Ambient Assistive Living (AAL) Technology for Dementia and Aging in Place: An inclusive approach to knowledge acquisition for the design community

By

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Anna Stranks

Abstract

The growing concern for safely, care and wellbeing of older people and increase in age related health issues such as dementia, has generated a great interest in AAL technologies as a means to support the elderly and caregiver needs in daily living task, extend aging at home, and maintaining social inclusion for as long as possible. As technology becomes more ubiquitous in home environments, new design challenges will arise for the design/build community. Literature searches revealed that there is no North American Guideline for AAL Technology available. This study required an integrated design process utilizing in-person and online survey which included interdisciplinary contributions from healthcare experts, building automation experts, interior designers and architects in the development of an educational structure for a proposed North American AAL Technology Guideline. Research indicated that the educational structure would need to consider the developmental continuum in learning for professionals as they move from novice to expert in practice.

Keywords: aging, ambient assisted living (AAL) technology, dementia, home automation, innovation models, Maslow's Hierarchy of Needs, professional developmental continuum.

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Dedication

To my parents, Jan and Czeslawa Kulewicz for their love and support through my journey in life, and to all the families who are living with dementia in their lives.

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1.1 Background

1.1.1 Overview of Aging

For the first time in history, senior populations are increasing at a rapid pace and outnumbering younger populations (World Health Organization, 2011, p. 1, Employment and Social Development Canada, 2015, Krauss Whitbourne, Whitbourne, & Konnert, 2015 p. 17, Phillipson, 2013, p. 11). The rapid growth in the aging population of baby boomers (born 1947 - 1966) is a widespread global phenomenon which will place strains and challenges on socio-economic and healthcare systems globally (Bharucha, et al., 2009, p. 88, Kinsella & He, 2009. p. 95).

Recent studies conducted by the World Health Organization(WHO) report that populations 60 years of age and older will increase from 900 million (12%) to 2 billion (22%) between 2015 and 2050 world-wide, with women continuing to outlive men and represent the majority of senior populations (World Health Organization, 2017). "The cause of the differential between male and female life expectancy is uncertain, but it appears to be partly explained by biological advantages and partly by environmental and

behavioural factors" (World Health Organization, 2013). Elderly women will however continue to experience higher levels of poverty as their lives have historically reflected lower wages than men, with more part-time work and gaps in their working lives due to family obligations (World Health Organization, 2013).

Trends in increased life expectancy, reduced birthrates, fewer children per household, increases in women entering the workforce, new family structures and dispersed families continue dominate the global social landscape (Hui-Chun-Huang, 2012, p. 488). Some research indicates that globalization is weakening family ties and threatening family support systems for the elderly. However, research conducted by (Phillipson, 2013, p. 110) shows that older people remain part of a "kin network" (Phillipson, 2013, p. 113) and "personal communities" comprised of friends, kin, neighbours and leisure associates who play a key role in maintaining social relationships and support networks in the care of seniors (Phillipson, 2013, pp. 116-117). This raises questions about how social inclusion and community can evolve in order to support active aging and enhance the quality of life as individual's age, especially for those individuals who lack personal community, experience age related health issues and live alone.

Research indicates that seniors, notably in developed countries, are wealthier, living longer, are generally more active and in better health than their predecessors. Current data from the (World Health Organization, 2017) highlights that there are many other variables which affect an individual's health and quality of life (QoL). "Although some of the variations in older people's health reflect their genetic inheritance", most is due to physical and social environmental influences on opportunities and health behavior. (Phillipson, 2013, p. 38) Phillipson notes that the quality of life in senior years is based on predictable and unpredictable "different social, cultural and historical constructs" which begin in childhood years and refers to this theory as "the social construction of aging" (Phillipson, 2013, p. 40). For example, we can assume that childhood development and growth is relatively predictable, however the decline of various aspects in functioning and cognition associated with aging are less predictable and fluid. This suggests that social constructs of aging are processes which occur at the following levels (Phillipson, 2013, p. 40):

- Macro Level (state and economy influence how aging is perceived in society)
- Micro Level (individuals construct their world through personal interactions)

- Meso Level (organizational and institutional structures and processes that inform daily social worlds and society)

"The major problems faced by the elderly…. are in large measured ones that are socially constructed as a result of our conceptions of aging and the aged. What is done for and about the elderly, as well as what we know about them, including knowledge gained from research, are products of our conception of aging. In an important sense, then, the major problem faced by the elderly are the ones we create for them" (Estes, 1979).

Current research suggests that aging populations are perceived as a burden on societies and an acute problem underpinned by recessions, unstable employment and demographic shifts (Phillipson, 2013, p. 166). Organizations such as the United Nations, The European Union and The World Health Organization are developing new social agendas and processes to build solidarity around age related issues such as housing, healthcare and social inclusion through policy development (Phillipson, 2013, pp. 167-177, World Health Organization, 2017, AALIANCE 2-European Next Generation of Ambient Assisted Living Innovation Alliance, 2014).

1.1.2 Aging in Canada

Baby Boomers represent the fastest growing population in Canada (Foot, 1998, pp. 25-27). Seniors, 65 years and older will reach 10.4 million and represent approximately one quarter of the total population by 2036 in Canada (Federation of Canadian Municipalities, 2013, p. 2, Krauss Whitbourne, Whitbourne, & Konnert, 2015, p. 15). Average life expectancy at birth is "79 years for men and 84 years for women" (Krauss Whitbourne, Whitbourne, & Konnert, 2015). Women will continue to represent the majority of seniors however, elderly men are living longer thus narrowing the precedent gap (Krauss Whitbourne, Whitbourne, & Konnert, 2015, p. 17).

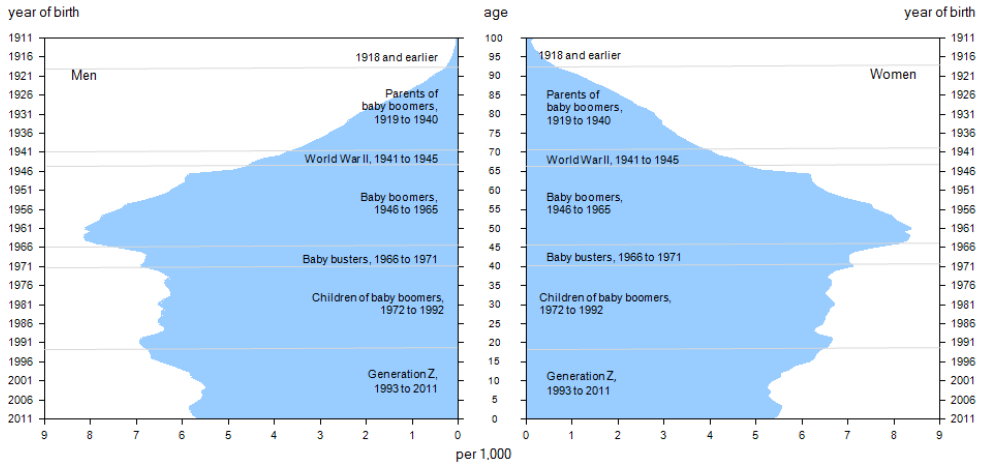

Figure 1: Portrait of generations, Canada 2011, http://www12.statcan.gc.ca/census-recensement/2011/as-sa/98-311-x/98-311-x2011003_2-eng.pdf. Retrieved January 17, 2017.

However, more recent studies and statistics are also indicating that poverty is on the rise amongst Canada's senior populations. (Statistics Canada, 2014). Poverty among older Canadian women will continue to keep in line with the global trend in aging women (Williams, 2010, pp. 13-20).

The baby boomer phenomena will continue to have massive implications in the overall care and housing needs of older Canadians in the twenty first century. Older adults require unique housing solutions. "To date, few studies have analyzed the determinants of this demand or projected how those determinants might change over time" (Wagner, Shubair, & Michalos, 2010, p. 406). Research consistently reveals that seniors wish to age in their homes and communities, close to familiar social structures rather than institutional facilities (Wagner, Shubair, & Michalos, 2010, p. 406, Wiles, Leibing, Guberman, Reeve, & Allen, 2011, p. 357, Canadian Institute for Health Information, 2011, p. 82). Data from the 2011 Census reported that 24.6% of seniors over the age of 65 lived alone and after the age of 70, women continued to represent the majority of this demographic (Statistics Canada, 2015)

Currently in Canada, housing options in retirement years are primarily dependent on government and privately run multi-story

institutional settings such as Long Term Care facilities (LTCF), retirement communities and emerging forms of co-housing. Choice in determining a senior's quality of life and ability to remain in one's preferred environment is tightly linked with income and social support from family and community networks.

Most research shows that institutional contexts are considered to be undesirable choices with senior populations and are a last resort due to lack of support, resources and income. Many assessments conducted over the years has revealed that institutionalization has negative impacts on the well-being of seniors and their ability to maintain autonomy, functionality and cognition (Sijuwade, 1996, pp. 367-373).

The shift to telehealth support systems in Canada are becoming key strategies in the care of aging populations and age-related health illness in home environments, reducing informal caregiver burden and can potentially respond to the shortage of skilled healthcare providers in a financially strapped healthcare system. Technologies are now available to monitor individuals from their homes and educate patients and their caregivers through diverse communication systems more effectively and efficiently (Scott, 2008). Remote mobile health monitoring is predicted to be the next major wave in healthcare

delivery system reform (Bharucha, et al., 2009, p. 2). As a result, there is a great interest in Ambient Assisted Living Technology (AAT) as a means to support aging populations and extend living in one's home and community for as long as possible.

1.1.3 Dementia

Despite the shift to improved quality of life (QoL) in senior populations and technological advances, living longer also creates significant physical and cognitive challenges. The Alzheimer's Society reports that Alzheimer's disease and strokes are the leading cause of brain damage in various forms of dementia affecting aging populations world-wide. Dementia is a progressive disease that affects brain functioning and an individual's ability to observe, encode, accumulate, regain and utilize information (Blackman, et al., 2015, p. 56). Currently there is no cure for dementia. Dementia will be discussed in more detail later.

Research continues to show that seniors including those with early stages of dementia prefer to age in their homes; most importantly, in an environment which is familiar, comfortable and connected to family, social networks and community (Canada Mortgage and Housing Corporation (CHMC), 2015). Home

modifications to primary areas such as kitchens, bedrooms and bathrooms, and adoption of assistive technology such as wearable devices and integration of telecommunication systems for security, monitoring and intervention currently assist seniors while they live at home. Unfortunately, older homes were not designed for aging in place. As a result, modifications to some home environments can be limiting due to spatial and infrastructure constraints as well as the financial costs associated with renovations.

1.1.4 Ambient Assisted Technology

Advancements in AAL technology, smart home design and wireless interfaces present opportunities to mediated barriers to aging in place, improve quality of life for seniors, particularly those experiencing early stages of dementia and assist informal caregivers. In addition, AAL technologies are being leveraged to reduce institutionalization and healthcare cost and enhance access to healthcare services.

As technology becomes more ubiquitous in home environments, new challenges will arise for the design/build community not only in how they approach designing future home environments which integrate these new technologies but also how they will go about

acquiring new knowledge in the domain of AAL technology in order to support this practice.

Literature reviews conducted for this study revealed that there is no published data on the inter-relationship between architectural design and AAL technologies for the design community. (Suh, Kim, & Chung, 2015, p. 6). Currently it is posited that most AAL technologies for elderly populations are being designed separate of spatial and architectural design. This lack of data indicates that architects, interior designers and builders are currently excluded in AAL technology research and development and therefore validates the need for this kind of study. This is an entry level study which suggests that more research needs to be conducted in the domain of the inter-relationship between architecture and AAL technology.

1.2 Objectives

The growing concern for the safety, care and wellbeing of older populations and increase in age related health issues such as dementia, has generated a great interest in the development of AAL technologies as a means to support the elderly and caregiver's needs in daily living activities, extend aging in one's home and maintaining social inclusion for as long as possible.

As a result, a network of stakeholders of academics, government, ICT designers, end users, healthcare service providers, manufactures and public and private organizations, are engaging in the research, development and deployment of AAL technologies.

Interior designers and architects, who play an essential role in creating safe and comfortable environments including the support the physical, emotional and cognitive needs of occupants, are currently not represented in the domain of AAL technology research and development. This may explain some of the challenges designers face in accessing data on AAL technology and its low application rate to residential design. Expanding the network of stakeholders to include the design community can help raise awareness of AAL technology within the profession and mediate issues in the early stages of research and design which arise from a mismatch between the environment and technology. In addition, designers can play an important role as members of an interdisciplinary team in advocating for changes to local building codes and standards which currently are presenting barriers to quicker adoption of AAL technologies in the consumer market. Ultimately, the challenge is to advance the adoption of AAL technologies in the home environment as means to support

maximum social inclusion in aging populations, particularly those with age related health issues such as dementia.

The objective for this study is to develop a framework for an information template that supports the education and application of AAL technology for the North American design community.

1.3 Research Questions and Methodology

Employing a methodology based in grounded theory, an inductive research approach utilized a mixed method design consisting of qualitative and quantitative methods to collecting, analyzing and synthesizing data. The study sought answers to the following questions:

1. What types of AAL technology and building automation systems that are driving innovation in building design and influencing the future of home design for aging populations?

2. How does the design community learn a new topic such as AAL technology and what are the tools and resources preferred in the professional education process to support the development of knowledge and application to practice?

Chapter 2: Research Methods

Designers use many resources and tools to acquire knowledge and apply the knowledge to practice (Daley, 1999, pp. 133-146). As such, this study utilized an inter-disciplinary approach for developing robust data. The study focused on the following research design and methods to inform the design of a template concept which can be utilized for the design of a future North American AAL technology guideline.

2.1 Design Model

This study was designed with the following five stages:

2.1.1 Stage 1. Literature Reviews

Literature reviews provided an integrative context and examined the following five domains of inquiry:

- The nature of dementia and its' impact on social and economic structures in society.
- Scoping of current AAL technology, applications and issues.
- Examination of Maslow's Hierarchy of Needs Model in the domain of dementia and assistive technology as a tool to gain

insight into how unmet needs of seniors in areas of health-related quality of life (HRQol) and acceptance of AAL Technology can be determined and analyzed.

- Examination and assessment of a benchmark case study: European Next Generation Ambient Assisted Living Innovation Alliance Road Map (AALAINCE2, 2014) which utilized an integrated design process in the development of an industry guideline and toolkit to establish standards, policies, legislation, funding for ongoing research and development in AAL Technology.

- Examination of learning and adoption frameworks to identify and conceptualize patterns and constructs for design professional learning and application.

2.1.2 Stage Two: Survey A- Technology and Healthcare Experts

One round, in-person surveys with experts consisting of building automation and communication engineers and educators, systems specialists in home automation and academic researchers working in the field of aging, dementia and AAL technology were conducted in order to scope out current technologies types, applications and issues.

2.1.3 Stage Three: Survey B- Design Community Experts

One round, online survey with licensed and practicing interior design and architectural professionals including educators was conducted to gather information on how the design community goes about learning a new topic and the tools and resources they use.

2.1.4 Stage 4. Data Analysis

In order to develop a conceptual template model for AAL technology applications in home environments, this mixed-method research approach will present the results in the analysis section as follows:

- Literature analysis used a narrative review to synthesize and prioritize common themes in aging, dementia, AAL technology and educational objectives. Prioritizing data assisted in generating template data which could be most relevant to a designer who is learning a new topic.

- Analysis of the in-person Survey A results used an interpretivist approach to develop categories which prioritized themes which were important to building automation experts and AAL healthcare researchers for advancing smart home and AAL

technology to home environments. Participants were asked semi-structured open-ended questions. Responses were organized in five major themes:

- Research areas of priority in aging populations.
- Barriers to knowledge acquisition in AAL technology
- Barriers to faster adoption of AAL technology in home environments
- Trends in telecommunications and home automation
- Opportunities for faster AAL technology adoption in home environments.

- Analysis of online Survey B, used descriptive statistical method to prioritize resources and learning tools used by the design community which could be applied to developing the structure of the template concept. The following themes were analyzed:
  - Open-ended Question 1 (Q1) prioritized topics that where currently most important in learning.

- Questions 2-4 (Q2-Q4) were multiple choice questions which prioritized resources and learning tools used by the design community.
- Question 5 (Q5) prioritized sectors of practice (commercial, healthcare, residential etc.).

2.1.5 Stage 5. Conceptual Template Model

This stage required an Integrated Design Process Model (IDP) to ensure the inclusion of many industry experts and researchers working in various domains of building and home automation, AAL technology and aging. As this is an entry level study, it was important to understand the complexities surrounding these fields in order to begin the discussion of the developing a future North American Guideline for AAL Technology application in home environments.

Chapter 3: Data Analysis

3.1 Introduction

AAL technology applications in home environments assisting elderly populations to age in their homes is a relatively new field of research and development. "It resides at the crossroads of advancing technology and advancing age" (Blackman, et al., 2015, p. 67). Research to date has revealed that there is inadequate data on the inter-relationship between AAL technology and the physical architectural design of home environments. Consequently, the lack of data will present challenges for the design community in coordinating efforts to support the application of these technologies to home environments. The following analysis represents various lenses that were used to gain a deeper understanding of the impact of AAL technology on design practice.

3.2 Literature Reviews

Literature reviews were sourced from academic data bases in medical, sociological, biomedical, computer-science and domains. Statistical information was sourced through census data bases. Gray sources such as google scholar were used to scope out journals, abstracts, websites and reports. In order to obtain the most current

data possible, sources predominately ranged from 2000 to 2017. In order to understand the broader context of AAL technology in relation to private home environments for individuals experiencing early stages of dementia, the literature reviews focused on AAL technology concepts and the implications this technology will have on the architectural design of homes for the design community. A key component to understanding technology adoption required scoping out papers relating to how professionals go about learning new information.

3.2.1 Nature of Dementia

The Alzheimer's Society of Canada reports that each individual will be affected differently by dementia, especially in the early stages (Alzheimer's Society of Canada, 2016). As a result, assisting people with dementia to remain safely in their homes for as long as possible will present unique challenges for society and the importance of understanding the needs of these individuals and their caregivers.

Dementia affects brain functioning and results in memory loss and behavioral changes. Memory is linked to the shaping of an individual's sense of self, independence and ability to carry out daily living activities. Positive self-identification plays a key role in managing

dementia and aging through socialization. "Social experiences are vital in shaping a person's subjective experience of life, especially in relation to an individual's sense of self as he or she ages" (Frazer, Oyebode, & Cleary, 2011, p. 678). Most importantly, social interaction with others facilitates reminders of one's experiences, achievements and abilities that are applied to present moment scenarios. Studies conducted by (Fratiglioni, Wang, Ericsson, Maytan, & Winglad, 2000, p. 1318) reported that individuals who lived alone and had no relatives or friends had a 60% increased risk of developing dementia and concurred with many other studies stressing the importance of keeping a high level of social inclusion for the elderly, particularly those experiencing dementia who live alone. Dementia jeopardizes self-identification and independence because it attacks long-term and short-term memory which are essential to tracking, organizing, managing and performing daily task.

For example, fear of leaving home and not remembering how to get back or the loss of driver's license present mobility issues in shopping, attending medical appointments or visiting family and friends (Frazer, Oyebode, & Cleary, 2011, p. 678). In home environments, multi-tasking and complex scenarios such as cooking require individuals to process information, sense conditions, pay

attention to time and perform precise movements (Blasco, Marco, Casas, Cirujano, & Pickering, 2014, p. 1630). As a consequence, aging and the onset of dementia result in the loss of performing activities independently without some form of assistance. In the case of a kitchen related activities, "household appliances, instead of fostering independent living, become a burden that adds to aging limitations" (Blasco, Marco, Casas, Cirujano, & Pickering, 2014, p. 1630).

The Alzheimer's Society of Canada provides the following data on various the various types of dementia and their symptoms (Alzheimer's Society of Canada, 2016):

Alzheimer's Disease

- Early stages include difficulty in remembering conversations, names, events and contribute to lack of interest and depression.
- Later stages include impaired communications, poor judgement, disorientation, confusion, behavior changes, difficulty in speaking, swallowing and walking.

Vascular Dementia

- Post-stroke brain injury, impaired judgement, poor planning and organization as opposite to memory loss.

Dementia with Lewy Bodies (DLB)

- Memory loss and impaired thinking, sleep disturbances, well-formed visual hallucinations, slowness and gait imbalance.

Parkinson's Disease

- Problems with movement; if dementia develops, symptoms include memory loss, impaired think, sleep disturbances, well-formed visual hallucinations, slowness and gait imbalance.

Frontotemporal Dementia

- Difficulty with language, personality and behavior changes.

Creutzfeldt-Jakob Disease

- Rapid decline in memory and coordination, causes behavioral changes.

Normal Pressure Hydrocephalus

- Difficulty in walking, memory loss and incontinence.

Huntington's Disease

- Involuntary movements, severe decline in thinking and reasoning, irritability, depression and other mood changes.

Wernicke-Korsakoff Syndrome

- Severe memory issues, social and other thinking skills may remain unaffected.

3.2.2 Socio-economic Impact of Dementia

The Alzheimer's Society of Canada (Alzheimer's Society of Canada 2017) reports the following social and economic impact of dementia:

- 564,000 people are currently living with dementia in Canada and will increase to 937,000 in 15 years.
- Combined direct medical costs and lost earnings by caregivers (indirect) resulted in $33 billion dollars per year.
- Family members represented $444 million dollars of unpaid caregiving for individuals with cognitive impairment. The trend will grow to $1.2 million dollars by 2040.
- Up to 75% of family caregivers will experience physical and psychological illness such as depression and poor physical illness due to the stress and strain of caring for a cognitively impaired individual.

- Individuals with mild forms of dementia and their caregivers have more unmet needs than those who have severe stages of dementia.

3.2.3 Vulnerability in Home Environments

Seniors experience high degrees of accidents and injuries in home environments due to changes in strength, sense of touch and smell, balance, gait, vision, hearing, mental health issues and decrease in bone density (ROSPA, 2016). Falls are the leading cause of injury among senior Canadians over the age of 65 which in some case lead to death. Stair, kitchens and bathrooms are primary areas for falling, followed by falling out of chairs and beds (ROSPA, 2016).

A study conducted by (Public Health Agency of Canada, 2016) reported the following data in regards to accidents and injuries in senior populations:

- 50% of falls occur in the home.
- 85% of senior hospitalization due to the result of falls.
- 1/3 of seniors enter long-term care facilities and cannot return to their homes after hospitalization.

- Fear of falling again limits senior's activities and contributes to lose of strength, confidence and self-esteem.

- Changes to vision contributes to depth perception and distances, sensitivity to glare and difficulties in adjusting from light to dark conditions and vice versa.

- Seniors experience decrease to sensitivity to heat, pain and pressure making it challenging to detect temperatures and changes in surface heights. Burns and scalding are common injuries and can also lead to death.

- Decrease in smell making it difficult to perceive spoiling foods, gas leaks and smoke from fires.

- Hearing loss making it difficult to hear fire and smoke detectors, telephones and door bells.

- Bone density diminishes with age and can lead to painful fractures and reduction or loss of mobility.

- Maintaining balance requires eyes, inner ear, muscular strength and joint flexibility coordination. Seniors experience difficulty in maintaining and recovering balance while slipping or tripping.

Elderly people are the most vulnerable to accidents and injuries in home environments. Older people take more time to recover from illness and injury, and in many cases, do not regain full functioning (AALIANCE 2, 2014, p. 35). As a result, they require more assistance with daily tasks and routines. In addition, the loss of independence makes older people prone to losing confidence in their capabilities and experience decrease in self-esteem; factors which can contribute to institutionalization (Blasco, Marco, Casas, Cirujano, & Pickering, 2014, p. 1630).

3.3 Ambient Assisted Living Technologies

"Ambient Assisted Living (AAL) refers to technologies (relying on the field of ambient intelligence) and intelligent systems (Novitzky, et al., 2015, p. 8) that assist the elderly in daily living activities, managing health issues, extend aging at home," and remaining physically and socially active. The AAL model of care is rooted in an integrated and holistic framework which links telecare, telehealth, smart home and mobile technology as a means to support the social and healthcare needs of older people (AALIANCE 2, 2014, p. 24).

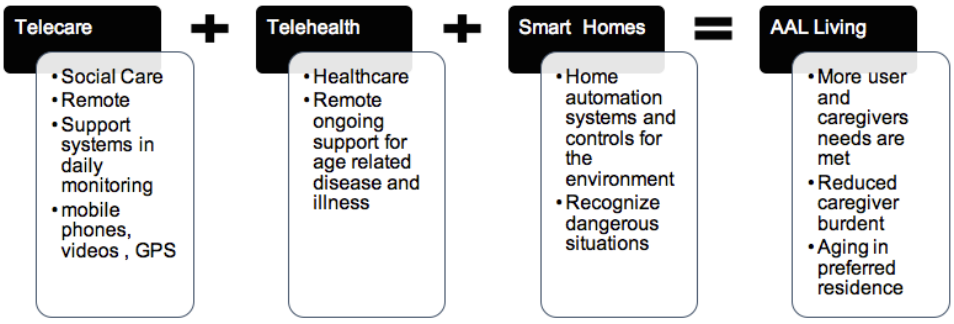

Figure 2: AAL Technology Frame Work (AALIANCE 2, 2014)

Based on the (AALIANCE 2, 2014) framework, Figure 2 illustrates a model for the adoption of an integrated healthcare delivery system utilizing telecommunications systems, products and services can improve QoL for dementia patients and their caregivers, and enhance access to services and support.

Emerging smart home concepts which embed information and communications technology with smart phone and sensor networks are creating more efficient and convenient lifestyles. Smart technologies such as AAL technologies are capable of perceiving environmental changes and human behavior in the home (Suh, Kim, & Chung, 2015, p. 1). Sensors networks provide opportunities for surveillance, monitoring and feedback in real-time directly to seniors, and remotely to caregivers and other healthcare service providers. Although, many individuals will benefit from smart home and AAL technology, current

senior populations, especially those experiencing dementia will be challenged in learning how to use these technologies due to the lack of experience with technology use in general over the course of their own life spans (Suh, Kim, & Chung, 2015, p. 1). However, most of the literature reviews conducted on AAL technology indicated that caregivers will benefit the most from AAL technologies by managing risks associated with older family members. These technologies will enable informal and formal caregivers to monitor older persons in real-time and connect with healthcare services more quickly and efficiently (Longhi, Siciliano, Germani, & Monteriu, 2014, p. 338). In addition, AAL technologies may also address the needs of elderly people living alone.

3.1.1 AAL Service Areas and Support Scenarios

Studies conducted by (AALIANCE 2, 2014) prioritized the following three key support areas for AAL technology and services to promote health and wellbeing inclusion for aging populations:

1. Prevention

- Intervention of strategies to reduce or obviate risk and diseases from occurring or manifesting into more complex scenarios.

- Cognitive and motor abilities are supported through monitoring and early detection including fall prevention strategies.

2. Compensation and Support

- Intervention of strategies and devices to assist individuals who are experiencing early onset of cognitive and motor decline and their caregivers.

- Includes home modification, telecare, nursing care, domestic help, personal care and assistance in daily tasks and activities.

3. Independence and Active Ageing

- Intervention of strategies, services and devices to support independent living in one's preferred place of residence and remain socially active for as long as possible (volunteer service, employment and leisure).

- Concepts of independent living and active aging are linked to improved QoL, autonomy, risk management and empowerment of seniors with age-related health issues and disabilities.

- Independent living and active aging is reliant of the use of ICT systems.

Researchers posit that the three AALIANCE2 service scenarios "are strongly related to the QoL of senior citizens" with regards to "(physical) health, (psychosocial) welfare, social contacts, activities and living environment" but further note that each of these factors will influence QoL based on personal experiences. (Longhi, Siciliano, Germani, & Monteriu, 2014, p. 339)

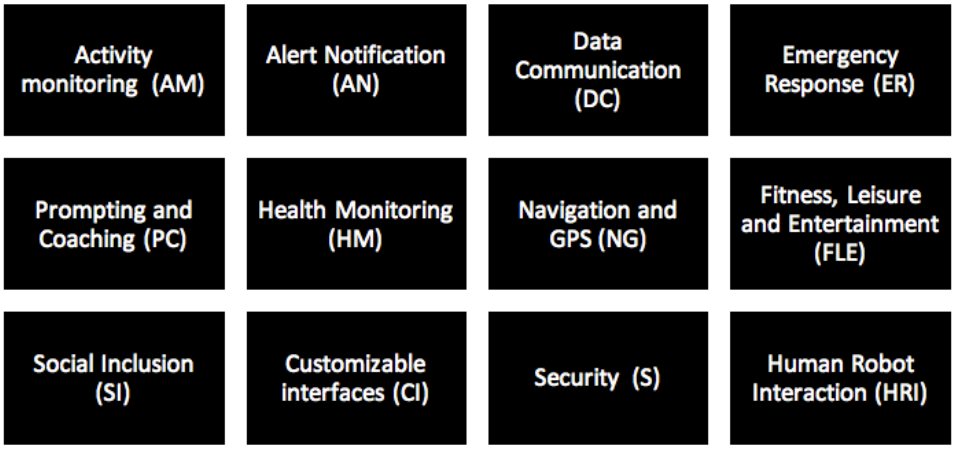

Figure 3: Service Scenarios of Support based on the AALAINCE2 Ambient Assisted Living Roadmap.

AALLIANCE2 workshops with AAL experts and a broad range of stakeholders, including end-users, identified 10 socio-medical services

scenarios for improving the QoL for aging populations including individuals with disabilities (AALIANCE 2, 2014, p. 36)

AALIANCE2 proposed the following ten AAL service scenarios:

1. Prevention in cognitive decline
2. Promotion of healthy living
3. Chronic illness management through more self-care
4. Resilient environments for changes in life circumstances, safety and security
5. Fall prevention
6. Autonomy and self-managed tasks and activities in daily living
7. Sustaining and enhance social inclusion
8. Create outdoor environments which are safe and provided easy movement through diverse settings
9. Reduce caregiver burden and isolation
10. Extend employment years for seniors

3.1.2 AAL Technology Systems Components

Assistive technology is a general term which refers to various technologies developed to assist individuals with specific needs, tasks and activities in daily living. Technology can range from individual low-tech devices such as canes, walkers and glasses to high tech ambient environments with sensors and intelligent systems, and robotic solutions (Blackman, et al., 2015, p. 57). Ambient assisted living (AAL) "is the result of a progression from individual devices assisting with one task or activity of daily living (ADL) to ambient systems in which the assistance or support completely encompasses the living area and person" (Blackman, et al., 2015, p. 57).

KET's or "Key enabling technologies" (AALIANCE 2, 2014, p. 63) are components of ICT and telecommunication systems. They are typically comprised of sensors (sensing) which collect user or environmental data, IT components which process sensor data and generate conclusions (reasoning), human machine interface components (interacting) and actuators (acting) that execute actions such as switching appliances off or raising alerts in the case of an emergency such as a stove that has been left on.

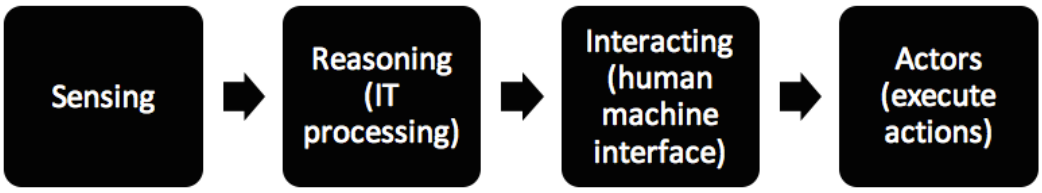

Figure 4: Basic Structure of AAL ambient assisted technology using telecommunications systems.

3.1.3 Three Generations of AAL Technology

First generation of AAL technologies are based on social and personal response systems using wearable devices, such as bracelets and pendants which require the user to initiate an alarm in order to receive assistance. A popular example of first generation devices includes LifeAlert (1992) which relays the message "Help, I have fallen and I can't get up!" (Blackman, et al., 2015, p. 57). Drawbacks to this technology include individuals with cognitive or physical disabilities may not be capable of pushing the alarm button and secondly, individuals must rely on memory to wear the device at all times (Blackman, et al., 2015, p. 57). However, the benefits of first generation technologies have the potential for faster response times to emergency situations, reduce hospitalization and provide older adults and their families with some sense of safety and security.

Second generation AAL technology integrate electronic systems that detect and alert individuals of emergency situations such as fire, carbon monoxide leaks or appliances that have been left on too long such as stoves, and door alarms if a senior with dementia attempts to wander outside of their home. Second generation AAL technology do not require the user to initiate action as it uses sensing technology. Although successful in their application, second generation technology is perceived to be intrusive in nature (Blackman, et al., 2015).

Third Generation AAL technology which are perceived as less obtrusive, can detect and report problems, and in some instances, prevent a problem from escalating. "These systems integrate computing systems and assistive devices into everyday living contexts in order to not only monitor the home environment but also to monitor the older person" (Blackman, et al., 2015, p. 58). For example, monitoring sensors for beds can alert a caregiver that the older adult has left their bed for a long period of time and may be unwell and in need of assistance. Bed sensors can also alert a caregiver if the older adult has wandered out of there bed in the middle of the night. However, there are limitations to the technology as it cannot necessarily prevent the individual from falling should they trip over bedding while climbing out of bed. As such, currently there are

limitations to AAL technology. However, advancements in cognitive aids that combine the use of environmental and wearable sensors, cameras and audio technologies are emerging concepts with the aim to deliver a more holistic and efficient approach to the needs of older adults and caregivers and improve QoL for both user and caregiver. The following three generations of AAL technologies supports a telecare delivery system:

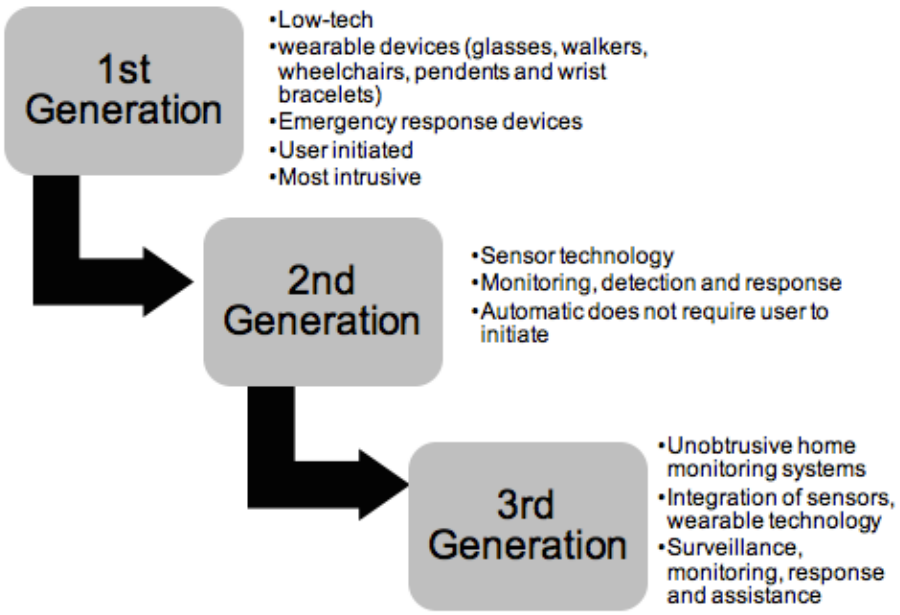

Figure 5: The evolution of ambient assistive technology (Blackman, et al., 2015)

Preferences for aging at home, reductions in hospitalization costs and "portable medical technologies (AALIANCE 2, 2014, p. 31)

are motivating growth in customizable homecare services which compensate, assist and enable more self-care in older adults.

Most literature provided in-depth information regarding the technical aspects of AAL technology itself. Only one paper addressed the lack of an integrated design process between technology, spatial and architectural design, consequently contributing to additional construction process and cost (Suh, Kim, & Chung, 2015, p. 6).

Spatial conditions can affect the visual range of surveillance cameras caused by incompatibly positioned architectural elements such as decorative beams or specification of materials can potentially degrade or refract sensor signals. In addition, energy issues exist despite advancements in technology. For example, one can assume that smart home technologies are designed for energy efficiency and cost savings in general, but older adults with declining physical and cognitive conditions require more equipment, devices and services to support them on a daily basis. They are most likely run them during peak periods of the day when billing rates are the highest. If an individual is experiencing memory issues, appliances may be left to run longer or simple sequencing of tasks such as forgetting to close a window when turning on air conditioning or heating results in inefficient energy consumption and additional utility costs.

Most research indicates that AAL technologies will play an essential role in advancing new models of care that respond to the needs of seniors who age in their home and assist their caregivers, however the lack of data on the inter-relationship between technology and architectural design suggests that the design community will be challenged in learning about AAL technology and applying it to practice. The literature reviews provide further evidence for a more robust integrated design process which is inclusive of the design community.

3.4 Maslow's Hierarchy of Needs and Assistive Technology

Every individual's behaviors and actions are motivated by specific in-born needs according to American psychologist Abraham Maslow. Well versed in the theories of Freud and Skinner but dissatisfied by "the negative implications of psycho-analysis and behaviorism for human potential because of their focus on psychopathology" (Zalenski & Raspa, 2006, p. 1121), Maslow proposed a conceptual model of 5 hierarchical levels of needs in which "people seek to satisfy progressively higher human needs, starting with physical needs like food and shelter, and advancing through safety and security, belonging and love, esteem and self-actualization" (Thielke, et al., 2012, p. 470).

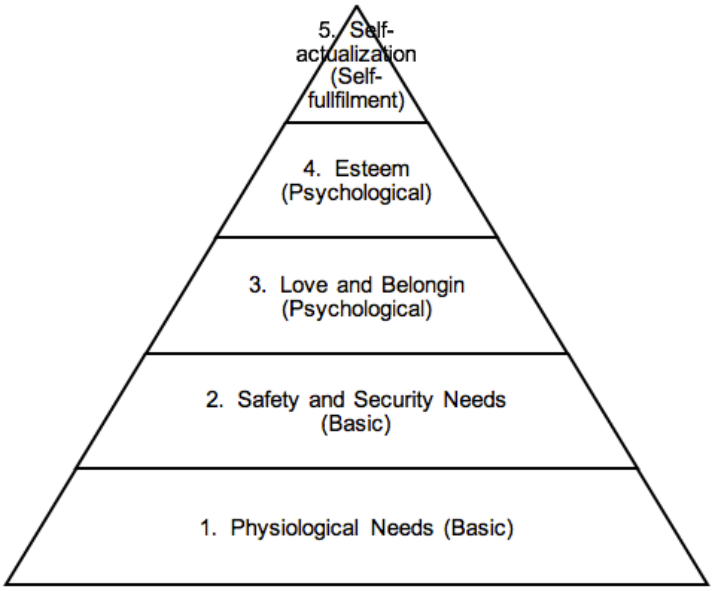

Figure 6- Maslow's Hierarchy of Needs Model (Thielke, et al., 2012, McLeod, 2016) posits higher level needs such as self-actualization cannot be met until lower levels such physiological needs are fulfilled.

This heuristic proposes that if lower level of needs cannot be satisfied, the individual will be unable to progress to the next levels (Thielke, et al., 2012, p. 473).

Maslow's Hierarchy of Needs theory has been used in many academic and commercial studies (Thielke, et al., 2012, p. 478) as a means for developing theoretical and practical frameworks in order to understand how to "achieve maximum human potential" (Zalenski &

Raspa, 2006, p. 1120). Interestingly, researchers (Scholzel-Dorenbos, Meeuwan, & Olde Rikkert, 2010, Thielke, et al., 2012, Zalenski & Raspa, 2006) posit that there has been little adaption of Maslow's model to understand the unmet needs of seniors in the areas of health-related quality of life (HRQoL) studies in the domain of assistive technologies and dementia. Many studies suggest that seniors, regardless of physical and mental health status, are hesitant to adopt assitive technology (Bharucha, et al., 2009, Novitzky, et al., 2015, Thielke, et al., 2012).

Table 1: AAL Support of Fulfilling Maslow's Hierarch of Needs for Dementia Individual

	Needs 1-Lowest 5-Highest	**Description**	**Dementia Patient Challenges**	**AAL Support**
1	Physiologic (Basic)	Food, water, warmth, sleep, equilibrium, excretion, sex	Memory, forgetting task sequences, carrying out activities	Prompting systems, robotics for assisting in tasks.
2	Safety + Security (Basic)	Security of body, health, family, property, morality and employment	Risk management, falls, scalding, burns, wandering	Sensor networks, alert systems, GPS
3	Love + Belonging (Psychological)	Intimacy, friendship, family, community	Isolation, fear of exposure of disability	Smart phone technology, email, skype, robotics.

4	Esteem (Psychological)	Self-esteem, respect for self, respect for others, confidence, accomplishment	Lack of independence, Memory, forgetting task sequences, carrying out activities	Prompting systems, robotics for assisting in tasks.
5	Self-actualization	Achieving full potential, creativity, morality,	Memory, lack of self-awareness, isolation. Lack of motivation	Level 5 is abstract. Challenge for AAL

The following discussion of Maslow Hierarchy of Needs Theory will provide insight into understanding the perspectives of the elderly in relation to aging, dementia and acceptance of assistive technologie.

Level 1: Physiological Needs

Researchers posit that people can fulfil most of their basic physiological needs with some assistance from others, while assistive technology is more used by individuals who have physical disabilities and may need assistance with activities such breathing, eating, drinking and bodily functioning (Thielke, et al., 2012, p. 476). Personal robots to assist with completion of tasks, reminders for medication and even reaching higher shelfs for items are in the research and development stages. Sensor technology in combinations with digital screens with interactive avatars can provide reminders of tooth

brushing and handwashing sequences. Research indicates that older disabled individuals are more likely to use low-technology such as walkers, wheelchairs, ramps, raised toilet seats and anti–scald temperature controls to maintain independence rather than rely on a personal assistant or high technology as the need for independence outweighs the physical needs (Thielke, et al., 2012, p. 476). Other research has revealed that seniors including those with disabilities such as early stages of dementia resist the use assistive technology because it "makes them appear helpless and challenges their self-image" (Sherer, 2004).

"The lines of evidence suggest that the adoption or rejection of technologies which help with physical needs may hinge not on the properties of the technologies, but rather on how their use fits with the users' attention to the higher-level needs of independence, belonging or social participation" (Thielke, et al., 2012, p. 476).

Level 2: Safety and Security Needs

Maslow's model reflects when the basic physical needs of people are met, they "seek protection from physical and emotional harm in daily needs such as avoiding dangerous conditions in and around the home, and more longer term needs such as creating overall safe

environments (Thielke, et al., 2012, p. 476). "These are more abstract needs than food, water and shelter and require some projective reasoning in order to continue to seek them" (Thielke, et al., 2012, p. 476). For individuals with early stages of dementia, safe environments are paramount and reasoning skills may be problematic. Although technology may prevent individuals from wandering to keep them safe, it may not necessarily improve the user's sense of security and safety" (Thielke, et al., 2012, p. 476). However, it may increase the sense of security with caregivers. They suggest the importance of distinguishing whose needs are being met in the development and application of assistive technology in home environments (Thielke, et al., 2012, p. 477). Current literature reviews for this study suggest that assistive technology will be of more benefit to caregivers in the long run but immediate safety and security needs for security in older people can potentially be met by wearable devices such as LifeCall pendants in which elderly individuals can initiate an alert should they fall and need assistance or devices which monitor blood pressure. Simple devices such as these may be more acceptable and also meet psychological or esteem as the users is not necessarily controlled by the technology and maintains some autonomy.

Research indicates that monitoring and surveillance technologies can undermine an individual's sense of security (Thielke, et al., 2012, p. 447), and potentially lead to "self-regulation and change in behavior for fear of negative feedback and potential punishment….the individual may privately maintain standards of behavior which he does not personally believe in" (Brittain, Corner, Robinson, & Bond, 2010, p. 10). Home represents a place of "confidence, trust, comfort, safety and privacy, (Novitzky, et al., 2015, pp. 1-32) and the "center of daily experiences" (Courtney, Demiris, Rantz, & Skubic, 2008, p. 197), however recent studies indicates that ubiquitous monitoring and surveillance raises a number of issues in regards to self-determination and ethical issues regarding privacy violations and potential exploitation. Consequently, these factors can influence an individual's perception of themselves and their home environment, thus contribute to rejection of technology, more stigmatization and isolation with the elderly, particularly those with dementia (Novitzky, et al., 2015, pp. 1-32). A study conducted on women with dementia who live alone by (Frazer, Oyebode, & Cleary, 2011, p. 685), revealed that women who were identified with dementia would cover up their mistakes of forgetfulness by isolating themselves from their families and social circles. It can be assumed that assistive technologies can impact on personal agency and social engagement.

(Thielke, et al., 2012, p. 477) posit "people's willingness to adopt technologies that intend to improve safety and security through health-related behaviors would be limited unless the connection between behavior and the improved security were obvious, self-relevant, and conditioned by experience". Persons with early stages of dementia have special needs which may not be clear to ICT/ AAL developers and researchers, thus stressing the importance of determining who will benefit from the technology as "social and cultural boundaries of surveillance" continue to being addressed (Thielke, et al., 2012, p. 477).

In addition, personal preferences with respect to ITC mediums can widen the "digital divide" and quality of care which affect the acceptance of the technology in older adults (Novitzky, et al., 2015, p. 32, Thielke, et al., 2012, p. 477). "Maslow's model suggests that the insecurity that arises out of being watched by a surveillance technology might impair one's capacity to satisfy security needs and to progress to higher-level needs (Thielke, et al., 2012, p. 477).

Level 3: Belong and Love Needs

Maslow's model Level 3 identifies an individual's need to feel love and be accepted. Love and belonging provide immediate and

direct benefits even for individuals with cognitive impairments (Thielke, et al., 2012, p. 478). Technology has provided many opportunities for communication over space and time through telephone, email, social networking and asynchronious communication such as skype in real time (Thielke, et al., 2012, p. 478) thus allowing individuals to stay connected with one another on a regular basis. This is particularly important for families who live away from loved one who are experiencing dementia and other disabilities. Research conducted by (Thielke, et al., 2012, p. 478) revealed that dementia patients demonstrated more concern over human contact than safety and security, and that behavioral issues can increase when these needs are not met. (Scholzel-Dorenbos, Meeuwan, & Olde Rikkert, 2010, p. 114) further support this notion and comment that social needs such as daytime activities and interaction with others are often unmet with individuals with dementia and manifest into psychological issues such as depression and anxiety.

Althought technology may provide some sense of belonging, intimacy and attachment as demonstrated with the use of robotic pets and robots designed to support social engagement for dementia patients, there is insufficient evidence that suggests these technologies may actually create a "true attachment with humans"

(Thielke, et al., 2012, p. 478). Many studies indicate that loneliness is a common factor with senior populations and "the growth of social networking websites for older adults may attest to their eagerness for even virutal connection with others" (Thielke, et al., 2012, p. 478). This might suggest that AAL technologies such as robots for design for social engagement and activities that are pleasurable may be more valued and accepted by older people and could potentially meet not only physiologica and safety needs but also higher needs (psycholigical) as belonging and confidence.

Level 4: Esteem Needs

Confidence and respect are derived from an one's ability to carry out activities that are important to an individual. (Thielke, et al., 2012, p. 478) posit that restrictions on "someone's agency for carrying out such activities can undermine his or her esteem". Research continues to show that seniors, even those experiencing a disability such as dementia wish to maintain their independence and will often portray themselves as healthy and capable (Thielke, et al., 2012, p. 479).

For example, literature reviews in this study revealed that seniors prefered to age in their own homes in order to maintain independence and autonomy. (Thielke, et al., 2012, p. 479) provide

the following example: "older adults become upset when they are advised to move out of their own homes into assisted living or nursing facilities, where they will have less responsibilities, but readier satisfaction of physical and belonging needs" however, constant supervision of healthcare staff and fixed schedules compromise self-determination. In the same way, an individual could be frustrated by technology which provides frequent reminders to take their medication and to exercise more or have ones activities monitored. As (Thielke, et al., 2012, p. 479) note " technologies that purport to know more than the user about the users' health behaviors, or directed rather than encouraged change…could meet with resistance because they appear to undermine users' capability to care for themselves and mange their own health". One can conclude that personal autonomy is a key factor to satisfy esteem needs. However, if we draw on Malsow's model "esteem focused reinforcement might fail to achieve benefits in many health-related behaviors" (Thielke, et al., 2012, p. 479). Most research indicates that rejection of AAL technology use is a result of seniors wishing to exercise more control over the use of techmnology and not have technology control them.

Level 5: Self-actualization Needs

In Mazlow hierarchy "The highest level of human needs involves being true to one's own nature and seeking self-fulfillment through creativity" (Thielke, et al., 2012) and can only be met once all lower levels have been achieved. Artistics pursuits, professional, benevolant and spiritual activities can be highly motivating in meeting this need. "Living at this level can lead to peak experiences and even transcendence the experience of deep connection with others, nature and God, and the perception of beauty, truth, goodness, and the sacred in the world" (Zalenski & Raspa, 2006, p. 1121). It is important to note that motivations behind self-actualization needs differ from the other levels as "they are not carried out in order to accomplish another end (e.g. food, water, belonging, a sense of security), but are rather ends in and of themselves" (Thielke, et al., 2012, p. 480), hence self-acutalization needs are not necessarily health-related needs nor are they the same for each individual. For example, in (Frazer, Oyebode, & Cleary, 2011, p. 683) study with women who experieced dementia and lived alone, the study revealed that "Participants talked about passing on values or skills to others" such expectations in life as a imigrant to a new country or dressmaking skills as a means to deal with the threat of loss of identity. Once again, if we draw on Maslow's model of

self-actualization, one could conclude that there is a desire for individuals to achieve this need even with individuals who have disabilities.

In Survey A conducted with healthcare experts in this study indicated that age health related issues are fluid in older person's physical and cognitive states, and they can change at any given time. They may be ill or disable at one moment and highly functioning at another time. This scenario can present challenges in AAL technology applications on many levels including the selection of appropriate technological interventions. Survey A experts also noted that injuries can escalate after a fall for example, due to fear of falling again. Technology cannot prevent someone from falling and thus would not meet security and safety needs directly with the individual but perhaps more so with caregivers who would value the monitoring and surveillance aspects of technololgy.

Due to the progressive and devestating nature of dementia, individuals with the diseaase are most challenged in reaching self-actualization due to memory loss. Memory is linked to shaping an individual's sense of self-awareness and positive social experiences which contribute to one's self-worth. If these elements are degraded over time, then one must consider the effectiveness of technology in

asssiting self- actualization. As (Thielke, et al., 2012, p. 480) suggests that most technologies are "based on material actions with reminders and suggestions for users", and do not address self-actualization due to the very complex nature of self-acutalization where by "methods and goals are highly personalized and hard to measure". However, they feel with technological advancement these needs may be addressed in some capacity.

There is a great interest in developing and integrating ambient assistive technologies and smart home environments, however studies are indicating that currently there is little evidence which supports the effectiveness of these technologies on users health and quality of life (Scholzel-Dorenbos, Meeuwan, & Olde Rikkert, 2010, Thielke, et al., 2012, p. 471). Survey A healthcare experts concurred with this notion. This may be a result of user needs not being clearly understood by technology developers, researchers, heathcare providers and consumers, limitation of the technology itself and lack of "real-world testing (Thielke, et al., 2012, p. 481).

For example, research continues to show that seniors are concerned about their finances which fall under safety and security in Maslow's model. Needs for financial security may not necessarily be satisfied by technology. (Thielke, et al., 2012, p. 481) also note that

patients were found to be comfortable in missing a dosage and that technological reminders did not generate higher feelings of security. In fact, (Thielke, et al., 2012, p. 481) observed that "technologies that appear to diminsh the agency of users can undermine can undermine esteem level. The nature of self-actualization in Level 5 is highly complex and very personalized by preferences and processes. Once again, current technology cannot anticipate and customize responses to diverse human needs at this level (Thielke, et al., 2012, p. 481).

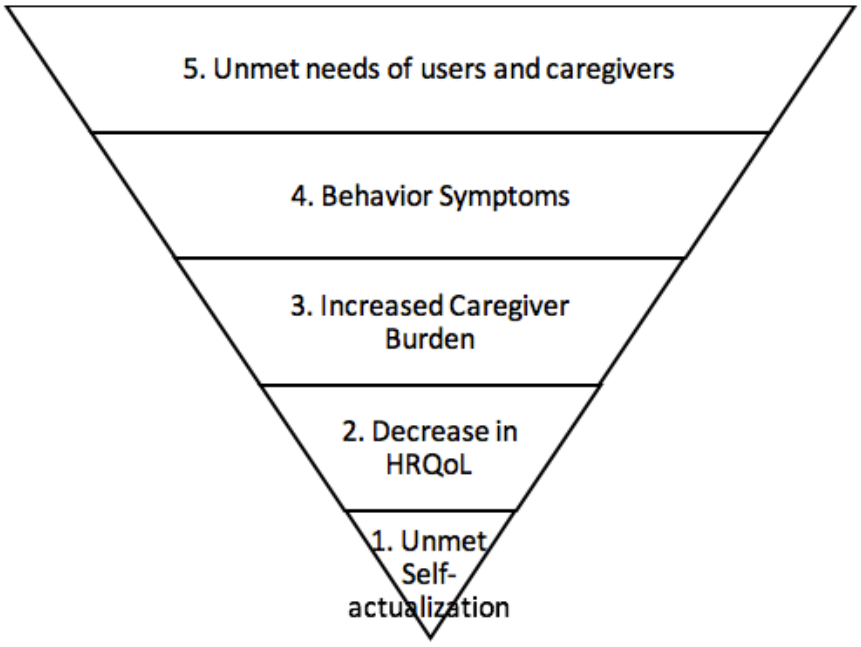

Figure 7: Maslow Hierachy of Needs in relation to dementia. Adapted from (Scholzel-Dorenbos, Meeuwan, & Olde Rikkert, 2010)

Studies conducted by (Scholzel-Dorenbos, Meeuwan, & Olde Rkeert, 2010) posit that too many unmet needs of individuals with dementia and their caregivers cause behavior issues and increase other needs in caregivers. Institutionalization is the final consequence. The application of AAL technology has the potential to support individuals with dementia and caregivers.

Table 2 demonstrates opportunities for AAL technology interventions that can assist the traditional duties of caregivers.

Table 2: AAL Support of Fulfilling Maslow's Hierarch of Needs for Caregivers of Dementia Individual

	Needs 1-Lowest 5-Highest	**Description**	**Caregiver Experiences and Challenges**	**AAL Support**
1	Physiologic (Basic)	Food, water, warmth, sleep, equilibrium, excretion, sex	Constant physical presence, caregiver fatigue	Prompting systems, robotics for assisting in tasks.
2	Safety + Security (Basic)	Security of body, health, family, property, morality and employment	Constant physical presence, caregiver fatigue, health issues, job loss due to responsibilities	Sensor networks, alert systems, GPS
3	Love + Belonging (Psychological)	Intimacy, friendship, family, community	Isolation due to constant physical presence in care of older person	Smart phone technology, email, skype

4	Esteem (Psychological)	Self-esteem, respect for self, respect for others, lack of accomplishment	Opportunities for personal growth diminished by responsibilities, isolation, anger, fear, fatigue	AAL technology can reduce physical presence
5	Self-actualization	Achieving full potential, creativity, morality,	Opportunities for personal growth diminished by responsibilities, fatigue, lack of motivation	AAL technology applications can increase time for self

The literature reviews conducted on the application of Maslow's Hierarchy of Needs model in the domains of dementia and assistive technolgy suggest that Maslow's model can be a valuable tool as a starting point to gaining a deeper understanding of dementia patients and their caregivers. However each indivudual's needs are unique as are their experiences and perceptions. (McLeod, 2016, Thielke, et al., 2012, p.473) suggest that reaching actualization is not a simple linear process. They argue that individuals can operate on several levels simultaneoulsy and that movement between levels is fluid and based on the individual's needs at any given time. For example, living in poverty does not prevent an individual from feeling love or having a sense of belonging. Dementia patients and informal caregivers have many health-related issues which are "unrecognized and unmet by

professionals and informal caregivers (Scholzel-Dorenbos, Meeuwan, & Olde Rikkert, 2010, p. 113), notably informal caregivers who experience depression and anxiety in caring for loved ones.

In respect to technology and smart home applications in assisting aging populations, particularly those experiencing early stages of dementia, (Thielke, et al., 2012, p. 481) posit Maslow's Levels of Need "clearly do not explain every aspect of how older adults perceive, use, or benefit from technologies, but this researcher suggest that they can be a practical tool in assessing and predicting motivation and behavior around technologies".

Lastly, Maslow's Hierarchy of Needs model may help to differentiate the needs of users versus caregivers, and improve technology effectiveness and appropriateness in order to advance technology adoption with end users in home environments. In addition, Maslow's model may be a useful tool for developing pleasing aesthetic design in the technology itself, particularly sensor and surveillence technology. As noted previously in this study, architectural design in not currently considered in the research and development of AAL technology environments. A integrated design process may result in more pleasing environments which reduce medicalization of home environments.

3.5 Case Study: European Next Generation Ambient Assisted Living Innovation Alliance Roadmap (AALIANCE2) 2014

Europe nations are experiencing similar social and economic challenges as other developed countries around the world. Current trend in aging populations and low birthrates has generated a new focus in addressing the needs of the growing demographic of elders in order to mediate the impact this trend will have on healthcare and social costs associated with aging. (AALIANCE 2, 2014, p. 12). In response to the growing concern and issues surrounding aging, the European Commission initiated and funded the ALLIANCE and ALLIANCE2 (2008-2014) programs to seek out new initiatives and policies in the domain of ICT solutions and AAL technology to support aging in place, extend employment years and maintain older populations as valued contributors to society. The ALLIANCE program brings together a diverse network of ICT and AAL stakeholders which include academic organizations, healthcare professionals, user associations (end users and informal care givers), designers, ICT developers, manufacturers and entrepreneurs, and other private and public sector organizations in order to ensure the inclusion of diverse perspectives for "social, service and technological contents" (AALIANCE 2, 2014, p. 7).

The program aims to improve efficiency and effectiveness in the social care of aging populations, improve quality of life, provide support and assistance in areas of physical and cognitive decline, and delay institutionalization through the application of assistive technology in daily living. Additional goals of the program include motivating older individuals to stay active, preventing social isolation and maintaining social inclusion (AALIANCE 2, 2014, p. 5).

Since 2008, the program has funded over a hundred other studies related to the application of ICT-based solutions, including the CIP-PSP program "ReAAL" which is currently installing 7,000 apartment units with ICT technology across Europe for trial testing. (AALIANCE 2, 2014, p. 2). ReAAL is an open service platform (universAAL) which evaluates interoperability of products and systems for pilot studies.

AALIANCE2 facilitates on-going forums, workshops and educational opportunities to advance the agenda for ambient assisted technology research, design and deployment as a means for aging well in society.

The final results of the studies carried out informed the first guideline "AALIANCE Ambient Assisted Living Road Map" (2010)

followed by "ALLIANCE2 Ambient Assisted Living Road Map (2014) which is more comprehensive, rich in data and provides analysis of aging societal needs, a strategic research agenda for AAL, an analysis of the AAL market, cost/profit models and business models for implementing ambient assisted living solutions are included. The AALIANCE2 roadmap also provides insights into standardization issues and potential recommendations, and additional opportunities to develop a sustainable network in the domain of AAL Technology.

The AALIANCE2 Ambient Assisted Living Roadmap is a comprehensive, 144 page, guideline for AAL technologies currently found in literature reviews and internet searches. A North American guideline for AAL technology has not been found to date. The AALIANCE2 Roadmap is examined through three lenses: 1) visual legibility and structure; 2) accessibility features for assistive computer technology such as screen reader; and 3) content usefulness. These lenses are considered key elements in the design of future guidelines.

Visual Legibility and Structure Assessment

AALIANCE2 roadmap is available on the internet in PDF format and can be converted to a word document. The structure of the roadmap is similar to that of a detailed report with very long narratives

in text format for all sections, supported by minimal graphics, images, tables and charts. The roadmap is rich in data which requires many hours of reading. Consideration should be given to creating an alternative format which is more streamlined and highlights key concepts as quick reference points for professionals. This could provide a more efficient measure to improve access to information in a timely manner and comprehension of information.

Accessibility Assessment

The ALLIANCE2 roadmap is not a fully accessible document with assistive technology. Although an accessible font such as Verdana is utilized, font sizes for body text and headings are smaller than those recommended in accessibility guidelines. The assessable guidelines recommend 12pt for body text and 12-20 pt. for all other heading types. A 'read out loud" test conducted in the Microsoft accessibility application revealed that many areas of text within the roadmap are not properly formatted for this application. Graphs, images, charts and tables do not provide alternative text, therefore assistive technologies such as screen reader will not be able to translate the contents of these elements. The rich content of text is single line spaced and not formatted to the recommended 1.5 line accessible spacing. As a result, individuals who have visual and cognitive disabilities may find the

current format presents challenges with comprehension of data. Future design of guidelines should ensure that all aspects of a guideline are accessible for a spectrum of readers.

Content Usefulness

The publication is composed of nine key sections which provide a rich narrative for each stage of the roadmap. The roadmap is constructed in a systematic approach: rationale for the project is provided; the methodology used to develop the study; overview of the main needs and requirements of all stakeholders with examples of personas for various user scenarios; status of the AAL market, description of the AAL service areas, description of the main Key Enabling Technologies (KETs) and research priorities; key issues to the implementation of AAL technologies including ethical issues; main recommendations by the AALIANCE Network for AAL stakeholders; and conclusion identifying social, technical and legal issues. Topics are in depth and address many conflicting issues surrounding AAL technology and its adoption to home, work and community environments. Description of the research methodology and methods in the roadmap contributed to an authentic and authoritative resource for many diverse stakeholders.

The ALLIANCE2 study was conducted by the AALIANCE2 consortium in collaboration with a diverse team of stakeholders. These included users, caregivers and families, organizations providing services for seniors, industry and organizations. Using an integrated design delivery model contributed to creating rich scenarios which are easily understood.

Key objective and barriers identified in this case study concur with other literature reviews and surveys with industry experts in this study.

Key objectives were identified in the case study:

1. Raise awareness in the application of AAL technologies as a viable solution for supporting aging populations and share good practices.

2. Establish consensus among all stakeholders.

3. Develop and promote policies to stimulate innovation in the public sector.

4. Resolve technical and regulatory barriers to market implementation.

5. Provide stimulus for research, innovation and funding.

Key Barriers to AAL Technologies identified in the case study:

1. Use of ICT technology is not optimized for use in AAL services.

2. Lack of extensive trials of AAL services in compliance with current European and national laws and care systems.

3. Inadequate sustainable business models, support policies, certifications and standards real care and market constructs.

4. Lack of end user perspectives in the research, design development and implementation stages in order to properly satisfy user needs.

5. People perceive technologies as invasive and could alter real habits in order to avoid negative consequences.

6. In adequate guidelines for privacy and security issues surrounding surveillance and data management.

7. Lack of standards and references for designing systems particularly in the case of third party applications.

The ALLIANCE2 Ambient Assisted Road Map, as a case study, demonstrated that an inclusive approach employing an integrated design process between all stakeholders resulted in an robust guideline. The project was able to establish a broad network of stakeholders, a viable roadmap and strategic plan with short and long term goals and definitions for standardization requirements. The project has successfully advanced an interest in integrating AAL technology as a means to support for aging population. Conferences, workshops and online forums connected to AALIANCE2 contribute to sustaining ongoing interest in AAL technology, advancing market integration and growing the knowledge base in this domain.

The AALIANCE2 Ambient Assisted Road Map case study will be useful in developing future guidelines for professionals who conduct research, design and provide services in the domain of aging populations and Ambient Assistive Technology. The review of the case study confirmed that the architectural design/build community perspectives continue to be excluded in AAL technology research for the built environment.

3.6 Professional Learning

Designer's needs, resources, tools and learning approaches change over the course of their careers, in addition to "how they think, how they practice and how they interact with their clients" (Daley, 1999, p. 133). This raises the questions of how do designers build knowledge and skills as they progress from novice to expert levels and how do they apply new knowledge to practice on an ongoing basis? In order to develop a conceptual template for a future AAL technology guideline, it was essential to examine learning and innovation theories used in education and professional development (Daley, 1999, p. 133). The following discussion will provide insight into understanding the relationship between cognitive processes in learning stages.

3.6.1 Bloom's Taxonomy of Educational Objectives

Bloom's Taxonomy of Educational Objectives is commonly used model in academia to development and structure curriculum, course content and learning outcomes (Betts, 2008, p. 99) based on a defined structure or "cumulative hierarchy" (Krathwohl, 2002, p. 212) which emphases the mastering of simple to abstract thinking and reasoning (cognition). Developed in 1956, the model has been used as a basis in the development of alternative cognitive frameworks for

learning. Bloom's Taxonomy is comprised of the following six levels in which each level must be mastered in order to progress to the next level of cognition.

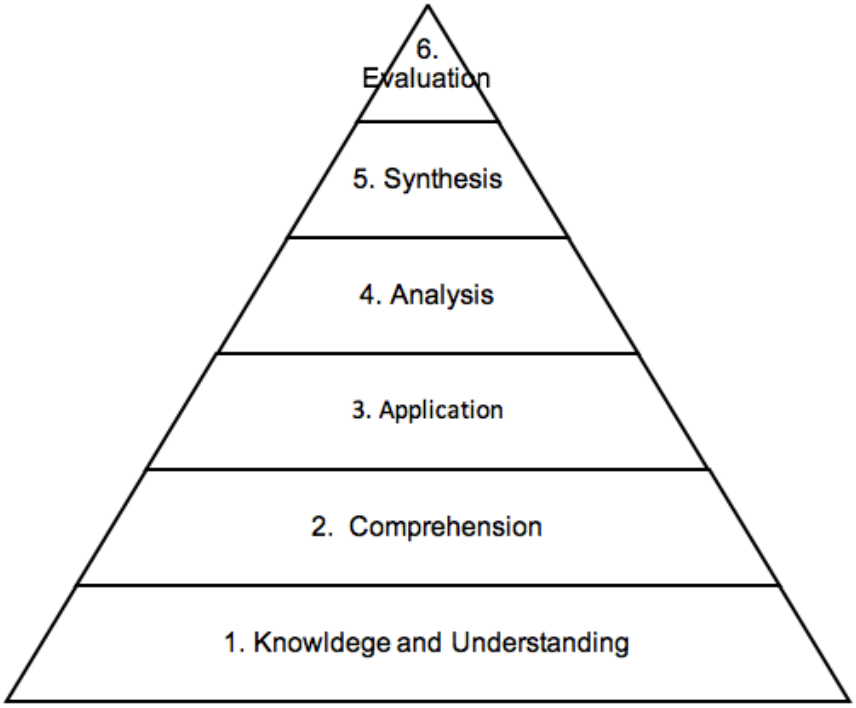

Figure 8: Based on original Bloom's Taxonomy of Educational Objectives.

The following modified model adapted by (Betts, 2008, p. 101) for graduate programs proposes a simpler structure which can be adapted for the professional development of designers with diverse

backgrounds. Key concepts from Bloom's original taxonomy are still retained in this reduced model:

Lower Levels: Knowledge and Comprehension

- Basic recall of information, discovery, observation, listing, locating, literal understanding, translating, summarising, and demonstrating.

Medium Levels: Application and Analysis

- New knowledge is applied in new ways using experimentation, problem solving methods, knowledge in broken down in parts, manipulated, redesigned, pattern recognition and analysis, organization of ideas, and identification of trends.

High Levels: Synthesis and Evaluation

- New innovations based on old concepts, modifying, predicting, assessing, evaluating outcomes, judging, recommending, rating.

Bloom's Taxonomy model provides a systematic scaffolding approach to reaching educational objectives by creating a common language to support "communications across diverse persons and subjects" (Krathwohl, 2002, p. 133). This model validates the need to

incorporate a structure in the design of the conceptual template for AAL technology in order to meet the learning continuum of novices to experts.

3.6.2 Exploration of Novice to Expert

In Canada professionals in the field of design and construction are required to complete formal institutional education followed by the requirement to participate in mandatory educational programs as part of regulatory body requirements. As a result, "the connection between learning and the development of practice is an issue at the heart of continuing professional education" (Daley, 1999, p. 133). Studies conducted by (Dreyfus & Dreyfus, 1980, Daley, 1999) determined that professionals move through 5 stages in their learning continuum and highlight that experiences guide their thinking and behavior in practice as they move toward to expert level. Research indicates that most teaching structures are geared to novices (Daley, 1999, p. 133) and that little data is available on the processes used to adopt new knowledge in practice (Daley, 1999, p. 134). The following discussion will focus on key theories of experience based learning and the implications for early adoption into practice which wil be discussed in later in Everett Roger's Diffusion of Innovation section.

Research by (Daley, 1999, Dreyfus & Dreyfus, 1980) describes the following developmental stages from novice to expert based on presecent studies conducted with nurses and pilots.

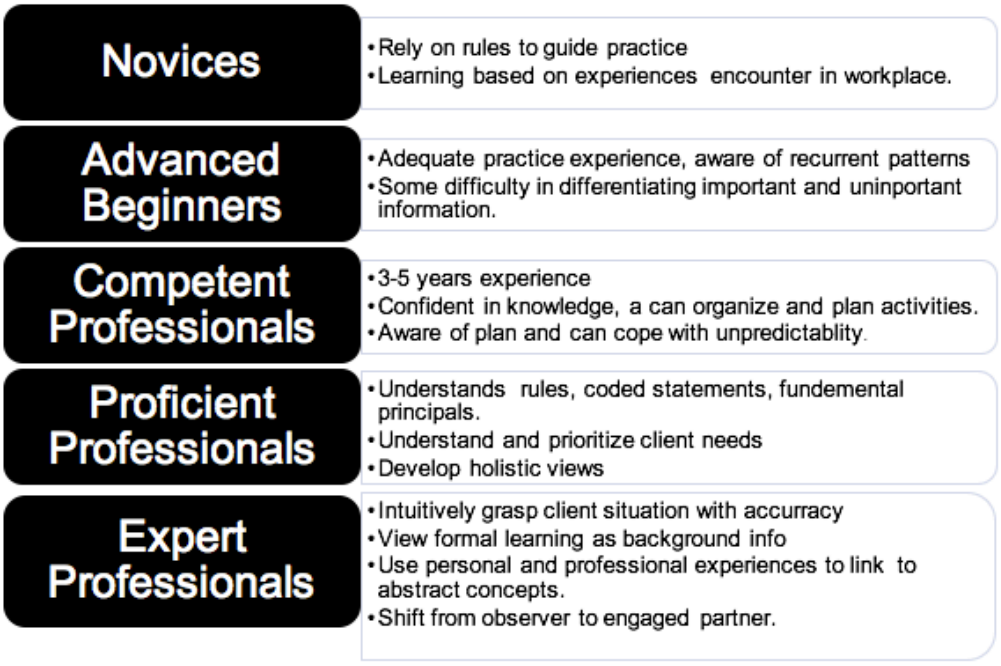

Figure 9: Five phase of developmental continuum of professional learning adapted from (Daley, 1999, Dreyfus & Dreyfus, 1980) models.

Novice:

- Have little experience with real life situations and rely on rules to understand contexts. In addition, they rely on older peers for guidance.

Advanced Beginners:

- Acceptable performance based on some life experiences.
- Able to perceive recurrent meaningful patterns but has difficulty in determining important factors vs. unimportant factors in situations.

Competent Professionals:

- 3/5 years experience enables them to organize and plan projects tasks and maintain awareness of the plans.
- Have some ability to cope with unexpected situations

Proficient Professional:

- Understand rules, coded statements and fundemental prinicipals.
- Understands and prioritizes client needs.
- Develops holistic views.

Expert Professional:

- Intuitive and is able to grasp situations quickly and focus with accurracy.

- Recognizes similar pattern recognition across hetergenous client situations.
- Construct knowledge based in context of practice and client needs.
- Create mental blue print of client needs and ensure that they have the required information.
- Perceive formal learning as background information to enhance knowledge and link new information to experiences.
- Use personal and professional experience to link to situations.
- Obtain knowledge primarily from reading, library research and collaboration with colleauges who are knowledgable and experienced colleagues.
- Positions shiftes from obsever to engaged performer and partner.

Analysis of the model demonstrates that professional's developmental continuum is primarily influenced by their experiences in practice as they move further away from novice to expert. The model indicates that "professional's working paradigm shifts from

reliance on abstract principals to concrete past experiences (Daley, 1999, p. 135). In addition, the model demonstrates that expert learning is usually a self-directed process (Daley, 1999, p. 140).

3.6.3 Everett Roger's Diffusion of Innovation Model

Roger's Diffusion of Innovation (DOI) theory has been commonly used to explain the adoption rate of networked information technology by individuals (Lyytinen & Damsgaard, 2001, p. 174). It is defined as "the speed with which an innovation is adopted by members of a social system" (Rogers, 1995, p. 206). It is a gradient indicator that measures the number of people who adopt new ideas within a specified period of time (Rogers, 1995, p. 206).

Networked information technologies such as AAL technologies are perceived as complex structures comprised of "complex problem solving elements" which are challenging to manage and control (Lyytinen & Damsgaard, 2001, p. 175) because they involve many stakeholders and components i.e. they include electrical supply systems, chemical industries, transportation systems, physical artifacts and manufacturers, regulatory bodies and scientific communities (Lyytinen & Damsgaard, 2001, p. 175).

The following factors explain "individual adoption decisions or intentions to adopt" (Lyytinen & Damsgaard, 2001, p. 174):

1. Access to information
2. Personal views and experiences of individuals
3. Context of social systems, norms, organization supports
4. Availability of adopters
5. The nature of communication systems (type and frequency at various stages of innovation)

Roger's classification of the five adopter categories can be a useful tool in explaining the slow adoption of AAL technology application to home environments for the elderly which are influenced by many conflicting factors within local and broader social and organizational constructs.

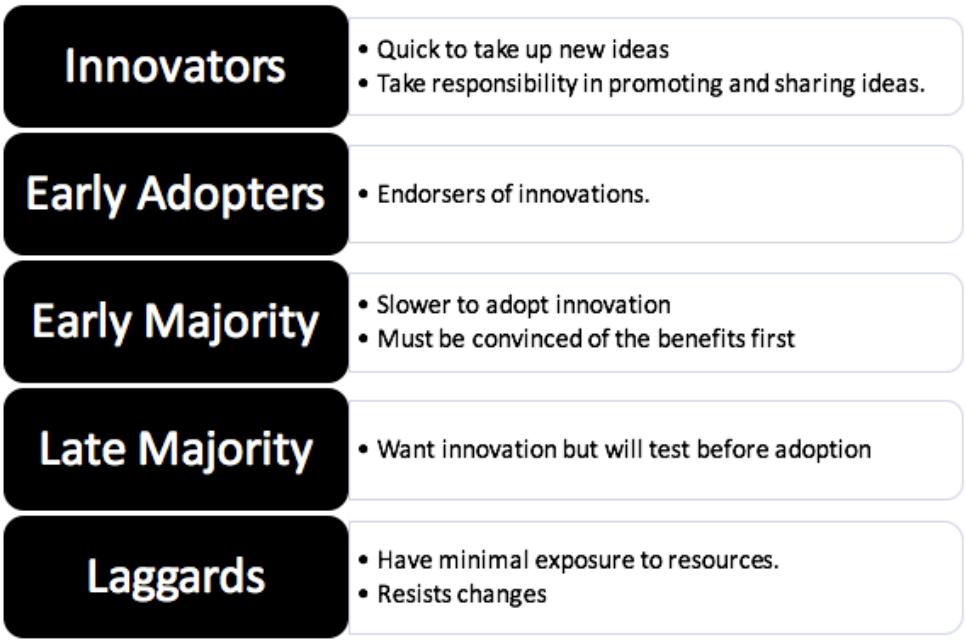

Figure 10: Temporal Levels of Adoption of New Ideas, Technology and Practices, based Everett M. Roger's Diffusion of Innovations Model (Rogers, 1995).

Analysis of the DOI theory suggests that the success of the adoption of innovation such as AAL technology may be heavily reliant on communication, collaboration and access to information.

This notion can be examined through several lenses. For example, as individuals age, mobility and social interaction become issues due to physical and cognitive decline. Social circles consisting of friends may also decline due to natural death and result in social

interaction primarily with family members. Seniors at this stage in life are depended on family members for information and decision making. Perspectives of family members are informed by their own social status, life styles and experiences and if these are limited (laggards), then family members as sources for information or decision making, may contribute to slow or no adoption of innovations which may improve QoL in older people. In this case, the DOI theory also correlates with some levels of Maslow's Hierarchy of Needs with respect to safety, security, belonging and esteem for example. AAL technology can play a valuable role in addressing these needs however, if family members fall into the laggard or late majority classification, then the success of AAL technology adoption for a loved one may be threatened. In addition, older persons who have a lifetime of ingrained practices are less likely to populate earlier categories of Roger's model.

At the other end of the DOI scale, members of the design community are more likely to fall into early adopters and innovators classifications. It can be assumed that design communities are creative, inquisitive, problem solvers, have a high degree of opinion and are generally good communicators; characteristics which fall under these to classifications. In addition, design communities work in highly

collaborative work environments which exposes them to a wide range of social, business and technological constructs. One can also draw a correlation between the DOI model and the developmental continuum model for professional practice in which expert professional learning is grounded in client needs and practice settings which lead to active integration of concepts (Daley, 1999, p. 141). This would suggest that design communities can play an active role in adopting and promoting innovations such as AAL technologies from a stance of early adopters and innovators since satisfying client needs through innovation is at the forefront of their practice.

To conclude, it was beneficial to the development of a guideline template to review innovation theories due to the complexities surrounding new innovations in technology and the many factors which impact on their rate of adoption. Review of educational theories relating to the developmental continuum in professional practice gave insight into learning tools and resources which professionals use as they move through their careers.

3.7 Survey A: In-person Interviews with Experts in AAL Technologies

Survey A was conducted with a pool of building automation experts (BA) and healthcare experts (HC) across Canada. Four Building automation experts consisted of engineers in commercial building automation, electrical mechanical, communications and network systems. Two healthcare experts consisted of academic researchers in the field of aging, dementia and AAL technology with backgrounds in occupational therapy, science and philosophy. Healthcare experts were actively engaged in developing and testing AAL technology applications in prototype lab settings with dementia patients and caregivers. Three Survey A participants self- identified as having experience as a caregiver for an older family member with dementia or other age related health issue. Results from the survey are summarized in the following tables.

Table 3: Summary of key research areas in aging and AAL Technology				
	Main Themes	Experts		Total
		BA N=4	HC N=2	% N=6
1	Research in Canada focused on aging, dementia and associated risk.	25% 1/4	100% 2/2	50% 3/6
2	Cognitive and mental health of people with dementia focus of AAL research	25% 4/4	100% 2/2	50% 3/6
3	Currently, greater interest in how AAL technology can assist caregivers.	50% 2/4	100% 2/2	67% 4/6
4	Technology is being examined for indoor and outdoor use.	50% 2/4	100% 2/2	67% 4/6
5	Caregivers want help with falls, wandering and assistance with tasks	50% 2/4	100% 2/2	67% 4/6
6	Insufficient evidence of AAL technology reduces falls, better for monitoring health risks	N/A	25% 1/2	17% 1/6
7	Interest in GPS, wearable devices, sensor and robotic technology	N/A	100% 2/2	33% 2/6
8	Separate studies underway for ethical issues with monitoring and privacy	50% 3/4	100% 2/2	83% 5/6
9	Many conditions in older people temporary, must systematically diagnose	N/A	50% ½	17% 1/6

10	Injuries escalate after accident. Fear of reoccurrence. Technology cannot help.	N/A	50% 1/2	17% 1/6
11	Technology is not final solution and must be combined with accessible design	50% 2/4	50% 1/2	50% 3/6
12	Accessible Design is more valued than assistive technology	50% 2/4	50% 1/2	50% 3/6

The data from Table 3 reported that aging, dementia and associated risk factors are the focus of Canadian research. Cognition and the mental health of people with dementia is the focus AAL technology research. Greater interest in AAL technology supporting caregivers. Separate studies are underway for ethic issues with monitoring, surveillance and privacy as these are factors which affect technology adoption. Survey A participants concurred that there is insufficient evidence that AAL technology will prevent accidents such as falls from occurring but is useful in monitoring. Lack of evidence is due to the lack of real-world testing. 50% of the participants reported that accessible design was valued more than AAL Technology.

Table 4: Summary of barriers to knowledge acquisition in AAL technology				
	Main Themes	Experts		Total
		BA N=4	HC N=2	% N=6
1	Do not engage designers and architects in frontline research, design and testing of AAL technology	75% 3/4	100% 2/2	83% 5/6
2	Design professionals not engage due to funding issues, demand for fees and lack of academic status	N/A	50% 1/2	17% 1/6
3	Participant did not think to include design professionals	75% 3/4	50% 1/2	67% 4/6
4	Researchers are focused on design and testing of technology with end users only	N/A	100% 2/4	50% 3/6
5	Most research in prototype phase, lack of real world test sites	50% 2/4	100% 1/2	50% 3/6
6	Academic researchers are trying to work with builder to advance AAL application	N/A	25% 1/2	17% 1/6
7	Consumers need information and help in selecting devices and service	25% 1/4	50% 1/2	33% 2/6
8	Most information is web-based, therefore excludes individuals with no relationship with service providers	25% 1/4	50% 1/2	33% 2/6
9	Shortage of service providers who have compatible systems with AAL technology	50% 2/4	50% 1/2	50%

				3/6
10	Challenges in keeping up with technological advancements	100% 4/4	50% 1/2	83% 5/6
11	Consumers want off-the-shelf products and reliable information	25% 1/4	50% 1/2	33% 2/6
12	Lack of unified compliance standards, based on geographical locations and authorities having jurisdiction	100% 4/4	N/A	67% 4/6

The data from Table 4 reported that experts have not engaged design professionals in front-end research, development and testing of AAL technology due to funding limitations and lack of academic status in formal research domain but also further commented that they would like to if the opportunity presented itself. Lack of "advanced" academic research training such as those situated in graduate programs may partly explain this bias. Researcher primarily focused on the technology itself and engagement of end users including caregivers. This may be indication that research in AAL technology is still in early stages and research into the interrelationship between architectural design and the technology is not a priority at this time. However, HC researchers noted that they were trying to engage home

builders as way to mediate the lack of design community engagement in their research.

Experts indicated that most AAL technology is still in prototype phase and lacks real world sites testing and as a result, published information is limited. This may explain why there was a lack of data to be found on the interrelationship between architectural design and AAL technology.

Experts reported that currently, there is a shortage of key telecommunications service providers who have compatible systems in place for AAL technology and challenges with keeping up with ever-changing technological advancements were contributing factors to slow adoption of technology. Healthcare experts noted that consumers lacked information on assistive technology and resource that supports consumer education and assistance in selecting appropriate devices and services. In addition, there are no sources (such as Consumers Report) which rate product and vendor performance and reliability.

Building automation experts highlighted a frustration for the lack of compliance standards in North America with cabling as cable is the backbone of technology. Cabling standards are based on geographical locations and authorities having jurisdiction. For example, climatic

conditions in Florida differ from those of Alberta and will have an impact on cable stability in relation to fire codes and safety. Building automation experts expressed a desire for a more integrated design approach to technology development and application.

Table 5: Technology (BA) and Healthcare (HC) Experts identifying key barriers in telecommunications, building automation and AAL technology adoption in home environments.

	Main Themes	Experts		Total
		BA N=4	HC N=2	%
1	Wireless technology is not a standard application in building design	100% 4/4	50% 1/2	83% 5/6
2	People without access to telecommunications are excluded from benefits of technology	N/A	50% 1/2	17% 1/6
3	Current business models do not support adoption of technology with developers, builders and service providers	100% 4/4	50% 1/2	83% 5/6
4	Technology needs to be added to as new standard (utility) with authoritative jurisdictions	100% 4/4	50% 1/2	83% 5/6
5	Residential market is transactional for developers and not a recurring revenue market (aesthetic upgrades only)	25% 1/4	N/A	17% 1/6

6	Residential developers not leveraging technology as an upgrade feature in home sales	25% 1/4	N/A	17% 1/6
7	Home automation is elitist due to high customization and costs	25% 1/4	50% 1/2	33% 2/2
8	Consumers lack education and knowledge in home technologies	50% 2/4	50% 1/2	50% 3/6
10	Consumer not motivated to upgrade telecommunications services due to lack of vendors for follow-up services and costs	50% 2/4	50% 1/2	50% 3/6
11	Sales of automation products are marketed to men. Industry does not promote technology well to women	25% 1/5	N/A	17% 1/6
12	Technology capabilities of devices not being optimized by consumers due to lack of education	25% 1/5	N/A	17% 1/6
13	Wireless and internet access challenging for rural areas	50% 2/4	N/A	33% 2/6
14	Power blackouts impact on AAL technology and will require backup power strategies	100% 4/4	50% 1/2	83% 5/6
15	Natural and artificial lighting present challenges for camera technology	N/A	100% 2/2	33% 2/6
16	Old infrastructure creates barriers to adopting technology	50% 2/4	50% 1/4	50% 3/6

17	Higher hydro bills for seniors with more devices and equipment used to support daily living	50% 2/4	N/A	33% 2/6
18	Changing batteries is key issue with sensors and equipment	50% 2/4	100% 2/2	67% 4/6
19	Diffraction issues with sensor signals due to material obstructions and room layouts	25% 1/5	N/A	17% 1/6

The data from Table 5 indicated that AAL technology is reliant on relationships with wireless service providers. Seniors without wireless technology will be excluded from the benefits of AAL technology, especially those who live in rural areas. Experts emphasized that wireless is not a building standard and changes to building codes needs to include wireless technology and other types of cabling as a basic home utilities. Experts concurred with findings in literature reviews that hydro bills are higher for seniors as they use more devices and equipment for daily support. Issues arise with power blackouts and lack of back-up power and old infrastructure creates issue for technology integration.

Building automation experts indicated that residential market is a transactional market for developers and not a recurring revenue

market. Residential developers generate revenues from aesthetic upgrades and have not leveraged technology as an upgrade to home design. They further noted that one key challenge with this notion is that there are no vendors who can provide follow-up technical support and manage homeowner data. In addition, experts indicated that consumers lacked adequate knowledge in home technologies, in particular women who have often been excluded from home technology marketing campaigns. As a result, it will be important to provide women with more educational opportunities to learn about home technologies as we move into the future based on statistical data presented in this study.

Experts noted that architectural obstructions, spatial layout and material specifications could create "de-fraction" in sensor networks which degrade their performance. Natural and artificial lighting conditions must be considered with camera use for monitoring in order to minimize facial distortion and manage lighting exposures.

This section of the Survey A was relevant to this study as it raised issues between the architectural design and technology that could not be found in the literature reviews.

Table 6: Summary of technology and home automation trends identified by BA and HC experts.

	Main Themes	Experts		Total
		BA N=4	HC N=2	%
1.	Wireless technology and network systems are an important component in the future design of homes and AAL technology	75% 3/4	50% 1/2	67% 4/6
2.	Smart Lighting and Visible Light Communications will be entering the residential market	50% 2/4	N/A	33% 2/6
4.	Power over Ethernet (POE) will lead in building design and be used within 5 yrs.	100% 4/4	N/A	67% 4/6
5.	Concepts of modularity used in commercial design could be useful in home design	75% 3/4	50% 1/2	67% 4/6
6	More technology in the home will increase need to more power sources	100% 4/4	100% 2/2	100% 6/6
7	Increased safety in home environments (sprinklers in homes)	25% 1/4	N/A	17% 1/6
8	Sensors, devices, equipment designed for energy efficiency	100% 4/4	50% 1/2	83% 5/6
9	Millennials are demanding more technology in homes	25% 1/4	50% 1/2	33% 2/6

Data from Table 6 identified Wireless technology and network systems as important drivers in the design of future homes environments. Many new technologies will be entering the market for home construction such as POE (power over Ethernet) smart lighting, visible light communications and sensors networks. Experts concurred that more technology will require more access to power sources. The application of POE and visible light communications in combination with mobile device interface suggests that light switches and wall outlets may begin to disappear in homes, for example. The integration of more sensors and cameras for AAL technology applications indicate new implications for spatial configuration, wall construction and lighting design. Life safety technology such automated sprinkler systems used in commercial applications are being integrated in new condominium developments and will also be making their way into the private homes.

Experts indicated that millennials are driving the demand for more technology in the home which they can operate from their mobile devices. Trends identified in this section of Survey A, indicate that the design community will need to give further consideration to new

approaches to practice and the design and construction of homes as they become ubiquitous ambient ecologies.

Table 7: Areas of opportunity for early adoption and knowledge acquisition of AAL technologies.

	Main Themes	Experts		Total
		BA N=4	HC N=2	% N=6
1	Mobilize knowledge at front-end of design and testing with larger interdisciplinary team	50% 2/4	50% 1/2	50% 3/6
2	Create new business models to support adoption of technology with builders and service providers (new upgrades)	100% 4/4	50% 1/2	83% 5/6
3	Technology adopted as new standard with authoritative jurisdictions (4th utility)	100% 4/4	50% 1/2	83% 5/6
4	Push for increased education and knowledge in home technologies with consumers to increase demand for technology	50% 2/4	50% 1/2	50% 3/6
5	Increase education and marketing of home automation to women	25% 1/5	N/A	17% 1/6
6	Promote and develop unified roadmap and framework in Canada and USA for AAL technologies and other building automation products and services	50% 2/4	N/A	33% 2/6

Collectively, the data from Table 7 analysed in Survey A indicated that research and development in the domains of AAL technology and home automation would benefit from a more robust integrated design process which engages diverse stakeholders including the design community at the front-end of research in order to promote and advance the adoption of AAL technology in home environments for the elderly and their caregivers. The study suggests that new synergies and innovations could be derived from the following:

1. Mobilize knowledge with a broader interdisciplinary team, which includes the design community, through all phase of research, design and testing of AAL technology.

2. Advocate for wireless technology as a standard utility in homes with authorities with jurisdiction to ensure that all people, regardless of personal status can benefit from diverse technology applications including AAL technology.

3. Engage developers and builders to leverage technology in home applications by creating new business models which are financially feasible and sustainable.

4. Increase awareness of AAL technology application for home environments through education and the development of a unified AAL technology framework in North America.

3.8 Survey B- Professional Design Practitioners

The purpose of the online survey was to gain an understanding of how design professionals in diverse design sectors go about learning a new topic and the kind of resources and tools they utilize in acquiring knowledge.

Participants consisted of 26 anonymous practicing licenced interior designers and architects. Work experience in the design and construction industry ranged between 5 and 35 years. It was necessary to include a wider range of design experience in order to identify potential shifts in learning approaches from novices to expert designers.

Q1- What was the last major new topic with regards to your design practice that you felt was the most important to learn about?

Q2- What kind of resources or tools did you use to learn about new topics or topics that you are trying to advance your knowledge about?

Q3- Rank the following design features in order of preference that you would prefer to see in information materials that are related to a new topic that you would like to learn about. Please check all that apply.

Q4- Please rate your current knowledge and expertise level with regards to Ambient Assisted Technology (AAL) in home environments.

Q5- What percentage of your practice represents residential design and construction? Please select the one that best describes your status.

Table 8: Q1 What was the last major new topic with regards to your design practice that you felt was the most important to learn about?

N=26 Code	Q1 Responses	Processes	Domain	Sustainability	Technology	Technical
		N=26	N=26	N=26	N=26	N=26
1	Design Thinking	1				
2	Risk Management	1				
3	Audio Transference					1
4	Design for Seniors		1			
5	Environmental Product Declaration			1		
6,15,22	Internet of Things				3	
7	Origin of Materials					1

8	User Experience of the spaces we create		1			
9	Emerging Trends		1			
10,18,24	Sustainability			3		
11	Evidence Based Design	1				
12	Precedents of similar projects in Europe		1			
13	Living spaces for the cognitive disability		1			
14	Student Engagement	1				
16	Accessibility	1				
17	Well Building	1				
19	WiFi and cyberspace security				1	
20	Collaboration in the workplace	1				
21	Healthcare Trends		1			
23	Change Management	1				
25	Mechanical Systems					1
26	Commercial realtor involvement in managing projects	1				
	Responses	35%	23%	15%	15%	12%
		9/26	6/26	4/26	4/26	3/26

Q1: Participants responses indicated that designers are interested in diverse range of topics. Participants ranked "processes" (35%) as a first priority and identified topics such as design thinking, risk management, change management, accessibility, evidence based

design in this category. Learning relating to "Domain" specific topics was ranked second at 23%. This may be an indication that first, participant skills and experiences fell more in-between the advanced beginner to expert professional range reflected in the developmental continuum of professional learning theory (Daley, 1999, Dreyfus & Dreyfus, 1980) and suggests that participant have shifted from "seeing situations as discreet, unrelated parts to seeing situations as part of a whole" (Daley, 1999, p. 135) and interconnected with past experiences. Second, the small gap in ranking between "process" and "domain specific" also suggests that designers were choosing learning topics which would enhance their skills and knowledge specific to their practice sector. However, the data did not ask designers if the topic they studied was based on an immediate project need or just for personal growth.

Table 9- Q2: What kind of resources or tools did you use to learn about new topics that you are trying to advance your knowledge about?

Preference	**High**	**Low**	**N/A**	**No Reply**
	N=26	**N=26**	**N=26**	**N=26**
Internet Searches	77%	19%	4%	
Responses	20/26	5/26	1/26	
Books	58%	34%	4%	4%
Responses	15/26	9/26	1/26	1/26

Academic Data Bases (Journal Articles)	50%	31%	15%	4%
Responses	13/26	8/26	4/26	1/26
CEU Seminars (In person)	47%	34%	15%	4%
Responses	12/26	9/26	4/26	1/26
Online CEUs	42%	27%	23%	8%
Responses	11/26	7/26	6/26	2/26
Online CEU Articles	42%	30%	20%	8%
Responses	11/26	8/26	5/26	2/26
Trade Magazines	38%	46%	12%	4%
Responses	10/26	12/26	3/26	1/26
Mentor	34%	27%	34%	4%
Responses	9/26	7/26	9/26	1/26
Online Courses	31%	38%	12%	19%
Responses	8/26	10/26	3/26	5/26
Trade Shows	27%	47%	22%	4%
Responses	7/26	12/26	6/26	1/26
Others in addition to above	**N=9**			
Professional Organizations	22%			
Responses	2/9			
Colleagues and Industry Professionals	22%			
Responses	2/9			
Academic and Health Conferences	22%			
Responses	2/9			
Organizations that offer this as a service	11%			
Responses	1/9			
Mental Health Professionals	11%			
Responses	1/9			

Software Packages	11%
Responses	1/9
Evidence Based Resources (INFORME Design)	11%
Responses	1/9
Note: Percentages are rounded up to the nearest number.	

Q2: 77% of participant ranked internet searches as the key tool for learning about new topics. This would suggest that designers seek out information which is quickly and easily accessed. Internet use in research is an attractive option as it is low cost or no cost and information is available at any time. However, internet searches are "dependent of system biases and algorithim ranking" (Asher, Duke, & Wilson, 2009, p. 447). Algorithim ranking displays web pages of most frequently visited sites and excludes less popular sites (referred to as echo chamber). As a result, designers will encounter barriers in accessing other important data. Future research should be conducted in how designers go about determining which data bases to use and how do evaluate scholarly sources (Asher, Duke, & Wilson, 2009).

Table 10- Q3: Rank the following design features in order of preference that you would prefer to see in information materials that are related to a new topic that you would like to learn about. Please check all that apply.

	Essential	Useful	Neutral	Less Likely to Use	Not Useful	NA
	N=26	N=26	N=26	N=26	N=26	N=26
Principals and Concepts	73%	27%				
Responses	19/26	7/26				
Strategies	61%	31%	8%			
Responses	16/26	8/26	2/26			
Graphic Illustrations	61%	39%				
Responses	16/26	10/26				
Case Study/Examples in Context	54%	38%	8%			
Responses	14/26	10/26	2/26			
Background of the Topic	34%	55%	11%			
Responses	9/26	14/26	3/26			
Hyperlinks to Other Sources	31%	57%	8%	4%		
Responses	8/26	15/26	2/26	1/26		
Glossary of Terms and Abbreviations	31%	50%	11%	8%		
Responses	8/26	13/26	3/26	2/26		
Compatibility with Assistive Technology	15%	20%	27%	23%	15%	
Responses	4/26	5/26	7/26	6/26	4/26	
Various Delivery Formats (digital, audio)	8%	31%	46%	11%	4%	
Responses	2/26	8/26	12/26	3/26	1/26	

Discussion Forum	4%	27%	34%	27%	4%	4%
Responses	1/26	7/26	9/26	7/26	1/26	1/26
	* Percentages are rounded up to the nearest number.					

Q3: Participants ranked "principals and concepts" (73%), followed by "strategies" (61%) and "graphic illustrations (61%) as priorities in learning about a new topic. The results suggest that more experienced professionals may prefer performance based information as opposed to prescriptive information as they are capable of making stronger connections by "abstracting principals to approach and solve a problem representation" (Daley, 1999, p. 134). However, design studios employ junior staff, for example, who are novices with limited personal and professional experience that they can draw upon to make sense of a current situation. Ranking graphic illustration as the third highest priority indicates that designers are visual individuals and maintain a preference for images, schematics and graphic representation of data. Reflecting back to the developmental continuum in professional learning theories (Daley, 1999), it can be assumed that the structure and content of an AAL technology guideline will need to respond to the learning needs of a diverse audience of professionals and include prescriptive material such as background

information, qualitative data, case studies and direction to additional resources as well as performance based concepts.

Table 11- Q4: Please rate your current knowledge and expertise level with regards to Ambient Assisted Technology (AAL) in home environments	**Responses N=26**
No knowledge or experience	42%
Responses	11/26
Awareness of the technology but no experience	39%
Responses	10/26
Knowledgeable but have with limited experience	15%
Responses	4/26
Very knowledgeable and have applied experience	4%%
Responses	1/26
Other	N/A
Responses	N/A
Note: Percentages are rounded up to the nearest number.	

Q4: 42% of participants identified as having no knowledge or experience with ambient assisted technology. This may be the result of practice being focused in one design sector, for example, more designers may be engaged in high demand sectors such as commercial, retail and hospitality design services where there is currently little or no application of ambient assisted technology in these kinds of environments. 39% of participants responded that they

were aware of the technology but had limited experience. This would suggest that these individuals could be designing in healthcare sectors who are slowing adopting AAL technology.

Table 12- Q5: - What percentage of your practice represents residential design and construction? Please select the one that best describes your status.

	Responses N=26
0-25%	76%
Responses	20/26
26-50%	8%%
Responses	2/26
51-75%	8%
Responses	2/26
76-100%	8%
Responses	2/26

Note: Percentages are rounded up to the nearest number.

Q5: Participants responses correlate with those of Q4 responses. Fewer designers are engage in residential design and more so in other design sectors such as commercial, retail and hospitality sectors. This could suggest a lower demand for residential designers due to financial constraints of fees for services. This brings to light that specialized residential design for aging and disabled populations is an untapped market which has the potential for growth.

Chapter 4 | Discussion and Conclusion

The literature reviews confirmed that issues surrounding the rapidly growing older population are dominating the social-economic landscape globally. Social construct of aging is perceived as an economic burden on society and threatens healthcare and socio-economic structures. Aging populations are less valued citizens. Age related health issues such as dementia, progressive disease which affects brain functioning is the leading cause of disability in older adults and an increasing socio-economic concern.

Most research indicated that seniors regardless of their physical and cognitive status wish to age in their home and community for as long as possible, remain socially engaged and maintain a high standard of active aging. Canadian social, economic and healthcare structures will face challenges in meeting the needs of aging populations while controlling healthcare costs and innovating new models of care for older people. As a result, the shift to telecare and telehealth utilizing telecommunications and network systems, research and development in AAL technologies and smart home design are being explored in order to leverage the needs and care of elderly people, improve QoL for seniors and their caregivers, reduce healthcare costs and institutionalization. Current data indicated that

informal caregivers are experiencing high levels of caregiver fatigue, depression, and physical fatigue. Data from Survey A and the literature suggest that caregivers will benefit the most from AAL technologies adoption in combination with accessible design in home environments. Collectively, data regarding aging revealed that "private homes where older people spend most of their time" is largely an underdeveloped domain in research and policies (Van Hoof & Kort, 2009, p. 217).

Analysis of Maslow's Hierarchy of Needs in relation to dementia and the adoption of AAL Technologies provided insight into how attitudes and motivation in older people influenced behavioral outcomes within the five hierarchical levels of need. Maslow's original model suggests that the highest level, self-actualization and fulfillment cannot be met if lower levels of needs are unmet. Maslow posits, basic physiological needs must be met before basic safety and security needs can be met, and love and belonging and esteem needs cannot be met before the two basic needs are met. However, others theorists determined that individuals can operate on several levels simultanelously and that movement is fluid between levels, and based on the individuals needs at any given time (McLeod, 2016, Thielke, et

al., 2012). Utilizing Maslow's Hierarch of Needs may be beneficial in differentiating the needs of user versus caregivers.

Reivew of the AALIANCE2 Assisted Living Roadmap as case study for the development of a North American guideline, demonstrated that employing an integrated design process with diverse stakeholders resulted in a well-coordinated, unified and sustainable structure for research in aging, development, manufacturing and deployment of AAL technology in Europe. In addition, the AALIANCE2 initiative was a key tool to inform policy development and legislation surround the social construct of aging and AAL technology development. The roadmap was robust in background information, AAL technology scenarios and technical issues, however there was no data relating to the inter-relationship of AAL and architectural design. As a result there is indication that the perspectives of design/build communities continue to be excluded in AAL research and development. However, the case study was useful in informing the design of the framework for the conceptual template developed for this study. Other searches for AAL technolgy guidelines revealed there are no similar guidelines available for the North America. The formation of the ALLIANCE consortium and the development of the ALLIANCE2 Ambient Assisted Living Road is strong

indicator of Europe's concern for the impact aging populations will have on their social, economic and healthcare structures. As a result, North America should also consider the importance of generating a similar model in AAL technology research and development.

Survey A with healthcare experts revealed that aging and age related health issues are a priority in aging research in Canada. There is great interest in AAL technology as a means asssist the eldery and their caregivers, improve LoQ and faciliate active aging. Experts reported that the lack of real world testing sites, a shortage of key telecommunications services providers who have compatable systems with AAL technology and diverse compliance standards for cabling and system networks across North America were identified additional barriers to advancing AAL technology and adoption in the consumer market. Wireless technology is not a required standard utility for homes, consequently individual who do not have access to wireless technology will be excluded from the benefits of AAL technology. Survey A indicated that wireless technology needs to become a standard utility in home environments. Buliding automation experts expressed a strong desire for unified compliance stardards across North America, similar to the ALLIANCE2 intiative. Analysis of the data also indicated that developers and home builders can play a key role in

advancing the adoption of home automation products and services such as AAL technology by creating new business models for recurring revenues through the leveraging of technology as an upgrade feature in new home design. However, developers will need to consideration how consumer data will be managed over the long course of time and by whom in the new business model.

Both healthcare and building automation experts expressed that consumers lacked adequate information and education in home automation and AAL technologies due to limited published data and resources. The Alzheimers Society is currently exploring information protals for consumers which identify types of assistive devices that are available on the market and information on manufactures and service providers. Healthcare experts indicated that consumers are unaware that some of the assistive devices they order online are in prototype phase and not availble. In addition, experts noted that some of these assistive device are not compatible with Canadian telecommunication systems. Network systems specialist experts also noted that technology was has not marketed well to women. Research indicated that women continue to outlive men and represent the majority of senior populations and the majority of caregivers and as technology advances, manufacturers and service providers of home automation

products will need to give greater consideration as to how they will address the needs of older women in technology use and adoption. Experts also noted that consumers may not be motivated to upgrade home automation due to confusing information, lack of reliable service providers and the associated costs for technology upgrades.

Analysis of Roger's Diffusion of Innovation (DOI) model in relation to aging populations, indicated that the older persons who have a lifetime of ingrained practices may not fall into the early adopter or innovation categories of the DOI model, and as a result could resist technology adoption. Likewise, caregivers who are decision makers for older family members, may themselves be hesitant to adopt technology based on their own experiences and perspectives. One might expect that caregivers who have limited or negative experiences with technology may be hesitant or slow to adopt AAL technology as a resource for the caring of older family members. Precedent studies revealed that seniors regardless of their physical and mental health status are hesitant to adopt assistive technology. The utilization of the DOI model in combination with Maslow's Hierarchy of Needs in the study of aging and AAL technology may be valuable tools for leveraging AAL technology adoption. Maslow's model can provide rationale behind senior and caregiver behavioral outcomes and

attitudes. Concepts from the DOI model could be applied to inform the development of new strategies which address negative behavior and attitudes, followed by the development of new solutions which assist individuals to shift away from old biases which created barriers to technology adoption. One might expect that seniors born after 1966 will fall into the early adopter and innovator categories in the DOI model due to the presence of technology early on in life, however, early adoption of AAL technology in current older senior populations will remain a challenge for many years to come.

Survey A also revealed that interior design and architectural professionals are not adequately engaged in AAL technolgy research and development due to funding issues, demand for fees and lack of academic status with Canadian research communities participating in this study. Fees and funding issues are a separate study in themselves, however it is important to address the findings from Survey A which pertain the lack of academic status in design communities as this notion is closely linked to the development of the conceptual template for AAL technology in this study. Initially, the lack of advanced research education, such as those situated in graduate programs may partly explain this bias. Accordingly, it is important to

include in the discussion, to examine the developmental continuum of learning for professionals.

In Canada and the U.S., professionals in the fields of design and construction are required to participate in mandatory continued education (CEU's) after formal institutional education to build and stay current in design knowledge. For example, Evidence Based Design Accreditation and Certification (EDAC) facilitated through the Center for Health Design has been promoted to the design community and construction industry whose practice is focused on healthcare environments. The program is also directed to hospital executive Initially, certification was directed to design professionals working in the healthcare sector, however the certification became popular with anyone who wished to expand their knowledge in research methods. The EDAC training program is a self-directed course delivered through a series of three paperback books and two- hour exam. Ongoing certification is maintained through 6 hours of approved CEU courses by EDAC every two years. No evidence could be found that that suggests that CEU and follow-up certification programs have any influence on formal research communities engaging the design community as qualified research partners in studies.

The results of Survey A regarding the lack of design community engagement in formal research, suggests that more investigation needs to be conducted in this domain. In addition, the study indicates that professional associations representing the design community may need to build stronger relationships with graduate schools and research communities in order to break down barriers that keep design professionals from contributing their real-world experiences and knowledge to frontline participation in research such as AAL technology. Building stronger ties with research communities can provide valuable insight and inform new and meaningful content to the developmental continuum of professional learning in order to increase opportunities for design communities to participate in research. This notion is extremely important because the developmental continuum of learning for professionals is most often self-directed and based on client needs and trending topics. As a result, design communities potentially can be removed from other important topics currently under research which may be of value and further distanced from opportunities for collaboration with research communities.

Analysis of Roger's DOI model strongly suggests that the design community falls under early adopters and innovators categories in the model and can play a key role in advancing the knowledge base,

promoting and integrating AAL technology at a faster pace if they are included in formal research studies at academic levels.

Survey B with design community professionals revealed that AAL technology currently is a relatively unknown topic to most participants and that topics relating to processes such as evidence based design, sustainability and risk management were considered a higher priority, followed by domain specific topics such as healthcare environments and environmental psychology. Internet search, books and academic data basis were identified as primary tools. This indicates that most likely there is a reliance on materials which can be easily and quickly accessed (Asher, Duke, & Wilson, 2009, pp. 446-447) in order to make their life simpler and reduce cognitive overload. A drawback to internet use for conducting research is that search engines are dependent on system biases and algorithim ranking (Asher, Duke, & Wilson, 2009, p. 447) thus creating an echo chamber effect in which only the most popular sites are displayed. Consequently, designers face barriers to accessing other important data which can be hidden due to system biases. Furthermore, it is not clear as to how designers evaluate these sources. Research suggests that "the ability to evaluate sources will become a highly-valued tool in the future" (Asher, Duke, & Wilson, 2009, p. 447). Further future

research into design professionals use of the internet collecting data is recommended.

Survey B revealed that the design community had a preference for information in a guideline which incorporates principals and concepts, strategies, graphic illustrations and case study examples. Background information could be useful but appeared not to be a top priority.

Data derived from the analysis of theories of learning, developmental continuum of professional practice and innovation emphasized the need to create a learning structure within a guideline which addresses the diverse backgrounds, levels of knowledge and experience of designers at their various stages in practice. The challenge in designing a future guideline will be to move content from basic knowledge to meaningful knowledge and discussion (Betts, 2008, p. 99, Daley, 1999, p. 146).

In conclusion, the study demonstrated that research into the development of an AAL technology guideline is not a linear process that requires many pathways to information and a "collective of expertise across various contexts and disciplines" (Daley, 1999, p. 146). Currently there is no single-entry point to accessing AAL

technology information, dementia and aging. This may contribute to poorly sourced data (Asher, Duke, & Wilson, 2009, p. 476) for the design community and ongoing exclusion from participating in formal research studies within academic settings.

This study validated the need for an integrated design process engaging a broad group of stakeholders which includes the design community, as valued partners at the frontline processes in AAL technology research and their contribution the development of a future North American AAL technology guideline. Utilizing an interdisciplinary structure will help to ensure that information is evidence based and meaningful to a larger audience.

The data presented in this study recommends further research in the development of a unified North American AAL Ambient Assisted Living Technology Guideline in order to mediate the complexities surrounding this domain, generate faster uptake in the consumer market and ultimately support healthy living to maximize social inclusion regardless of an individual's personal status or situation. In addition, creating a single trusted entry point for accessing data on AAL technologies has the potential to contribute to faster AAL technology adoption into design practice. The development of the

educational structure of the guideline will be presented in Chapter 5 and a sample of the proposed template can be found in Appendix A.

Although this study has focused on home environments for aging populations, the benefits of AAL technology can extend to commercial, hospitality and retail environments. Currently AAL technology is more focused on healthcare solutions, monitoring and surveillance and assisting caregivers and older people who live in their home but opportunities for AAL technology can be integrated into many other environment settings such as retail and hospitality industries. The hotel and tourism industry have long recognized the significance of the baby boomer demographic to their market sector and opportunities for innovation and financial rewards. The AALIANCE2 initiative in Europe is conducting research in AAL technology applications for work environments to extend older people's ability to participate in the workforce.

Chapter 5 | Conceptual Template Sample

The educational structure of the conceptual template (Appendix A) required the use of an integrate design process which included review of literature to scope out information in the domains of aging and dementia and AAL technology applications to flush out common themes and patterns which contributed to background content in the template. In addition, interdisciplinary contributions from various healthcare experts, building automation experts and design professionals were required in order to develop a holistic view of the many constructs that impact will need to be considered in the development of the educational structure of the conceptual template.

Analysis of the developmental continuum of learn for professionals identified learning behaviors in professionals as they shifted from novice to expert status in their careers, and contributed to developing a scaffolding learning structure within an AAL scenario which can meet the needs of a range of users.

Each scenario is supported by prescriptive and performance-based information. AAL technologies are organized by scenarios such as "fall prevention" and supported by twelve key indicators for learning and proposed actions. Refer to Appendix A for detailed information

about the various sections and key indicators of the conceptual template. In order for a guideline to be current with up to date technical information, case studies and other information that may be helpful, links to external resources are proposed in the conceptual template. Designers are visual individuals thus information is supported by text and visual materials such as info graphics, icons and illustration. In the development of a final guideline it would be necessary to ensure that all content is compatible with assistive technology for individuals who use them. Overview of the proposed conceptual template structure is as follows:

1. Table Contents

2. Instruction on how to use the guideline supported by visual material is included and explains the intention and goals of each key indicator.

3. Sample of a scenario page.

Each scenario is structured with the following 12 indicators which are supported by text and infographics for quick reference:

Indicator 1: identifies the scenario “Fall Prevention”

Indicator 2: Infographic of technology provides quick visual reference for the technology type used to support the scenario.

Indicator 3: The background paragraph explains characteristics of the individual (person represented in the scenario) and scenario issues. Background information helps novices to make connections between user needs and rationale for the technology.

Indicator 4: "Principals" identify the overall goal setting idea for the scenario i.e. implement sensor technology to monitor falls (performance based). Less experienced professionals may adopt principals as rules to apply in practice. Survey B participants ranked principals as the top priority for displaying information. This indicates that designers at any level of the developmental continuum still require principals to assist them in making sense of how they relate as whole to a given situation.

Indicator 5: Identifies three service areas of AAL support (prevention, compensation and support, independent and active living) are coded with the use of an infographic for quick reference. This section contextualizes the three services area of support for aging and dementia within social settings and the built environment. The service areas suggest the kinds of results that can be anticipated by

employing the principal from Indicator 4 which can be useful in assisting in decision making processes with professionals in determining important factors vs. unimportant factors.

Indicator 6: Identities who will benefit from the technology and associated benefits of the technology. This section would be of most benefit to novices as it demonstrates the interconnectedness between broader range of individuals or social and healthcare structures when dealing with dementia scenarios.

Indicator 7: Quick Tools provides a quick reference to additional sources which have vetted or peered reviewed for content integrity. Sources can include real world case studies that pertain specifically to the scenario. The tool provides a benchmark to understanding the solution and its value to the scenario. Indicators 7 and 8 will useful for professionals who have little experience with real world situations and rely on benchmarks to understand implementation of concepts better.

Indicator 8: The "Additional Resources" section provides recommendations to other resources that also been peer reviewed such as books, periodicals, journals and internet sources. Indicators 7 and 8 would like be most appreciated by Expert learners who primarily use reading materials to acquire knowledge.

Indicator 9: The "Did You Know" section provides facts that help to reinforce the importance of the scenario with statistical data or other relevant information by linking concepts to real world conditions. This data could be valuable to designers if clients request evidence in project work.

Indicator 10: The "Strategies" section (prescriptive based learning) suggested actions or measures which can be taken to fulfill the goals set out in the service area of support for AAL technology. Providing strategies has the potential to facilitate ongoing discussions and inspire new innovations. Survey B participants ranked strategies within the top three preferences for displaying information.

Indicator 11: Strategies are supported by visual data for concepts that cannot be explained easily in text format. Survey B participants ranked graphic illustrations within the top three preferences for displaying information and suggests that designers rely on visual information equally as they do with text based information.

Indicator 12: "Frontline Project Partners" provides the reader with recommendations for project collaborators who can bring valuable expertise and new insights into hidden topics and issues.

By utilizing an integrated design process, an educational structure was developed that captured and summarized key data that would be relevant to professionals learning about the topic of AAL technology applications in home environments for older people. Data collected in the study indicated that professionals prefer information to be displayed efficiently in simple format, with "need to know now" information and links to additional resources for further contemplation.

A scaffolding learning structure was implemented to address the learning behaviors of professionals as them move from novice to expert in their developmental continuum of learning throughout their career. The conceptual model is presented in Appendix B.

Limitations to the Study

The objective for this study is to develop a framework for an information template that supports the education and application of AAL technology for the North American design community. While the mixed methods approach of the study to strengthen the relevance and timeliness of the data analyzed, there are limitations to the study that need to be recognized.

Sample sizes in surveys was not considered large enough to make definitive conclusions but it is recommended that further research be conducted with these groups. The pool of participants for this entry level study was limited to a smaller pool of experts because there is no similar North American study available and the subject matter is very complex which would require the involvement of many disciplines. Information pertaining to home automation and AAL technology is limited to 2016 and 2017.

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Appendix A: Glossary and Abbreviations

Active Aging: is the process of optimizing opportunities for health, participation and security in order to enhance the quality of life as people age. It applies to both individuals and populations (Federation of Canadian Municipalities, 2013).

Aging in Place: refers to the ability to remain in one's home and community safely, comfortably and independently later in life (Federation of Canadian Municipalities, 2013).

Ambient Ecology: a space populated by connected devices and services that are interrelated with each other, the environment and the people, supporting the users' everyday activities in a meaningful way (Goumopoulus & Kameas, 2009, p. 922)

AAL: Abbreviation for Ambient Assisted Living. Refers to intelligent systems, products and services which assist to improve quality of life in one's preferred living environment (Canada Mortgage and Housing Corporation (CHMC), 2015).

AAL Technologies: Ambient Assisted Living Technology

Alzheimer's Disease (AD): neurocognitive disorder in which an individual experiences progress and irreversible cognitive decline (Alzheimer's Society of Canada, 2016).

Baby Boomer: Individuals born 1947-1966. (Statistics Canada Sex and Gender, 2012).

BA: Abbreviation for building automation experts (mechanical, electrical, communication engineers and network systems specialists)

Dementia: Is an overarching term used to describe a number of disorders which affect brain functioning, mood and behavior. Memory loss, problem solving and language are some of the symptoms which impair a person's ability to perform everyday activities

Design Community: Designers of the build environment represented by interior designers, architects, engineers, builders, contractors, developers.

Developed Countries: political terminology for a sovereign state or nation that has a highly-developed economy and advanced technological infrastructure. Europe, North America, Japan, Australia, New Zealand and some nations formally in the Soviet Union are

considered to be developed countries. (Krauss Whitbourne, Whitbourne, & Konnert, 2015, p. 17).

Developing Countries: political terminology for agrarian-based economy with lower levels of healthcare, education and income (Krauss Whitbourne, Whitbourne, & Konnert, 2015, p. 17).

Diffraction: Phenomena which occurs when a signal encounters an obstruction that causes the signal to bend or loose it's intensity https://en.wikipedia.org/wiki/Diffraction

HC: Abbreviation for healthcare professionals, researchers and educators in the field of aging, physical and cognitive impairments.

HRQoL: Abbreviation for health-related quality of life.

Ecology: The inter-relationship of organisms and their environment.

ICT: Information and Communication Technology information is accessed through telecommunications (internet, wireless networks, mobile devices and other tele-communication mediums) https://techterms.com/definition/ict

Telehealth: a means to delivering a healthcare services, public health and health education through the use of telecommunications systems and products.

QoL- Abbreviation for Quality of Life, the degree to which a person is able to function at a usual level of activity without, or with minimal, compromise to ability to pursue daily activities, experience overall enjoyment of life and sense of well-being.

Appendix B: Proposed Conceptual Template

Table of Contents

Our Goal for the AAL Technology Guideline

The domain of Ambient Assisted Living (AAL) technology is a fluid and growing sector which is leveraging telecommunications, intelligent systems and healthcare services to assist older and disable people in daily living tasks and activities, maintain independence and social inclusion, and remain in their homes for as long as possible.

AAL technologies are complex structures because they involve many stakeholders and components. In order to mediate the complexities surrounding this domain and generate faster deployment into the consumer market this guide was created to assist interior designers, architects, engineers, contractors, developers, researchers and any other stakeholders engage in the design of the home environments utilizing Ambient Assisted Living (AAL) technology and home automation. The guideline has been designed using an integrated design process with multidisciplinary collaboration for maximum inclusion of knowledge and expertise.

The guideline aims to explain AAL technology application to home environments, contribute to the existing body of knowledge and inspire new design solutions for the built environment in the ongoing effort to support aging in one's home and community.

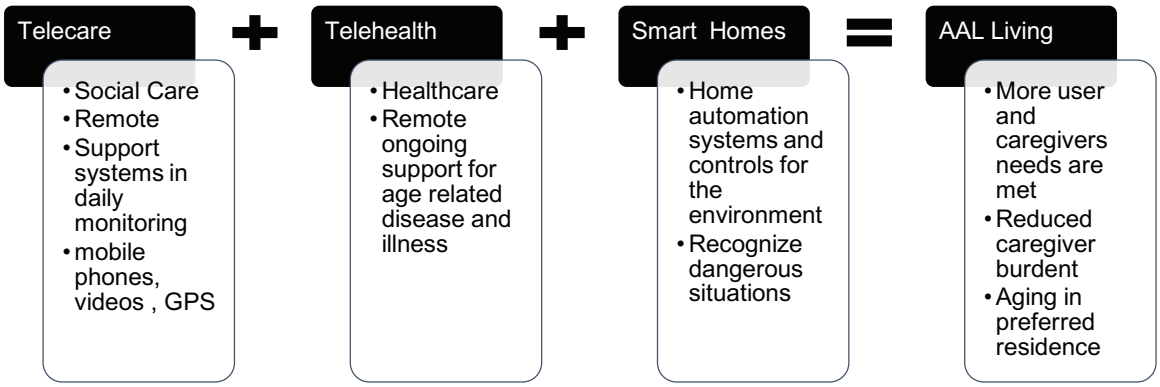


Figure 1: AAL technology framework.

How to Use This Guideline

The guideline has been organized into key indicators for each scenario of AAL for ease of use. Each scenario is supported by prescriptive and performance-based information. AAL technologies are categorized by scenarios i.e. ”Fall Prevention”. Twelve indicators are used to support each scenario. Links to additional external resources such as online sources, books and articles are also included for each scenario.

You can use each scenario in the guideline as a structure to develop and expand your own strategic plan for actions, design opportunities and deeper understanding of specific issues that need to be captured and resolved in your project. The guideline provides recommendations for external project partners who can bring valuable expertise and insight into hidden issues. The following pages will provide you with attributes for each key indicator within the scenario.

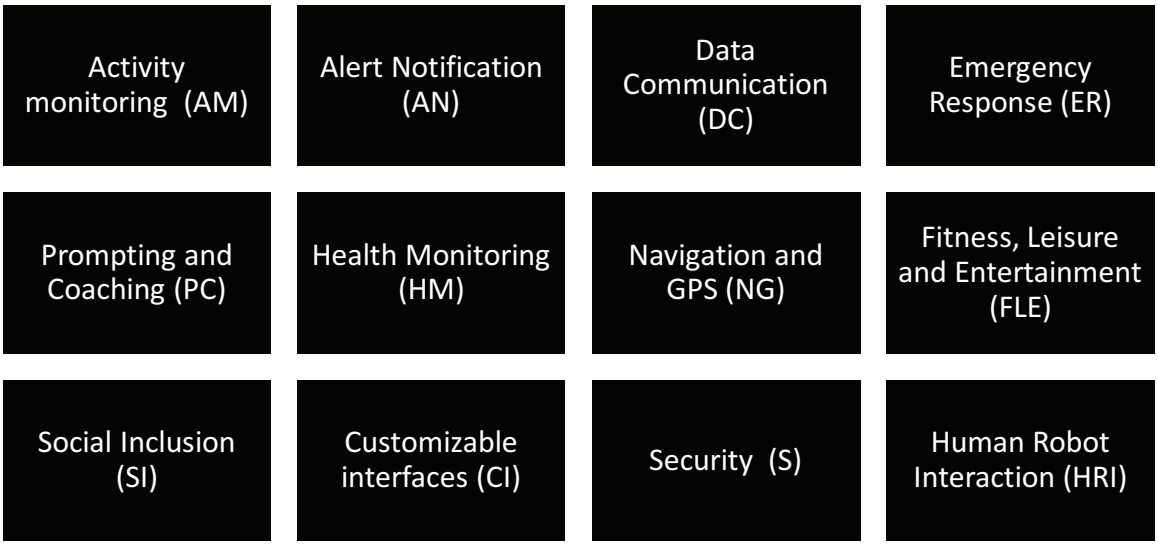
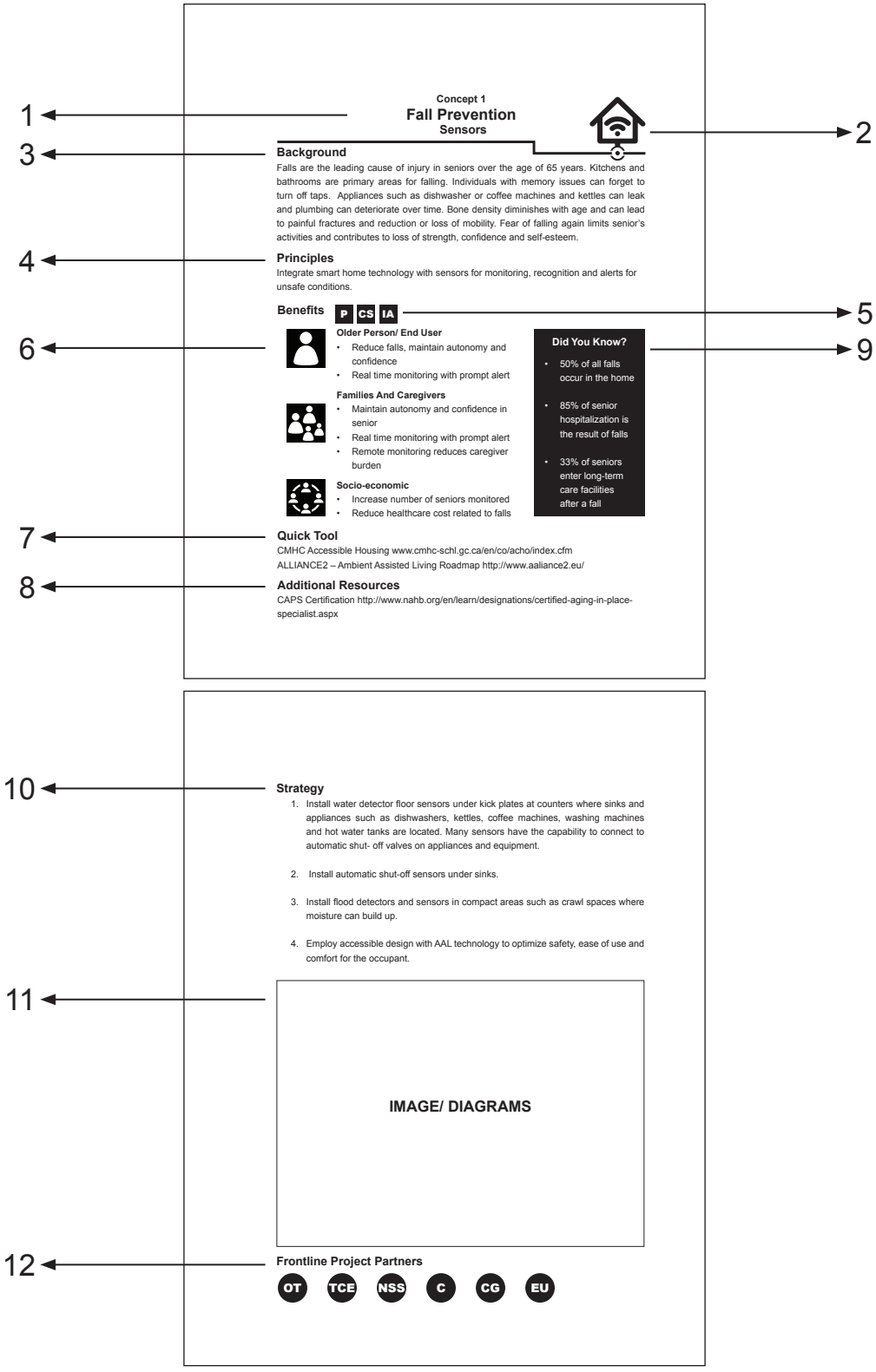


Figure 2: Service scenario of AAL support.

AAL Technology Indicator Descriptions



Key Indicators

1 Identifies the scenario or issue i.e. “Fall Prevention”.

2 Graphic information provides a quick visual reference for the type of technology that is used to support the scenario.

3 Background information provides characteristics of the individual and scenario issues.

4 Identifies the over goal setting idea for the scenario.

5 Identifies the following service areas and scenarios:

P	Prevention
CS	Compensation and Support
IA	Independent + Active Aging

6 Icon identifies who will benefit from AAL Technology.

7 Quick Tools provides a quick reference to additional sources such as real world case studies that pertain specifically to the scenario. The tool provides a benchmark to understanding the solution and its value.

8 Additional Resources provide recommendations to other resources that have been peer reviewed such as books, periodicals and internet sources.

9 “Did You Know?” Provides interesting facts that help to reinforce the importance of the scenario.

10 Strategy provides suggested actions. We hope that this section inspires up to generate additional innovations to the scenario.

11 Images/Diagrams provide visual support of the technical aspects of the technology.

12 Each project has specific needs and requirements which need to be identified and addressed at the planning stages of any project. Frontline Project Partners are suggestions for collaborators which can provide valuable insight, expertise and experience to your project.

Occupational Therapist

Telecommunications Engineer

Network Systems Specialist

Contractor

Caregiver

Enduser

Concept 1

Fall Prevention

Sensors

Background

Falls are the leading cause of injury in seniors over the age of 65 years. Kitchens and bathrooms are primary areas for falling. Individuals with memory issues can forget to turn off taps. Appliances such as dishwasher or coffee machines and kettles can leak and plumbing can deteriorate over time. Bone density diminishes with age and can lead to painful fractures and reduction or loss of mobility. Fear of falling again limits senior's activities and contributes to loss of strength, confidence and self-esteem.

Principles

Integrate smart home technology with sensors for monitoring, recognition and alerts for unsafe conditions.

Benefits

P **CS** **IA**

Older Person/ End User

- Reduce falls, maintain autonomy and confidence
- Real time monitoring with prompt alert

Families And Caregivers

- Maintain autonomy and confidence in senior
- Real time monitoring with prompt alert
- Remote monitoring reduces caregiver burden

Socio-economic

- Increase number of seniors monitored
- Reduce healthcare cost related to falls

Did You Know?

- 50% of all falls occur in the home
- 85% of senior hospitalization is the result of falls
- 33% of seniors enter long-term care facilities after a fall

Quick Tool

CMHC Accessible Housing www.cmhc-schl.gc.ca/en/co/acho/index.cfm

ALLIANCE2 – Ambient Assisted Living Roadmap http://www.aaliance2.eu/

Additional Resources

CAPS Certification http://www.nahb.org/en/learn/designations/certified-aging-in-place-specialist.aspx

Strategy

1. Install water detector floor sensors under kick plates at counters where sinks and appliances such as dishwashers, kettles, coffee machines, washing machines and hot water tanks are located. Many sensors have the capability to connect to automatic shut- off valves on appliances and equipment.

2. Install automatic shut-off sensors under sinks.

3. Install flood detectors and sensors in compact areas such as crawl spaces where moisture can build up.

4. Employ accessible design with AAL technology to optimize safety, ease of use and comfort for the occupant.

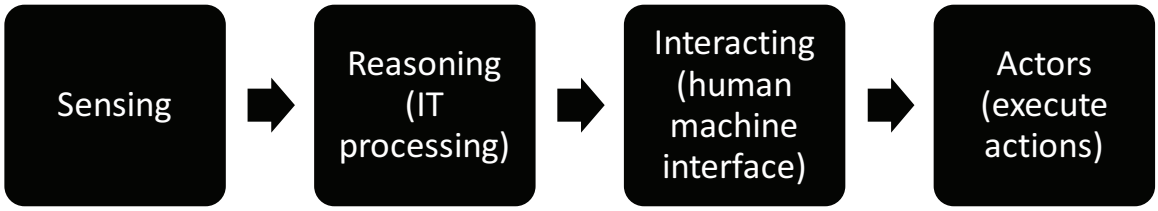


Figure 3: Basic structure of AAL ambient assisted technology systems.

Frontline Project Partners