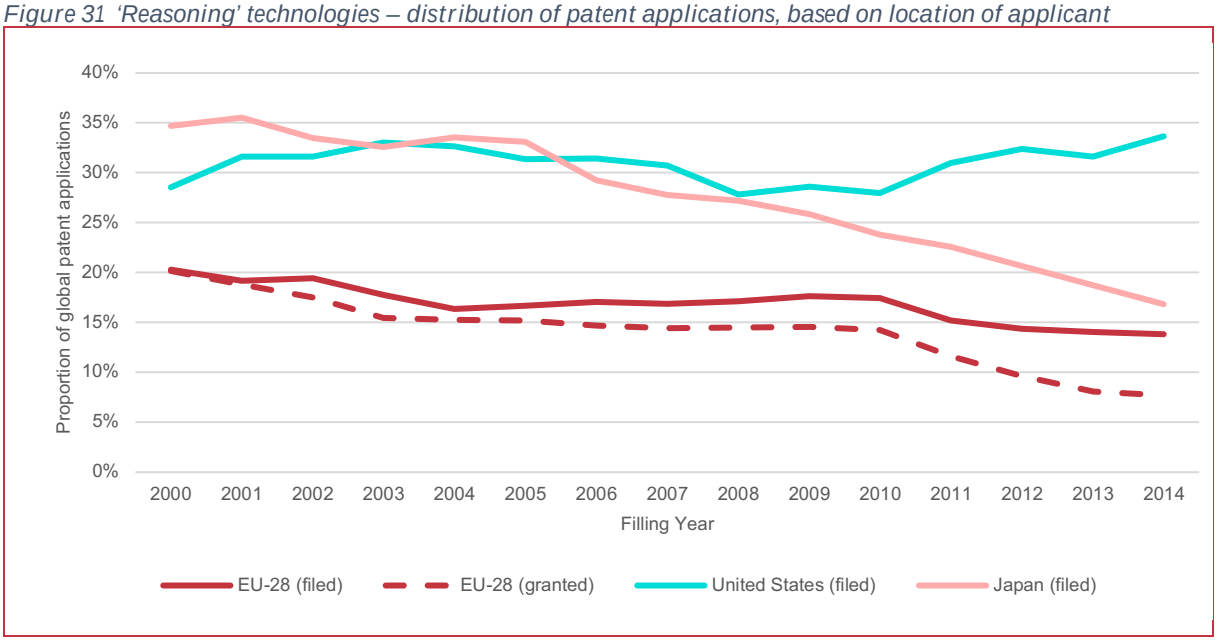
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 30 'Reasoning' technologies – patent analysis, based on location of applicant



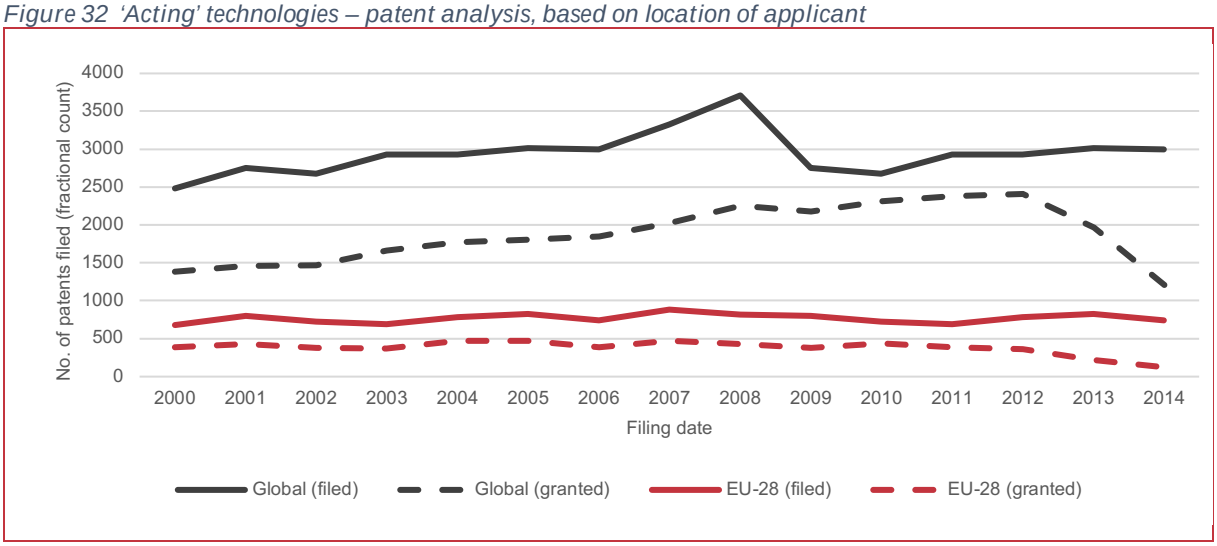
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 31 'Reasoning' technologies – distribution of patent applications, based on location of applicant



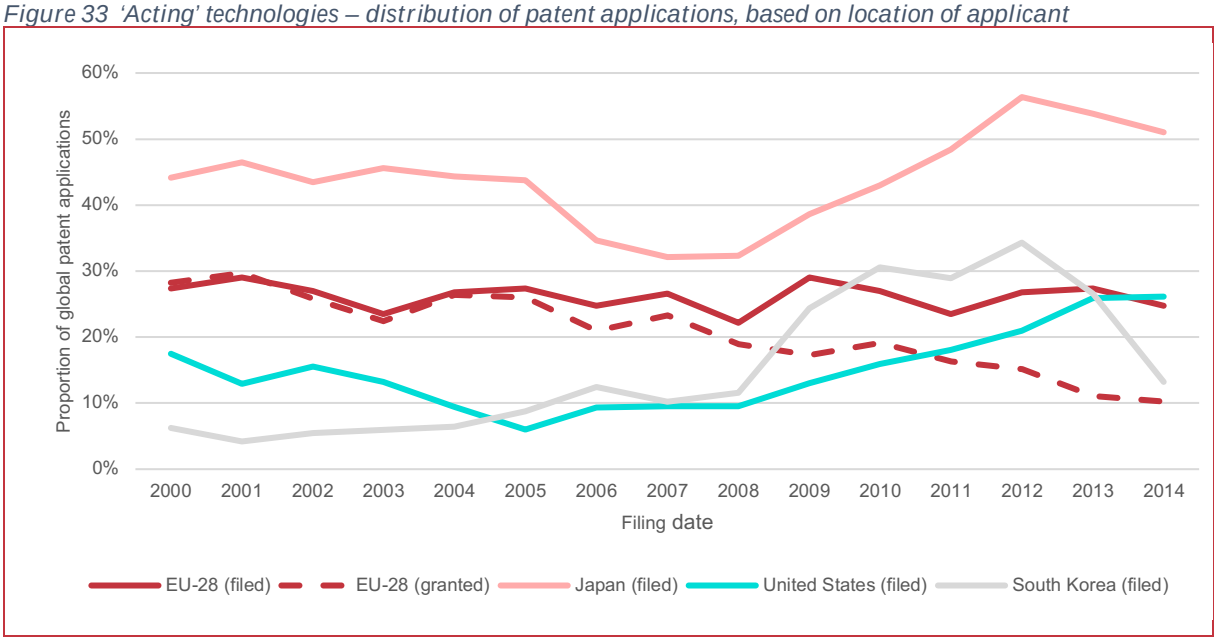
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 32 'Acting' technologies – patent analysis, based on location of applicant



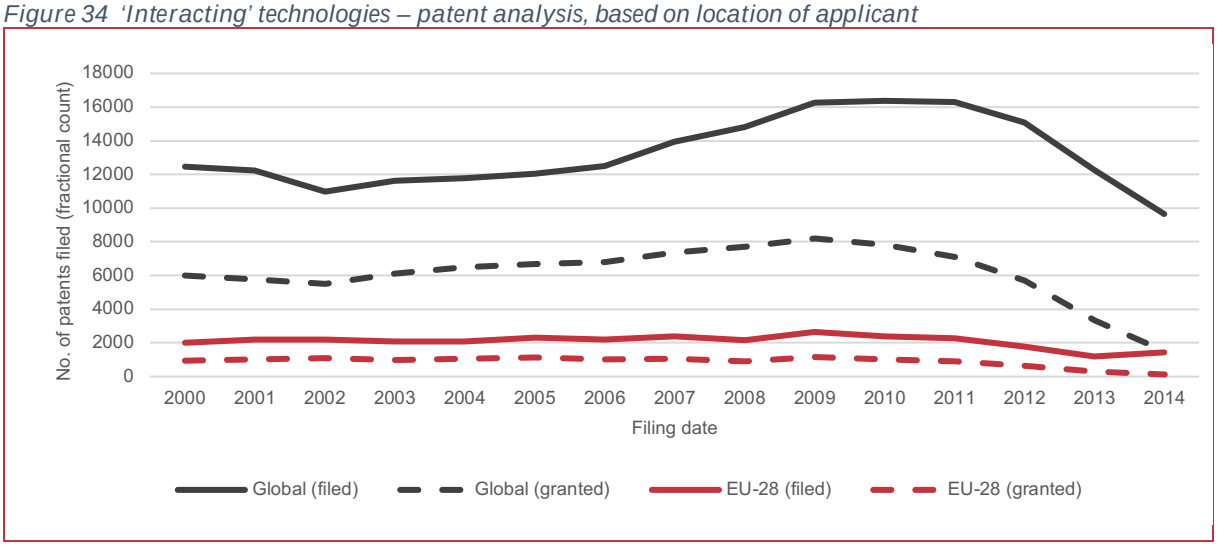
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 33 'Acting' technologies – distribution of patent applications, based on location of applicant



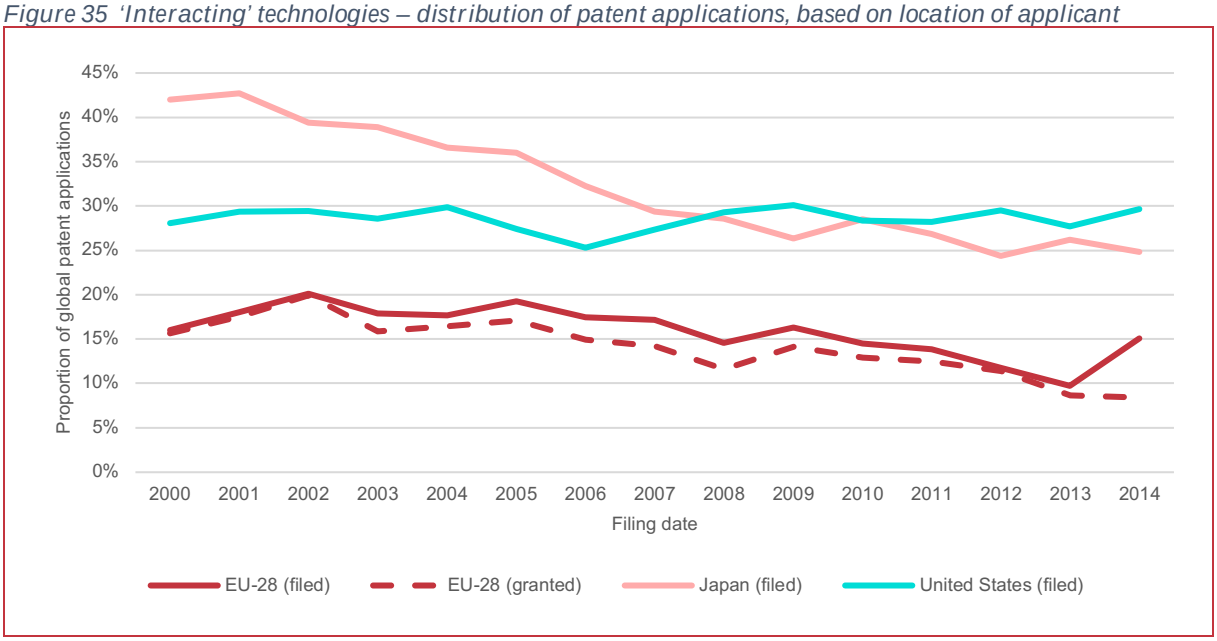
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 34 'Interacting' technologies – patent analysis, based on location of applicant



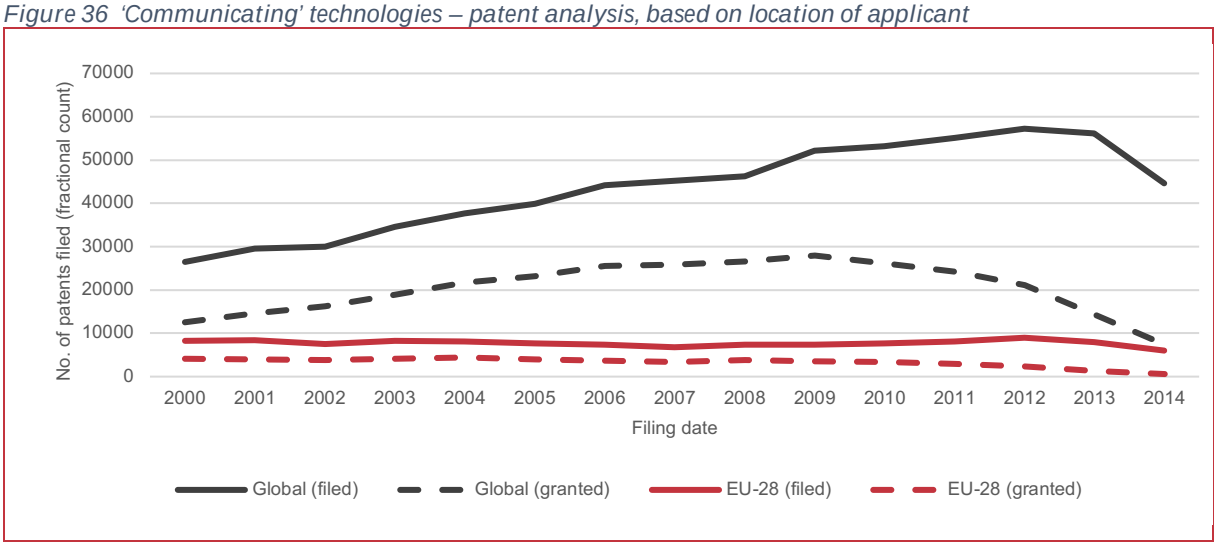
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 35 'Interacting' technologies – distribution of patent applications, based on location of applicant



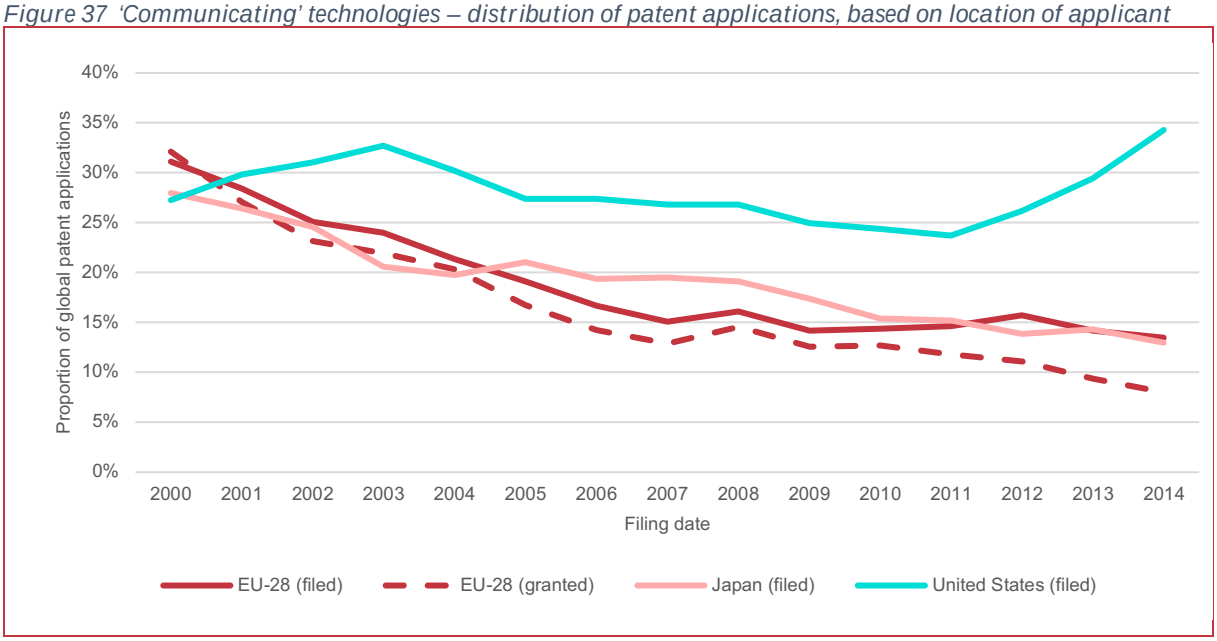
Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 36 'Communicating' technologies – patent analysis, based on location of applicant



Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

Figure 37 'Communicating' technologies – distribution of patent applications, based on location of applicant



Source: Technopolis, based on PATSTAT, Release: Autumn (2016)

A.4 Top 30 global applicants / inventors

Table 18 Sensing – top 30 global applicants / inventors (companies and universities only) (2000-2015)

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
1	HUAWEI TECH CO LTD	CN	Company	10237	1 (-)	5839
2	IBM	US	Company	9054	2 (-)	5650
3	ERICSSON TELEFON AB L M	SE	Company	7828	4 (↓1)	3314
4	SIEMENS AG	DE	Company	7710	5 (↓1)	2946
5	QUALCOMM INC	US	Company	6268	6 (↓1)	2674

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
6	MICROSOFT CORP	US	Company	5533	3 (↑3)	3532
7	NOKIA CORP	FI	Company	5183	7 (-)	2618
8	ZTE CORP	CN	Company	5091	8 (-)	2329
9	SAMSUNG ELECTRONICS CO LTD	KR	Company	4214	9 (-)	2121
10	MITSUBISHI ELECTRIC CORP	JP	Company	4112	12 (↓2)	1712
11	HITACHI LTD	JP	Company	3609	10 (↑1)	1866
12	SONY CORP	JP	Company	2926	11 (↑1)	1842
13	INTEL CORP	US	Company	2920	13 (-)	1704
14	ALCATEL LUCENT	FR	Company	2659	=17 (↓3)	1247
15	CISCO TECH INC	US	Company	2637	15 (-)	1561
16	LG ELECTRONICS INC	KR	Company	2525	14 (↑2)	1563
17	MATSUSHITA ELECTRIC IND CO LTD	JP	Company	2436	26 (↓9)	931
18	RESEARCH IN MOTION LTD	CA	Company	2195	16 (↑2)	1254
19	FUJITSU LTD	JP	Company	2117	20 (↓1)	1141
20	BOSCH GMBH ROBERT	DE	Company	2036	31 (↓11)	694
21	KONINKL PHILIPS ELECTRONICS NV	NL	Company	1952	39 (↓18)	573
22	TENCENT TECH SHENZHEN CO LTD	CN	Company	1930	38 (↓16)	578
23	NEC CORP	JP	Company	1908	23 (-)	1051
24	FISHER ROSEMOUNT SYSTEMS INC	US	Company	1886	25 (↓1)	933
25	STATE GRID CORP CHINA	CN	Company	1873	24 (↑1)	944
26	CANON KK	JP	Company	1829	22 (↑4)	1054
27	FRANCE TELECOM	FR	Company	1781	41 (↓14)	564
28	HONDA MOTOR CO LTD	JP	Company	1769	=17 (↑10)	1247
29	BROADCOM CORP	US	Company	1763	19 (↑10)	1240
30	HEWLETT PACKARD DEVELOPMENT CO	US	Company	1689	21 (↑9)	1068

Source: Technopolis, based on PATSTAT, Latest release: Autumn (2016).

Table 19 Reasoning – top 30 global applicants / inventors (companies and universities only) (2000-2015)

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
1	CANON KK	JP	Company	11752	1 (-)	7696
2	SONY CORP	JP	Company	9721	2 (-)	5451
3	KONINKL PHILIPS ELECTRONICS NV	NL	Company	6371	12 (↓9)	2085
4	SAMSUNG ELECTRONICS CO LTD	KR	Company	6100	5 (↓1)	2941
5	FUJITSU LTD	JP	Company	5916	4 (↑1)	3158
6	MICROSOFT CORP	US	Company	5786	3 (↑3)	3623
7	HITACHI LTD	JP	Company	4533	8 (↓1)	2395
8	SIEMENS AG	DE	Company	4293	15 (↓7)	1869
9	HONDA MOTOR CO LTD	JP	Company	3849	7 (↑2)	2843
10	MATSUSHITA ELECTRIC IND CO LTD	JP	Company	3768	21 (↓11)	1442
11	SEIKO EPSON CORP	JP	Company	3735	10 (↑1)	2243
12	IBM	US	Company	6773	11 (↑1)	2100

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
13	TOSHIBA CORP		Company	3410	36 (↓23)	907
14	NEC CORP	JP	Company	3196	20 (↓6)	1447
15	SILVERBROOK KIA	AU	Individual	3120	9 (↑6)	2258
16	GEN ELECTRIC	US	Company	2890	18 (↓2)	1578
17	HEWLETT PACKARD DEVELOPMENT CO	US	Company	2818	14 (↑3)	1907
18	RICOH CO LTD	JP	Company	2448	13 (↓5)	1979
19	LAPSTUN PAUL	AU	Individual	2434	17 (↑2)	1628
20	FUJIFILM CORP	JP	Company	2418	22 (↓2)	1430
21	SHARP KK	JP	Company	2331	23 (↓2)	1358
22	KOREA ELECTRONICS TELECOMM	KR	Other	2213	27 (↓5)	1134
23	XEROX CORP	JP	Company	2105	16 (↑7)	1655
24	MITSUBISHI ELECTRIC CORP	JP	Company	2098	26 (↓2)	1181
25	SILVERBROOK RES PTY LTD	AU	Company	2090	28 (↓3)	1161
26	TOSHIBA TEC KK	JP	Company	2053	29 (↓3)	1089
27	BROTHER IND LTD	JP	Company	2026	25 (↑2)	1252
28	QUALCOMM INC	US	Company	1953	47 (↓19)	724
29	OMRON TATEISI ELECTRONICS CO	JP	Company	1918	34 (↓15)	974
30	XEROX CORP	US	Company	1918	16 (↑14)	1655

Source: Technopolis, based on PATSTAT, Latest release: Autumn (2016).

Table 20 Acting – top 30 global applicants / inventors (companies and universities only) (2000-2015)

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
1	SEIKO EPSON CORP	JP	Company	1510	6 (↓5)	410
2	HONDA MOTOR CO LTD	JP	Company	1369	1 (↑1)	892
3	YASKAWA DENKI SEISAKUSHO KK	JP	Company	1313	4 (↓1)	472
4	FANUC LTD	JP	Company	1037	2 (↑2)	614
5	YASKAWA ELECTRIC CORP		Company	876	5 (-)	460
6	SONY CORP	JP	Company	855	3 (↑3)	496
7	KUKA ROBOTER GMBH	DE	Company	778	8 (↓1)	336
8	SAMSUNG ELECTRONICS CO LTD	KR	Company	766	9 (↓1)	322
9	TOYOTA MOTOR CORP		Company	738	7 (↑2)	341
10	ABB AB	SE	Company	496	13 (↓3)	213
11	FANUC CORP	JP	Company	488	17 (↓6)	176
12	KAWASAKI HEAVY IND LTD	JP	Company	436	11 (↑1)	261
13	DENSO WAVE INC	JP	Company	417	14 (↑1)	210
14	INTUITIVE SURGICAL OPERATIONS	US	Company	412	26 (↓12)	148
15	CANON KK	JP	Company	402	25 (↓10)	149
16	OLYMPUS CORP	JP	Company	337	59 (↓43)	89
17	LG ELECTRONICS INC	KR	Company	337	16 (↑1)	185
18	HON HAI PREC IND CO LTD	TW	Company	318	10 (↑8)	305
19	TOYOTA MOTOR CO LTD	JP	Company	304	18 (↑1)	173
20	SAMSUNG HEAVY IND	KR	Company	300	12 (↑8)	244
21	ABB RESEARCH LTD	CH	Company	300	35 (↓14)	131
22	APPLIED MATERIALS INC	US	Company	298	32 (↓10)	139
23	COMMISSARIAT ENERGIE ATOMIQUE	FR	Other	296	29 (↓6)	143
24	UNIV GUANGXI		University	294	47 (↓23)	105
25	HONGFUJIN PREC IND SHENZHEN	CN	Company	286	22 (↑3)	156
26	SIEMENS AG	DE	Company	274	44 (↓18)	112
27	MATSUSHITA ELECTRIC IND CO LTD	JP	Company	273	33 (↓6)	136
28	MITSUBISHI ELECTRIC CORP	JP	Company	268	28 (-)	145
29	IROBOT CORP	US	Company	262	23 (↑6)	155
30	TAKENAKA TORU	JP	Individual	258	19 (↑11)	169

Source: Technopolis, based on PATSTAT, Latest release: Autumn (2016).

Table 21 Interacting – top 30 global applicants / inventors (companies and universities only) (2000-2015)

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
1	MICROSOFT CORP	US	Company	7617	1 (-)	4031
2	SONY CORP	JP	Company	7004	3 (↓2)	3440
3	SAMSUNG ELECTRONICS CO LTD	KR	Company	6760	5 (↓2)	1938
4	IBM	US	Company	5323	2 (↑2)	3709
5	LG ELECTRONICS INC	KR	Company	4597	4 (↑1)	2061
6	KONINKL PHILIPS ELECTRONICS NV	NL	Company	3859	9 (↓3)	1476
7	CANON KK	JP	Company	3568	8 (↓1)	1496
8	NOKIA CORP	FI	Company	3362	12 (↓4)	1153
9	NEC CORP	JP	Company	2951	13 (↓4)	1144
10	MATSUSHITA ELECTRIC IND CO LTD	JP	Company	2936	10 (-)	1317
11	FRAUNHOFER GES FORSCHUNG	DE	Other	2864	7 (↑4)	1538
12	APPLE INC	US	Company	2672	6 (↑6)	1572
13	SHARP KK	JP	Company	2574	15 (↑2)	1080
14	QUALCOMM INC	US	Company	2540	14 (-)	1110
15	FUJITSU LTD	JP	Company	2400	11 (↑4)	1258
16	TOSHIBA CORP		Company	2085	19 (↓3)	765
17	PANASONIC CORP	JP	Company	1966	18 (↓1)	863
18	GOOGLE INC	US	Company	1829	16(↑2)	975
19	YAMAHA CORP	JP	Company	1567	17 (↑2)	946
20	HUAWEI TECH CO LTD	CN	Company	1563	21 (↓1)	746
21	DOLBY LAB LICENSING CORP	US	Company	1430	24 (↓3)	678
22	RICOH KK	JP	Company	1355	41 (↓19)	430
23	RESEARCH IN MOTION LTD	CA	Company	1336	29 (↓6)	529
24	SEIKO EPSON CORP	JP	Company	1267	35 (↓11)	476
25	SILVERBROOK KIA	AU	Individual	1172	20 (↑5)	751
26	LAPSTUN PAUL	AU	Individual	1149	23 (↑3)	723
27	ERICSSON TELEFON AB L M	SE	Company	1146	30 (↓3)	529
28	NIPPON TELEGRAPH & TELEPHONE		Company	1112	25 (↓3)	658
29	MITSUBISHI ELECTRIC CORP	JP	Company	1110	44 (↓15)	406
30	HITACHI LTD	JP	Company	1082	38 (↓8)	443

Source: Technopolis, based on PATSTAT, Latest release: Autumn (2016).

Table 22 Communicating – top 30 global applicants / inventors (companies and universities only) (2000-2015)

Filled					Granted	
Rank	Name	Country	Sector	Total	Rank	Total
1	QUALCOMM INC	US	Company	48479	1 (-)	20499
2	HUAWEI TECH CO LTD	CN	Company	34332	2 (-)	14257
3	SAMSUNG ELECTRONICS CO LTD	KR	Company	26393	3 (-)	11938
4	ZTE CORP	CN	Company	25700	6 (↓2)	9869
5	ERICSSON TELEFON AB L M	SE	Company	23550	5 (-)	9894
6	LG ELECTRONICS INC	KR	Company	22947	4 (↑2)	11229
7	NTT DOCOMO INC	JP	Company	18211	7 (-)	8936
8	NOKIA CORP	FI	Company	17366	8 (-)	7587
9	NEC CORP	JP	Company	12735	9 (-)	6629
10	INTERDIGITAL TECH CORP	US	Company	11763	10 (-)	5933
11	FUJITSU LTD	JP	Company	11291	11 (-)	5556
12	RESEARCH IN MOTION LTD	CA	Company	9901	12 (-)	5293
13	IBM	US	Company	8686	18 (↓5)	3269
14	INTEL CORP	US	Company	8124	13 (↑1)	3896
15	SONY CORP	JP	Company	7738	15 (-)	3637
16	ALCATEL LUCENT	FR	Company	7668	16 (-)	3489
17	MATSUSHITA ELECTRIC IND CO LTD	JP	Company	7164	23 (↓6)	2259
18	KOREA ELECTRONICS TELECOMM	KR	Other	6781	14 (↑4)	3642
19	MOTOROLA INC	US	Company	6648	21 (↓2)	2588
20	SIEMENS AG	DE	Company	5537	24 (↓4)	2238
21	SHARP KK	JP	Company	5189	33 (↓12)	1850
22	SK TELECOM CO LTD	KR	Company	5117	19 (↑3)	3082
23	KYOCERA CORP	JP	Company	4885	22 (↑1)	2293
24	KONINKL PHILIPS ELECTRONICS NV	NL	Company	4872	32 (↓8)	1863
25	PANASONIC CORP	JP	Company	4657	27 (↓2)	2026
26	BROADCOM CORP	US	Company	4635	20 (↑6)	3035
27	MITSUBISHI ELECTRIC CORP	JP	Company	4593	26 (↑1)	2053
28	CISCO TECH INC	US	Company	4566	17 (↑11)	3297
29	LUCENT TECHNOLOGIES INC	US	Company	4214	30 (↓1)	1979
30	MICROSOFT CORP	US	Company	3781	29 (↑1)	1997

Source: Technopolis, based on PATSTAT, Latest release: Autumn (2016).

Appendix B Meltwater data and approach

Meltwater allows for monitoring and analysis of media, providing breakdowns based on geography, time, sentiment, frequency of posting and trending topics. The data used in the analysis covers online news articles.

The analysis covers the period 2010-2016 for which data is available for full years, which is linked to how far back Meltwater has recorded information. Moreover, the coverage analysis is limited to news media in Europe.

The query is structured upon simple *Boolean operators* through an advanced search. They define relationships between keywords and exclude the irrelevant mentions. Therefore, sectors and technologies were paired through an "AND" operator for each year. This operator is used when looking for two specific words to appear together in a document. As an example, the keywords "Smart home" and "Older people" are paired through the query: ("Smart home" AND "Older People"). The query returns results for documents where "Smart home" and "Older people" are both included. The query is not case sensitive.

Moreover, the keyword "aging" and "ageing" were comprised within the same query through the Boolean operator "OR". This operator is used when looking for one or more words. As such, the keywords "Smart home", "ageing" and "aging" are paired through the query: ("Smart home" AND ("ageing" OR "aging")). Therefore, either the term before or the term after the "OR" must appear in the document returned from the query. The reasoning behind selecting both the British and American writing of the keyword is linked to the fact that news medias around Europe use both styles of writing and both can yield relevant results

Sectors:

- Smart home
- Telehealth
- Telecare
- eHealth

Technologies:

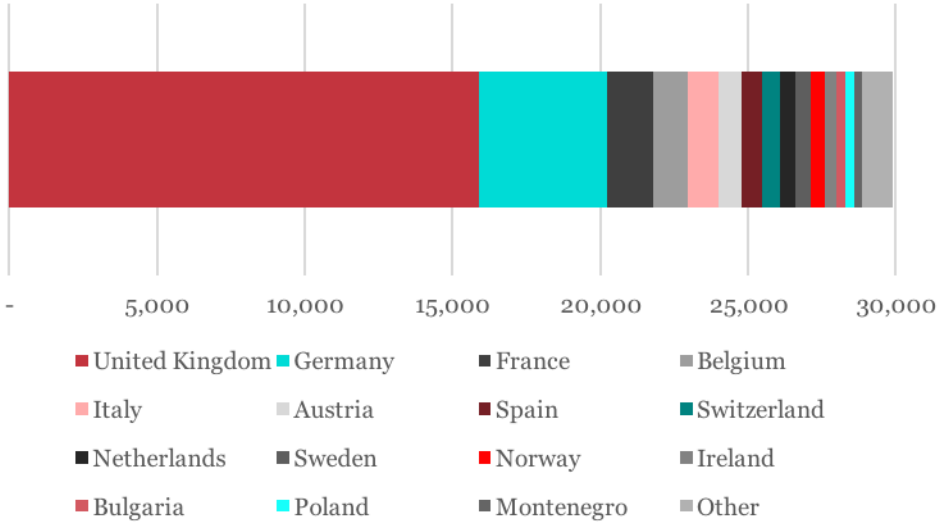
- Robotics
- Gamification
- Wearable technology
- sensor

Demographics:

- Older people
- Ageing
- Aging
- Elderly
- Independent living

The selection of adequate keywords is crucial to the quality of the results. However, a limitation arising from the present query is linked to the language of the keywords. Indeed, by using keywords in English, results are limited to articles and other news to this specific language. This might entail concentrating that the results are limited geographically to English speaking-countries. Figure 38 illustrates the previous statement. Indeed, the present figures shows that the majority of results originate from the United Kingdom. Adjusting keywords to represent all languages of Europe could provide more geographically relevant results.

Figure 38 Media count AAL sectors and technologies by geography (2009-2016)



Source: Data from Meltwater, Technopolis analysis

Appendix C Incubators and accelerators

Table 23 Incubators and accelerators in the EU active in digital technologies

Name	City	Country
EIT Digital	Brussels	Belgium
Accelerace Life	Riga, Tallinn	Denmark
DigitalHealth.London Accelerator	London	England
Dotforge Health + Data	Manchester	England
FICHe	London	England
Healthbox	London	England
MassChallenge, Inc.	London	England
Startupbootcamp IoT | Connected Devices	London	England
West Midlands Academic Health Science Network's	Birmingham	England
Health Spa	Espoo	Finland
Vertical Accelerator	Esbo	Finland
Grants4Apps Accelerator	Berlin	Germany
EyeFocus Accelerator	Berlin	Germany
Helios.Hub	Berlin	Germany
Medtec Europe Start-Up Academy	Siegburg	Germany
Merck Accelerator	Darmstadt	Germany
Startupbootcamp Digital Health Berlin	Berlin	Germany
XLHEALTH	Berlin	Germany
BioUpper	Milan	Italy
SUPERPARTES*	Brescia	Italy
Wellness Accelerator	Venice	Italy
Startupbootcamp Smart City & Living	Amsterdam	Netherlands
Rockstart Digital Health Accelerator	Nijmegen	Netherlands
Startupbootcamp HighTechXL	Amsterdam	Netherlands
Hacking Health	Amsterdam, Strasbourg, Valais	Netherlands, France, Switzerland
CREA (TSB)	Paterna, Valencia	Spain
Emprende In Health (UnLtd Spain)	Madrid	Spain
Moebio	Barcelona	Spain
Startupbootcamp Internet of Things & Data	Barcelona	Spain
Frogleap Accelerator	Stockholm	Sweden
Healthy Habits	Lund	Sweden

Source: https://digitalhealthtoday.com/resources/accelerators-incubators/, https://www.superpartes.biz/en/, http://www.wmahsn.org/

Appendix D Stakeholder consultation

Table 24 Overview of experts consulted

Name	Affiliation
Marc Lambrechts	Senior Investment Manager, Capricorn Venture Partners
Roel Smolders	CEO, Activ84Health
Rolf Kistler	Head of Ambient Assisted Living Research, iHomeLab - Lucerne University of Applied Sciences and Arts
Francisco Florez-Revuelta	Associate Professor, Department of Computing Technology, Polytechnic School, University of Alicante
Sebastian Conran	CEO and Founder of Consequential Robotics
Marc Yvon	IBM Human Centric Innovation Center
Alex Davidge	BUPA, Global Healthcare Provision and Funding
Eric Kihlstrom	KareInn, Ageing 2.0

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