Coordination Action in R&D in Accessible and Assistive ICT

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Coordination Action in R&D in Accessible and Assistive ICT

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Trends on Inclusive User Interface Design

ADVANCE DRAFT REPORT

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Background

This report aims to form a key part of the overall CARDIAC objective for developing research agenda roadmaps that highlight research priorities to favour Assistive and Accessible ICT in the future and will form a basis for continuing discussion on ***What type of research is missing that could facilitate development of inclusive HCI?***

Executive Summary

This report is an “advanced draft version” of WP3, Inclusive Human-Machine Interaction, Deliverable 3.2, entitled “Trends on Inclusive User Interface Design”.

What follows is an advanced draft including an in-depth explanation of how we are analysing the findings of the San Sebastián SDDP2.

D3.2 is intended to describe the current Trends on inclusive user interface design. This report identifies research and development areas (that should be further explored) that could benefit the development of inclusive human interfaces accessible for all people, and proposes a road map on inclusive HCI research.

Deliverable D3.2 in the Context of WP3

Overall goal of WP3

In recent years, a large number of international projects had to address the need for guaranteeing accessibility and usability in user-system interaction. To this end, a number of diverse approaches, methodologies and technologies have been proposed. Many research and development activities have been carried out on different aspects of accessibility of ICT equipment and services with an Assistive Technology approach, and more recently, the Design for All approach has been explored.

Positive results have been achieved combining both approaches. In particular, accessibility problems of specific groups of users have been addressed through AT based adaptations, and systematic Design for All approaches have been elaborated and applied in various domains at a research level. Still, the field is currently in need of a breakthrough towards the adoption of design approaches in practice, based on the accumulated knowledge, leading to accessible and usable inclusive interfaces.

The specific goals of Work Package 3 are:

- To study the advancements in inclusive Human-Computer Interaction (HCI) reached in the recent years, principally within European projects.
- To gather data from the involved industry about the needs for methodologies and tools for the design of inclusive interaction systems.
- To analyze current research trends in inclusive HCI and to select recommendable methodologies and technologies and to identify R&D gaps
- To propose a short/medium/long term set of objectives for the achievement of inclusive HCI.

Contributing tasks

The Tasks contributing to the work carried out in the context of Work Package 3 are as follows:

- T3.1 State-of-the art studies on inclusive HCI (including user modelling and user adapted interaction methodologies, and tools for the design of adaptive multimedia interfaces).
- T3.2 Review of the advancements in the field of inclusive HCI from past and current European projects in order to elaborate a catalogue of HCI methodologies and tools developed and/or used by European projects in the e-accessibility area.
- T3.3 To define a common set of short, medium and long-term objectives for inclusive HCI (from Task 3.1 and 3.2) and to write the last version of the report on “Trends on inclusive user interface design”
- T3.4: To elaborate a list of European industries and research centres with high expertise in the development of methods and tools for inclusive HCI design (from

the results of T3.1 and T3.2). To conduct and consult on-line with the list of experts in order to identify the key issues that must be discussed in the Structured Dialogic Design Process (SDDP) by WP2 and to gather "Factsheets" on what is being done in other major countries outside Europe. To prepare the materials including the analysis of the preliminary contributions. The results of this consultation will be used to propose a short list of triggering questions and a short list of key experts for the SDDP conducted by WP2 in order to produce a road-map on inclusive HCI research and development priorities.

WP3 workplan

The workflow in the context of the WP3 workplan is illustrated in the Figure 1.

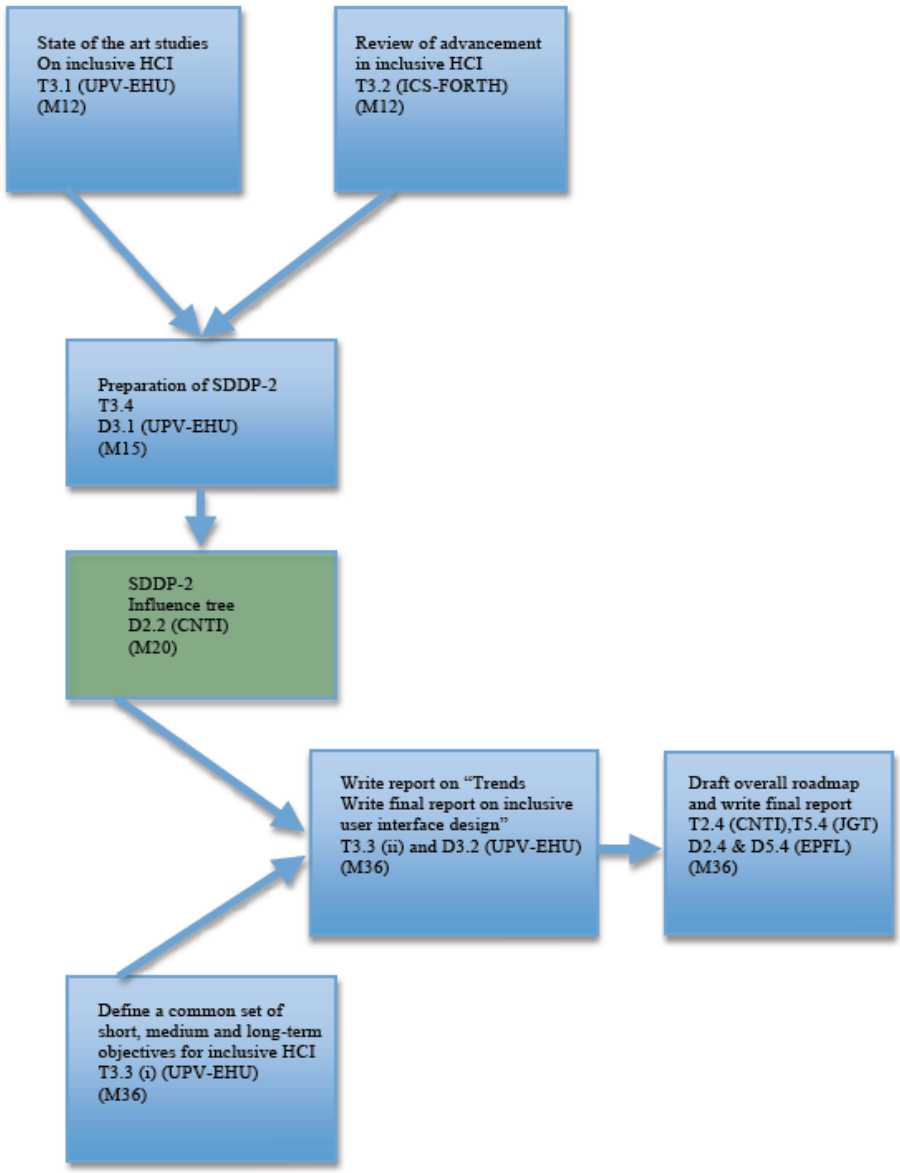

Figure 1: Workflow for CARDIAC Workpackage 3

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Acronyms and Abbreviations

AT	Assistive Technology
DfA	Design for All
HCI	Human-Computer Interaction
HMI	Human-Machine Interaction
ICT	Information & Communication Technologies
SDDP	Structured Dialogic Design Process
TT	Technology Transfer
UI	User Interface

1. Introduction

This interim report presents a first approach to analyze the current trends on Inclusive User Interface Design Research and a provisional set of proposals to be included in the research road map on inclusive HCI.

The main source of data for this analysis is the second Structured Dialogic Design Process (SDDP-2) of the CARDIAC Coordination Action, which was held in San Sebastian (Basque Country, Spain) between 28th and 29th of June, 2011. There, eight invited experts and fourteen CARDIAC members met to discuss and answer the triggering question "What type of research is missing that could facilitate development of inclusive HCI?" that was previously formulated by the consortium. The structuring of this SDDP seminar led to the generation of an influence tree where the answers were structured and ordered in a directed graph.

In addition, other sources have been consulted. Namely, other European initiatives and projects involved in prospective R&D and road-mapping, a number of European and non European experts, as well as scientific literature. These alternative sources served to verify the validity of the SDDP2 approach, to confirm its results, and to complete the gaps detected.

The resulting proposals have been thoroughly examined, discussed and checked. Nevertheless, they have to be seriously read. Even if the CARDIAC consortium has tried its best to include all the points of view, no one human group can pretend to know and understand all the parameters involved in such a complex field.

The last version of this report is due in February 2013, which gives the CARDIAC consortium a period to enhance the results. Therefore these provisional results must be taken only as a first approach to the inclusive HCI roadmap.

2. Methodological approach towards a roadmap

For the roadmap on Inclusive User Interface Design we adopted the methodology that was presented in the deliverable “D1.2: Production of Accessible & Assistive ICT Systems and Materials” [Heck, 2012], and used for the CARDIAC Technology Transfer roadmapping process. This methodology comprises the following systematic steps (schematized in Figure 2):

1. **Describe and analyse the current situation.**

   The present circumstances of Inclusive HCI are summarized in the chapter 3 Inclusive HCI, in this document. It contains a very brief summary of the more complete introduction to Inclusive HCI that can be found in the Cardiac Deliverable D-3.1: “Report with background material needed to support SDDP-2 Meeting” [Klironomos, 2011].

2. **Build a vision of a desired future with respect to Inclusive HCI.**

   The vision is a result from the 2nd CARDIAC SDDP workshop on Inclusive HCI, especially from the explanations of the generated ideas, collected in “D2.2: Influence Tree for the Road-map on inclusive HCI research and development priorities for WP3” [Laouris, 2012]. It is described in section 4.6 “A vision of inclusive Human-Computer Interaction”.

3. **Identify the gaps between the current situation and the vision and identify supporting factors (“bridges”) and limiting factors (“barriers”) in realising the vision.**

   This step is based on the analysis and comparison of the current situation with the vision contained in section r 4.7 “Bridges and barriers in achieving the vision”.

4. **Identify activities to overcome the gaps.**

   A structured list of ideas for activities that was a major outcome of the 2nd CARDIAC SDDP workshop. This step is performed considering the interactions contained in the most relevant branches of the influence three as sown in the section 4.8 “Identify activities to overcome the gaps”

5. **Prepare a first plan of activities to reach the vision.**

   The first plan of action in form of a dependency graph was the second major outcome of the 2nd CARDIAC SDDP workshop.

6. **Build a draft roadmap with goals, actions, sub-actions, involved stakeholders, and potential support activities of the European Commission.**

   A first approach to developing a complete R&D roadmap is presented in chapter 6. "Recommendations towards a Roadmap of Actions Supporting R&D in Inclusive HCI design"

This methodology provides the opportunity to cycle back from each step to one of the previous steps if necessary. This gives the chance to include new findings from other sources later on (other projects, feedback from external experts, future SDDP meetings) and so to enhance the roadmap without destroying earlier results.

Other parallel steps are interwoven in the course of the CARDIAC project, in order to complete the sources of information and to verify and validate the adequacy and feasibility of the actions.

- Consultation to other experts
- Verification of the proposals from other European initiatives on and technological roadmapping.

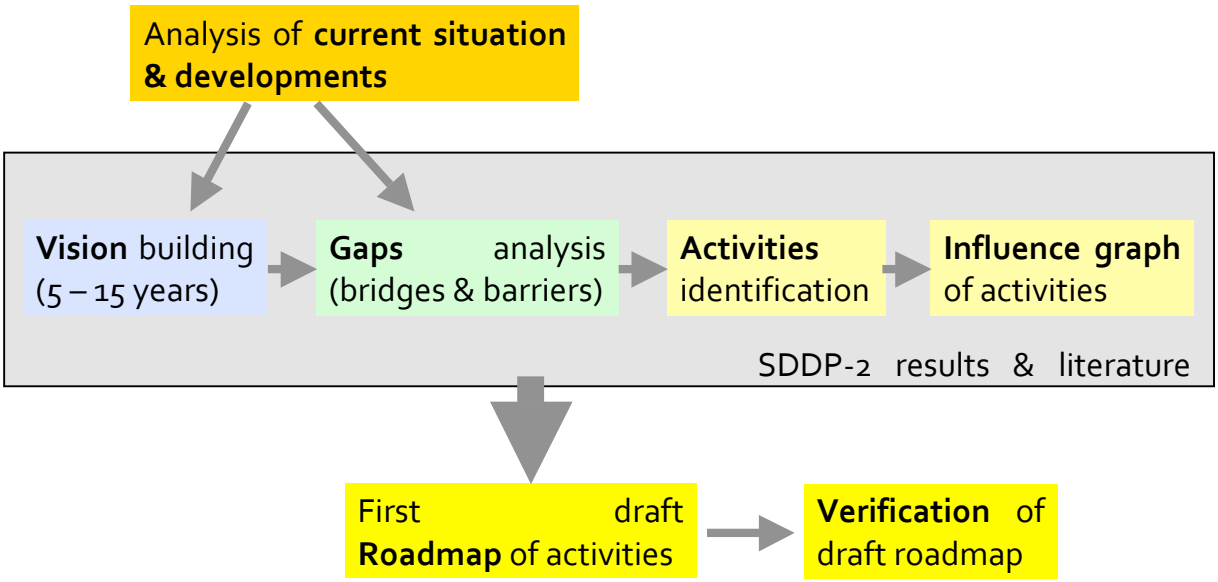


Figure 2: First steps of road-mapping

Sources of information

The CARDIAC Inclusive HCI roadmapping process mainly builds on:

- Results from the 2nd CARDIAC SDDP workshop on Inclusive HCI with the participation of external experts representing different types of stakeholders
- Results from other projects to complete the description of current situation and activities identification, described in chapter 5: Road maps from other European initiatives.

- Feedback from external experts, depicted in chapter 4: Consultation with non-European experts

This information is enhanced by various sources, including the expertise of various stakeholders:

- Feedback from the reviewers
- Results from the 1st and 3rd CARDIAC SDDP workshops on Technology Transfer and on Network-based Applications.

3. Inclusive HCI

This section contains a very brief description of the Inclusive HCI field, which is the main objective of this work. A more complete introduction to Inclusive HCI can be found in the Cardiac Deliverable D-3.1: “Report with background material needed to support SDDP-2 Meeting” [Klironomos, 2011].

In recent years, many research activities have focused on design that aims to produce universally accessible systems, taking into account special needs of various user groups. These special needs are associated with many user factors, such as impairments of speech, hearing or vision, cognitive limitations, aging, as well as with various environmental factors. Fields that address this problem, such as Usability, Universal Accessibility, Universal Design, or Inclusive Design have been developed as relatively independent domains, but they share many aspects with other HCI disciplines. However, researchers and practitioners are often not aware of interconnections among concepts of universal accessibility and “ordinary” HCI. In view of this situation show that there is a fundamental connection between multimodal interface design and universal accessibility, and that awareness of these links can help both disciplines. Researchers from these areas may use different terminology, but the concepts they use often have essentially the same meaning.

3.1. Human-Computer Inclusive design

Experience shows that a large amount of HCI systems are designed for someone conceived as the "standard man" leaving out the scope all the people with different physical, sensory or cognitive features. Having in mind that the most common human characteristic is just variety, most designs do not completely fit individual user’s needs.

The problem of matching product features with users' characteristics is most frequently addressed by the own user adapting himself or herself as much as possible to the interface. As a consequence, people that are not able to adapt themselves are simply left out of the possibility of using these products or services.

There exist design techniques and methodologies able to address users’ diversity, by means of modelling and adaptation. Nevertheless, they are not adequately known and used. In fact, the marginalization of large sectors of users was –and frequently is– justified by limitations of technology. Nowadays we know that technology can be designed in a most inclusive way avoiding the inclusion of unnecessary barriers. Inclusive Design aims to consider the needs of all users in mainstream applications and not only in the systems especially designed for people with physical, sensorial or cognitive restrictions.

The most distinctive characteristic of the accessible human-machine interaction is the critical importance of the human. Systems designed without taking into account the characteristics, needs, interests, likes, behaviours, etc, of the users are bound to failure. Unfortunately, interaction technologies are generally designed for the mythical “normal user” ignoring the huge human diversity. One of the reasons for this may be the designers’ deficient awareness

of methodologies and tools to include the users in the whole process of design and development. Another reason may be the complexity of applying existing methodologies. For this reason, CARDIAC aims to propose a roadmap on inclusive and accessible human-machine technologies, methodologies and tools that are rooted and centred in the users.

3.2. Advantages of Inclusive Design

Inclusive Design is based on the conviction that humans are naturally very diverse. The partition into "normal users" and "other users" is artificial and the frontiers between both populations are arbitrary. In fact, there are abundant examples where technology has eliminated or alleviated these frontiers. Something as simple as glasses –nowadays of common use– allow several people with eyesight restrictions to enhance their vision. More complex technologies, such as computers, give people with motor and speech impairments a way to personal and remote communication, and to control their environment.

Evidently, Inclusive Design has ethic and social origins. Universal Accessibility is supported by the conviction that all the human beings have the same rights. In practical terms this means that they should be able to access to the same services and to enjoy the same opportunities. Technological designs that unnecessarily establish barriers to universal use effectively exclude users with physical, sensory or cognitive restrictions.

In addition, to its ethics roots, inclusive technology is highly practical and useful. It frequently has a higher impact over the market because accessible products are directed to a broader population of potential consumers. In fact, people without disabilities usually find inclusive technology easier and more practical to use. On the other hand, the new ways to interact with mobile and ubiquitous technology frequently require hand and sight-free interaction, and as a result they can very much benefit from Inclusive Design. For instance, people wanting to read their email while they drive to work do need auditory interfaces, similarly to several vision impaired people. In addition they will need voice input to enter commands to the system, similarly to many people with severe motor restrictions.

3.3. Accessible Human-Machine interaction and Assistive Technology

The term Assistive Technology (AT) includes an ample set of technologies, devices and applications intended to assist people with disabilities to perform diverse tasks, such as communicate, gain access to computers, control their environment, navigate the physical environment, manipulate objects, etc. Therefore, AT promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to or alternative methods of interacting with the technology needed to accomplish such tasks. Likewise, disability advocates point out that technology is often created without regard to people with disabilities, creating unnecessary barriers to hundreds of millions of people. Even the manufacturers of AT technologies will often still argue that universal design is preferable to the need for AT and that universal design projects and concepts should be continuously expanded. People with

disabilities usually need assistive devices and programs that have been specifically designed to cover their needs taking into account their capabilities. These devices (e.g. Braille displays) are frequently used to access services or other devices (e.g. computers) that have not been specifically designed for them. The latter also have to be designed in a way that does not impose extra barriers to people with disabilities. Therefore, it is crucial to determine what are the technologies, methodologies and tools that allow the design of accessible and inclusive human interaction systems. These accessibility procedures must be applied to the design of both assistive technologies and mainstream technologies in order to avoid any type of barrier or exclusion.

4. Interpreting the results from SDDP2

4.1. The 2nd Structured Dialogic Design Process

The second Structured Dialogic Design Process (SDDP-2) of the CARDIAC Coordination Action, which was held in San Sebastian from 28th to 29th of June 2011, sought answers to the triggering question: **"What type of research is missing that could facilitate development of inclusive HCI?"**

A complete description of the activities carried out through the CARDIAC Wikispace, the seminar itself held in San Sebastián, and the subsequent discussions and results can be found in the Deliverable D2.2: Influence Tree on inclusive HCI Research and Development priorities for WP3 [Laouris, 2011] submitted for the second annual review.

4.2. Detecting the main areas of interest

The answers to the triggering question were collected before the meeting (by means of a Wiki site), during the meeting held in San Sebastian, and after it (by means of virtual meetings). The responses were grouped into clusters by the experts themselves. The criteria for clustering were principally related to users groups, application fields, underlying technologies, etc (See Table 1).

Table 1: Clustering

Cluster no.	Title	#Answers	Selected answers	Non selected answers
1	Beyond HCI	7	19,21	1,8,16,39,43
2	Cognitive Interaction [Cognitive load]	5	2,32, 45	65,66
3	Innovative user interfaces	9	3,13, 44,72, 74	23,31,36,73
4	Accessibility resource materials	7	4,10, 61	26,34,54,60
5	Adaptive user Interfaces	8	5,6, 15,35,	9, 22,41,50
6	Methodologies	4	7,29,47,63	
7	Knowledge sharing	2	69,71	
8	[Decision Making]	1	11	
9	[Design for all]	3		12,20,53
10	Universal Remote Console	3	14,27,46	
11	Ubiquitous computing	1		17
12	Simplification	2		62,70
13	Social Interaction	1		30
14	Human Factors	11	25, 40, 52, 64	24,28,38,48,49,55, 67
15	[Text interfaces]	1		37
16	Research on adoption of accessibility	1		42
17	User profiles	1	57	
18	Design tools	1		75

The complete list of ideas that received more that one vote from the panel of experts is in Table 2. In order to enrich the results, i.e. identify the participants' perceived degree of importance among the twenty ideas that received one vote each a second voting took place.

The ideas that received eight or more votes, selected in this second voting round, are in Table 3.

Table 2: Ideas that received more than one vote

No	Votes	Proposal
19	5	Research on inclusive user-interaction in ambient intelligence environments
32	5	Support research that looks how to reduce the complexity of user interaction whilst retaining functionality
15	4	Delivery of the interface - based on personalization, customization, adaptation and open APIs (such as REST) - to many more varied platforms
52	4	Support research on the implications for people with disabilities of the use of biometric systems for identification and security
61	4	Ways to move from purchase to lease or renting accessibility and assistive technology (exploring market, policy and technology challenges)
63	4	Research on automated evaluation aids
69	4	New mechanisms for international collaborations
2	3	Research aiming at avoiding cognitive barriers in the design of Human Machine Interfaces
7	3	Promote research in methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking
14	3	Develop and enforce standardized and harmonized remote HCIs
35	3	Support research on how affective computing can assist accessibility interfaces
40	3	Promote methodologies to include the human diversity in user interface design
41	3	Use reasoning (AI) techniques for personalization
44	3	Accessible telecommunications technologies for people with no or little speech
64	3	Basic research needs to be made on AT abandonment/adoption
71	3	Research on sharing accessibility knowledge with developing countries
3	2	Development of new haptic interfaces and methods for haptic usability
4	2	Design clearing house for inclusive HCI
6	2	Research of the use of context awareness to adapt user interfaces
10	2	Facilitate the creation of digital accessible materials to non accessibility experts
11	2	Promote tools for decision making in the user-centered design process
13	2	Support research on novel human-machine interfaces for recreational activities
21	2	Consider not only the interface as it appears but the entire interaction dialogue
27	2	To do research on how to use mobile technologies as a universal middleware in public and private environments
29	2	Research methodologies that efficiently collect data about users including existing HCI quantitative tools
45	2	Research on the cognitive load associated with various user interfaces
46	2	Promote interoperability among devices and services to enhance accessibility
47	2	Research on methodologies to analyse collaborative accessibility and undertake collaborative user- and usage centered design
57	2	Further research on static and adaptive user interaction profiles
72	2	Dynamic composition complex interfaces (mash-up of services)

The results of both voting procedures were used in order to select ideas for the following structural process. The participants were able to structure 33 out of the 50 ideas which received votes. This includes all ideas that received two and more votes (30 ideas) plus those ideas that initially received one vote and received the most votes during the second voting cast (3 ideas). The resulting “Tree of Influences” demonstrates the most influential ideas, i.e. those, which have the greatest impact. The tree is made up of 5 levels of influence, 33 ideas and 101 connections.

Table 3: Screening of the ideas that received one vote in the first voting

No.	Votes	Proposal
25	11	*Research on who could be excluded from using novel user interfaces*
5	8	*Development of practical adaptive user interfaces*
74	8	*Support research on accessible interaction with robots*

4.3. Influence tree

The complete set of answers to the triggering question was structured in an oriented graph, called influence tree, which provides revealing interrelations between the diverse research proposals. This structure was obtained by answering the question "*Assuming that we make progress in addressing factor X will this help us significantly in addressing factor Y?*", for each pair of proposals X and Y, using the software CogniscopeTM.

Analyzing the structure and content of this tree, illustrative information can be obtained. The following sections provide a synthesis of ideas generated.

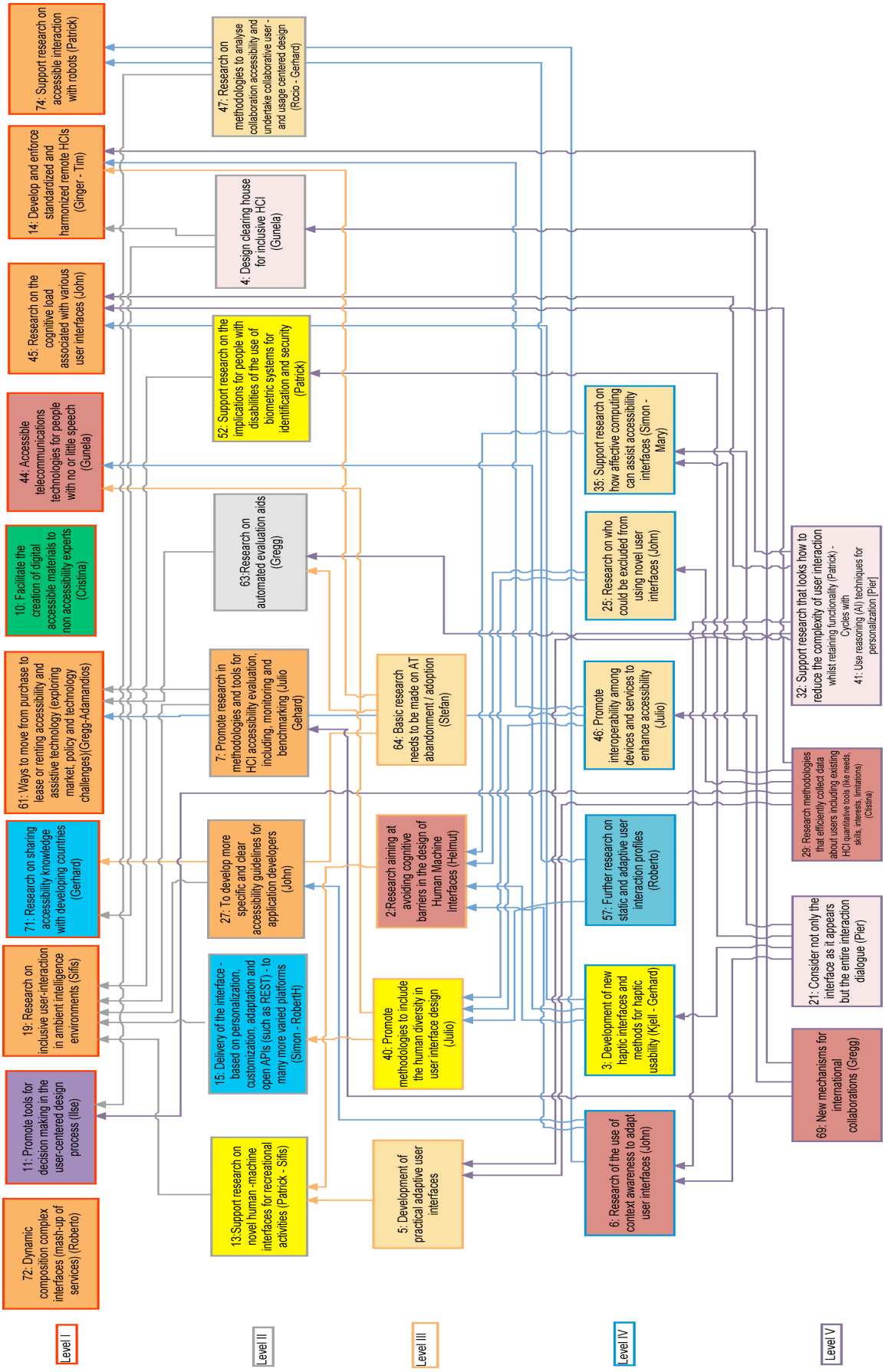


Figure 3: Influence tree from SDDP2 form deliverable D2.2 [Laouris, 2011].

4.4. Matching technological proposals with the users needs

The main criterion for an R&D programme in this field is to solve the needs of people with disabilities. Most of the R&D ideas proposed by the experts are intended to enhance the user experience for people with any type of disabilities. This is the case, for instance, of the user modelling, adaptive interfaces, guidelines and methodologies for accessible design, automatic tools for accessibility evaluation, etc. In addition some proposals are oriented to solve specific needs of concrete user groups that require precise interventions. The following paragraphs summarize a first attempt to match the technological proposals with the users that require them.

As can be seen in Table 4, most of the proposals affect to some degree all types of restrictions. Nevertheless, some of them are specially indicated for people with specific disabilities.

Table 4: Matching technological proposals with the users needs

N#	Proposal	Visual	Auditory	Motor	Cognitive	Elderly
19	Research on inclusive user-interaction in ambient intelligence environments					
32	Support research that looks how to reduce the complexity of user interaction whilst retaining functionality					
15	Delivery of the interface - based on personalization, customization, adaptation and open APIs - to many more varied platforms					
52	Support research on the implications for people with disabilities of the use of biometric systems for identification and security					
61	Ways to move from purchase to lease or renting accessibility and assistive technology					
63	Research on automated evaluation aids					
69	New mechanisms for international collaborations					
2	Research aiming at avoiding cognitive barriers in the design of Human Machine Interfaces					
7	Promote research in methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking					
14	Develop and enforce standardized and harmonized remote HCIs					
35	Support research on how affective computing can assist accessibility interfaces					
40	Promote methodologies to include the human diversity in user interface design					
41	Use reasoning (AI) techniques for personalization					
44	Accessible telecommunications technologies for people with no or little speech					
64	Basic research needs to be made on AT abandonment/adoption					
71	Research on sharing accessibility knowledge with developing countries					
3	Development of new haptic interfaces and methods for haptic usability					
4	Design clearing house for inclusive HCI					
6	Research of the use of context awareness to adapt user interfaces					
10	Facilitate the creation of digital accessible materials to non accessibility experts					
11	Promote tools for decision making in the user-centered design process					
13	Support research on novel human-machine interfaces for recreational activities					
21	Consider not only the interface as it appears but the entire interaction dialogue					
27	To do research on how to use mobile technologies as a universal middleware in public and private environments					
29	Research methodologies that efficiently collect data about users including existing HCI quantitative tools					
45	Research on the cognitive load associated with various user interfaces					
46	Promote interoperability among devices and services to enhance accessibility					
47	Research on methodologies to analyse collaborative accessibility and undertake collaborative user- and usage centered design					
57	Further research on static and adaptive user interaction profiles					
72	Dynamic composition complex interfaces (mash-up of services)					
25	Research on who could be excluded from using novel user interfaces					
5	Development of practical adaptive user interfaces					
74	Support research on accessible interaction with robots					

4.5. Main directions and general approaches

The base of the tree is composed of a small set of general purpose recommendations that provide a sort of work philosophy that guides all the specific research recommendations. In the SDDP2 four main approaches were pointed out.

- Holistic approach to inclusive HCI
- Decrease complexity and effort of user interaction
- Adopt user modelling techniques to tailor the interaction
- Promote open technologies and worldwide collaborations

Additionally, in a preliminary analysis by the SDDP steering committee a compact classification of the answers was produced. Four main areas were identified. At a first glance, these areas provide a general idea of the main issues that where in the minds of the experts.

- Promote Human Factors studies
- Promote the application of technological advancements
- Promote standardization and interoperability
- Advanced methodologies and tools to overcome accessibility barriers

As a first exercise, Table 5 presents the general approaches selected by the experts and Table 6 the main advancement directions, retaining the five priority levels obtained from the SDDP. All of them serve as a basis to structure the research approach.

Table 5: General approaches

	Holistic approach to inclusive HCI	Decrease complexity and effort of user interaction	Adopt user modelling techniques to tailor the interaction	Promote open technologies and worldwide collaborations
Level I		• 45: Cognitive load associated with various user interfaces		• 71: Sharing accessibility knowledge with developing countries • 61: Ways to move from purchase to lease or renting accessibility and assistive technology (exploring market, policy and technology challenges) • 10: Digital accessible materials to non accessibility experts
Level II				• 4: Clearing house for inclusive HCI
Level III	• 40: Methodologies to include the human diversity in user interface design	• 2: Avoid cognitive barriers in the design of HMI	• 5: Practical adaptive user interfaces	
Level IV			• 6: Use of context awareness to adapt user interfaces • 57: Further research on static and adaptive user interaction profiles	
Level V	• 21: Consider not only the interface as it appears but the entire interaction dialogue	• 32+41: How to reduce the complexity of user interaction whilst retaining functionality	• 29: Methodologies that efficiently collect data about users including existing HCI quantitative tools (like needs, skills, interests, limitations)	• 69: New mechanisms for international collaborations

Table 6: Main directions

	Promote Human Factors studies	Promote Technological advancements	Standardization and Interoperability	Advanced methodologies and tools
Level I		• 19: Inclusive user-interaction in ambient intelligence environments • 44: Accessible telecommunications technologies for people with no or little speech • 74: Accessible interaction with robots	• 72: Dynamic composition complex interfaces • 14: Standardized and harmonized remote HCIs	• 11: Tools for decision making in the user-centred design process
Level II	• 52: Implications for people with disabilities of the use of biometric systems for identification and security	• 13: Novel human-machine interfaces for recreational activities	• 27: Use of mobile technologies as a universal middleware in public and private environments • 15: Delivery of the interface - based on personalization, customization, adaptation and open APIs (such as REST) - to many more varied platforms	• 7: Methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking • 63: Automated evaluation aids • 47: Methodologies to analyze collaborative accessibility and undertake collaborative user- and usage centred design
Level III	• 64: Basic research on Assistive Technology abandonment/ adoption			
Level IV	• 25: Who could be excluded from using novel user interfaces	• 3: New haptic interfaces and methods for haptic usability	• 46: Interoperability among devices and services to enhance accessibility	• 35: How affective computing can assist accessibility interfaces
Level V				

4.6. A vision of inclusive Human-Computer Interaction

The following lists present a summary of visionary ideas for Inclusive HCI, how the desired future in 5 to 15 years should look like, from the 2nd CARDIAC SDDP workshop, derived from the ideas for supportive mechanisms and their explanations. (The references show the numbers of the corresponding idea descriptions; see Annex 1.)

Vision facet VF-1: Holistic approach to inclusive HCI

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-1:** **Holistic approach to inclusive HCI**	Research in inclusive HCI has to take into consideration all the factors implicated in the interaction. Only in this way effective integration can be achieved. Working modes, world models and general performance of both humans and computers need to be understood and taken advantage of. From a more general point of view, non technological factors should also be considered. These factors include technology availability, participation of all the stakeholders, social impact, ethical issues, delivery scheme, and economical issues. • Consider not only the interface as it appears but the entire interaction dialogue (from #021) • Promote methodologies to include the human diversity in user interface design (from #040)

Vision facet VF-2: Decrease complexity and effort of user interaction

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-2:** **Decrease complexity and effort of user interaction**	The reduction of the cognitive load imposed by many applications and interfaces was pointed as one of the key issues. Research should be oriented to reduce the complexity for the human side, taking full advantage of the increased capacity of the computers, networks, applications, etc. Artificial Intelligence, reasoning techniques, modelling and adaptation, etc., appear to be recommendable approaches to enhance the accessibility and usability, decrease human effort, and achieve enhanced functionalities. • Support research that looks how to reduce the complexity of user interaction whilst retaining functionality (from #032) • Use reasoning (AI) techniques for personalization (from #041) • Research on the cognitive load associated with various user interfaces (from #045)

	• Research aiming at avoiding cognitive barriers in the design of Human-Machine Interfaces (from #002)

Vision facet VF-3: Adopt user modelling techniques to tailor the interaction

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-3:** **Adopt user modelling techniques to tailor the interaction**	Many human-machine interfaces consider a "standard" or "normal" user and force people to adapt themselves to this model. Current advancements in user adaptation allow the situation to be reversed: the interface can automatically adapt itself to the features, needs, likes and circumstances of each specific user. User adaptive systems require building and maintaining users' models. A special effort is recommended in user modelling techniques based on data collected from previous interactions in order to personalize all the aspects of the interaction. • Research methodologies that efficiently collect data about users including existing HCI quantitative tools (from #029) • Delivery of the interface - based on personalization, customization, adaptation and open APIs (such as REST) - to many more varied platforms (from #015) • Development of practical adaptive user interfaces (from #005) • Research of the use of context awareness to adapt user interfaces (from #006) • Further research on static and adaptive user interaction profiles (from #057)

Vision facet VF-4: Promote Human Factors studies

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-4:** **Promote User centred design**	The progress to full accessibility requires a design centred in the user, taking into account human diversity, and avoiding all types of barriers that affect to user with permanent or occasional disabilities due to cognitive, sensory or physical restrictions. • Support research on the implications for people with disabilities of the use of biometric systems for identification and security (from #052) • Basic research needs to be made on AT abandonment/adoption (from #064) • Research on who could be excluded from using novel user interfaces (from #025)

Vision facet VF-5: Promote Technological advancements to design innovative user interfaces and assistive technology

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-5:** **Promote Technological advancements to design innovative user interfaces and assistive technology**	Some technological fields seem to be mature enough to produce advanced Assistive Technologies if the necessary research and development effort is allocated to them. Innovative interfaces and pervasive computing were pointed out. • Research on inclusive user-interaction in ambient intelligence environments (from #019) • Accessible telecommunications technologies for people with no or little speech (from #044) • Support research on accessible interaction with robots (from #074) • Support research on novel human-machine interfaces for recreational activities (from #013) • Development of new haptic interfaces and methods for haptic usability (from #003)

Vision facet VF-6: Standardization and Interoperability

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-6:** **Standardization and Interoperability**	Users with disabilities require the use of diverse devices, applications, and services locally and remotely provided. Most of them are based in diverse user interfaces and operating systems. There is also a specific need for interoperable Assistive Technology. • Dynamic composition complex interfaces (mash-up of services) (from #072) • Develop and enforce standardized and harmonized remote HCIs (from #014) • Research on how to use mobile technologies as a universal middleware in public and private environments (from #027) • Promote interoperability among devices and services to enhance accessibility (from #046)

Vision facet VF-7: Promote Advanced methodologies and tools

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-7:** **Promote Advanced methodologies and tools**	The provision of accessible human-machine interfaces and of well suited Assistive Technology for the mainstream applications and products requires that the knowledge about how to design accessible products, and the tools to do it in a reliable way, are available to all the designers. • Promote tools for decision making in the user-centred design process (from #011) • Promote research in methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking (from #007) • Research on automated evaluation aids (from #063) • Research on methodologies to analyse collaborative accessibility and undertake collaborative user- and usage centred design (from #047) • Support research on how affective computing can assist accessibility interfaces (from #035)

Vision facet VF-8: Promote open technologies and worldwide collaborations

Setting: **Inclusive Human-Computer Interaction** **Vision facet VF-8:** **Promote open technologies and worldwide collaborations**	Advancement towards full accessibility also requires that the knowledge is spread among all the possible stakeholders. Progress to the full availability of accessibility resource materials was seen as a basic need. This area includes proposals from these clusters: Knowledge sharing, and Accessibility resource materials. Even if the intended scope of this exercise is future research in Europe, the experts opine that any advancement in HCI accessibility requires a coordinated effort with other world regions. Collaboration with developed countries ensures better exploitation of the resources and compatibility of the results. Sharing methodologies, materials and tools allows for simpler and cheaper solutions available to a larger population, included people in developing countries. It is crucial to be open to new forms to combat the digital divide affecting especially people with disabilities and elderly people. Imaginative inexpensive solutions based on mobile communications and low cost basic devices can also provide acceptable solutions for disfavoured communities in developed countries. In addition, the expansion of the markets would make available assistive services

	and devices to most people. • New mechanisms for international collaborations (from #069) • Research on sharing accessibility knowledge with developing countries (from #071) • Design clearing house for inclusive HCI (from #004) • Ways to move from purchase to lease or renting accessibility and assistive technology (exploring market, policy and technology challenges) (from #061) • Facilitate the creation of digital accessible materials to non accessibility experts (from #010)

4.7. Bridges and barriers in achieving the vision

The following lists present the supportive factors ("bridges") and the limiting factors ("barriers") in realising the "vision"; based on the analysis of the current situation and the vision presented in the previous section. The references indicated the number of the related ideas from the 2nd CARDIAC SDDP workshop (see Annex 1).

Vision facet VF-1: Holistic approach to inclusive HCI

Bridges:	Barriers:
• The mainstream market is also demanding a holistic approach to human-machine interaction in order to unify and reduce the complexity of the user interfaces, taking into account all implicated issues: the users, their social and physical environment, their technology, etc. • Methodologies that consider the entire interaction dialogue and that include the human diversity in user interface design support this objective (from #021 and #040)	• There is a shortage of available methodologies able to deal with all the issues that intervene in the interaction. • A large dispersion and variety of technologies can be observed in the everyday usage of people with disabilities: diverse Assistive Technology (for communication, mobility, environment control, etc.); TV/DVD/CD remote controls; mobile phones, etc.

Vision facet VF-2: Decrease complexity and effort of user interaction

Bridges:	Barriers:
• General usability studies promote the simplification of the interfaces in order to decrease the cognitive load bore by the	• Latest devices, applications and services tend to sophistication and require complex interfaces in order to obtain full

users. • Advanced technologies, such as artificial intelligence, help to reduce the complexity of user interaction whilst retaining functionality (from #032 and #041) • Studying the cognitive load associated with the user interfaces will help to eliminate the cognitive barriers present in many Human-Machine Interfaces (from #045 and #002)	functionality. • Cognitive load models are not sufficiently well known and used by many mainstream HCI designers.

Vision facet VF-3: Adopt user modelling techniques to tailor the interaction

Bridges:	Barriers:
• Mainstream Human-Computer interaction is also making an effort in the development of practical adaptive user interfaces (from #005) • The application of static and adaptive profiles for user modelling, and of context awareness well-known techniques allow the automatic adaptation of the user interface (from #057 and #006) • Personalization and customization techniques can be applied to allow the adaptation to varied platforms (from #015) • User data collection require efficient and privacy aware methodologies (from #029)	• The industry tends to fancy colourful user interfaces that are cheaper and easier to develop than adaptive user interfaces. • Most current data-collection methods accumulate unnecessary data and are not respectful to the user's privacy.

Vision facet VF-4: Promote Human Factors studies

Bridges:	Barriers:
• User centred design is well accepted by the mainstream HCI community. These methods support human diversity. They can be the starting point to avoid the barriers that affect users with permanent or occasional disabilities due to	• It is known that the rate of Assistive Technology abandonment is relatively high (from #064) • The appearance of new devices, applications or services frequently excludes specific user populations from

cognitive, sensory or physical restrictions. • Support research on the implications for people with disabilities of the use of biometric systems for identification and security (from #052)	using novel user interfaces (from #025) • Many efficient identification systems, which can help in user adaptation, do not provide enough trust and safety to the user (from #052)

Vision facet VF-5: Promote Technological advancements to design innovative user interfaces and assistive technology

Bridges:	Barriers:
• Current interaction technology is able to produce advanced Assistive Technologies provided that the necessary research and development effort is done. • Innovative interfaces and pervasive computing advancements can converge to more accessible interfaces. • Home robots can be a very supportive Assistive Technology if their interface is accessible (from #074)	• Telecommunications technologies are frequently not accessible for people with no or little speech (from #044) • Ambient intelligence environments were envisioned without considering accessibility (from #019) • Most novel human-machine interfaces for recreational activities are inaccessible (from #013)

Vision facet VF-6: Standardization and Interoperability

Bridges:	Barriers:
• Current technologies allow the dynamic composition of complex interfaces (from #072) • Standardization at the user interface level allows the dynamic creation of harmonized remote HCIs (from #014) • Adequately adapted mobile technology can provide access to diverse interoperable devices and services enhancing accessibility (from #046) • Ubiquitous computing is developing interesting research through universal middleware in public and private environments (from #027)	• Current Assistive Technology is mostly not interoperable. Diverse operating systems and interfaces make impossible to operate the different systems that a single user needs. • Competition between the diverse industrial interests makes it difficult to achieve interoperability • The production of standards at the user interface level is slow and costly.

Vision facet VF-7: Promote Advanced methodologies and tools

Bridges:	Barriers:
• Promote research in methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking (from #007) • Research on automated evaluation aids (from #063) • Research on methodologies to analyse collaborative accessibility and undertake collaborative user- and usage centred design (from #047) • Support research on how affective computing can assist accessibility interfaces (from #035)	• Shortage of tools for decision making in the user-centred design process (from #011) • Knowledge about how to design accessible products, and the tools required to create well suited Assistive Technology for the mainstream applications and products it in a reliable way are not always available to all the designers.

Vision facet VF-8: Promote open technologies and worldwide collaborations

Bridges:	Barriers:
• Advancement towards full accessibility also requires that the knowledge is spread among all the possible stakeholders. Progress to the full availability of accessibility resource materials was seen as a basic need. • Awareness of the need for coordinated effort with other world regions in accessibility issues for a better exploitation of the resources, and the compatibility of the results, • It is known that collaboration with underdeveloped countries facilitates the availability of simpler and cheaper solutions, and a larger market. • Imaginative inexpensive solutions based on mobile communications and low cost basic devices also provide acceptable solutions for disfavoured communities in developed countries.	• The digital divide (affecting especially people with disabilities and elderly people) is not decreasing. • Non accessibility experts lack resources for the creation of digital accessible materials (from #010) • There is a shortage of efficient and effective mechanisms for international collaborations with developing countries (from #069) including sharing materials (from #071) and accessibility knowledge. • Assistive Technology is frequently too expensive to be purchased and there are an insufficient number of ways of acquiring it, such as leasing or renting (from #061) • Lack of a global market for affordable assistive services and devices in order to reach most people.

4.8. Identify activities to overcome the gaps

The 2nd CARDIAC SDDP workshop produced as a major outcome a structured list of ideas for research activities in the area of Inclusive HCI. These ideas have been represented in the Influence Tree (displayed in Figure 3), a directed graph that provides information about the mutual relationships. They were structured considering if the advancement of each idea would have a positive influence in the implementation of the other ideas.

As it was previously mentioned, the participants in the SDDP2 seminar sorted the proposals answering this question: "*Assuming that we make progress in addressing factor X will this help us significantly in addressing factor Y?*" In the answer is "yes" the straight interpretation is: factor X should be addressed beforehand in order to facilitate addressing factor y. For instance, Figure 4 shows a direct influence from factor 32: "Support research that looks how to reduce the complexity of user interaction whilst retaining functionality" in factors 45: "Research on the cognitive load associated with various user interfaces" and 14: "Develop and enforce standardized and harmonized remote HCIs". But it can be also interpreted in the following way: The support of research that looks how to reduce the complexity of user interaction whilst retaining functionality requires advancements in the research on the cognitive load associated with various user interfaces and in developing and enforcing standardized and harmonized remote HCIs. Therefore each branch of the tree requires specific analysis and interpretation.

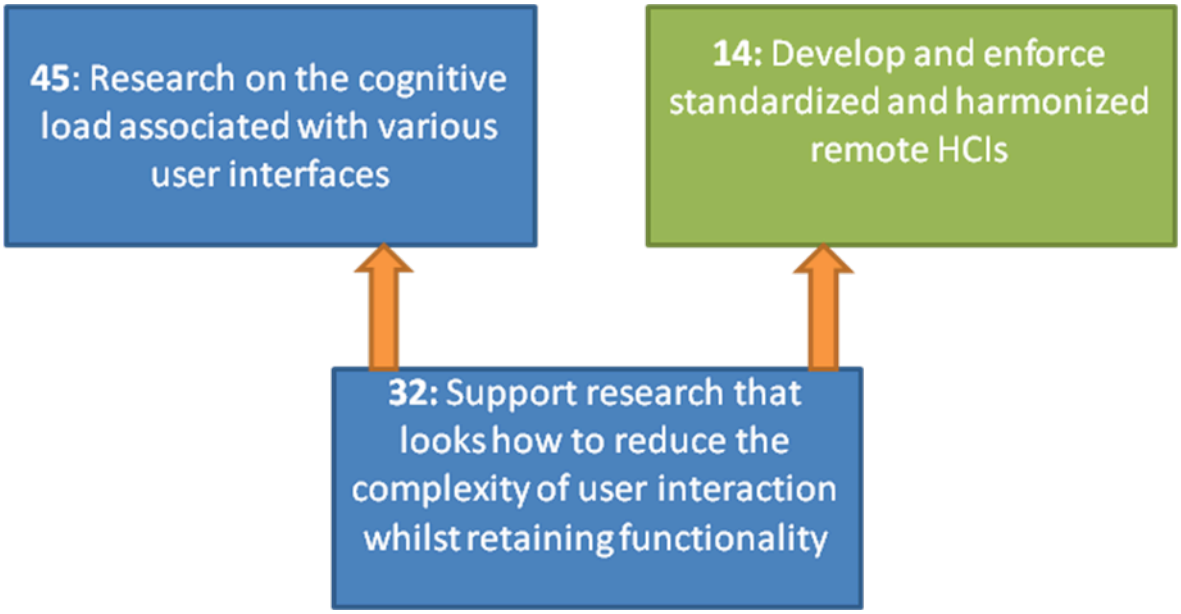


Figure 4: From policies to actions

In addition, the Influence Tree shows complex relationships among the proposals that can not be univocally and simply interpreted. For instance, Figure 5 could be directly interpreted in this way: in order to achieve factor 74: "Support research on accessible interaction with robots", factors 6 "Research of the use of context awareness to adapt user interfaces" and 57: "Further research on static and adaptive user interaction profiles" should be addressed.

But factor 6 requires significant progress in factors 32: “Support research that looks how to reduce the complexity of user interaction whilst retaining functionality” and 21: “Consider not only the interface as it appears but the entire interaction dialogue”. This branch of the Influence Tree cannot be understood as a temporal sequence. It is more the combination of knowledge fields that are required to progress through specific technological objectives.

Therefore, even if the Influence Tree looks like an ordered graph, it is not a mathematical representation of the relationships, and therefore an arrow does not imply a “total order relation”. In fact, interconnected actions can be also developed in parallel. In addition, other implicit aspects must be considered in order to temporally schedule the required R&D actions. For instance, the availability of the required knowledge, technology and resources is a key factor to take decisions in this field.

Finally, policy issues that are out of the scope of this study can have a key role in the general planning of the European R&D actions, for instance the coincidence with the main priorities and social objectives of the EU; the existence of competing R&D European actions; the possibility of collaboration with other R&D European programmes; and the availability of the required financial support.

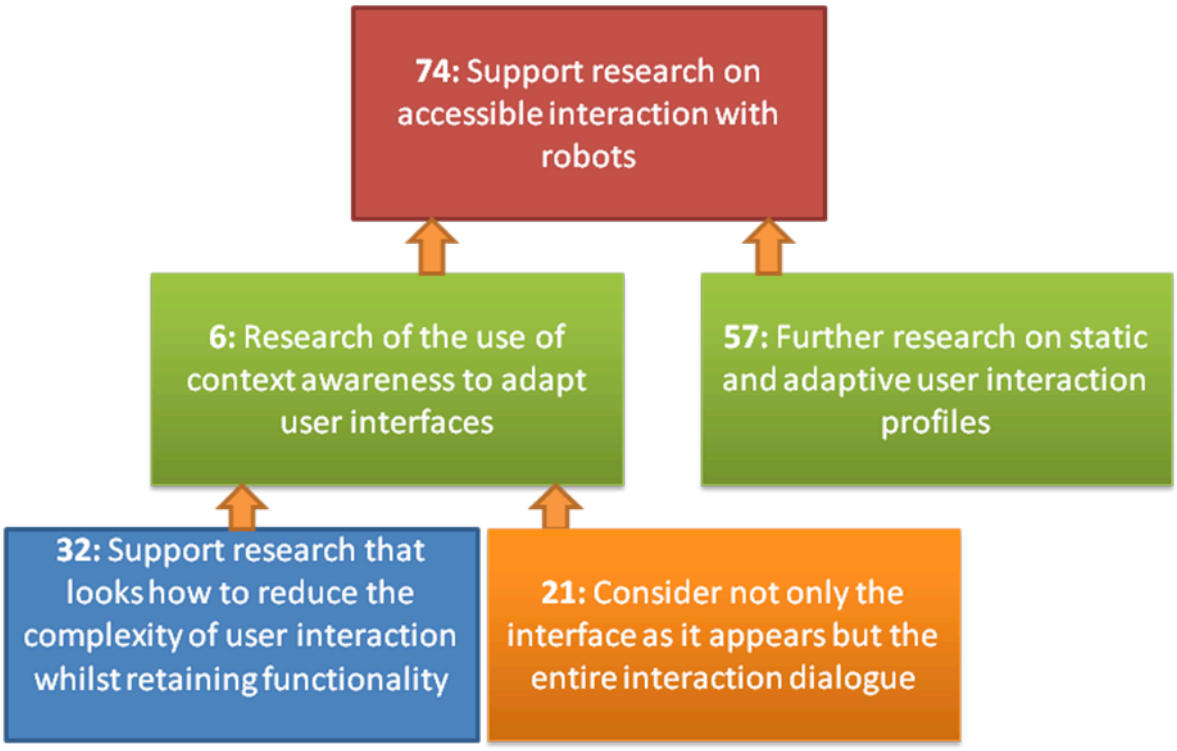


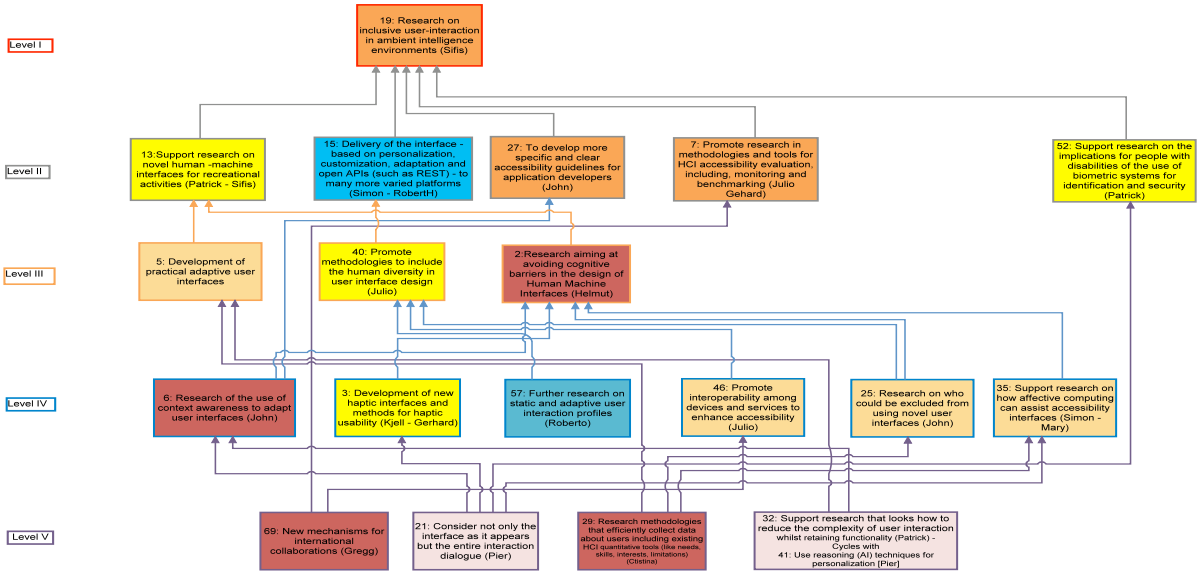
Figure 5: A multilevel influence sub-tree

A complete presentation and initial analysis of the Influence Tree can be found in the deliverable D2.2: “Influence Tree for the Road-map on inclusive HCI research and development priorities for WP3” [Laouris 2011]. In this report the branches of the Influence

Tree have been extracted and interpreted separately in order to show the procedure to identify the activities that can contribute to overcome the detected gaps. For instance, in the following page the structure of the most complex branch converging to factor 19 is presented, namely: Research on inclusive user-interaction in ambient intelligence environments.

Table and sub-influence map for Factor #019 (5 votes)

	Supported by	Supported by	Supported by	
Factor #019	#013	#005	#029	
			#032 & #041	
		#002	#003	#021
			#025	#029
			#035	#021
				#029
			#006	#021
				#032 & #041
	#015	#040	#057	
			#046	
			#025	
	#027	#006	#021	
			#032 & #041	
	#007	#069		
	#052	#021		



5. Other sources

5.1. Consultation with external experts

5.1.1. Consultation with non-European experts

In order to complete the general vision about what research should be supported in the field of accessible HCI and Assistive Technology, three non-European accessibility experts were contacted and asked about their views regarding what research should be supported in the field of accessible HCI and Assistive Technology, in the short, medium and long term. We specifically asked their insights on the need for: Specific Technologies; Methodologies; Tools; Standards, Norms and Guidelines; and any other related issue, such as Social/Ethical Issues, Collaboration Frameworks, etc.

The intention was not to conduct a poll with a balanced sample of selected people from large number of non-European experts. To the contrary, we sought direct exchange of ideas with a small number of experts, in order to discover if there are subjects that had not been considered so far in our perspective. In order to avoid any bias, they were not previously informed about the results that had been obtained from the Structured Dialogue Design Process (SDDP) co-laboratory held on June in Donostia-San Sebastian, with the purpose of generating an influence map in response to the Triggering Question "What type of research is missing that could facilitate development of inclusive HCI".

The experts contacted were:

- Professor Albert Cook[1] of the University of Alberta (Canada) (AC).
- Professor Jonathan Lazar[2], Director of the Universal Usability Laboratory, Towson University (USA) (JL).
- Professor Zhengjie Liu[3], Director of the Sino-European Usability Center, Dalian Maritime University (China) (ZL).

The following paragraphs summarize their insights about these questions.

The Short Term

The experts were questioned about their perspectives in this field in the short term (less than five years from now). All the experts agreed that there is a need of supporting the deployment of some specific assistive technologies. As examples of technologies that can generate promising results in the short term, the experts mentioned the following:

[1] More information about Professor Cook in http://www.uofaweb.ualberta.ca/spa/AlbertCook.cfm

[2] More information about Professor Lazar in http://triton.towson.edu/~jlazar/

[3] More information about Professor Liu in http://usability.dlmu.edu.cn/english/lzj.htm

“technologies to make affordance of ubiquitous ICT universally visible by all the people and to enable underserved communities to be fully involved in the social life that is increasingly a mix of offline and online” (ZL); “Alternative sensing methods that allow access by people with severe motor impairments and access methods for those with athetoid cerebral palsy movements (AC); “Improvements in existing screen readers, less expensive alternative keyboards and pointing devices” (JL).

The experts were also questioned about what methodologies should be promoted in the short term in this area. They pointed out “methodologies to understand, design, and evaluate ubiquitous social media applications across different contexts and communities” (ZL), “Greater use of cloud and ubiquitous computing to allow devices to be automatically customized for particular environments and applications - especially for cognitive disabilities” (AC), “More case studies of successful use of assistive technology in workplaces, more empirical research on how people with disabilities use mobile devices” (JL).

The experts also recognized the need for specific tools, for instance: “Tools and methods to accurately capture and measure low educated people’s subjective feedback to ICT applications” (ZL); and “better automated software evaluation tools for web accessibility” (JL).

In relation to the support of Standards, Norms and Guidelines, the experts opined that there is a need for “guidelines for designing and evaluating ubiquitous social media applications for and across different contexts and communities” (ZL); “for implementing and managing web accessibility—what policies can be put into place, what tools to use, how often to check? (JL); “for mobile apps that ensure minimum good practice procedures are followed in development” (AC). In addition “consistencies between mainstream mobile technology platforms to ensure accessible technologies are platform independent” (AC) should be searched. On the other hand “Standards/policies to ensure ongoing accessibility need to be available” (JL).

With respect to the universal accessibility goal, “disability access to the most basic mainstream technologies (e.g. basic cell phone) to ensure access for those in developing countries who have only those technologies” (AC) looks indispensable.

As a general comment, they indicated that “there is a need for more information/openness/clarity from EU on their accessibility goals” (JL).

Table 7: Experts' proposals for the short term

Field	Non European experts recommendations	Parallel SDDP2 recommendations
Technologies	Ubiquitous ICT universally accessible	[17], [19], [39]
	Alternative sensing methods	[33], [3]. [31]
	Screen readers, alternative keyboards and pointing devices	None
Methodologies	Understand, design, and evaluate ubiquitous social media applications	[30]
	Cloud and ubiquitous computing for automatically customized devices	[72], [14], [4]
	AT case studies in workplaces	None
	Empirical research on mobile device use	None
Tools	Capture and measure people's subjective feedback to ICT applications	[22]
	Better automated software evaluation tools for web accessibility	[63], [7]
Standards and Guidelines	Guidelines for designing and evaluating ubiquitous social media	None
	Guidelines for implementing and managing web accessibility	[7], [26]
	Guidelines for mobile apps to ensure minimum good practice procedures in design	None
Universal accessibility	Access to the most basic mainstream technologies (e.g. cell phone) to ensure access for developing countries having only those technologies	[71], [69]

The Medium Term

Similar questions were posed taking into consideration a horizon between five and ten years from now.

With respect to the support to the development of specific technologies, the experts proposed "greater options for individuals for mobility assistance and access to other than text-based information, and technologies that will extend the world of congenital deaf-blind children beyond their fingertips" (AC). They identified a "need to find ways to make tactile and Braille displays less expensive" (JL) and "Technologies to help people to make use of their skills in physical world in dealing with the virtual world things and technologies to enable machines to be context aware like human beings" (ZL).

Looking to the methodologies, "automatic adaptation of access controls & methods to accommodate for growth in children and lost function in progressive diseases (e.g., ALS)" (AC), and "methodologies to understand and model human's context awareness scheme so as to be able to build up a real context-aware system in human's sense" (ZL) were stressed. In addition, a need for "much more research and methodological understanding of people with cognitive impairments as individuals, rather than large umbrella of cognitive impairment which is misleading" (JL) was pointed out.

Regarding to the requirement of tools, there is a "need more effective automated tools for publicly monitoring national government web site accessibility" (JL).

In relation to Standards, Norms, Guidelines, etc., there will be a "need guidelines for mobile app accessibility. More governments need to harmonize with WAI guidelines rather than design their own" (JL). In addition, "basic access methods built into mobile device operating systems like Easy Access (e.g., sticky keys, etc) was developed for PC and Macintosh

operating systems. These focussed on touch screen and other input/output methods that are typically employed in mobile devices" (AC).

As general comments, they identified a need for "design for all extended to wider range of potential limitations to accommodate for aging population that doesn't want to be considered "disabled" (AC), and for "more openness and transparency in government progress on accessibility (this is true in many different countries), with posted data about accessibility levels of government web sites on a monthly basis" (JL).

Table 8: Experts' proposals for the medium term

Field	Non European experts recommendations	Parallel SDDP2 recommendations
Technologies	Mobility assistance and access to other than text-based information for congenital deaf-blind children	None
	Less expensive tactile and Braille displays	None
	Context aware support	[6]
Methodologies	Automatic adaptation for growth in children and lost function in progressive diseases	[5],[41],[57]
	Understand and model human's context awareness	[6]
	Consider people with cognitive impairments as individuals	[2], [45]
Tools	More effective automated tools for publicly monitoring national government web site accessibility	None
Standards and Guidelines	Guidelines for mobile app accessibility	None
	National guidelines need to harmonize with WAI guidelines	None
	Basic access methods built into mobile device operating systems	None
Universal accessibility	Design for all extended to wider range of potential limitations to accommodate for ageing population	None

The Long Term

For the long term a time span of more than 10 years from today was considered. Obviously, as the observed time period gets longer the prospective activity becomes more difficult. For this reason, the experts only attempted to provide some hints regarding the long term.

They argued that there will be a need of "Technologies to help people to make use of their skills in physical world in dealing with the virtual world things" (ZL). On the other hand, they proposed "more work on brain-computer interfaces" (JL). They observed a "need for methods for incorporating accessibility/AT into primary, secondary, and post-secondary education so that it's considered mainstream since people grow up with it and learn about it in their education" (JL). In addition, they detected a "need to develop software tools that can automatically evaluate non-web-based interfaces, such as corporate applications, mobile apps, and operating systems" (JL). As an expected standard, "most consumer devices need to become accessible-out-of-the-box". With respect to a stronger support to universal accessibility "maybe in the long term, the UN can get more involved with accessible technology standards" (JL).

Table 9: Experts' proposals for the long term

Field	Non European experts recommendations	Parallel SDDP2 recommendations
Technologies	Technologies to help people to make use of their skills in physical world in dealing with the virtual world things	None
	Brain-computer interfaces	[23]
Methodologies	Incorporating accessibility/AT into primary, secondary, and post-secondary education	*[62]*
Tools	Software tools that can automatically evaluate non-web-based interfaces, such as corporate applications, mobile apps, and OS	[63], [7]
Standards and Guidelines	Most consumer devices need to become accessible-out-of-the-box	None
Universal accessibility	International institutions more involved with accessible technology standards	[69]

Conclusions

A detailed analysis and comparison of these answers with the ones obtained in the SDDP co-laboratory allowed us to conclude that:

- There is a large general coincidence in the general objectives and approaches with the ones expressed in the SDDP2.
- There are some proposals from the experts that are not related to similar recommendations from the SDDP2 due to the fact that the SDDP2 was focused on Inclusive HCI, while comments of experts are more general.
- There are some new ideas that should be included in our roadmap.

As a conclusion we can state that the answers from these three experts were extremely valuable to validate and complete our approach.

Possible contributions to the CARDIAC Inclusive HCI roadmap

- 101: Improvements in existing screen readers, less expensive alternative keyboards and pointing devices.
- 102: More case studies of successful use of assistive technology in workplaces.
- 103: More empirical research on how people with disabilities use mobile devices.
- Guidelines for designing and evaluating ubiquitous social media.
- 104: Guidelines for mobile apps to ensure minimum good practice procedures in design.
- 105: Guidelines for mobile apps to ensure minimum good practice procedures in design.
- 106: Technologies that will extend the world of congenital deaf-blind children beyond their fingertips.
- 107: Technologies to make less expensive tactile and Braille displays.
- 108: More effective automated tools for publicly monitoring national government web site accessibility.
- 109: National guidelines need to harmonize with WAI guidelines.
- 110: Basic access methods built into mobile device operating systems.

- 111: Design for all extended to wider range of potential limitations to accommodate for ageing population.
- 112: Technologies to help people to make use of their skills in physical world in dealing with the virtual world things.
- 113: Most consumer devices need to become accessible-out-of-the-box.

5.1.2. Consultation with European experts

A similar request was sent to nine European experts after directly contacting them and agreeing their collaboration. However, only three answers were received. The experts that provided their answers were:

- Martin Maguire[4]. Loughborough Design School, Loughborough University (MM).
- Edward Chandler and Steve Tyler. Royal National Institute of Blind People (EC&ST).
- David Sloan[5]. School of Computing. University of Dundee (DS).

The following paragraphs summarize their insights about these questions.

The Short Term

These experts proposed some examples of technological oriented research. For instance, a "convenient way to read out or enlarge paper based documents, e.g. post, or instructions/labels on packages" (MM); "less complex IT that make computer and internet usage hard for people not experienced with computers and possibly people with cognitive impairments" (MM); "a technology that can overcome the large number of passwords that people need to have for their life online" (MM); "research into mobility scooters, how they are used and how they can be better designed for the needs of older and disabled people" (MM); "implementation of complex technologies in a non complex way. As an example a smart phone can provide a lot of solutions (internet access/navigation via GPS/barcode scanner) but the user needs to know about the phone interface, downloading apps etc. Is there a way of delivering complex solutions but with a very simple interface which uses a dialogue base approach to interact with the user?" (EC&ST).

With respect to the required methodologies, "User-Centred Methodology that is implicit with systems design and is practiced by designers and developers" (MM). "Inclusive user experience: We need to explore the effectiveness of accessibility guideline conformance as predictors of level of inclusion a particular ICT supports, by applying user experience research methods to focus on quality of ICT usage by currently excluded groups. The objective would be to develop a deeper understanding of how we can best measure quality

[4] More information about Doctor Maguire: http://www.lboro.ac.uk/departments/lds/staff/dr-martin-maguire.html

[5] More information about Dr. Sloan in: http://www.computing.dundee.ac.uk/staff/dsloan/

of ICT usage experience reported by excluded groups, and use this understanding to develop methods for more effectively applying best practice in accessible ICT design" (DS).

In relation to the needed tools, "A population map for Europe that shows clearly the numbers of people with specific impairments and can respond to proposed design features e.g. text of 16 point can be read by 75% of people" (MM); "Archive of older and disabled people's stories about problems in everyday life that designers can draw from" (MM); Data Analytics for Accessibility: Organisations have access to increasingly rich and large quantities of automatically gathered data on users of their web sites and the journeys that users undertake. How can we make better use of our ability to collect and analyse large datasets to understand more about the profile and behaviours of specific user groups, with the goal of identifying the location, nature and impact of accessibility barriers? How can we best use this information to focus efforts on addressing accessibility barriers, while recognising potential legal and ethical constraints under which such activities would have to take place? (DS); "Inclusive content creation: As content creation becomes more ubiquitous – different platforms, different tools, different formats – so, less underlying technical knowledge is required to create and share digital content. How can we better provide tools that support inclusive content creation, so that non-experts have the best chance of providing accessible content out-of-the-box?" (DS).

In the field of Standardization, "More understandable accessibility design guidelines for web designers" (MM); "Guidelines or standards for accessible mobile interfaces" (MM);

Finally, in relation with other issues, such as universal accessibility, social ethical issues, collaboration frameworks, etc., "Better understanding of older and disabled people's strengths while may be superior to the mainstream rather than just considering them less able" (MM); "Research to understand what charities, universities and NGO's are doing in relation to inclusive ICT/HCI. This should include top level strategies, projects and campaigns that are being carried out or in the pipeline. It will also be a good way at bringing together research performed by these organisations to understand why they are focusing on a specific area (e.g. access to ATMs)" (EC&ST); "Dynamic ageing and effect on ICT use: Extending current activity researching challenges facing older ICT users, by applying a longitudinal dimension to studies of older people's usage of ICT users. The focus would be to establish the effect of the interplay between age-related factors such as change in capability social and economic situation, and changes in technology (hardware, software, new user interface and interaction paradigms), with the aim of improving ICT design and the support network available to older ICT users" (DS); "Inclusive ICT education: Accessibility and digital inclusion is still seen as a niche area, a specialism. Basic principles of good digital resource creation need to become more widely entrenched in digital literacy curricula – so what are the most effective processes for raising awareness and skill levels amongst learners of all ages, from primary school to adult learners?" (DS).

Table 10: Experts' proposals for the sort term

Field	European experts recommendations	Parallel SDDP2 recommendations
Technologies	Convenient way to read out or enlarge paper based documents (post, instructions/labels, etc.).	None
	Less complex IT for computer inexperienced people and for people with cognitive impairments.	[2], [32], [45]
	Overcome the large number of passwords that people need to have for their life online.	N/A
	Research into mobility scooters, how they are used and how they can be better designed for the needs of older and disabled people.	N/A
	Implementation of complex technologies in a non complex way, delivering complex solutions with simple interfaces.	[2], [5], [45]
Methodologies	UCD methodology that is implicit with systems design and is practiced by designers and developers.	[47], [11], [40], [60]
	Inclusive user experience: to develop a deeper understanding of how we can best measure quality of ICT usage experience reported by excluded groups, and use this understanding to develop methods for more effectively applying best practice in accessible ICT design.	None
Tools	A population map for Europe showing statistics about people with specific impairments and the expected impact by proposed design features.	N/A
	Archive of older and disabled people's stories about problems in everyday life that designers can draw from.	[4]
	Data Analytics for Accessibility: collect and analyse the existing large quantities of automatically gathered data on users to understand more about the profile and behaviours of specific user groups, with the goal of identifying the location, nature and impact of accessibility barriers, and use this information to focus efforts on addressing accessibility barriers, while recognising potential legal and ethical constraints.	[29], [25], *[60], [52]*
	Inclusive content creation: to provide tools that support inclusive content creation, so that non-experts have the best chance of providing accessible content out-of-the-box.	[10], *[49]*
Standards, Norms and Guidelines	More understandable accessibility design guidelines for web designers.	None
	Guidelines or standards for accessible mobile interfaces.	None
Universal accessibility	Better understanding of older and disabled people's strengths while may be superior to the mainstream rather than just considering them less able.	None
	Research to understand what charities, universities and NGO's are doing in relation to inclusive ICT/HCI.	N/A
	Dynamic ageing and effect on ICT use: Extending current activity researching challenges facing older ICT users, by applying a longitudinal dimension to studies of older people's usage of ICT users.	N/A
	Inclusive ICT education: digital literacy curricula to raise awareness and skill levels amongst learners of all ages, from primary school to adult learners.	*[62]*

Note: Some of the recommendations are considered out of the scope of the CARDIAC Inclusive HCI study and marked N/A. Although they will be included in a general considerations chapter of the final report.

The Medium Term

For the medium term, these experts proposed the following technological advancements: “Virtual helper (possibly an avatar) that can give specific help on any IT activity knowing what you are trying to achieve” (MM); “Single tablet interface that can interact with home technology by proximity presenting a simple and consistent user interface” (MM); “A My Google database and search facility that is based on a single person’s own history to give them memory support” (MM); “Human-computer interfaces that can assess a person’s needs and adapt to them automatically” (MM); “Design of cars for people disqualified from driving due to impairment” (MM); “Which technologies will be the most influential to disabled people if they are delivered in the correct manner. For instance NFC could have huge potential but only if the implementation is thought about and the solution is meaningful. However there maybe another technology which supersedes it (Bluetooth 4 as an example). For instance we have Braille on pharmaceutical packaging and barcode scanners which can tell a user what the item is, but could there be another technology either available or being researched that could solve this problem (MM);

In the field of required methodologies, “A methodology that merges accessibility and AT needs into the mainstream design and specification” (MM);

The suggestions on required tools included: “Simulation ‘suits’ for many physical conditions that can provide an insight into what it is like to be older or infirmed in today’s society” (MM); Rapid prototyping tools that allow AT ideas to be mocked up and tested with limited technical knowledge” (MM); Cash machines that can safely be used by visually impaired people” (MM);

And with relation to other factors, including design for all, social ethical issues, collaboration frameworks, etc., the experts pointed: “A better understanding of minimum physical dimensions of mobile devices e.g. physical and touch screen buttons for a given population of users. (Currently I am not aware of standards for mobile device controls) ” (MM); “A better understanding of how new technologies e.g. Google, Wikipedia contribute to general education and to older and disabled people’s needs” (MM); “Research to understand what the private sector (industry) is doing in relation to inclusive (or non inclusive) ICT/HCI. Some of this will be confidential but they should be able to tell you the types of technologies they are focussing on (or the ones they are avoiding - such as TTS for example) and what they expect to happen over the next period (say three years) ” (EC&ST).

Table 11: Experts' proposals for the medium term

Field	European experts recommendations	Parallel SDDP2 recommendations
Technologies	Virtual helper to provide specific help on any IT activity.	None
	Single tablet interface that can interact with home technology by proximity presenting a simple and consistent user interface.	[6]
	A database and search facility based on a single person's own history to give them memory support.	None
	Human-computer interfaces that can assess a person's needs and adapt to them automatically.	[5], [15]
	Design of cars for people disqualified from driving due to impairment.	N/A
	Study which technologies will be the most influential to disabled people if they are delivered in the correct manner.	N/A
Methodologies	A methodology that merges accessibility and AT needs into the mainstream design and specification.	[40]
Tools	Simulation 'suits' for many physical conditions that can provide an insight into what it is like to be older or infirmed in today's society.	None
	Rapid prototyping tools that allow AT ideas to be mocked up and tested with limited technical knowledge	None
	Cash machines that can safely be used by visually impaired people.	None
Standards, Norms and Guidelines	A better understanding of minimum physical dimensions of mobile devices.	None
Universal accessibility	A better understanding of how new technologies e.g. Google, Wikipedia contribute to general education and to older and disabled people's needs.	N/A
	Research to understand what the private sector (industry) is doing in relation to inclusive (or non inclusive) ICT/HCI.	N/A

Note: Some of the recommendations are considered out of the scope of the CARDIAC Inclusive HCI study and marked N/A. Although they will be included in a general considerations chapter of the final report.

The Long Term

"Computers that prompt mental and physical development by challenging people with specific impairments to overcome them" (MM); "Computer-based medical assistance and diagnoses that a patient can interact with to assist with chronic or more serious conditions, reducing diagnosis errors or delays in diagnosis" (MM); "Creation of modular assistive technologies so that they can become more flexible and cheaper to produce" (MM); "How can charities, universities and NGO's come together to steer industry into adopting technologies which have benefit to disabled users" (MM);

With respect to the methodologies, they mentioned a "User Centred Design methodology that implicitly includes older and disabled people without needing to distinguish between 'accessibility' and 'usability'" (MM);

In relation to needed tools, the pointed: "Simulation facility for cognitive impairments" (MM). In the area of standardization, "Online standards and guidelines facility for easier access to information" (MM).

Finally, speaking about other factors including design for all, social ethical issues, collaboration frameworks, etc., they indicated: "Establishment of online etiquette as practice

that makes people take responsibility for what they post online and give respect to respect others" (MM); "What are the experts/consultants in the field of Ergonomics/Human Factors/HCI/User Centred Design/User experience etc., working on and where do they see work coming from. As these people sell their services, they will be able to inform you where their services are being utilised by their clients and which areas of HCI/ICT they are having successes or failures in, in terms of selling their services. For instance web accessibility might be a big topic and bring in business but designing TV interfaces and user interaction might not bring in money. The purpose of doing these is as follows. They allow you to get a snapshot of what is going on and what is likely to happen in the foreseeable future (as an example the group at the event on the 19th January were not aware that RNIB was running an ATM nor that banks were now making their ATMs accessible). You can understand where on-going work means that no intervention (in terms of research) and are there solutions or technologies that are not coming through as people thought they would. Finally, you should then be able to cross reference the three pieces of research to understand whether or not group 1, group 2 and group 3 are in sync or whether they are going in polar opposites. If it is the later, further workshops and collaboration may be needed to understand how to bring the three together" (EC&ST).

Table 12: Experts' proposals for the long term

Field	European experts recommendations	Parallel SDDP2 recommendations
Technologies	Computers that prompt mental and physical development by challenging people with specific impairments to overcome them.	None
	Computer-based medical assistance and diagnoses that a patient can interact with to assist with chronic or more serious conditions, reducing diagnosis errors or delays in diagnosis.	[12]
	Creation of modular assistive technologies so that they can become more flexible and cheaper to produce.	[72]
Methodologies	How can charities, universities and NGO's come together to steer industry into adopting technologies which have benefit to disabled users	N/A
	UCD methodology that implicitly includes older and disabled people without needing to distinguish between 'accessibility' and 'usability'.	[67]
Tools	Simulation facility for cognitive impairments.	None
Standards, Norms and Guidelines	Online standards and guidelines facility for easier access to information.	[4]
Universal accessibility	Establishment of online etiquette as practice that makes people take responsibility for what they post online and give respect to respect others.	N/A
	What are the experts/consultants in the field of Ergonomics/Human Factors/HCI/User Centred Design/User experience?	N/A

Note: Some of the recommendations are considered out of the scope of the CARDIAC Inclusive HCI study and marked N/A. Although they will be included in a general considerations chapter of the final report.

Conclusions

A detailed analysis and comparison of these answers with the ones obtained in the SDDP co-laboratory allowed us to conclude that there is also a large general coincidence in the general objectives and approaches with the ones expressed in the SDDP, even if some proposals from the experts are related to general accessibility issues, while the SDDP2 was focused on Inclusive HCI, while comments of experts are more general. Nevertheless, there are a number of new ideas that should be included in our roadmap. The answers from these experts were also extremely valuable to validate and complete our approach.

Possible contributions to the CARDIAC Inclusive HCI roadmap

- 114: Tools to read out or enlarge paper based documents (post, instructions/labels, etc.).
- 115: Deeper understanding of how we can best measure quality of ICT inclusive usage experience reported by excluded groups.
- 116: More understandable accessibility design guidelines for web designers.
- 117: Guidelines or standards for accessible mobile interfaces.
- 118: Better understanding of older and disabled people's strengths while may be superior to the mainstream rather than just considering them less able.
- 119: Virtual helpers to provide specific help on any IT activity
- 120: A database and search facility based on a single person's own history to give them memory support.
- 121: Simulation tools for many physical conditions that can provide an insight into what it is like to be older or disabled in today's society.
- 122: Rapid prototyping tools that allow AT ideas to be mocked up and tested with limited technical knowledge.
- 123: Cash machines that can safely be used by visually impaired people.
- 124: Better understanding of minimum physical dimensions of mobile devices.
- 125: Computers that prompt mental and physical development by challenging people with specific impairments to overcome them.
- 126: Simulation facility for cognitive impairments.

5.2. Road maps from other European initiatives

Similarly to the CARDIAC project, other initiatives that aim to guide the European Commission in the development of R&D policies that promote accessibility and inclusion have produced reports that may serve as examples of prospective technologies and roadmapping for the development of accessible and inclusive human-machine interaction. Using diverse methods, these projects have conveyed to prospective studies, roadmaps or guidelines that, far to be ignored, are used as valuable input to the CARDIAC discussions. They can provide inspiration and orientation to the CARDIAC work. These reports are briefly outlined in the following.

5.2.1. Interim Roadmap for ICT and Ageing

The deliverable D6.1 “Interim Roadmap for ICT and Ageing”, from the BRAID European Project [Camarinha-Matos 2011] contains some converging proposals that are extracted in Table 13.

Table 13: Some proposed actions from the BRAID European Project [Camarinha, 2011]

BRAID			*Parallel SDDP2 recommendations*
5.2 Proposed actions under the Healthy Living perspective	***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	*[12]*
	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	N/A
	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.	[3, 5, 6, 19, 74]
	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	N/A
5.3 Proposed actions under the Occupation in Life perspective	***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	[4, 1, 69, 71]
	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	[5, 6, 15, 29]
	Leverage legacy	Develop environments that empower and enable seniors to create a legacy capitalizing on their invaluable and transferable personal / professional knowledge and experience	N/A
	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, behaviours, and issues of physical, cultural and emotional health	N/A
	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	N/A
5.4 Proposed actions under the Recreation in Life perspective	***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.	[13]
	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	[3, 19, 44, 74,]
	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	N/A
	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	N/A
	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.	N/A
	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	N/A

Note: Some of the proposed actions are considered out of the scope of the CARDIAC Inclusive HCI study and marked N/A. Although they will be included in a general considerations chapter of the final report.

Possible contributions to the CARDIAC Inclusive HCI roadmap

Table 13 shows that several actions proposed by BRAID are close related to similar ones proposed by the SDDP2 seminar. In addition, there are interesting proposals for eHealth and Elderly people support that are out of the Scope of the Inclusive HCI CARDIAC study. However, two important requirements for the research in Inclusive HCI are confirmed:

- 201: Sensorial systems for the monitoring of health conditions combined with intelligent diagnosis functionalities, understanding of the environment and other context factors, and smoothly adaptable to the needs of each senior individual.
- 202: 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.

5.2.2. AALIANCE Ambient Assisted Living Roadmap

As regards Ambient Intelligence and the associated services that have been enabled by the convergence of pervasive computing, ambient networks and intelligent-user interfaces, this document emphasises current trends. Some of the guidelines related to HCI are summarised as follows:

- The intelligent interaction of people with systems and services is an important aspect for applications and will need to incorporate specific requirements to cope with people's abilities.
- Technological advances enable the design of new functions and features that could well support people who need help, e. g. by assisting people in their daily activities, by creating social networks or by stimulating healthy behaviour.
- Ideally, AAL products and services that support people in dealing with real-world problems well be intuitive to use and automatically adapt to user needs and context of use.

Design process

The interaction-design process, which results in user interfaces for the AAL applications, is a structured process.

- End users are generally involved throughout the design and development process.
- The development of prototypes and stable systems can be facilitated by providing common interface standards, design guidelines and toolkits.
- The user testing phase can be supported by providing living labs, which enable designers to make fast design iterations based on user feedback in a realistic setting.

Connectivity

- It is expected that products will be increasingly linked together in such a way that users can choose the appropriate user interface based on the context of use and can control all functions available in the home.

Awareness

- Context awareness enables personalization and adaptation of user-system interaction
- To create trusted products, we should therefore make sure that users can inspect and update system information at an appropriate level.

Table 14: AALIANCE recommendations on Inclusive HCI

AALIANCE Ambient Assisted Living recommendations related to Inclusive HCI		Parallel SDDP2 recommendations
General	• Specific requirements for the intelligent interaction of people with systems and services to cope with people's abilities.	[41]
	• Technological advances that enable the design of new functions and features that could well support people who need help.	[3], [13], [44], [72], [74]
	• AAL products and services intuitive to use and automatically adaptable to user needs and context of use	[5], [15], [57]
Design process	• Involvement of end users throughout the design and development process.	None
	• Common interface standards, design guidelines and toolkits.	[14], [26],
	• Using testing based on living labs for fast design iterations based on user feedback in a realistic setting.	None
Connectivity	• Products linked together to allow users to choose the appropriate UI for each specific context.	[46]
Awareness	• Personalization and adaptation of user-system interaction based on context awareness	[6]
	• Trusted products that users can inspect and update system information at an appropriate level.	None

Table 15: Roadmap 13: Interacting [van den Broek 2010]

Roadmap 13: Interacting

Category	2010–2015	2015–2020	2020–2025
Design Process	Common generic interface standards Toolkits Living Labs		
Initiative	User initiative, adaptable interfaces	Mixed initiative, self-adaptive interfaces	Avatar robots, brain-computer interfaces Social + emotional awareness
Modalities	Local (touch) screen-based	Rich interaction through distributed objects	Avatar robots, brain-computer interfaces
Awareness	Context-awareness of predefined factors	Learning	Social + emotional awareness
Connectivity	Standalone products (including mobile phones)	Products networked inside home	

Possible contributions to the CARDIAC Inclusive HCI roadmap

- 203: Involvement of end users throughout the design and development process.
- 204: Using testing based on living labs for fast design iterations based on user feedback in a realistic setting.
- 205: Trusted products that users can inspect and update system information at an appropriate level.
- 206: User interfaces for mixed initiative (or shared control in robotics).
- 207: Rich interaction through distributed objects.

5.2.3. Human Factors; Inclusive eServices for all: Optimizing the accessibility and the use of upcoming user-interaction technologies

The European Telecommunications Standards Institute (ETSI) established a Specialist Task Force (STF) 377 on "Inclusive eServices for all: Optimizing the accessibility and use of upcoming user interaction technology"[6]. The aim of this working group was to systematically evaluate ongoing and forthcoming interaction technologies. This STF was perceived as necessary because the experience has constantly shown that user-interface improvements for consumer products are being researched and developed without taking into account the needs of people with disabilities. This situation is worsened by the fact that the developers are frequently unaware of the requirements of people with restrictions and therefore they lack the insight into appropriate design solutions, even if they may not be very demanding in terms of R&D and production costs [Rodriguez-Ascaso, 2010].

This Specialist Task Force participated in the drafting of two interesting reports:

- ETSI EG 202 848. Human Factors; Inclusive eServices for all: Optimizing the accessibility and the use of upcoming user-interaction technologies. ETSI EG 202 848 V1.1.1, 2011.

  This document is intended to provide guidance for the user interaction design of telecommunication devices and services that are likely to become available for large-scale rollout to consumers in the next five to ten years. In particular, the document identifies provisions that have to be made in order to ensure that forthcoming interaction technologies deployed in devices and services will be usable by all users including older people and/or people with disabilities. Within the scope of the document are those interaction technologies that are likely to be used in information and communication products and services and are likely to achieve a mass-market breakthrough between 2010 and 2020.

  The report lists user interaction technologies likely to be employed in future devices and services in the form of a technology roadmap. For each identified technology, key characteristics specified include: user requirements impacted by the technology; benefits and accessibility barriers that will result from deployment; solutions related to accessibility barriers (both those benefiting disabled users only as well as those being useful for all users in different contexts). In addition, measures are identified that need to be addressed prior to the large-scale implementation of those technologies in order to ensure their usability by users with the widest range of characteristics.

  Figure 6 shows an example of roadmap for haptic/tactile output technologies and Table 16 shows an example of guidelines for advanced speech synthesis, both of them are taken from [ETSI EG 202 848, 2011]

- ETSI TR 102 849. Human Factors (HF); Inclusive eServices for all; Background analysis of future interaction technologies and supporting information. ETSI TR 102 849 V1.1.1 Technical Report (2010-11).

[6] ETSI Specialist Task Force 377: Inclusive eServices for all: optimizing the accessibility and use of upcoming user interaction technologies: http://portal.etsi.org/stfs/STF_HomePages/STF377/STF377.asp

ETSI published this report as a response to the fact that new products and services are frequently being offered that do not take sufficiently into account the needs of people with mild or severe impairments. It is oriented to listing forthcoming user interaction technologies, and identifying for each technology likely accessibility issues and possible solutions that rectify those shortcomings.

This document complements EG 202 848 by providing additional information related to the approach taken for and results of that document. In particular, the following issues are addressed: a) the focus of the EG on 'atomic' user interface technologies as opposed to higher-level user interaction concepts; b) the application of the user interaction technology roadmaps giving guidance on how to identify relevant user interaction technologies for any given eService; c) the approach for assessing accessibility issues of forthcoming user interaction technologies; and d) the question of inevitable insecurities in predictions and their outcome.

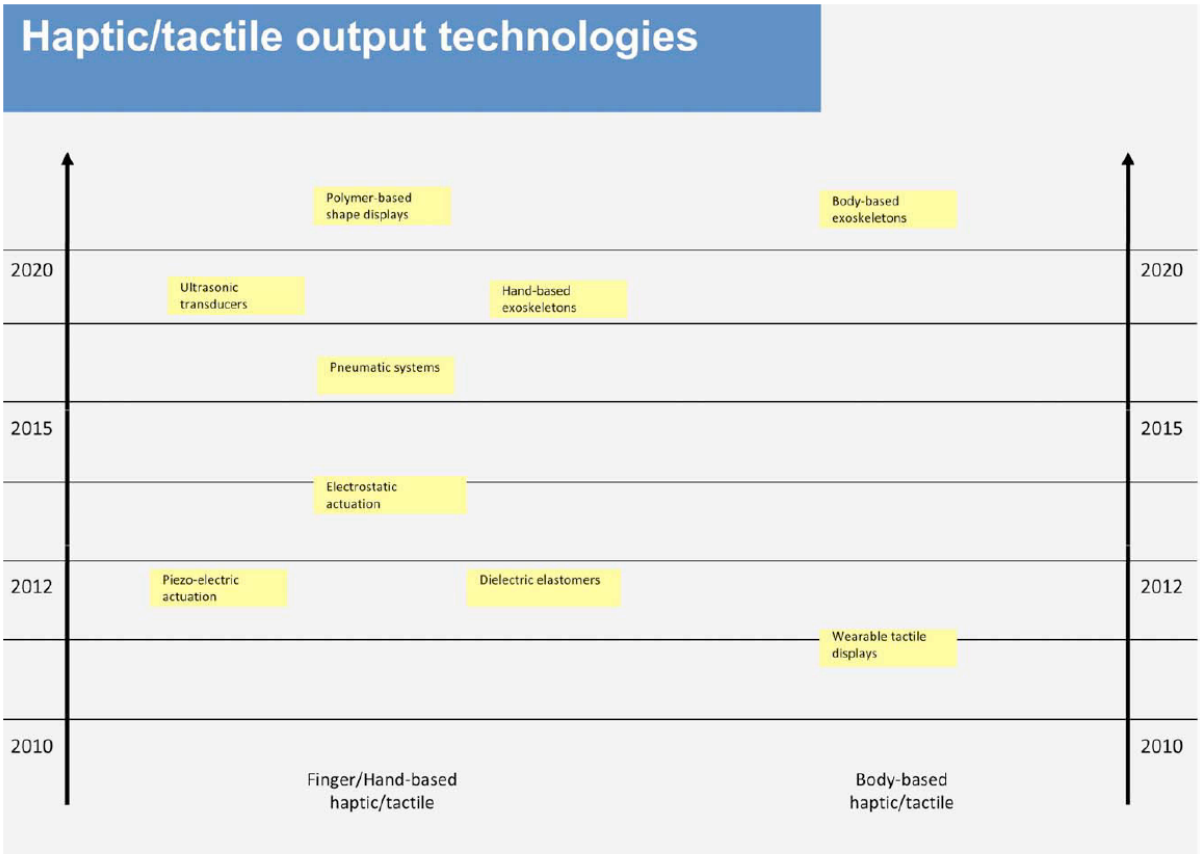


Figure 6: An example of roadmap: Haptic/tactile output technologies roadmap from [ETSI EG 202 848, 2011])

Table 16: An example of guidelines from Advanced speech synthesis [ETSI EG 202 848, 2011]

Characteristic	Definition
Name	Advanced speech synthesis
Description	Speech synthesis is the artificial production of human speech. A computer system used for this purpose is called a speech synthesizer, and can be implemented in software or hardware. A text-to-speech (TTS) system converts normal language text into speech; other systems render symbolic linguistic representations like phonetic transcriptions into speech. Synthesized speech can be created by concatenating pieces of recorded speech that are stored in a database. Systems differ in the size of the stored speech units; a system that stores phones or diphones provides the largest output range, but may lack clarity. For specific usage domains, the storage of entire words or sentences allows for high-quality output. Alternatively, a synthesizer can incorporate a model of the vocal tract and other human voice characteristics to create a completely "synthetic" voice output. The challenge for advanced Speech Synthesis systems is to reproduce human speech to a qualitative level that makes it difficult or even impossible for a human listener to determine whether the speech has been uttered by a human or a machine. This includes inter alia the consideration of prosodics and emotional contents e.g. to determine whether a "speaker" is smiling. Some people argue that it should always be possible for the listener to determine whether speech is uttered by a person or by a machine.
Mass market deployment	By 2012
Sub category	Voice-output technologies
Related technology	Speech recognition Distributed speech recognition Audio-visual speech recognition Intelligent word spotting
User requirements	02 Perceive auditory information
Accessibility barriers -	People with hearing impairments and possibly those with cognitive impairments may need vocal information to be presented redundantly through text.
Solutions related to accessibility barriers	- Allow users to adjust sound characteristics. - Provide interface for assistive devices. - Multimodal presentation: ensure that output can also be represented as text.
Cultural issues -	- People are very sensitive to national and regional accents some of which may not be well received in some countries.
Benefit for all users -	Offers inexpensive audio text output.
Benefits for older people and people with disabilities	- High-quality implementation presents an acceptable replacement of spoken (by a human) text for visually impaired people.
Deployment pros	- Easy to implement in mobile devices.
Deployment cons	- Needs to be much better than today's state of the art in terms of intelligent modulation, otherwise very tiresome to listen to.
Implementation requirements	None identified
Harmonization	None identified

Possible contributions to the CARDIAC Inclusive HCI roadmap

- These reports contain detailed roadmaps on most input/output technologies: Acoustic/audio input and output and output technologies; Kinaesthetic input technologies; Presence/location/proximity-based input technologies; Recognition/mood/activity-based input and output technologies; Smell-based input technologies; Touch-based input and output technologies: Visual input and output technologies; Haptic/tactile output technologies; and Taste-based output technologies. Even if the provided technical details are valuable for designers, they are out of the scope of CARDIAC Inclusive HCI roadmap.

5.2.4. Accelerating the development of the e-health market in Europe

The document entitled "Accelerating the development of the eHealth market in Europe" published by the European Commission. [EC KK-70-07-022-EN-C, 2007] proposes some guidelines for the e-Health market. Even if these guidelines refer to slightly different issues, some of them converge with the inclusive HCI development, and can be reformulated and adopted for HCI research. For instance, the guidelines in Table 17 are excerpted from chapter 6: "Roadmap for Implementation of eHealth Task Force Lead Market Initiative Policy Recommendations".

Table 17: Guidelines extracted from "Roadmap for Implementation of eHealth Task Force Lead Market Initiative Policy Recommendations" [EC KK-70-07-022-EN-C, 2007].

Aim	Target	Measurable Action
A. Reduce market fragmentation and lack of interoperability	A3. Enhance e-Health interoperability	Adopt recommendation on e-Health interoperability
		Favour the application of Recommendation on e-Health interoperability by enhancing cooperation between MS to build coherence in their health systems
		Define required standards, establish review committee to identify focus areas
	A4. Provide adequate certification	Issue guidelines for certification of e-Health applications
		Form expert group to encourage MS to establish a coordinated work program
B. Improve legal certainty and consumer acceptance	B2. Ensure adequate protection of personal data in e-Health systems	Adopt initiative to enforce Personal Data Protection legislation for products and services

Even if these recommendations are focused to the eHealth field, there are some key aims that can serve as possible contributions to the CARDIAC Inclusive HCI roadmap:

- 208: Reduce market fragmentation and lack of interoperability: Adopt recommendations on UI interoperability; Favour the application of Recommendations on UI interoperability by enhancing international cooperation.
- 209: Improve legal certainty and consumer acceptance. Adopt initiative to enforce Personal Data Protection legislation for products and services

5.3. The WAI-ACT European Project

WAI-ACT[7] "Web Accessibility Initiative - Cooperation Framework for Guidance on Advanced Technologies, Evaluation Methodologies, and Research Agenda Setting to Support eAccessibility" is a European Project of the 7th Framework Programme.

WAI-ACT builds on and extends WAI processes to address the following needs:

- Expanded cooperation in Web accessibility
- Authoritative guidance on implementation
- Harmonized evaluation methodologies
- Coordinated research and development

The input from WAI ACT project is extremely interesting for CARDIAC project for two main reasons:

- The number of human-computer interaction instances that are carried out through the Web is constantly increasing.
- There is enormous experience and know-how that has been collected regarding Web accessibility that may be applied to analyze and enhance accessibility to other fields of HCI.

Research and Development Working Group (RDWG) Wiki

The Research and Development Working Group (RDWG) is a part of the WAI-ACT project. This working Group collaboratively maintains a Wiki to collect information about Web accessibility research and development activities.

So far CARDIAC has identified specific issues related to the Web Accessibility that should be included in the European research priorities. Nevertheless, in order to detect research fields that could be missing in the CARDIAC approach and to outline common approaches, the project has performed a first exercise to compare the WAI-ACT provisional research agenda with the current issues on Web Accessibility identified in the different investigations (see Table 18). The missing research topics detected in this comparison will be included in the CARDIAC roadmap for R&D in inclusive HCI.

[7] http://www.w3.org/WAI/ACT/

Table 18: Extension of Web Accessibility experience to general HCI (In smaller font the answers non included in the dependence tree, in square brackets the numbering of the statements as included in the dependence tree)

Topics in the WAI-ACT research agenda[8]	Parallel SDDP2 recommendations
Mobile and Touch - Combine; Accessible Mobile Web Applications; Touch Interfaces	[27], [36]
Accreditation Methods (Accreditation, Accessibility, Certification.)	None
Authoring Accessibility (Simple, Authoring Language, Rapid Development.)	[11]. [75]
Benchmarking Web Accessibility Evaluation Tools (Evaluation, Benchmarking, Metrics, Samples.)	[7], [63]
Easy to Read (Guidelines, Language, Internationalization.)	[2], [32], [45], [37], [62]
Guideline Specification Languages (Guidelines, Evaluation, Conformance, Specification.)	[26]
Open Research Frameworks (Framework, Open Research, Accessible Tools.)	[4], [60]
Web Inclusion (Inclusion, Developing Regions, Internationalization, Low Income.)	[69], [71]
Web Page Sampling (Evaluation, Quality Assurance, Conformance.)	None
Ubiquitous Web Accessibility (Guidelines, Evaluation, Accessible Tools.)	[19], [27], [17], [39]
User Evaluation Methods for Web Accessibility Evaluation (User evaluation, evaluation, conformance, guidelines.)	[7], [40], [29], [47], [60]
Benefits of Accessibility.	[34], [54]
Accessible Security (Security, Language, Questions, Easy to read)	[52]
Cloud Computing Accessibility (Chances, Risks, Tools)	[4]
Accessible Ads (Guidelines, Mobile)	None
CSS Accessibility (CSS, Style)	None
AT WAI-ARIA Support (Guidelines, Assistive Technologies)	None
Browser WAI-ARIA Support (Guidelines, Assistive Technologies)	None
Technologies for Accessibility such as Voice and Braille Interface	[36]
Virtual Reality technologies (Opportunities and dangers, Guidelines)	None
Augmented Reality / Internet of things (Opportunities and dangers, Accessibility tagging)	None
Accessible Maps (Guidelines, Mobile, Assistive Technologies)	None
Text Customization (people with low vision, visual processing disorders, dyslexia, and similar disabilities that impact reading; guidelines/standards; user agents; user interfaces)	[37]

Extension of Web accessibility knowledge to general HCI

The Web Accessibility Initiative has developed an extremely interesting experience in practical accessibility support that includes:

- Provision of diverse sets of accessibility guidelines to be used by designers and evaluators.
- An open work methodology that attracted users as well as people from the industry, academia and public administration.

[8] This is an initial, non-exhaustive list of proposed research topics that will be continually expanded and refined by RDWG.

- A strategy to increase awareness about accessibility barriers among the designers, the policy makers and the general public.

An interesting question is whether this experience can be extrapolated to other fields in the HCI area. And, if this is possible, what are the requirements for research and development needed to advance in that line.

Table 19 contains a first attempt to analyse the extensibility of Web Accessibility experience and some provisional recommendations.

Table 19: Extension of Web Accessibility experience to general HCI

Web accessibility	General-purpose HCI accessibility	Recommended Action	Parallel SDDP2 recommendations
Web accessibility guidelines are almost universally accepted even if it is recognized that they are insufficient.	Most of the Web accessibility guidelines can directly be applied to general HCI or adapted to this field.	To extend accessibility guidelines to specific application and to general purpose interfaces	[26]
Accessibility automatic evaluation tools. Most of them are exclusive for the web environment because they analyze web technologies such as HTML, XML, CSS, etc.	Accessibility evaluation tools for non-web interfaces are only possible if they are coded in a User Interface Description Language (UIDL) that specifies the content, presentation and behaviour of the interface. Usual coding does not allow to verify most accessibility problems.	To study the development of UIDLs that allows the evaluation of most accessibility issues by analyzing the code.	None
Accessibility manual evaluation methodologies. Complete evaluation of the web accessibility requires a combination of automatic and manual evaluation both by experts and by users.	Even if accessibility evaluation methods are very much advanced, there is not a consensus similar to the WAI procedures for accessibility evaluation. Most of the manual evaluation techniques are based on the observation of both the interface and the user.	To adapt and formalize evaluation methodologies to be applied to the field of general accessibility	[7], [63]
Public awareness and general consensus about the accessibility as a civil right and hence the need for standards and regulations	There is low awareness about the exclusion imposed by non-accessible interfaces for non-web applications others that web.	To extend the awareness of accessibility to general purpose applications as a civil right and to develop suitable standards and regulations	None
Open knowledge effort. International collaboration, participation of diverse protagonists (users, industry, academia, administration) and knowledge sharing	General-purpose interfaces are usually connected to commercial applications, and therefore they can hardly be shared. Nevertheless, UIDLs, tools, and methodologies can be public.	To impulse the creation of repositories of shared tools, methodologies and accessibility knowledge in general.	[4], [10], [47], *[60],* [69], [71]

Possible contributions to the CARDIAC Inclusive HCI roadmap

- 210: Web Accessibility Accreditation and Certification Methods.
- 211: Repositories of Web Pages intended to sampling for evaluation, work benching for quality assurance, and conformance verification.
- 212: Guidelines for mobile accessibility and accessible Adds design.
- 213: Guidelines for the creation of Accessible Rich Internet Applications compatible with Assistive Technologies.
- 214: Guidelines for the design of browsers that support Accessible Rich Internet Application.
- 215: Opportunities and dangers of Virtual Reality technologies and propose guidelines for their accessibility.
- 216: Opportunities and dangers of Augmented Reality and the Internet of things, especially for their application to accessibility tagging.
- 217: Guidelines for the research on Accessible Maps compatible with Assistive Technologies and mobile devices.
- 218: User Interface Description Languages that allows the evaluation of most accessibility issues by analyzing the code.
- 219: Awareness of accessibility to general purpose applications as a civil right and to develop suitable standards and regulations

6. Recommendations towards a Roadmap of Actions Supporting R&D in Inclusive HCI design

The following sections contain a number of provisional recommendations of actions supporting R&D in Inclusive HCI design. They have been compiled, selected and processed following the methodology introduced in chapter 2 “Methodological approach towards a roadmap”, staring from the SDDP methodology. In addition, other sources of information have also been consulted, such as European actions devoted to R&D prospective, and direct consultation to experts. These recommendations, numbered from 100 to 300, are included as bullets. Additionally, some of the proposals have been combined and rephrased in order to focus or clarify their aim and scope.

All the recommendations have been classified in the following categories:

- User centred design
    - Holistic approach to inclusive HCI
    - Human Factors studies
    - Overcoming the cognitive load
- Innovative user interfaces
    - User interfaces to grant access to advanced environments
    - Interoperability and standardization
- Advanced methodologies and tools to overcome accessibility barriers
    - Promote the application of latest advancements in UI design
    - Design methodologies and tools
    - User modelling and adaptive user interfaces
- Collaborative research and international knowledge sharing to overcome accessibility barriers
    - Collaborative research
    - Worldwide collaboration and knowledge sharing
    - Innovative service delivery

With respect to their temporal development, they have been classified into three categories: short, medium and long term proposals. As it is explained in section 4.8 “Identify activities to overcome the gaps”, the temporal classification has been extracted from the precedence outlined in the dependencies tree provided as a result of the SDD2 seminar. In addition the recommendations from external experts have been also considered. This organization is only provided for guidance and has to be reconsidered taking into account a number of other

factors, such as technological availability, social request, interaction with other EU R&D programmes, etc.

This preliminary proposal will be extended, completed, refined and justified by the CARDIAC consortium for the definitive version of this deliverable.

6.1. User centred design

Most current User Centred methodologies are not able to cope with the features of all people. Designers wanting to produce accessible Human-Machine interaction systems need sound methodologies and commercial tools to do it. Most designers are used to advanced design environments, therefore, in order to be adopted by the industry; these methodologies must be sound and usable in large scale software development projects.

6.1.1. Holistic approach to inclusive HCI

Short Term

Methodologies that consider not only the interface as it appears but the entire interaction dialogue (#021)

The traditional separation between applications and human-computer interfaces has been very beneficial to the progress of HCI methodologies. Nevertheless, the danger exist that designers concentrate only in the interface itself ignoring relevant aspects of the interaction such as the physical and social context, the tasks to be performed, etc. For best accessibility the design has to consider the whole interaction process, including human mental models and procedures.

- *Research to get rid of HCI (#001)*
- *Design for all extended to wider range of potential limitations to accommodate for ageing population (#111)*

Medium Term

Methodologies to include the human diversity in user interface design (#040)

Most current User Centred methodologies are not able to cope with the features of all people. Designers wanting to produce accessible Human-Machine interaction systems need sound methodologies and commercial tools to do it. Most designers are used to dealing with advanced design environments, therefore, in order to be adopted by the industry; these methodologies must be sound and usable in large scale software development projects.

- *Research on mid to long term interaction by disabled and elderly people (#038)*
- *To promote common research on user needs and preferences to be used by all e-inclusion projects (#060)*

- *Deeper understanding of how we can best measure quality of ICT inclusive usage experience reported by excluded groups (#115)*
- *Better understanding of older and disabled people's strengths while may be superior to the mainstream rather than just considering them less able (#118)*

6.1.2. Human Factors studies

Knowledge about user features, needs and likes is a fundamental requirement to the design of accessible interaction systems. Studies about the impact on accessibility and the resulting exclusion are urgent. Side effects, such as impact over safety and privacy can not be neglected either. In addition the causes of success/failure and acceptation/rejection of the Assistive Technology must be studied.

Short Term

Research on who could be excluded from using novel user interfaces (#025)

Companies designing products with new interfaces need to know, before the product is on the market, who will find their interface difficult or impossible to use. This needs to be matched against the target market for their new product.

- *Research about the exclusion that has been created by HCI (#028)*
- *Identify Human Factors barriers to health, education and participation of low income groups (#055)*

Medium Term

Basic research on Assistive Technology abandonment/adoption (#064)

There are only a handful of papers on AT abandonment, mostly from the 90's. In order to address fully the distressing level of AT abandonment (40-70%) a principled, longitudinal research agenda of this phenomenon, segmented by AT and user type and compared to similar non-AT systems needs to be launched. The implications of the resultant body of knowledge could potentially deeply affect AT from design to marketing.

- *More case studies of successful use of Assistive Technology in workplaces (#102)*

Long Term

Implications for people with disabilities of the use of biometric systems for identification and security (#052)

ICT technologies to solve the needs of people with disabilities have been frequently applied without considering their side effects on privacy, autonomy, socialization, etc. This lack of non technological vision sometimes led to systems with a serious impact

on ethical issues. Even if this issue requires deep research in general, it is especially required in the case of systems that collect biometric information. How to guarantee privacy and the provision of alternative ways for people rejecting this possibility are two of many topics that should be studied.

- *Consensus on values, ethical principles, rights, safety and privacy issues (#202)*

6.1.3. Complexity and effort of user interaction

Many users experience frustration and displeasure when trying to perform a task using computers just because they require an extra effort due to the cognitive overload imposed by the interface. This frequent situation gets worse for people who experience physical, sensory or cognitive restrictions, because they cannot use alternative sources of information or alternative ways to carry out the task, if they are not provided by the system. Evidently all the advancements in overcoming the cognitive load imposed by the use of computers will not only be beneficial to people with disabilities, but also to other users.

Short Term

Reduce the complexity of user interaction whilst retaining functionality (#032)

Many user interfaces are created taking into account a mental model of the task that is not shared by most users. That means that they do not clearly understand several procedures, making the interaction complex and unpleasant. Methods are needed to facilitate the intelligibility of the whole interaction simplifying the procedures, but without loosing the functionalities provided by the application.

Medium Term

Avoiding cognitive barriers in the design of Human Machine Interfaces (#002)

The introduction of computers eased or even allowed many tasks to be carried that were not previously possible for many people. However, computers frequently increase the cognitive workload required to perform some tasks. The lack of matching between the mental models of the user and the computer, the complexity of the language, and the ignorance of the users needs are some of the causes of complexity that have to be avoided.

- *Simulation facility for cognitive impairments (#126)*

Long Term

Decrease the cognitive load associated with multimodal user interfaces (#045)

With interfaces provided in more than one modality, the different interfaces may impose different cognitive demands on the user. For instance, it is easy to get ‘lost’ with auditory output of a complex interface which was designed for visual presentation.

- *Text normalization, simplification, personalization and evaluation (#037)*

6.1.4. User participation in all the phases of the design, development and tests

The participation of the users and/or their representatives in all the phases of the R&D process for Inclusive HCI is a key condition to ensure quality and adequacy and successful results. This includes not only the test with real users, but also their participation in the preliminary studies, the initial conception and the development.

- *Training programs for disability representatives to effectively participate in R & D processes (#024)*
- *Involvement of end users throughout the design and development process (#203)*
- *Using testing based on living labs for fast design iterations based on user feedback in a realistic setting (#204)*

6.1.5. Privacy, Safety, and Trust

- *Trusted products that users can inspect and update system information at an appropriate level (#205)*
- *Improve legal certainty and consumer acceptance. Adopt initiative to enforce Personal Data Protection legislation for products and services (#209)*

6.2. Advanced methodologies and tools to overcome accessibility barriers

Inclusive human-computer interaction requires methodologies and tools that facilitate the design of a) effective Assistive Technology-based user interfaces able to provide access to mainstream devices and services, and b) accessible user interfaces for mainstream devices and services, that may be handled by means of Assistive Technology devices. Recent advancements in HCI methodologies and tools can provide a new and enhanced approach to this purpose.

6.2.1. Advanced design methodologies and tools

Short Term

Methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking (#007)

Even if the Web is far from being universally accessible, it is one of the environments were accessibility requirements are better known. One of the reasons is the availability of accessibility guidelines to help the designer and the evaluator.

Accessibility guidelines also allowed the creation of automatic accessibility evaluation methods and tools. A similar set of clear and unambiguous accessibility guidelines would help to advance in accessible HCI evaluation. In addition this experience can be used to benefit the development of similar tools for the automatic evaluation of non-Web application interfaces. Since these tools are mostly based on finding barrier patterns in mark-up languages (such as HTLM) the definition of suitable User Interface Description Languages seem to be a good option to advance in this field.

- *User Interface Description Languages that allow the evaluation of most accessibility issues by analyzing the code (#218)*

Medium Term

Tools to facilitate the creation of digital accessible materials to non accessibility experts (#010)

The inclusion of people with disabilities not only requires that the user interface is accessible but also that the contents are free of accessibility barriers. Content creators frequently ignore accessibility requirements or do not have appropriate tools to assist them in their application. Therefore, there is a need to create tools to help authors to produce material/contents that are accessible to all.

- *Create development environment for accessibility solutions (#075)*

Long Term

Tools for decision making in the user-centred design process (#011)

A large number of methods and tools are available to guide the user centred design in the early stage of the process. For example methods are available for participatory and co-design. These methods are suitable until the prototype stage. To take the step from prototypes to implementation in real life situations additional tools are necessary. There is a need for tools that facilitate the decision making process between different stakeholders in the final stages of the user centred design process. These tools should guarantee equality between the inputs from all stakeholders, facilitate cooperation and provide guidelines to look for alternatives and compromises when requests from stakeholders are not aligned.

- *Simulation tools for many physical conditions that can provide an insight into what it is like to be older or disabled in today's society (#121)*
- *Rapid prototyping tools that allow AT ideas to be mocked up and tested with limited technical knowledge (#122)*

6.2.2. User modelling and adaptive user interfaces to tailor the interaction

Short Term

Methodologies that efficiently collect data about users (#029)

The creation of user profiles by directly questioning the user can be disruptive, inopportune and annoying. To minimize the need of explicitly provide personal data, automatic collection of user information is required. Collection may be based in reasoning over statistical measures of user activities. In addition, methodologies such as Data Mining may be useful to collect large quantity of date that can be used to model the users by means of Machine Learning techniques. In any case it is crucial to develop techniques that preserve user privacy.

- *Support the research in detecting the behaviour, emotions and intentions of the user without the conscious control by the user (#022), preserving their rights.*

Use of context awareness to adapt user interfaces (#006)

The physical and social contexts where users perform their actions are valuable sources of information that allow the optimization of the human interface in order to minimize the physical effort and the cognitive load and maximize the efficiency of the user actions. Context models, similar to user models, may be required to store and process this type of information. In addition, task models can be useful to complete the information required by adaptive user interfaces.

- *Understanding of the environment and other context factors, and smoothly adaptable to the needs of each senior individual (#201)*

Medium Term

Further static and adaptive user interaction profiles (#057)

Medically based categories of disabilities do not provide useful information about the needs of the individual. Many people “fall through the cracks” or feel that their needs are stereotyped according to one classificatory category when ICT access solutions are delivered according to traditional disability groupings[9], because such categories do not provide useful information for configuring an ICT system. Diverse approaches to user interaction profile creation and maintaining are possible. The user (maybe assisted by an expert) can create her or his own individualized personal profile from a list of common functional descriptors. This enables a one-size-fits-one response from

[9] For instance, a classification of being “blind” does not indicate whether they are Braille literate, have any tactile sensation in their fingers, what language they speak, whether they have good hearing, whether they have residual sight, colour or light sense.

a system that is able to transform, augment or choose from a pool of diverse resources[10]. There is also the possibility of designing systems for automatic collection and maintaining of user models, usually based on ontologies.

Long Term

Practical adaptive user interfaces (#005)

The user interfaces need to be adapted to the user characteristics and preferences. In addition, they have to dynamically adapt to changing user needs (e.g. due to highly dynamic impairments); physical context (e.g. indoors, outdoors); task constraints, etc. Adaptive interfaces that consider the characteristics and needs of people with disabilities are highly required.

6.3. Innovative user interfaces

The access to services provided by ICTs is frequently prevented by the use of "traditional" user interfaces. Recent advancements in sensoring, wireless networking, among other technologies, make possible the development of new kinds of user interfaces able to avoid the barriers imposed by previous interaction systems. These advancements would also be fundamental to develop new types of Assistive Technology that provides access to mainstream devices and services.

Short Term

Innovative interaction devices for accessibility: Advanced Assistive technology

Current technologies provide a number of new interaction methods that are able to enhance the capacity to handle the interaction of specific groups of users. For instance, haptic interfaces have proved to be useful to blind people. Similar techniques should be developed for other categories of disabilities, e.g. people with cognitive and motor impairments. Similarly, enhanced interfaces based on eye tracking could be beneficial. The accessibility of other alternative input systems, such as multi-touch surfaces and brain-computer interaction, etc., should also be explored.

- *Tangible artifacts to promote e-inclusion of people with special needs in technologically mediated environment (#008)*
- *New interaction metaphors and paradigms for computing (#016)*
- *Realistic brain-computer interfaces for people with special needs (#023)*
- *Eye-tracking and tongue piercing based interfaces (#031)*
- *Non-visual interfaces for all (#036)*

[10] This approach was first specified in the IMS AccessForAll standard and later in the ISO24751 multi-part standard [Source: proposal of FP7 IP project: "Cloud4all"].

- *Inclusive HCI for highly dynamic impairments (e.g. hospitalized people that temporally cannot speak) (#050)*
- *Improvements in existing screen readers, less expensive alternative keyboards and pointing devices (#101)*
- *Technologies to extend the world of congenital deaf-blind children beyond their fingertips (#106)*
- *Technologies to make less expensive tactile and Braille displays (#107)*
- *Technologies to help people to make use of their skills in physical world in dealing with the virtual world things (#112)*
- *Tools to read out or enlarge paper based documents (post, instructions/labels, etc.) (#114)*
- *Virtual helpers to provide specific help on any IT activity (#119)*
- *A database and search facility based on a single person's own history to give them memory support (#120)*
- *Cash machines that can safely be used by visually impaired people (#123)*
- *Computers that prompt mental and physical development by challenging people with specific impairments to overcome them (#125)*

Affective computing to assist accessibility interfaces (#035)

While still novel, measures of stress – based on say Galvanic Skin Response (GSR) – have been, and are becoming, increasing common measures in experiments to quantify human behaviour, particularly anxiety frustration disorientation and hesitation. However, what is the possibility of using other affective detection systems (along with predictive task models) to quantify interaction problems and automatically adapt the interface in such a way that stress is reduced and interactivity progresses faster. They can also contribute to understand the areas of frustration that are common among different user groups and change the interface such that these areas of stress are reduced.

Medium Term

Accessible interaction with robots (#074)

Robots are increasingly going to be present as companions and assistants of the people with disabilities. In order to completely fulfil their role, accessible interfaces suitable for their specific tasks are required, such as voice and gesture interaction systems.

- *User interfaces for mixed initiative (or "shared control", in robotics) (#206)*

Novel human-machine interfaces for recreational activities (#013)

The need of having a satisfactory life includes access to communication, education, labour and leisure. Even if research has concentrated on the firsts areas, the last one is by no means less important than the others. A special effort is required to provide novel interfaces that provide access to leisure to people with disabilities. The experience says that this kind of interfaces frequently provides enhanced access to other activities.

- *Make social media inclusive (#030)*

Long Term

Accessible telecommunications technologies for people with no or little speech (#044)

People experiencing complex communication needs have limited possibilities in using telecommunications technologies, such as the mobile phone. This term principally refers to people with no or little speech that have a combination of disabilities (e.g. cerebral palsy combined with a laryngectomy, an acquired brain injury or a stroke). It is the combination of physical impairments that present challenges in finding ways for them to seamlessly link telecommunications with their alternative and augmentative communication devices.

6.3.1. Web accessibility

The Web is currently the largest digital services provider and its interface is the most universally used human-computer interaction system. Web access exclusion experienced by different groups of people, including people with disabilities and elderly people, impedes their social integration and seriously damages their civil rights. Therefore, it is crucial that web interaction is made possible by the technology and supported by adequate legislation.

- *More understandable accessibility design guidelines for web designers (#116)*
- *Rich interaction through distributed objects (#207)*
- *Web Accessibility Accreditation and Certification Methods (#210)*
- *Repositories of Web Pages intended to sampling for evaluation, work benching for quality assurance, and conformance verification (#211)*
- *Guidelines for the creation of Accessible Rich Internet Applications compatible with Assistive Technologies (#213)*
- *Guidelines for the design of browsers that support Accessible Rich Internet Application (#214)*
- *Opportunities and dangers of Virtual Reality technologies and propose guidelines for their accessibility (#215)*

- *Opportunities and dangers of Augmented Reality and the Internet of things, especially for their application to accessibility tagging (#216)*
- *Guidelines for the research on Accessible Maps compatible with Assistive Technologies and mobile devices (#217)*

6.3.2. User interfaces to grant access to advanced environments

Advancements in ubiquitous computing allowed the design of Ambient Intelligence and Ambient Assisted Living environments that provide ad-hoc local services. People with disabilities can very much profit from these services if barriers to Assistive Technology are removed and dynamically adapted user interfaces are provided.

Short Term

Mobile technologies as access interfaces for public and private ubiquitous environments (#027)

Adequately adapted mobile devices, such as smartphones, can be used to access local services provided by intelligent machines, such ATMs, by means of ubiquitous computing techniques. Accessibility to these services require dynamically created adaptive user interfaces based on user profiles that may be provided by the own user mobile device or may be available in the cloud.

- *More empirical research on how people with disabilities use mobile devices (#103)*
- *Guidelines for mobile apps to ensure minimum good practice procedures in design (#104)*
- *Basic access methods built into mobile device operating systems (#110)*
- *Guidelines or standards for accessible mobile interfaces (#117)*
- *Better understanding of minimum physical dimensions of mobile devices (#124)*
- *Guidelines for mobile accessibility and accessible Adds design (#212)*

Medium Term

Inclusive user interaction in ambient intelligence environments (#019)

Although a great deal of research is already dealing with “smart” environments and Ambient Intelligence technologies, it is important not to shift the focus away from the user aspects involved. In that respect, research on issues related to accessible user interaction in these so-called “Smart environments” is needed, focusing on people with disabilities and older people. Emphasis on the technological side could be placed for example on adaptive and adaptable User Interface design, on ubiquitous computing, and so on. Apart from the technological aspects however, other issues affecting user interaction in smart environments, including ethical issues, socio-

cultural, economic and educational characteristics, user abilities and functional limitations, privacy, security and safety concerns should be further investigated. It is obvious that all such issues have a direct effect on technological development. It is crucial however, for the successful deployment of inclusive Human Computer Interaction that the development of new technologies, interaction paradigms, design methodologies and tools, all address these issues.

- *Identify where research is needed to obtain universal access in ambient intelligence environments (#043)*

6.4. Interoperability and standardization

The diversity of procedures, layouts, behaviours, etc., of the diverse interfaces needed to access remote services creates important accessibility and usability problems to people with disabilities. Interoperability of equipment can provide a way to access to diverse services and devices using a unique interface well adapted to each user.

Short Term

Interoperability among devices to enhance accessibility to ubiquitous computing environments (#046)

Ubiquitous computing environments usually download a unique basic interface into the user device in order to provide control of each service provided. These interfaces are designed for standard mobile devices but may not be compatible with Assistive Technology equipment. To avoid accessibility barriers it is required that all the Assistive Technology is compatible and interoperable with all the ubiquitous environments. That may require promoting the definition or adoption of a common/standard middleware as accessible interoperability framework.

- *Reduce market fragmentation and lack of interoperability: Adopt recommendations on UI interoperability; and Favour the application of Recommendations on UI interoperability by enhancing international cooperation (#208)*

Medium Term

Standardized and harmonized remote HCIs (#014)

People trying to gain access to diverse applications usually find different user interfaces based on different paradigms or using diverse procedures. This heterogeneity generates large use difficulties compromising their usability, accessibility and compatibility with assistive technology. Remote standardized and harmonized interfaces can provide homogeneous ways of interaction to facilitate the interaction and ensure the compatibility with specific Assistive Technology. Another possibility is to provide each service with a well defined protocol that allows interoperability with each particular interface compliant with the protocol. In this way, each user gains access to every service though her or his own well adapted interface.

Long Term

Dynamic composition of complex interfaces (mash-up of services) (#072)

The dynamic composition of complex interfaces is an emerging trend that focuses on the automatic generation of personalized interfaces by using a combination of Web services. In order to provide the most suitable interface to a specific person a personalized interface can be created by making use of modelling and personalization capabilities. The required interface functionalities are obtained from diverse Web Services, such as automatic translation or screen reading services.

- *Greater use of cloud and ubiquitous computing to allow devices to be automatically customized for particular environments and applications - especially for cognitive disabilities*

6.5. Collaborative research and international knowledge sharing to overcome accessibility barriers

In developed countries Universal Accessibility is defined with a narrow focus. Availability of resources, infrastructures and education means is taken for granted. Nevertheless, disfavoured populations both in developed and developing countries are excluded from this focus because they do not have access to the basic requirements. Sharing knowledge and resources and collaborating in R&D can broaden the reachable population, increase the size of the markets and lower the prices of Assistive Technology.

6.5.1. Collaborative research

Short Term

Methodologies to analyze collaborative accessibility and undertake collaborative user- and usage centred design (#047)

Social approach to better collecting end users' requirements and opinions, as well as evaluating prototyped UI solutions, (for example, using Web 2.0 facilities). Collaborative approaches to Web accessibility start by identifying barriers by disabled people themselves and raising the social pressure for example on Website administrators. Best practice examples of such collaborative approaches are Web sites (e.g. IBM's work, or the FixTheWeb initiative) used for "fast and easy" reporting accessibility issues of online services and content but also detailed information about how to fix problems. Similarly, a geographical information system for mobility impaired people may allow active collaboration by identifying wheelchair accessible/non accessible locations. A system may allow a correction of speech recognition captioning of audio recording for educational purposes, and where caption editing could be provided voluntarily by hearing class mates when funding for professional captioning is not available. All these are good existing examples for Web

2.0 services improving accessibility through “crowd sourcing”. It is unclear if such approaches are to be scaled up to the extent and quality of commercial services like Facebook and large voluntary organizations such as Wikimedia. This requires further analysis and implementation with the involvement of end user organizations.

Medium Term

Clearing house for inclusive HCI (#004)

A clearing house is an online information transaction process for bringing together a wide cross-section of design methods, relevant standards and existing products as well as ongoing research. A design clearing house for inclusive HCI will draw together valuable information online so that companies can quickly and clearly understand inclusive HCI. Commercial companies have limited time to develop interfaces and to encourage them to use inclusive design practices, a central place online with impartial information would be valuable.

- *Repositories of Web Pages intended to sampling for evaluation, work benching for quality assurance, and conformance verification (#211)*

6.5.2. Worldwide collaboration and knowledge sharing

Short Term

New mechanisms for international collaborations (#069)

Universal Accessibility often takes for granted that the user can be provided with adequate Assistive Technology. Even if this is true for some sectors of the population, mostly in developed countries, the real situation is that the largest sector of the population does not have the possibility of obtaining this kind of technology. This is true for poor people in developing countries, but also for sectors of the population in developed countries. A worldwide international collaboration would contribute to better face the accessibility problems of a larger population. Sharing solutions would help to lower the prices and facilitate the provision

Medium Term

Research on sharing accessibility knowledge with developing countries (#071)

Few researchers in developing countries such as Thailand or China are investigating accessibility in their culture, using their own language and developing an understanding of the processes involved in creating a sustainable impact. Often the economics demand low budget solutions. The development of eScience has shown in the past a possible approach to creating distributed research groups. Developing countries may become involved in research on accessibility if training material is provided, best practice approaches described and pitfalls are expressed.

6.5.3. Open technologies and innovative service delivery

The accessibility of the user interface can also be conditioned by the way it is delivered. Innovative service delivery schemes should be investigated and tested.

Short Term

Open APIS for the delivery of the interface to many more varied platforms (#015)

We are seeing a convergence of devices and the people who use them along with a divergence of the devices themselves. This means that developers must make their applications more flexible, more customizable, and more personalized – in effect more open – if they are to deliver these applications to the many different types of devices – and interfaces on those devices – without creating additional work by building an application for each individual device. Assistive technologies can, and will, take advantage of this flexibility and openness and become just another device to which flexible applications, content, and interfaces need to be delivered. By understanding that assistive technology is really just extreme adaptation we can implicitly encourage developers to create openness not previously experienced when the only platform for delivery was a closed predictable desktop environment.

- *Research and development on provision of accessible interfaces inclusive products and services in a ubiquitous manner (#017)*
- *Research on how to enforce accessibility in consumer goods (#034)*
- *Most consumer devices need to become accessible-out-of-the-box (#113)*

Medium Term

Ways to move from purchase to lease or renting accessibility and Assistive Technology (exploring market, policy and technology challenges) (#061)

In the recent years we talk about software-as-a-service while for several decades now we are all used to the concept of leasing a car or equipment or a house. So it seems that it is high time that we make the transition towards new ways to move from purchase to lease or renting accessibility and assistive technology. Why own a communication aid if you can lease one? And why own a navigation system for blind or elderly while renting one as a service? Social insurance agencies may also have their own views on this – it may prove more cost-efficient for them both for the long run and for an immediate introduction; however there is need for exploring market, policy and technology challenges and dynamics. Finally accessibility matters here again: if you leave the ownership model to move to the leasing or renting, you need intuitive accessibility in the offered solutions as your users don’t regard anymore the learning of the system as an asset. As long as you may use a system for a few days

or weeks, it needs to be easy-to-use and make the life of the user easy regarding manipulation and maintenance.

6.5.4. HCI and eHealth

One of the most promising application fields for Inclusive Human-Computer is eHealth. Even if most of the precedent recommendations are also valid for this application area, there are some specific recommendations that mainly affect the interaction with elderly people.

- *Promote research on the role of inclusive HCI to support self-management in health care (#012)*
- *Sensorial systems for the monitoring of health conditions, combined with intelligent diagnosis functionalities, understanding of the environment and other context factors, and smoothly adaptable to the needs of each senior individual (#201)*
- *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 (#202)*

6.5.5. HCI designers: Education and awareness.

Advancement in accessibility is deeply dependent on the awareness by the designers and their employers of accessibility issues. In addition, they require suitable education and training in inclusive HCI techniques.

- *More specific and clear accessible guidelines for application developers (#026)*
- *Inclusive practices of professionals responsible to develop new products or services (#049)*
- *Research on how to increase and widen accessibility in professional education (#054)*
- *Digital literacy stepping stones (#062)*

6.6. Policy related proposals

Both in the SDDP2 seminar and in the consultations to extern experts and projects many policy issues aroused. Even if they can not be assumed as research oriented recommendations, they should be considered in order to create the conditions that allow an adequate management of the research.

Some of the proposals are:

- *Research on reasons why existing knowledge and standards on accessibility are not known or applied by HCI developers (#042)*

- *How to make accessibility simpler to deliver, apply, configure, support and use and explain to policy makers (#070)*
- *More effective automated tools for publicly monitoring national government web site accessibility (#108)*
- *National guidelines need to harmonize with WAI guidelines (#109)*
- *Awareness of accessibility to general purpose applications as a civil right and to develop suitable standards and regulations (#219)*

Table 20: Summary of R&D proposals

Category		Short Term	Medium T.	Long T.
User centred design	**Holistic approach to inclusive HCI**	Methodologies that consider not only the interface as it appears but the entire interaction dialogue	Methodologies to include the human diversity in user interface design	
	Human Factors	Research on who could be excluded from using novel user interfaces	Basic research on Assistive Technology abandonment/ adoption	Implications for people with disabilities of the use of biometric systems for identification and security
	Complexity and effort of user interaction	Reduce the complexity of user interaction whilst retaining functionality	Avoiding cognitive barriers in the design of H-MI	Decrease the cognitive load associated with multimodal UIs
	User participation	Involvement of end users throughout the design and development process	Training programs for disability representatives to effectively participate in R & D processes	Using testing based on living labs for fast design iterations based on user feedback in a realistic setting
	Privacy, safety and trust	Trusted products that users can inspect and update system information at an appropriate level	Improve legal certainty and consumer acceptance.	
Advanced methodologies and tools to overcome accessibility barriers	**Advanced design methodologies and tools**	Methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking	Tools to facilitate the creation of digital accessible materials to non accessibility experts	Tools for decision making in the user-centred design process
	User modelling and adaptive UIs	Methodologies that efficiently collect data about users Use of context awareness to adapt UIs	Enhanced user interaction profiles	Practical adaptive user interfaces
	Innovative user interfaces	Innovative interaction devices for accessibility: Advanced Assistive technology Affective computing to assist accessibility interfaces	Accessible interaction with robots Novel human-machine interfaces for recreational activities	Accessible telecommunications technologies for people with no or little speech
	UIs to grant access to advanced environments	Mobile technologies as access interfaces for public and private ubiquitous environments	Inclusive user interaction in ambient intelligence environments	
	Web Accessibility	More understandable accessibility design guidelines for web designers Web Accessibility Accreditation and Certification Methods Repositories of Web Pages intended to sampling for evaluation, work benching for quality assurance, and conformance verification	Rich interaction through distributed objects Guidelines for the creation of ARIA compatible with AT Guidelines for the design of browsers that support ARIA	Augmented Reality and the Internet of things, especially for their application to accessibility tagging Virtual Reality technologies and guidelines for their accessibility Guidelines for Accessible Maps compatible with AT and mobile devices
Interoperability and standardization	**Interoperability and standardization**	Interoperability among devices to enhance accessibility to ubiquitous computing environments	Standardized and harmonized remote HCIs	Dynamic composition of complex interfaces (mash-up of services)
Collaborative research and international knowledg	**Collaborative research**	Methodologies to analyze collaborative accessibility and undertake collaborative user- and usage centred design	Clearing house for inclusive HCI	
	Worldwide	New mechanisms for international collaborations	Research on sharing accessibility	

e sharing to overcome accessibility barriers	**knowledge sharing**	New mechanisms for international collaborations	countries	
	Open technologies and innovative Service delivery	Open APIs for the delivery of the interface to many more varied platforms	Ways to move from purchase to lease or renting accessibility and Assistive Technology	
Other issues	**HCI and eHealth**	Research on the role of inclusive HCI to support self-management in health care	Sensorial systems for the monitoring of health conditions	Increase the potential of ICT support for "healthy living environments"
	HCI designers: Education and awareness research	More specific and clear accessible guidelines for application developers	Inclusive practices of professionals responsible to develop new products or services	H how to increase and widen accessibility in professional education Digital literacy stepping stones
	Policy related proposals	Why existing knowledge and standards on accessibility are not known or applied by HCI developers How to make accessibility simpler to deliver, apply, configure, support and use and explain to policy makers	More effective automated tools for publicly monitoring national government web site accessibility	National guidelines need to be harmonized with WAI guidelines Awareness of accessibility to general purpose applications as a civil right and to develop suitable standards and regulations

7. Some observations about the priorities for European activities in eInclusion[11]

Most of the activities carried out so far have been based on a "market" perspective, based on the acknowledgement that the market is fragmented and that most of companies working in the field of assistive technology (AT) are too small for investing in development of new technology. Even if the characteristics of this market are peculiar, due to the fact that it is not producing products paid by the users, but mainly by service providers, it has been taken for granted that by supporting companies in the development of new products it would favour their European diffusion reducing fragmentation and increasing availability.

This approach has not worked and the situation has barely improved, even if it should be pointed out that these considerations are based only on the consideration of the sectors of access to information and communications. In other sectors (e.g. prostheses) the situation may be completely different. Looking at the Eastin databases the quantity and quality of products meant to support people in accessing information and communicating does not seem to have particularly increased and the situation of people with activity limitations, even before the present economic crisis, did not improve significantly. There have been improvements, but due to the mainstream developments in the field and to general initiatives such as the development of the WAI initiative.

The idea, common to all European programmes, of putting together industry and academy for carrying out research activities is sound, has worked in many different environments, and is probably the most efficient (if not the only) way of an efficient technology transfer. The problem in eInclusion has been that this cooperation has not been normally at the level of research, but at the level of development of specific products (time to market 2 to 3 years). In addition to the fact that this could be considered an intrusion in the market mechanisms, it is not using resources in an effective way, because members of the academia are normally trained for and able to develop new ideas and not to develop products. Therefore, the level of development they are able to carry out is far from what is necessary for a real product. Then, the resources necessary for industries, normally marginal in the consortia, to arrive to a real product are too great for companies to be able to invest in them. The developed prototypes and ideas belong to the consortium and normally they die with the consortium itself. Mechanisms should be probably studied to make the knowledge available if not used after some time.

Moreover, this approach leads to incremental improvements of available products and therefore to limited advantages for the users. Incremental improvements are working in some

[11] Extracted from the document "Some priorities for European activity in eInclusion" in response from CARDIAC coordination action to the EU eAccessibility future consultation (27.11.2011) redacted by Pier Luiggi Emiliani.

fields of consumer electronics, where products are bought as a status symbol and not for real advantages. If you are a wealthy young person who owns an iPhone 4, you will try to get an iPhone 4S if your friend has it. This is not the case with e.g. a screen reader for a blind person, if you have one that is satisfactory, even if with some limitations, and even more so if it has been difficult to learn how to use it. It is the same reason why people stay with their Windows XT until they change computer and are forced to change the operating systems. When there is something that makes a real difference, users and the market are very fast in taking advantage of it. For example, when the first screen readers based on speech synthesis where made available, many blind people paid to have one of them and the market immediately reacted to make different products available. This is not the case with most marginal innovations made available in eInclusion.

The situation is even worse with deployment pilots. In this case, industries are happy to be paid to show their products, but very reluctant to invest in adapting them for the needs of pilots. A typical example is the AAL environments. A lot of different sensors and technology are deployed in the houses. What is of interest for people is how to interconnect them and construct in the environment enough intelligence to construct real support functionalities. Environments should be able to reason about the situation of inhabitants, but this is not yet considered important for the general market and industries are not interested in investing. Putting together what is available will probably lead again to marginal advantages for users and therefore to a lack of interest by users and service providers.

7.1. Research

Therefore, European support should be devoted to research, i.e. to the development of the knowledge necessary for allowing industry to compete. For example, when GSM was developed, the support was not in designing real products, but in the creation of the basic knowledge that could allow the set-up of an infrastructure and specify equipment for efficient mobile digital communication. Then, starting from this knowledge a revolution was built on the market. The same approach should be adopted in this particular field, aiming to the development of general knowledge and platforms to innovate in the field. Software platforms to produce adaptable and adaptive interactions are an example. A second example is the development of tools and platforms for the introduction of “intelligence” in emerging ambient applications.

This is also clear in the results of the HCI SDDP of CARDIAC, where the suggestions contained in the influence tree were put forward.

These suggestions are not referring to specific equipment or technologies but to general investigations and tools. For example, platforms for introducing intelligence in the emerging environment where sensors are deployed could be sought and made available, so that system integrators could compete in setting up new environments, tools for introducing adaptability in interfaces, tools for evaluating efficacy of used supports and so on.

This would also allow for proper consideration of the technology transfer activity, which is not the transfer of products to users, but the transfer of technology to be used for the design of

new products. For example, the Bell Laboratories did not transfer transistors or equipment embedding transistors, but the idea that a junction could be used to control the control in a semiconductor material.

It is also necessary to reconsider how users should be part of this activity. If a technology is available and someone wants to adapt it to people with activity limitations, then it is possible to ask them to test it and suggest possible solutions to be implemented. But, when a technology is not yet available, it is only possible to work at the level of general functionalities and application scenarios. Methodologies and tools for extracting information at this level are necessary.

Another issue emphasized by the experts is the need for sharing knowledge; eAccessibility frequently requires software resources or written materials that should be shared by the developers in order to be used by a sufficiently broad community. To this end it is convenient to set up a network that ensures the availability and quality of the shared materials, helps to retrieve them and facilitates all the process. Some examples of such activities already underway are the “Raising the Floor” initiative and the Claud4all project.

7.2. Legislation and standardization

Obviously legislation is very important, as results obtained in the USA show. However, it is necessary to consider that the situation in Europe, where different legislations exist, based on different principles.

An example is the introduction of the WAI guidelines as a technical approach to Web accessibility. While, it would be very important to have a common European legislation, there are some statements in the WAI guidelines that cannot be accepted in some European legislation. For example, a statement of the type “as far as it is technically feasible” cannot be accepted in some legislations, where the law sets mandatory specifications.

Therefore it would be interesting to investigate what are the compatibility of the different technological specifications with the national legislations.

There is also a need to establish a body to monitor the protection of the rights of the users against invasive technology. Most technology designed to support people with physical, sensory or cognitive restrictions or dependent people may have a considerable impact over their privacy, autonomy, sociability, and many other ethical issues. Current privacy laws are not sufficient to protect people with disabilities. It is vital to establish a permanent body that monitors and controls the impact of the R&D projects, starting with the initial plans (not only after the project is finished and the product is almost delivered).

Standardisation clearly has an important role to play both in terms of supporting legislation and developing international standards that cover the needs of everyone[12]. An example that

[12] The importance of the role that standardisation plays in technology transfer was highlighted in the suggestions formulated during the first CARDIAC SDDP in Cyprus on the theme of technology transfer.

has been mentioned during the discussions is the need to define a middleware standard. Research on Ambient Assisted Living supported by the EC has evidenced the need for a standard middleware, or the definition of a gateway to allow interoperability among the diverse proposals.

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ANNEX 1: Mechanisms proposed in SDDP2[13]

#001: Research to get rid of HCI.

#002: Research aiming at avoiding cognitive barriers in the design of Human Machine Interfaces.

#003: Development of new haptic interfaces and methods for haptic usability.

#004: Design clearing house for inclusive HCI.

#005: Development of practical adaptive user interfaces.

#006: Research of the use of context awareness to adapt user interfaces.

#007: Promote research in methodologies and tools for HCI accessibility evaluation, including, monitoring and benchmarking.

#008: To do research on tangible artifacts to promote e-inclusion of people with special needs in technologically mediated environment.

#009: To promote research that closes the gap between interfaces for inclusion.

#010: Facilitate the creation of digital accessible materials to non accessibility experts.

#011: Promote tools for decision making in the user-centered design process.

#012: Promote research on the role of inclusive HCI to support self-management in health care.

#013: Support research on novel human-machine interfaces for recreational activities.

#014: Develop and enforce standardized and harmonized remote HCIs.

#015: Delivery of the interface - based on personalization, customization, adaptation and open APIs (such as REST) - to many more varied platforms.

#016: New interaction metaphors and paradigms for computing.

#017: Research and development on provision of accessible interfaces inclusive products and services in a ubiquitous manner.

#018: [Deleted] Research on collaborative accessibility.

#019: Research on inclusive user-interaction in ambient intelligence environments.

#020: Create a paradigm that avoids the traps of either forcing all to use a single new technology or for all content to be rewritten.

[13] The proposals that received more than one vote are in bold type. A number of proposals were deleted (by agreement of the experts) to avoid repetitions.

#021: Consider not only the interface as it appears but the entire interaction dialogue.

#022: Support the research in detecting the behavior, emotions and intentions of the user without the conscious control by the user.

#023: Development of sophisticated brain-computer interfaces for people with special needs.

#024: Training programs for disability representatives to effectively participate in R & D processes.

#025: Research on who could be excluded from using novel user interfaces.

#026: More specific and clear accessible guidelines for application developers.

#027: To do research on how to use mobile technologies as a universal middleware in public and private environments.

#028: Research about the exclusion that has been created by HCI.

#029: Research methodologies that efficiently collect data about users including existing HCI quantitative tools.

#030: Make social media inclusive.

#031: Promote research into the cost of eye-tracking and tongue piercing based interfaces.

#032: Support research that looks how to reduce the complexity of user interaction whilst retaining functionality.

#033: [Deleted] Extend quantitative tools from HCI to inclusive design.

#034: Research on how to enforce accessibility in consumer goods.

#035: Support research on how affective computing can assist accessibility interfaces.

#036: Non-visual interfaces for all.

#037: R&D on text normalization, simplification, personalization and evaluation.

#038: Research on mid to long term interaction by disabled and elderly people.

#039: Promote ubiquitous computing and programming tools.

#040: Promote methodologies to include the human diversity in user interface design.

#041: Use reasoning techniques for personalization.

#042: Research on reasons why existing knowledge and standards on accessibility are not known or applied by HCI developers.

#043: Identify where research is needed to obtain universal access in ambient intelligence environments.

#044: Accessible telecommunications technologies for people with no or little speech.

#045: Research on the cognitive load associated with various user interfaces.

#046: Promote interoperability among devices and services to enhance accessibility.

#047: Research on methodologies to analyse collaborative accessibility and undertake collaborative user- and usage centered design.

#048: Create a meaningful use of HCI clearly supporting activities.

#049: Inclusive practices of professionals responsible to develop new products or services.

#050: Promote research on inclusive HCI for highly dynamic impairments.

#051: [Deleted] Support research on emotional interaction.

#052: Support research on the implications for people with disabilities of the use of biometric systems for identification and security.

#053: Research into how AT can provide better than typical results (e.g. cyber-human).

#054: Research on how to increase and widen accessibility in professional education.

#055: Identify Human Factors barriers to health, education and participation of low income groups.

#056: [Deleted] User interface as a service (exploring market and technology challenges) .

#057: Further research on static and adaptive user interaction profiles.

#058: [Deleted] Research on the methods for haptic usability.

#059: [Deleted] Research on inclusive interfaces for entertainment.

#060: To promote common research on user needs and preferences to be used by all e-inclusion projects.

#061: Ways to move from purchase to lease or renting accessibility and assistive technology (exploring market, policy and technology challenges).

#062: Digital literacy stepping stones.

#063: Research on automated evaluation aids.

#064: Basic research needs to be made on AT abandonment/adoption.

#065: Interface design - knowledge of computer paradigms.

#066: Interface design: input and output.

#067: Usable accessibility.

#068: [Deleted] Standards for accessibility.

#069: New mechanisms for international collaborations.

#070: How to make accessibility simpler to deliver, apply, configure, support and use and explain to policy makers.

#071: Research on sharing accessibility knowledge with developing countries.

#072: Dynamic composition complex interfaces (mash-up of services).

#073: Accessibility of IPv6 enabled consumer appliances.

#074: Support research on accessible interaction with robots.

#075: Create development environment for accessibility solutions.

ANNEX 2: Mechanisms proposed by the external experts[14]

#101: Improvements in existing screen readers, less expensive alternative keyboards and pointing devices.

#102: More case studies of successful use of Assistive Technology in workplaces.

#103: More empirical research on how people with disabilities use mobile devices.

#104: Guidelines for designing and evaluating ubiquitous social media.

#105: Guidelines for mobile apps to ensure minimum good practice procedures in design.

#106: Technologies to extend the world of congenital deaf-blind children beyond their fingertips.

#107: Technologies to make less expensive tactile and Braille displays.

#108: More effective automated tools for publicly monitoring national government web site accessibility.

#109: National guidelines need to harmonize with WAI guidelines.

#110: Basic access methods built into mobile device operating systems.

#111: Design for all extended to wider range of potential limitations to accommodate for ageing population.

#112: Technologies to help people to make use of their skills in physical world in dealing with the virtual world things.

#113: Most consumer devices need to become accessible-out-of-the-box.

#114: Tools to read out or enlarge paper based documents (post, instructions/labels, etc.).

#115: Deeper understanding of how we can best measure quality of ICT inclusive usage experience reported by excluded groups.

#116: More understandable accessibility design guidelines for web designers.

#117: Guidelines or standards for accessible mobile interfaces.

#118: Better understanding of older and disabled people's strengths while may be superior to the mainstream rather than just considering them less able.

#119: Virtual helpers to provide specific help on any IT activity.

[14] This annex contains only the proposals that are substantially different to the ones obtained from SDDP2. Some of the remaining proposals from the external experts have been used to focus, rephrase or complete the ones obtained from SDDP2.

#120: A database and search facility based on a single person's own history to give them memory support.

#121: Simulation tools for many physical conditions that can provide an insight into what it is like to be older or disabled in today's society.

#122: Rapid prototyping tools that allow AT ideas to be mocked up and tested with limited technical knowledge.

#123: Cash machines that can safely be used by visually impaired people.

#124: Better understanding of minimum physical dimensions of mobile devices.

#125: Computers that prompt mental and physical development by challenging people with specific impairments to overcome them.

#126: Simulation facility for cognitive impairments.

ANNEX 3: Mechanisms extracted from the proposals compiled by other European actions and projects[15]

#201: Sensorial systems for the monitoring of health conditions, combined with intelligent diagnosis functionalities, understanding of the environment and other context factors, and smoothly adaptable to the needs of each senior individual.

#202: 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.

#203: Involvement of end users throughout the design and development process.

#204: Using testing based on living labs for fast design iterations based on user feedback in a realistic setting.

#205: Trusted products that users can inspect and update system information at an appropriate level.

#206: User interfaces for mixed initiative (or shared control in robotics).

#207: Rich interaction through distributed objects.

#208: Reduce market fragmentation and lack of interoperability: Adopt recommendations on UI interoperability; Favour the application of Recommendations on UI interoperability by enhancing international cooperation.

#209: Improve legal certainty and consumer acceptance. Adopt initiative to enforce Personal Data Protection legislation for products and services.

#210: Web Accessibility Accreditation and Certification Methods.

#211: Repositories of Web Pages intended to sampling for evaluation, work benching for quality assurance, and conformance verification.

#212: Guidelines for mobile accessibility and accessible Adds design.

#213: Guidelines for the creation of Accessible Rich Internet Applications compatible with Assistive Technologies.

#214: Guidelines for the design of browsers that support Accessible Rich Internet Application.

[15] This annex contains only the proposals that are substantially different to the ones obtained from SDDP2. Some of the remaining proposals from other European actions and projects have been used to focus, rephrase or complete the ones obtained from SDDP2.

#215: Opportunities and dangers of Virtual Reality technologies and propose guidelines for their accessibility.

#216: Opportunities and dangers of Augmented Reality and the Internet of things, especially for their application to accessibility tagging.

#217: Guidelines for the research on Accessible Maps compatible with Assistive Technologies and mobile devices.

#218: User Interface Description Languages that allow the evaluation of most accessibility issues by analyzing the code.

#219: Awareness of accessibility to general purpose applications as a civil right and to develop suitable standards and regulations.