Collaborative Ecosystems in Ageing Support

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Abstract. New integrated and technology-supported services are needed to face the challenges of rapidly ageing societies. Collaborative networks provide a promising framework for the development of such services, which require the involvement of multiple stakeholders. In this direction, a roadmapping initiative is addressing the implementation of a new vision for technological support to ageing. To support this vision, a strategic research plan focused on four life settings - independent living, healthy living, occupation in life, and recreation in life - is introduced. A large number of stakeholders coming from different backgrounds contributed to the design and validation of this roadmap.

Keywords: Collaborative networks, ICT and Ageing, Collaborative Ecosystems, Roadmap.

1 Introduction

The rapidly increasing proportion of the elderly in western societies is creating a demographic unbalance, which raises serious social and economic concerns. It is thus timely to reassess the understanding of such terms as ageing and retirement, and questioning the common assumptions associated with work, personal fulfillment, leisure, community involvement etc. with respect to old age.

The current common association of senior citizens with a dependent stage of life does no longer match the way the European society is developing. The adoption of the concept of **"active ageing"** provides a more appropriate understanding of the later phases of life, given both the social and technological trends and outlook for the future [1]. Furthermore, the notion of **"productive ageing"** [2] has opened new perspectives for a change in the way society often perceives older people.

At present, most elderly citizens, following retirement, quickly become marginalized as they feel discarded by the society which often fails to even recognize their worth, instead of appreciating it and benefiting from it. Elderly is often seen as a cost burden rather than a resource, capable of value creation. This feeling of exclusion creates a vacuum in the life of the elderly citizens which can affect their health and well being. Even when remaining active at work, nowadays when a person gets older, his/her position becomes increasingly fragile in society, especially in moments of economic crisis when the competition for jobs intensifies. A critical challenge for society in respect to active ageing process is to create an environment in which the elderly citizens do not feel excluded, rather have a chance to use their knowledge and

expertise in a fruitful way, by making a valued contribution to the communities in which they live [3], [4], [5].

ICT, and particularly high-speed pervasive broadband connectivity and web-based technologies, combined with intelligent robotics, smart homes, intelligent sensor networks and related technologies, offer new opportunities to provide care and assistance, create new ways of working, facilitate social interaction, and reduce limitations imposed by physical and mental conditions, location and time, thus increasing personal control. Nevertheless the sensitivity of the area, the dependency on the interplay between the introduction of new organizational and service models and creation of a new culture in society, the lessons learned with the limited success of past experiences, the risk of continuously developing technology that is not taken-up by target users, among others suggest the need for a careful analysis and a better planned approach towards what concerns new developments.

The creation of adequate support environments for the ageing citizens requires the involvement and effective coordination of multiple stakeholders. The concept of *collaborative ecosystem*, which can be seen as a particular case of a VBE and gets some inspiration on the principles and mechanisms of biological ecosystems, provides a promising conceptual framework to guide new conceptual and technological developments. Such support environments can also be seen as a materialization of the notion of *Services Society*, i.e. going beyond the concept of service ecology by considering not only the services and the actors affected by them, but also the context, organizational structures, and their governance principles, namely constituting the logical part of a service oriented architecture.

Nevertheless, such notions have emerged in enterprise-related business contexts and have not yet been explored in this domain. As such, *roadmapping* needs to play a fundamental role in the identification of a strategic research agenda and prioritization of needed actions. This paper introduces first results of the ongoing European roadmapping initiative BRAID.

2 Towards a Strategic Research Agenda

Realizing the critical issues of our ageing society, the European Commission has made a considerable investment in e-inclusion, ICT and ageing in its Framework Programmes. A number of related initiatives and experimental approaches have also emerged in other geographical regions, e.g., Australia, Canada, Japan and the United States. As a result, good progress has been made in various aspects of e-inclusion and particularly with regard to assistive technologies. A set of good practices and identified gaps is also available. Further research needs to build on these results and be guided by a strategic roadmap which provides an extended look at the future of active ageing and ageing well as a result of the knowledge and imagination of stakeholders, including experts, visionaries and drivers of change in this field. A well conceived roadmap needs to be drawn on the basis of an inspiring *vision* of what society wants to achieve in future [6], [7]. Vision-building is a mechanism to *define* the future that we wish to reach.

In addition to a number of RTD projects, particularly in FP7, four recently finished roadmapping projects – AALIANCE, CAPSIL, ePAL, SENIOR – have addressed different and complementary perspectives of ICT and ageing. Collectively, they covered major aspects of care and assistance, health care, extension of professional life and active ageing, and the related socio-economic and ethical issues. Furthermore, each one of these four projects developed efforts to organize communities of stakeholders. It is now urgent to **proceed to the next level of ambition,** towards a comprehensive *vision* and *strategic roadmap*, through the integration of these partial results and combination of perspectives, thus overcoming the fragmentation that has plagued the previous era of ICT and ageing. In addition to integration and consolidation of recent results, BRAID is exploring new synergies resulting from a holistic consideration of ageing, analyzing the trends and potential impacts of new disruptive technologies, and investigating a number of plausible scenarios of socio-economic crisis that might have a profound impact on the life of senior citizens.

Perspectives of analysis. ICT and Ageing represents indeed a complex area that can be analyzed from multiple perspectives and requires the contribution of multiple disciplines. In this work four perspectives or life settings are considered particularly relevant and selected as the basis for focused consideration in the various phases of the roadmapping process:

- *Independent living* - how technology can assist in normal daily life activities e.g. tasks at home, mobility, safety, agenda management (memory help), etc.
- *Healthy living* - how technology can assist in health monitoring, disease prevention, and compensation for disabilities.
- *Occupation in life* - how technology can support the continuation of professional activities along the ageing process.
- *Recreation in life* - how technology can facilitate socialization and participation in leisure activities.

The next sections introduce the vision and plan of actions for each setting.

3 Independent Living

This life setting addresses how technology can assist in normal daily life activities e.g. tasks at home, mobility, safety, agenda (memory help), etc. Main developments under this perspective are focused on assistance at home, namely for elderly living alone, which goes hand-in-hand with developments on smart homes. It includes services such as living status monitoring, with connection to care providers in case of any emergency, agenda manager to compensate for memory losses, companion and service robots, integration of intelligent home appliances, etc. Support outside home, namely in terms of mobility assistance, shopping assistance, and other daily life activities, is also considered.

Taking into account the current baseline, identified driving forces (technological, societal, organizational, economic, and regulatory driver), and major trends, as well as ideas emerging in numerous future scenarios developed in various research projects, the following vision (Table 1) is proposed for the independent living setting.

Table 1. Vision for Independent Living

In the coming decade, senior citizens will be empowered to live long, fulfilling, and independent lives through support from technological, societal, organizational, economic, and regulatory mechanisms. This includes ensuring security, safety, mobility and transport, facilitating access to relatives, carers and the community, and assisting with daily life activities, such as house-keeping, buying food, and personal hygiene care among others, to be equipped to live independently.

Main desired facets:

VI1. Established infrastructure and networks as the base for the support of independent living by technology

VI2. Assistive technology and support services that facilitate independent living

VI3. Monitoring devices and technologies supporting ambient intelligence solutions

VI4. Supporting tools and environment that foster the development of technologies for independent living

VI5. Advanced set of organized and commercial services aiming to enhance diminishing abilities of seniors and caring for seniors so that they can live independently

VI6. Tools to ensure security, ethics, rights, and privacy on data and used services

VI7. Mechanisms to increase knowledge dissemination, training and learning through sharing, both for seniors and all other stakeholders.

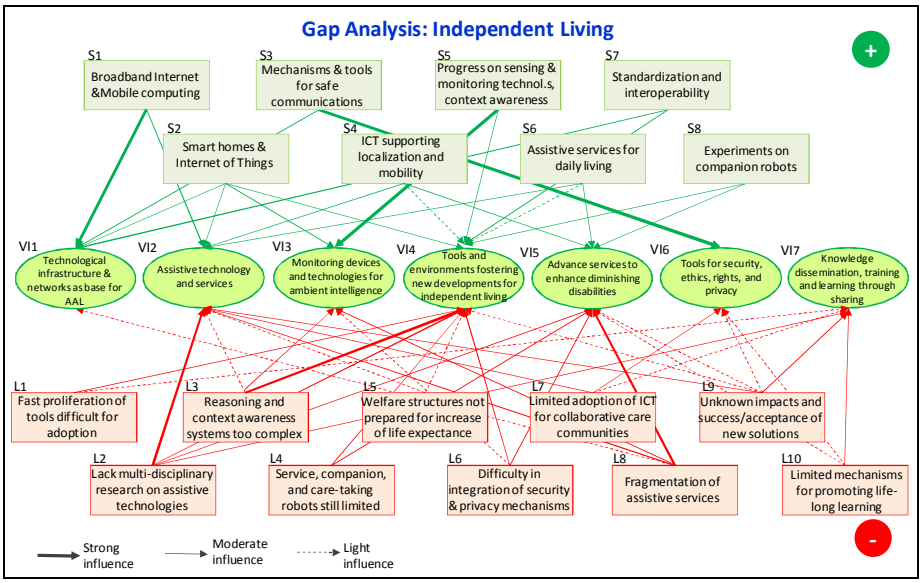

Fig. 1 – Gap analysis – independent living example

Comparing this vision with the current situation, a systematic gap analysis was conducted, as illustrated in Fig. 1. As a result of an extensive brainstorming, group discussion and consensus building among a variety of stakeholders, a set of strategic research actions (AI1-AI6 in Table 2) are proposed. These actions are chosen in order to cover all stated facets of the vision (not necessarily a one-to-one correspondence between facets and actions), while being feasible considering the current situation (baseline) and trends, and taking into account the results of the gap analysis. Further to the research actions, policy recommendations or socio-economic research actions are also included (RI1-RI2 in Table 2).

Table 2. Strategic research actions for Independent Living

AI1	***Monitor well-being.*** *Design, develop and integrate open and scalable sensor network environments both home-centered and human-centered, with intelligent monitoring, including new levels of security, safety, and privacy.*
AI2	***Extend capabilities****. Investigate, develop and integrate intelligent functionalities to compensate diminishing cognitive and physical capabilities and to design and develop intelligent, context-aware and self-adapting tools for personal assistance in planning and performing daily activities and facilitating societal participation.*
AI3	***Build supportive environments****. Design, develop, and validate preventive and responsive interventions based on situational awareness.*
AI4	***Establish collaborative environments****. Design and develop novel collaborative environments, combining social networking and collaborative networks of care provision stakeholders to facilitate support, companionship, and community participation.*
AI5	***Assist mobility****. Integrate and customize methods and tools to assist mobility, including services for localization, trip planning, navigation, orientation in complex environments, driving assistance, and inter-modal transportation, focusing elderly needs.*
AI6	***Align independent and sustainable living****. Explore the alignment of ICT for Independent Living with smart grid and sustainable development technologies.*
RI1	***Assess impacts.*** *Promote integrative studies on the sociological, economic, ethical, and quality of life impacts of introducing services and technologies for independent living.*
RI	***Training for new environments.*** *Define new community-based training programs leveraging the potential of new technology-based assistive environments.*

Collaborative aspects. As it can be observed in the proposed action plan, there is an aim to evolve towards more integrated services, involving multiple stakeholders, through well coordinated collaborative communities / ecosystems. As such, and beyond the "traditional" approaches followed in ICT and Ageing, the discipline of collaborative networks is likely to bring an important contribution to the development of future ageing support systems. This can be addressed at community level - social networking, re-enforcing community links, reducing loneliness, exchanging support through time banks, etc. - or at the specialized care provision level through collaboration among diverse stakeholders - care providers, health care centers, ambulance services, social security departments, NGOs, etc.

At the mobility assistance level, and in alignment with current trends in advanced transport infrastructures, collaboration among multiple stakeholders is also needed - e.g. transport operators, traffic management entities, toll operators, parking lot operators, and other service providers. Finally, at the home infrastructure level, and as we progress towards more intelligent appliances and subsystems, collaborative networks principles and mechanisms can provide a better framework for systems integration (a new perspective for *systems of systems*).

4 Healthy Living

This life setting addresses how technology can assist in health-related activities (remote health monitoring, emergency assistance, sensing environments, exercise assistance, prescription reminding, etc). Similarly to the previous case, the following

vision (Table 3) and plan of actions (Table 4) are proposed.

Table 3. Vision for Healthy Living

In the coming decade, as a part of the ageing well paradigm, support for healthy living will become a high priority strategy across Europe. The emerging health care technologies and services will be used in new ways in the society, across a distributed infrastructure focusing on decentralized models, while sensible to the ethical consequences of the introduced innovations and providing mechanisms for the protection of individual rights. Both business-based and societal organizations supporting healthcare will adapt to this new environment.

Main desired facets:

VH1. Regulatory and technological infrastructure to support consumer driven healthcare (supporting data privacy, standards)

VH2. Advanced devices, robots, and tools supporting interventions for monitoring and provision of health care

VH3. Information based assistive services supporting the health care of seniors and involvement of other stakeholders

VH4. Appropriately designed home based interventions and support systems, based on seniors' cognitive and emotional status, which adapt whilst they age

VH5. Mechanisms to raise awareness on the formation of values, ethics, rights, and privacy on health related data and advanced ICT tools to ensure data security

VH6. Organized logistics and commercial networks of health care providers in the society, adapted to demographic change

VH7. Sensor based technologies, which are context aware, for healthcare support.

Table 4. Strategic research actions for Healthy Living

AH1 ***Develop health monitoring systems.*** *Design, develop and integrate sensorial systems for health conditions monitoring, combined with intelligent diagnosis functionalities, understanding of the environment and other context factors, and smoothly adaptable to the needs of each senior individual.*

AH2 ***Establish safe infrastructure.*** *Develop a safe and adaptable infrastructure, aligned with relevant standards in e-health, to support the provision of consumer-driven healthcare services.*

AH3 ***Design integrated assistive services.*** *Create a multi-stakeholder framework for the emergence of integrated information-based assistive health care services, with particular emphasis on quality of service, recipient's quality of life.*

AH4 ***Develop interventions.*** *Design, develop and assess advanced devices, intelligent robots, and intelligent tools to support home-based interventions and associated support systems, which are self-adapting to the cognitive, emotional, and physical status of the senior and respect the established safety and ethical principles.*

AH5 ***Establish healthcare ecosystem.*** *Define new organizational and business models and develop support tools for the establishment of collaborative healthcare ecosystems involving healthcare providers, social security and regulatory authorities, forming the backbone for the emergence of new services for healthy living support.*

AH6 ***Introduce innovative therapeutic approaches.*** *Exploring ICT to create novel therapeutic environments and support palliative care.*

RH1 ***Develop regulatory framework.*** *Promote studies to elaborate and assess new organizational forms, legal structures and business models for healthcare provision to ageing population from a multi-sectoral collaboration perspective.*

RH2 ***Establish organizational and business models.*** *Identify critical elements in ICT-based support services for healthy living.*

RH3 ***Raise ICT awareness and skills in health and care.*** *Launch actions and develop mechanisms to increase the potential of ICT support for "healthy living environments" and to form a consensus on values, ethical principles, rights, safety, and privacy issues.*

Collaborative aspects. Also for this life setting, the role of collaborative networks can be identified in some of the proposed actions:

- Actions AH3 and AH5 clearly indentify the need for collaborative healthcare ecosystems as enablers for the emergence of novel integrated healthy living support services. This should be complemented with appropriate regulatory frameworks and business models (RH1 and RH2).
- Principles and mechanisms developed in the collaborative networks area can also bring important contributions to the safe infrastructures supporting health monitoring (AH1 and AH2).

5 Occupation in Life

This life setting addresses how technology can support the continuation of professional activities. The life setting of occupation in life can look very different for individuals, depending on the background work structure, sector, individual goals, capabilities, flexibility, opportunities, and functional ability. It covers both pre-retirement and post-retirement activities. In fact, in face of economic crisis and the growing pressure on the pension systems, it is likely that the notion of retirement as an abrupt even will change in the coming years. This setting includes both voluntary and paid work.

The following vision (Table 5) and plan of actions (Table 6) are proposed for this life setting.

Table 5. Vision for Occupation in Life

In the coming decade, due to the ageing population in Europe, an opportunity will arise to create a new framework for a model of work selected by seniors and adapted as they age, enabling them to earn a living through continued employment or have some form of continued work engagement. This framework will require support for its technological, socio-organizational, legal and political aspects. The aimed vision capitalises on the talents and expertise of senior workers, facilitating value creation through the use of ICT for the benefit of the individual, the economy and European society as a whole.
Main desired facets:
VO1. Established technological infrastructure (including support for connectivity, mobility and cloud computing) as the base for senior professionals' activities
VO2. Mechanisms to build associations of senior professionals and actively engage them, and support services for formation / management of teams of professionals
VO3. Advanced software environments to support seniors with adaptive personalized interfaces and affective interactions (within a context-aware and configure-yourself enriched environment)
VO4. Organized support for training and continued life-long learning for seniors
VO5. Increased social awareness about the value of senior professionals and their social cohesion and knowledge transfer (facilitating active involvement through networking, with emphasis on cross-generational and gender issues)
VO6. New business models for involvement of seniors within existing economical system
VO7. New policies and regulations for employment and protection of rights of senior professionals, particularly those who fall into other vulnerable groups (e.g. as a result of ethnicity, sexual orientation, gender, etc).

Table 6. Strategic research actions for Occupation in Life

AO1	***Build collaboration platforms and systems.*** *Design and develop open ICT collaboration platforms, support, and systems aimed at facilitating value creation, addressing the specific needs of communities of senior professionals, and which promote inter-generational interaction and socialization, which are enhanced by affective computing, context awareness, and trust establishment.*
AO2	***Generate adaptive solutions and services.*** *Develop and integrate self-adaptive and configurable technology solutions and services in ICT environments, applying principles of e-accessibility, design for all, and usability in order to facilitate technology acceptance and enable customization for/by seniors.*
AO3	***Leverage legacy.*** *Develop environments that empower and enable seniors to create a legacy capitalizing on their invaluable and transferable personal / professional knowledge and experience.*
AO4	***Create a model framework.*** *Develop approaches, models, and reasoning methods related to older people's occupation life cycle and their participation in the economic system, including value systems, behaviors, and issues of physical, cultural and emotional health.*
AO5	***Create trusted knowledge network****. Create a trusted knowledge network that provides an integrative framework to enable seniors within their occupation in life, whether professional or voluntary.*
AO6	***Join online and offline collaboration****. Develop integrative framework for identity management which effectively and seamlessly joins online and offline collaboration, for seniors, to create invaluable connections between virtual and real-world aspects of their occupation in life.*
RO1	***Improve working practices.*** *Investigate new models of working practices and related reward and taxation models for seniors, taking account of work-life balance, aging well and gender, and promote the findings to positively influence societal perception of older workers.*
RO2	***Enhance policy and legislation.*** *Identify and assess current national and European policy, legislation and incentives relevant to active participation of seniors in the socio-economic system and recommend new approaches that lower barriers and promote and support active aging.*
RO3	***Guide career transition.*** *Define new life-long training programmes and realistic practices that prepare for and guide the successful transition of senior knowledge holders from full employment to occupation in life.*

Collaborative aspects. The creation of collaborative networks to facilitate the continuation of the involvement of seniors in the socio-economic system and to leverage their value creation potential is explicitly addressed in actions AO1, AO5, and AO6. In particular, the integration of existing communities of senior professionals with other existing networks (e.g. SME networks) constituting some novel forms of hybrid collaborative networks need to be explored. The lack of such integration has led to some *ghettization* of associations of senior professionals.

Furthermore, new working practices, policy and legislation facilitating and promoting flexible continuation of professional life and inter-generational collaboration are needed.

6 Recreation in Life

This life setting addresses how technology can facilitate socialization and participation of ageing citizens in social, leisure, learning, and even religious, cultural and political activities.

The following vision (Table 7) and plan of actions (Table 8) are proposed for this life setting.

Table 7. Vision for Recreation in Life

In the coming decade, ageing citizens will increase their pursuit of active recreational lifestyles that suit their abilities and preferences, which creates new opportunities for innovative supporting products and services. Recreation is seen as a broad set of activities involving peoples' participation and enjoyment in cultural life, craft, hobbies, sport and physical activity, entertainment, socialising, travel & leisure, political engagement, spiritual and faith groups, life-long learning, passing on personal wisdom, history and experience, keeping pets, and playing games. Active recreational interests and lifestyles may improve mental well-being, and have a positive effect on the physical health and well-being of seniors. New technology solutions can support communications between seniors, families, friends, and peers, strengthening community participation and forming new communities and social networks with similar interests.

Main desired facets:

VR1. Infrastructure and required technological platforms (connectivity, communications and networking infrastructures and pervasive applications and services that are universally accessible)

VR2. Adequate features and training support to enable seniors to access and use ICT safely (free from harm) and with security (free from threat or intrusion)

VR3. Appropriately designed software services to support seniors with personalized interfaces and affection-based interactions, that can adapt to users' sensory, cognitive and physical capabilities (within a context-aware and configure-yourself enriched environment)

VR4. Mechanisms to increase social cohesion, access to community and networking of seniors (including support for transport and mobility)

VR5. Growth and development mechanisms to increase knowledge dissemination and learning through sharing

VR6. Established associations of seniors and communities of interest, allowing active engagement (physically and virtually).

Collaborative aspects. Although many elderly social networks, focused on their socialization, have emerged in the last years, the proposed action plan (Table 8) aims at promoting the development of participatory, and thus collaborative, communities. Through these networks senior citizens can actively engage in community activities, inter-generational interactions and joint recreation initiatives.

Collaborative gaming is another relevant direction, focused both on novel games for seniors - aiming at stimulating and preserving their cognitive capabilities - and games designed for inter-generational interaction and re-enforcement of family links.

These actions require both novel models and technology development, as well as new policies and regulatory frameworks.

Table 8. Strategic research actions for Recreation in Life

AR1	***Build recreational platforms, solutions and services.*** *Design and develop open, secure, interoperable, flexible, customizable and affordable ICT recreational platforms, solutions and services for senior citizens.*
AR2	***Build novel interfaces.*** *Develop novel human-machine interfaces with high quality of usability and applying design for all principles, oriented towards seniors' active engagement in recreational activities, considering their cognitive and physical capabilities, and including augmented reality, affective computing, companion artifacts, pervasiveness, etc.*
AR3	***Find new recreational channels.*** *Elaborate innovation portfolio of new ICT-supported recreational activities for seniors, exploring tele-presence, remote participation in cultural events, collaborative gaming, intelligent urban environments, etc.*
AR4	***Build participatory communities.*** *Design, develop and implement local and regional participatory communities that combine online and offline participation through social networking, inter-generational interaction, and local government involvement, focusing participatory recreational life and wellbeing.*
AR5	***Create and promote gaming.*** *Design, develop and promote novel physical, recreational and cognitive games for seniors, with a holistic focus on recreation, wellbeing, socialization, and inter-generational collaboration.*
RR1	***Assess recreation impact.*** *Promote multi-disciplinary studies on the impact of physical and cognitive recreational activities for seniors.*
RR2	***Train for digital lifestyle.*** *Create and deploy training programs and mechanisms oriented to help senior citizens enter and explore new lifestyles in the digital age, with particular attention to rural areas.*
RR3	***Promote studies in recreation.*** *Promote studies on all aspects of ICT-enabled/induced social innovation oriented to participatory involvement of elderly in recreational, cultural and social life.*

7 Roadmap Validation

The proposed vision statements and strategic actions plan resulted from a multi-stage construction and validation process. An initial formulation was prepared by the BRAID consortium following a series of consultation workshops and brainstorming sessions. Once a set of strategic actions emerged as a result of the brainstorming exercise, it was then necessary to proceed with a verification of those actions. The adopted verification process, at the early stages of the roadmapping process, comprised two main activities [6], [7]: (i) Verify that the proposed actions adequately cover all facets of the vision. (ii) Assess the feasibility of each action considering the results of the gap analysis. Fig. 2 illustrates the first step of validating the roadmap results for the action AI4 under the independent living perspective.

Regarding the second step of validation, related to feasibility, the adopted approach was to consider how the supporting and limiting elements at European level identified in the gap analysis facilitate or make difficult the implementation of each action. Fig. 3 illustrates the assessment of the feasibility of action AI4 under the Independent Living perspective. This verification needed to be conducted by experts and depends on the perception of each individual according to his/her background knowledge. Therefore a qualitative scale (scale: Moderate, Hard, Very Hard) was adopted.

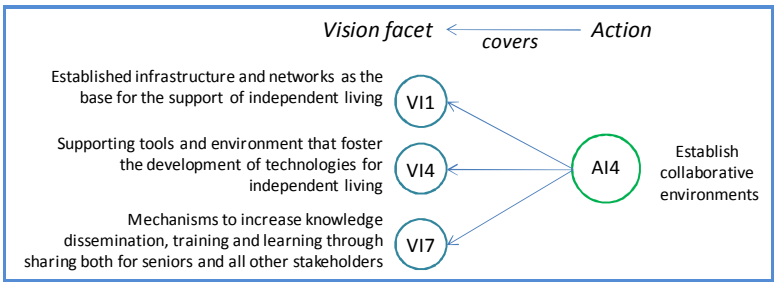

Fig. 2 - Covering the vision facets – an example

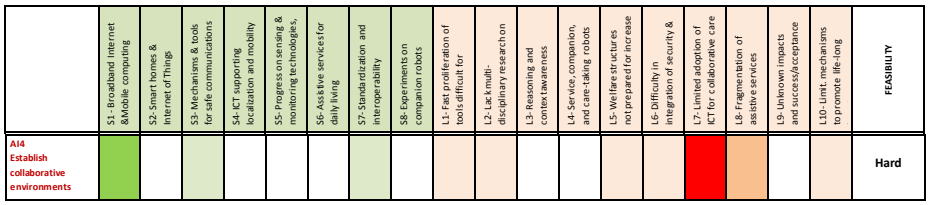

Fig. 3 - Assessing feasibility – an example

The current phase of the project is focused on the refinement and **consensus-building** among relevant stakeholders. For this purpose, a number of *Consensus Building Events* are organized in different regions of Europe. This is a ongoing activity and until the current phase more than 60 stakeholders and experts have been involved in the validation process.

After the validation phase, and once a wider consensus is achieved on the appropriateness of the proposed vision and list of actions for each life setting, a more detailed description of the actions and the involved research challenges will be prepared. Furthermore, and in order to allow the development of an implementation plan, each strategic action will be decomposed into a number of more focused sub-actions. The last phase of the roadmapping process will focus on the development of the implementation plan for the proposed research agenda. Three modalities of implementation are considered:

- R&D – focusing on fundamental research and prototype development / proof of concept, aimed at addressing longer term challenges.
- Trials – oriented towards the development of pilots and validation scenarios that allow verification and refinement of the results of previous phase with the objective of facilitating the development of innovative products and services.
- Broad deployment and continuous improvement – aiming at large scale validation – large pilots – of new technologies and services, as a mechanism to facilitate their take-up by society.

The implementation schedule and inter-dependencies among actions will be established at this stage. Finally the main stakeholders, their roles in the implementation plan, and suitable organizational structures will be identified.

Since a roadmap is not a static plan, principles for implementation monitoring and roadmap revision / updating need to be included in the implementation plan.

8 Conclusions and Further Work

The increase in the percentage of aged population is a critical issue in most Western countries. Together with a number of other big changes in society, this creates large challenges, such as the need for society to care for a much bigger number of elder people than before, but also many new opportunities, as e.g. the possibility to make use of a bigger accumulation of wisdom and knowledge than before.

ICT can play an important role in the provision of support services, and many research projects have developed partial solutions. It is now time to pursue more integrated solutions, combining contributions from multiple stakeholders, an area where collaborative networks can provide an encompassing framework. In order to support further developments in this area, a strategic research roadmap is being developed, which covers the perspectives of independent living, healthy living, occupation in life, and recreation in life. Interim results in the form of a vision and research agenda are now available and going through a consensus building process.

The systematic roadmapping process behind the proposed roadmap as well as the extensive validation process involving a large community of stakeholders, are important factors for providing confidence in the adequacy of the proposed roadmap. Nevertheless, as normal in any "futures planning" initiative, a roadmap is a dynamic construct that needs to be periodically revised alongside its implementation, taking into account new trends as they inevitably emerge.

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