e-Accessibility 2020

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The Second Interim Report

Tentative Recommendations

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Tentative Recommendations

This section as already mentioned in the Introduction summarizes the bigger picture that started to emerge from our research so far and the many conversations held with experts and stakeholders over the last few months.

The Impact of the Smart Phone

The development of the smart phone has had a major impact on all our lives, but in particular on the quality of life of people with disabilities. Mainstream users of mobile phones however might easily wonder what use is a phone to a deaf person, or a phone with a camera to someone who is blind. In both cases the answer is emphatically "very useful" but the reasons are not immediately obvious or intuitive either for mainstream users of mobile phones or for mobile app developers aiming at mass markets.

The video conferencing facility available on many smart phones, allows deaf people to communicate using sign language. SMS and other features are helpful too, but signing remains one of the best and most efficient ways to 'speak' to someone who is deaf. For now it is not uncommon to see deaf people waving their fingers in front of the keyboard or screen of a mobile phone to communicate with someone else using sign language. A device that was once only useful for those who can hear is of great utility even to those who have been deaf since birth. Basic video conferencing provides a first or a second general solution to the problem of communication for deaf people and there are many opportunities to go beyond the simple use of video-conferencing.

Blind people can take a picture when lost, send it to a friend or a forum and ask "where am I?" The reply will often come back in seconds and the usefulness of a camera for someone who is blind becomes immediately clear. A blind person can call a friend, someone wave the phone around them, allowing that person to see where they are, and ask them if there is a restaurant nearby. Similar strategies work for people traveling in foreign countries and dealing with language problems, trying to read a menu in a restaurant in a foreign country or dispute the bill with a waiter who cannot speak your language. Many applications already exist that do simple but useful tasks, others might take for granted. Some recognize colors and can help the user choose what tie to wear with a certain suit. Mainstream users would never normally understand the need for such an application, nor the kind of value it can create.

These features however are not available on all phones just yet. By 2020 it is highly likely that they will. In the meantime many other applications are needed, most of which are not at all intuitively obvious to mainstream users or developers. The simple fact of having a camera with automatic focus and being able to transmit the picture over the internet using something akin to SMS enables many useful strategies for coping with a disability. Combining this with image recognition and voice technology will extend these capabilities even further in the coming years.

Ensuring that Mobile Innovation has an Impact on Accessibility

Pure invention in mobile applications could hardly be easier. The cost to develop an application is made easy by the tools and development environments (innovation platforms) that mobile companies provide. They do little of their application development in-house, instead they create a community of developers provide them with low cost development tools, a means to test their products, a distribution channel (OVI for Nokia, App Store for Apple), payment mechanisms (iTunes for Apple) and a transparent profit sharing agreement (in the case of Apple the developer keeps 70% of the revenues it

generates). As a result innovators can focus on inventing. They don't have to create an ab initio market, their sales and distribution network or the infrastructure to support billing and payment or other business functions. They can develop a new application in a matter or days or weeks. The system has built-in scalability in the sense that when an App is successful, there is no limit on how many downloads can be made, how much revenue can be generated or how quickly all of this can grow, the required global infrastructure is already in place.

To understand how powerful the mobile innovation model actually is, consider that the first such platform was launched by Apple in July 2008. Now a developer only has to pay $99 to benefit from the innovation platform-infrastructure that Apple provides. These days Windows is adding 1,200 new app developers to its community every week. In the US alone there are already more than 400,000 apps available for download. Over 33 million iPhone apps are downloaded each day. Of course only a fraction of these are accessibility tools. All of this has happened in less than 4 years. By the end of 2014 it is estimated that the total number of downloaded apps will have reached 185 billion and that total revenues from games and other apps will exceed $8.3B. In the 6 year from now until 2020 the pace of innovation will only increase. We can expect even bigger changes by leveraging this 'platform approach' to innovation in other domains. This subject is discussed in more detail further on.

The development of innovative new applications, whether for mainstream users or for groups with specific needs, can be done very rapidly and at very low cost. The bottle neck is not in the technology. High resolution cameras, multi-touch screens, GPS sensors, motion detectors and other advanced sensor technologies have become commodities and will be universally available at very low cost in 2020. In the near future new voice recognition technologies, ever better image recognition technologies and advanced search technologies will become commodities as well, platform capabilities that programmers can exploit when they develop new mobile apps. The main difficulties or bottlenecks for developers of mobile access or assistive technologies occur outside of the realm of basic technology.

The Ideation Bottleneck

One of those bottlenecks lies in the initial ideation process related to the development of deep insights into the needs of specific user groups. As explained above, it is far from intuitively obvious to a mainstream smart-phone user, what kind of functions or applications will be of value to someone with a specific disability. This kind of insight can only be obtained from careful observation or from the integration of people with those specific unmet needs into the early ideation process. Even then it may require considerable effort and creativity on the part of future-users to discover their own unmet needs and express them in ways that translate into new products and service concepts. Technically this bottleneck can be broken by creating communities of lead-users that actively participate in development initiatives. This is the living-lab approach that the EC has championed in recent years. Another approach is to execute market research initiatives that gather insights from well defined user groups, that disseminate these insights to developer communities providing them with starting points for their new development efforts, and that even channel the efforts of these communities using competitions and prizes. We refer to this as 'the Vodafone model' referring to the highly successful competition that Vodafone launched in collaboration with the EDF and the AGE platform in 2011. Originally developed in the context of mobile telephony this kind of innovation initiative will play an increasingly important role in the period until 2020.

Brussels based Leo Exter, a former Coca Cola marketing executive and founder We Start-Up, a firm that supports first time entrepreneurs in sectors such as healthcare and accessibility, is adamant that 3 to 5 year long research projects are not well suited to the needs of entrepreneurial start-ups in this domain. Short intense, market oriented initiatives are much effective in helping companies get off the ground.

The Living Lab model and the Vodafone model are good example of approaches that work. These approaches can play an important role in meeting the needs of people with disabilities in the future. In principle, the EC can support this in a variety of different ways. It can support socio-economic research on needs and disseminate this to communities of developers, essentially augmenting the technical tools provided by technology firms with timely insights into the needs and wishes of specific users groups.

On the other hand it might decide to support SMEs that rely on communities of outside developers, by helping them expand their communities to European or international level, and supporting their efforts in the organization of prizes, competition, developer weekends and hack-fests. The same can be said of grand challenges or grand prize approaches. These issues are explained in more detail in the innovation chapter of this report.

The Fragmentation Bottleneck

Ideation based on deep market intelligence or user insight is not the only bottleneck in the development of accessible ICT. Fragmentation is also a major barrier to large scale adoption of high value technologies by people with disabilities.

Mobile operating systems are highly fragmented. So when an application is developed for one device for example for the iPhone, that application is not immediately available on devices that run other operating systems for example on the Blackberry or on devices using the Windows, Android or Symbian OS.

The number of models available is also an issue. The situation is simplest in the case of Apple because Apple has only a small number of models. However the situation is different for other phone makers. Each model and each different maker is different in terms of its memory capacity, its ability to communicate with other devices, access the internet, the size and resolution of its screen, the layout of its keyboard and the use of short-cuts. Add to all of that a further layer of complexity due to language. Add to that the fact that fierce competition obliges phone companies to bring out new models at least once a year. Finally note that for most people the phone is the primary access device and not the only one. In addition to access via phones, people also need access via other channels such as tablets, readers, laptops or work-stations. Soon the TV will add itself to this list. All of this makes it more expensive to realize a single proven innovative concept on a different device.

A small developer of a mobile phone app aimed at people with disabilities may only develop for one device, for example for the iPhone. The iPhone is one of the most expensive devices and iPhone users are considered users who can afford to pay for useful services. The kind of services described by

Traditional research programs fund innovative new ideas. In general they stop at the proof of concept. It is assumed that any further work after this is commercial and should be funded from private sources or investors. However the gap to sustainability is generally too great. Companies that have already developed screen readers and other useful apps, mainly because they are obliged to by law, struggle to adequately support and maintain them in the face of complexity and increasingly rapid change. The situation is going to get worse due to the increasing pace of change. Braillenet of France has done a lot to highlight this problem, but for the time being a solution is not forthcoming.

If the very innovative and highly effective applications available on platform such as the Apple are to be available to all people with disabilities, then they must be available on all platforms, or at least on platforms affordable by all income segments. Otherwise the benefits will only be available to those who can afford the high end models of mobile phone.

This issue could be approached in many ways. One approach is to encourage coordination among main industry players on initiatives that will simplify the development and maintenance of SW for accessibility. Standards have a role to play, but also tools and developer environments and awareness.

Industry associations attending Braillenet conference have repeatedly called out for international initiatives that bring together actors from the major supply chains involved in both hardware and content development with SW developers. That includes the makers of screens as well the producers of content for those screens and the developers of basic operating systems. Coordination on that level is required to make the job of the development and maintenance of new access technologies easier and to ensure they reach the greatest public possible. Many of the major actors lie outside Europe for example in the US, Taiwan and Korea. These need to be brought into the dialogue. The efforts of W3C alone are not enough as there are many issues that go beyond the scope of their activities.

One of the greatest difficulties to be addressed is a general perception by companies that accessibility only concerns a small minority of users and therefore does not justify any or more than minimal levels of investment. Accessibility is not a feature on which companies generally compete. The business case for accessibility has to be made more compelling. Once more Braillenet has done a lot of good work on this in recent years and is developing an action agenda that goes beyond access and focuses on performance. This appears to be one of the most promising paths for the future. We examine it in more detail later on.

The Compliance Bottleneck

There are many compliance related issue that are relevant for disability. These range from the provision of ramps for wheelchair access or the accessibility of ATMs and vending machines, to reasonable accommodation by employers and guidelines for web-site content and e-publication. They are examined in some detail in the relevant chapters on citizenship and activism, media and communication as well as the chapter on transport and mobility. As a general rule however it is fair to say that so far compliance legislation has not had the desired impact. It will be interesting to see how this issue evolves in the coming years and EC financed monitoring activities will keep us informed. It is safe to say however that compliance will always remain to some extent an uncompleted project and the need to deal with compliance gaps will always exist. There are many reasons for this. One is the high cost of modification or retro-fitting old infrastructure. This is one of the main reasons why most buses and bus-tips in most countries are not yet wheelchair accessible. One might excuse this on the basis that the money is not available due the financial crisis, but this may not be an accurate portrayal of reality. Many countries are redesigning their metros and buses to discourage those who don't want to pay their fare for public transport. These barriers make access more difficult and drivers generally don't help people in wheelchairs for reasons that include the risk of aggression. The financial crisis of course adds another argument to an already long list of reasons not to comply.

Often a business case can be made for compliance. This usually relies on reasoning inspired by the Universal Design philosophy or the Economic Model of Disability. In reality the real reason for non-compliance is usually a combination of high cost combined with a lack of understanding of how compliance creates value.

Sometimes however there are valid technical reasons why compliance is difficult. This is certainly the case for web compliance and may account for the very low level of compliance even by government sector and state company websites. The development of accessibility guidelines for websites is carried out by a number of working groups of an organization called W3C, under the umbrella of their Web Accessibility Initiative. Their work is sponsored by major companies such as IBM and HP as well as the European Commission and the US DOE.

The goal of web-compliance legislation is to make a web-site easy to use for a disabled user. This means for example that a blind person should be able to browse a site, find any page on it they want, navigate forward or backward, understand what is contained in the pictures, videos, diagrams and links. They should know if they are reading headings, sub-headings or text. They should be able to interact with the site to plan a trip, order a book, upload or download a file, make a payment or play a game. They should be able to do so whether they are using a laptop, tablet or mobile phone. In future they should be able to do so via large screen TV as well.

Legislation now exists in 55 countries requiring public websites to comply with web access guidelines to ensure that the site does not discriminate against or exclude anyone with a disability. Few companies manage to do this. One of the reasons is that the guidelines which sound reasonable to users are often ambiguous from a developer's point of view. Available tools intended to help developers, though helpful, are often incomplete or inconsistent. For example different audit tools intended to tell if a site is compliant and where it falls down often give different answers. Furthermore formal compliance does not guarantee good design and ease of use. Finally most organizations don't have one small site, they may indeed have hundreds. These may contain hundreds of pages, many lost or rarely visited. The content may change on a weekly basis, to reflect changes in weather, buying patterns or commercial offers. Web-sites compliant in one browser may not be compliant for another. Much of the content is generated by visitors or user community members who are unaware of guidelines or compliance issues. Even sites that are in principle static will deteriorate over time as browsers, viewers and underlying operating systems change. The makers of these systems do not know how to preserve compliance of a site as they migrate from one version of browser or OS to another.

A huge effort is currently required to simplify the situation so that it is feasible to audit and upgrade existing sites to make them compliant. This process needs to be automated as much as possible. In effect a new ICT service sector is struggling to emerge. The market is guaranteed by the existence of public legislation that makes compliance a duty for all companies.

The ideal is to build compliance into the original design of the site. Some tool providers are already working on this, but further work is needed, not only on tool development but on training, and not only for web developers but for business executives, designers and content developers.

The task will become more complex as the range of web-enabled devices increases. What is good for a laptop or PC is not good for a mobile phone, a tablet, multi-user surface or a large screen TV. The nature of interaction will no longer be based on the click of a mouse it will also rely on multi-touch and multiple users as well as voice input as well as voice output. The meaning of compliance will change as these things change. The task will only increase in complexity.

The previous discussion really only concerns public-facing websites, but internal employee-facing sites are important too. If the employee is not able to interact with the site confidently and efficiently, they may not be able to carry out their job to the satisfaction of their employers, partners or other peers. Inspecting public sites is easy. Inspecting internal sites however is a more delicate matter. These include CRM and ERP sites, accounting and HRM sites as well as collaborative work spaces. One way or another the attention given to public web-sites must also be lavished on internal ones as these condition to what extent someone with a disability is able to work at a given firm. We already know that by 2020 all work will be virtual work. It is reasonable to expect that by 2020 the vast majority of websites, both employee-facing and client-facing will have reached a high degree of compliance with accessibility guidelines in force at that time.

Shadi Abou-Zahra, head of the W3C-WAI believes there is a danger that the compliance gap will grow if we do not make real progress and stay in the current catch-up mode. It is not that change is fast, but that change is accelerating. Right now we are in the midst of an revolution in how we use the internet due to low cost screens, touch and voice technology. In the future we will live other revolutions thanks

to a combination of ubiquitous access, the internet of things, personal and community or corporate clouds, big-data and dense sensor networks. He claims that for now no one has written the road-map on how to bridge that gap.

Braillenet of France may already have identified some of the near term actions required. The good news is that the business case for compliance is strong. For example MS reports that accessible websites experience increases of 30-40% in traffic to the site due to better design. The level of awareness however is very low and extremely few schools teach accessibility as part of their course on web-design. Robin Sinclair Chief Accessibility Officer at MS points out that whereas everyone who studies architecture learns bout wheelchair access, but almost no-one who studies web-design learns about web-access. MS has developed course in house and is willing to share them they recommend efforts to socialize resources such as these and reduce duplication of efforts.

Many of the initiatives needed to achieve a state of compliance or near compliance by 2020, require immediate investments in research and technology, to support the development of new tools and services, to ensure adequate progress on standards and practice. Other initiatives however are needed that go beyond research. These include cluster initiatives aimed at creating competitive world class web-design and e-content eco-systems. Initiatives are needed that focus on the lack of suitably trained engineers, awareness of the business case for accessibility as well the cost of non-compliance.

Compliance versus Norms and Practices

Compliance occurs at many levels, at the level of legal obligation and at the level of norms of practice. In discussing accessibility and compliance so far we have mainly evoked issues related to web-sites and mobile telephony. The larger industrial eco-systems involved in content production also require attention. Content is produced by networks of small specialized companies and individuals. In some sectors for example in film, music and general book publishing, production is organized by a small number of large companies. In other sectors such as educational publishing there has been less consolidation. In any case content is often re-purposes for different platforms and production involves long complex production processes. Accessibility of the final product relies on accessibility being built into the every stage of the production process.

In the case of book publication ePUB is the emerging standard but take up in areas such as education is slow. Collaboration is poor. The area of publication for education and training is worthy of special attention. On the one hand it is an important sub-sector of the publishing industry. It is highly fragmented and has its own technical requirements due to the fact that technical issues such as layout and diagramming play such an important role in the pedagogical approach of the overall work. Being dominated by SME an extra effort may be required to encourage take up of norms such as ePUB and help the sector achieve higher levels of productivity and performance. The sector is also important because access to educational and training material determines someone's level of educational attainment and determiners their employability. Actions aimed that this sector could help to ensure that the greatest number of people have the greatest possible access to educational opportunities and therefore to jobs.

The Problem with Content

Braille Net has worked hard on issues related to mobile access, web-accessibility and e-Publication. It has emphasized the need for a systemic approach to the issues by including all members of the supply chain or industrial eco-system in coordination, training and awareness initiatives. However there may be new areas that will require greater attention in future. The film industry is undergoing a radical transformation right now, as has music and will TV. These other broad content categories may need closer scrutiny in future to identify and address accessibility compliance issues that the rapid pace of

technology convergence and supply chain transformation is bond to create. It is reasonable to expect that all of these new content formats will have accessibility built in by 2020.

So far we have mainly discussed designed-content. That is a website or e-publication, its structure and layout as well as all of the text, images and other elements it contains. In principle it is easy to caption images or video and provide all of the alternative text required to make it accessible. Next generation editing, content and workflow management tools should help to ensure that this is the case. There are other forms of content though. This includes text, image, sound and video content generated in real time by visitors, collaborators or dense sensor networks. We should also consider legacy content, content that was crated long ago before systems were sophisticated enough to label or annotate or add appropriate meta-data. Old movies and videos are an example, as well as old photos and unstructured data-sets. Making all of this accessible will require automation or clever tricks such as the CAPCHA/RECAPCHA mechanisms explained in the chapter on media and entertainment that aggregate the tiny efforts of millions of users several times a day asked to solve image or word puzzles, presented as part of the security process on so many websites.

By 2020 all information should be captioned appropriately regardless of the nature of that data, whether it is text, image, audio or video and regardless of its language. Doing so is necessary not only to allow access for people with disabilities, but access for anyone speaking a foreign language, and for the robots that will help us mine big-data and understand the content of our vast personal, community and corporate clouds.

Everything discussed to date is of relevance and importance for accessibility and corresponds to an immediate technological reality that will continue to evolve at a fast pace until 2020.

We now turn to a number of issues that are newer and in some cases more speculative, but mainly in the sense of their timing, less so in terms of their technical or scientific feasibility.

Voice, Touch and Gesture will Change Accessibility for Ever

The immediate frontier for change is in the area of voice technology. The game of mobile telephony changed when Apple introduced Siri. Now all companies are introducing advanced voice technologies. Before Siri voice technology was clunky and poor, a curiosity for those who love to play with technology. Siri has shown that it can really work and work well. Since the introduction of Siri most mobile companies have launched their own Siri-like service. Competition is already fierce and this technology will only improve. For now voice-based interaction is confined to big ticket items like HD web-enabled TV or high-end smart-phones. For now they are not more generally available but that will change. A good example of what is coming down the road is the Croatian start-up called Servus Control that has developed a voice command system that controls lights, air-conditioning, TV and any other connectable device. By 2020 voice will be an important interface option on almost all domestic and mobile devices.

Other interface paradigms are on the way, for example 3D image and video, virtual and augmented reality, as well as multi-screen, multi-touch, multi-person interfaces and tactile screens will have a very important and positive impact on all issues related to accessibility and is very likely to become a normal part of the way we access the ICT products and services in our environment. How these technologies have evolved and how they are likely to evolve in future is dealt with further on in our report. For the next few years, voice, touch and gestures appear to be the main driver of change in the way we access ICT. These features will be of help to people with disabilities, but we cannot rely on the intuition of mainstream users and people developing for mainstream markets to anticipate where and how the greatest value is to be gained.

We need to pro-actively adopt strategies such as those described here, to realize the full potential of this revolution.

Assistive Technologies for Cognitive or Behavioral Disabilities

People with cognitive and behavioral disabilities can easily finds themselves confined to institutions. When young they are often excluded from school on the basis that they are disruptive. Later on they often miss out on the chance to work, have a family and participate in many of the ordinary activities of modern life. This category includes not only people with learning difficulties or low IQ, but people with dyslexia, ASD or ADHD. It also includes people suffering from depression, addiction or work-related stress. It includes people with sleep or eating disorders as well as those with chronic medical conditions such as diabetes. What all of these have in common is that they require assistance in acquiring new ways of behaving or losing old ways of behaving that alleviate the problems they and their co-dependents may experience. The general approach is often referred to as cyber-therapy and involves the use of technology for monitoring, data-gathering and managing behaviors. Already the first generation of solutions has appeared. These typically employ the use of smart phones, tablet computers and wearable sensors. They represent a real breakthrough in personal performance and health, in the sense that occasional advice from a doctor or carer, even good accurate well intended advice whose value is clear to the receiver, often has little effect. The reason is that people forget or they lose motivation, and they find it very heard to judge how 'good' or 'bad' their actions are. Eating is not a linear phenomenon. Appetite is governed by many things and can be controlled by timing when you eat or drink and what you eat or drink. Moods can be managed as well as can periods of productivity and restfulness. These new technologies provide ways of knowing or using all of this complex information, which can be obtained by personal data gathering, again made easy buy technology. This technology has the potential to make great impact on behavior by intervening with the right advice at the right time. Advice received every three months to eat less, become a quiet word several times a day and daily reminders of the progress being made. In this way everyone can be more pro-actively engaged in their own health or performance using tools that could be as good has having a permanent personal life coach.

The pioneering users of today are people obsessed with performance. It is the start of a long journey and advocates expect that by 2020 considerable progress will have been made making these approaches more effective and more generally accessible to general users. It is considered an application of personalized medicine and has the potential to make a contribution to improving peoples overall health and well-being especially into old age, improving their productivity, extending their working life, and helping to slow the progress of memory loss due to Alzheimer's, and through preventative health strategies to avoid or reduce the impact of disabling complications associated with chronic conditions such as obesity, diabetes or Alzheimer's. The goal is greater levels of social inclusion and longer more enjoyable and independent lives. This domain has the potential to become a very important industry in itself.

By 2020 it is expected that this will become an integral part of the personal hygiene of a large part of the population.

Social and Companion Robotics

This is another area that seemed like science fiction just a few years ago. The very impressive and equally costly pioneering robots developed by Japanese companies such as Honda and Sony have all but disappeared from the news. These have been replaced by a new generation of commercial humanoid robots. One of the world leaders is a French company called Aldeberan, maker of a small humanoid robot called NAO. This one can walk, talk, wave its arms, sit and dance. It can recharge itself. It can navigate around the home and pick itself up when it is knocked over. It can recognize its owner and make basic conversation. For the time being it does not do much more than that. It is also

quite expensive. However the founder of the company plans to bring the price down to the something like the cost of a laptop over the next five years. The difference between a robot that can play the violin and one that cannot is mainly software, so Aldeberan is building a community of innovative software developers that will make applications for NAO. They have brought to the domain of social robotics the open-innovation model that Apple pioneered for the mobile phone.

Small animal-like robots that emote are already used in Europe and elsewhere to provide cognitive therapy for elderly people with dementia. In South Korea it is considered that social robotics will become a future engine of economic growth. Official policy aims at one robot per home by 2020. It is in the process of introducing a female assistant teaching robot in maternal schools and plans to have deployed 8,000 by the end of 2013. The technology is improving very quickly and a global eco-system of specialized companies has already sprung up. Some focus on dexterous hands, others on whole arms or faces. An internet enabled robot can not only do anything a mobile phone can do and more. It can monitor someone to make sure they are OK and perform increasingly complex physical tasks. The most advanced models are able to do things like go to the fridge and take out an egg without breaking it.

It is reasonable to expect that by 2020, small low cost humanoid or animaloid companion robots will feature in many homes and institutions, helping out in little things, monitoring the people in their care and providing support for cognitive and behavioral therapy, doing many of the repetitive tasks that friends, family or professional carers have trouble find time for. Eventually they will gain autonomy and we will delegate more tasks and responsibilities to them. They will accompany us out of the house, into town or anywhere every where we wish them to go.

Being life-like is important in certain situations because the human being is pre-programmed to respond to other humans. It is highly likely that people will bond with their humanoid robots at least as much or as intensely as they do with animals. However robots don't have to look like small or even life-size humans to be useful. They could also come built into the TV, or the mobile phone as a form of agent. In principle they could also be distributed across platforms. A conversation stared with the robot could be continued with the TV, with the mirror in the bathroom and eventually once out in the street with the mobile phone. The key technology behind this is the ability to understand and process human speech, and to carry out purposeful human-like conversation. The big breakthrough in this has been Siri, and progress if likely to continue for many years to come.

Exo-skeletons and Wearable Robotics

Scientists involved in the domain consider the exo-skeleton as a form of wearable robotics. It has also been referred to as a form of smart clothing and as 'the jeans of the future'. It is no longer in the realm of science fiction in the sense that powerful light weight exo-skeletons have already been developed that enable the wearer, typically a soldier, to perform 500 consecutive press-ups with 100kg on his back without breaking into a sweat. Military-style exo-skeletons like this have been developed in the US, in France and in Italy. However it is unlikely that they will be deployed in battle just yet. The battery life is an issue and until it is possible for someone to wear it for several days without recharging, its use in war is limited. In the meantime however other more domestic applications may already make sense.

Exo-skeletons are currently being tested in Japan for use by nurses who have to lift patients as well as on construction sites, and as aids for older people working on farms or in gardens. There is also interest from adventure sports enthusiasts and they are being seen as an option for someone who would normally be confined to a wheelchair.

There are still a number of issues that need to be tackled before they can be deployed on a large scale, but there is no good reason why these issues cannot be resolved between now and 2020. One issue is comfort and wearability. This can be solved by improved design and research collaboration involving

companies working in textiles or sports equipment. Another issue is the latency or responsiveness of the system to the user. This again seems to be mainly a design issue and the best available systems already allow the wearer to play football. A key issue of course is pricing or business model. Good design and business model innovation will play an important role in the development of this industry and in the adoption of these assistive technology tools by a significant part of the population.

Speaking at Braillenet 2012 Robin Christopherson of AbilityNet UK, recently urged those in the domain to experiment with technologies such as these because they had the ability to transform the lives of those living with disabilities. It is clear that an exo-skeleton could be of great help to someone with mobility issues. It would enable them to go places where accessibility compliance has either failed or would normally prove impossible, for example on a mountain walking trail. However this technology is of great potential value to a much larger range of users. The best thing that can be done now to make this available at low cost to someone with a disability is to encourage its adoption as an assistive technology of use to the widest number of uses and situations. The uses of course should not be confined to professional uses, but to entertainment and leisure uses as well.

DARPA, the military funding agency of the US has used a mixture of grand challenges and strategic research procurement to boost progress in this domain. A similar approach might work in Europe to bring together all of the major industrial and research across around a common project that will move the technology onto he next level of performance. These mechanisms are discussed in more detail in the chapter on innovation further on.

Self-Drive Cars and Other Assistive Devices

Robin Christopherson of Ability Net in the UK also thinks we should now be experimenting with self-drive cars. These have been demonstrated many times in the last few years and the Google Car in particular has received a lot of press coverage. Many European car companies however have already developed a self-dive capability. Volkswagen uses self drive cars for example in testing. Some companies have plans to market self-drive models in the coming years. Already the state of Nevada in the US has legislation for self-drive cars. The general idea is that the person in the care should have a license in case something goes wrong in traffic. Many see this as an intermediate step towards universal access to self–drive cars on the road. We should pursue a goal of legalizing self-drive car use by blind people by 2020 or soon after. This would provide access to personal transport not only for people who are blind but for people with a wide range of disabilities, physical cognitive and behavioral. It also provides a transport solution to people under the influence of alcohol, under the legal age to drive. Intermediate steps could include the development of services based on self-drive or driverless taxi and delivery services, business models based on sharing, or cars driven by telepresence. Certainly other approaches to mobility are worth exploring.

The use of remote telepresence robots has a role to play in the future. Although this started in the US, already several European companies have acquired a capability in this domain. By 2020 they may enable some of the regions to realize policies for accessible public spaces.

It is likely that the EV or Electrical Vehicle technology will transform both public and private transport in ways that go beyond the initial intended impact on the environment. EV technology is so different from petrol or diesel technology that it opens up entirely new design possibilities for small, efficient, low-cost vehicles unlike anything we have seen before. Many new concept individual or two-seater vehicles resemble advanced hi-tech wheelchairs or scooters. They may even surpass motorized wheelchairs in terms of price and performance. They will certainly surpass them in terms of style.

New manufacturing paradigms based on OS hardware and 3D printing enable mass customization. This should be developed not only as a path to the mass customization of personal transport, but as a source of solutions for a much wider range of assistive technology needs. By 2020 one can reasonable

hope to see industrial eco-systems across Europe leverage our strength in design and exploit the opportunities provided by these game-changing manufacturing technologies.

Brain Computer Interfaces

Brain computer interfaces based on EEG headsets have been around for many years. They have been of interest because they provide the possibility of controlling a machine suing only ones thoughts. In particular they provide the possibility of controlling a keyboard or computer interface using ones thoughts. Until recently these systems were very bulky and expensive. They were only available in hospitals or clinics and were only used on patients. This situation has changed and there are already two commercially available EEG headsets. One called Mindwave by Neurosky and another called Epoc by Emotiv. These cost only $100 and $400 each and they have brought the use of brain signals into the public domain and within the reach of essentially any interested researchers. This has changed the rhythm of innovation in the domain and now there are very many more researchers working on these issues than ever before. IMEC in Leuven, Europe's largest micro-electronic researcher centre has developed its own headset which it claims is better than either Mindwave or Neurosky.

Right now however such systems are generally not good enough to function as useful computer interface devices. They do work, but too slowly. Even for people with lock-in syndrome, other approaches based for example on muscle movement or eye gaze usually work better. Many feel that a real breakthrough is needed, perhaps based on better brain modeling using the kind of insights that projects such as EC funded "Human Brain" project might provide. Others feel that such systems will only be good enough when the electrodes are paced beneath the scalp on the surface of the brain, rather than outside over the skull and hair.

It turns out however that the real value of the EEG headset may not be as a computer control device but as a sensor that can monitor ones level of stress, mood or attention. Apart from research and games, the EEG headsets are used in neuro-marketing and in performance improvement. In particular they are used in Japan to help improve the performance of top sports people in golf, tennis and baseball.

It is not clear that the needed breakthrough in the use of EEG headsets for computer interface will occur by 2020. It is possible however that the EEG headset may never prove very useful as an access technology, but may provide useful as part of an assistive technology that monitors the wearer's level of stress, comfort and attention or quality of sleep.

Neuro-Engineering

Many scientists and neuro-engineers believe that efficient, direct brain-machine, machine-brain and even brain-brain communication will one day be possible. Some go so far as to claim that one-day everybody will use such systems, not just those who are locked-in or living with a sever form of disability such as ALS. All admit however that this day is far away and that their vision will only really become feasible with the use of invasive brain interfaces.

The EEG headset is an example of a non-invasive brain interface in the sense that it never pierces the skin or otherwise enters the body. Other kinds of brain-machine interface are invasive and involve the placing of systems of electrodes beneath the skull for example resting on the hard membrane that covers the brain. Some kinds of brain-machine interface sit on the surface of the brain or even penetrate deep inside the brain. This is the case for deep-brain stimulation is used to control pain or eliminate tremor.

The placing of systems of electrodes under the skull, but above the dura involves risks that are comparable to surgery under general anesthetic. When electrodes are placed on the surface of the brain

or inside the brain the risks are much higher. In particular there is a much higher risk of infection that could even result in permanent damage to the brain.

Research involving invasive or highly invasive techniques is relatively rare in the EU. The level of research using invasive techniques on animals seems to be declining. It is much more common however in the US.

One researcher felt that there seems to be a contradiction or inconsistency in the European approach to research on invasive brain-machine interfaces. He remarks that ethics boards readily approve highly invasive and therefore highly risky procedures such as deep brain stimulation, but deny approval for less invasive procedures with much lower associated risks.

He felt that this has slowed progress in advancing the state of the art in brain-machine interfaces using safe-invasive techniques, which would give much cleaner signals and remove much of the latency involved in interpreting brain signals.

One way of making progress in the area of invasive brain interfaces is to work with animals. The same researcher was of the opinion that the amount of animal based research was also in decline.

His feeling is that when the breakthroughs finally come in this domain, Europe will not be in a good position to build upon them, as it is losing any capability it has in this domain.

The only bright light seemed to be in the area of advanced prosthetics where a number of groups have recently developed know-how in interfacing not so much with the brain but with the nervous system, with a view to providing a limited sensation of "feeling" to the extremities of artificial limbs.

The overall message seems to be that apart from areas such as deep brain stimulation, not much progress can be expected in Europe on these frontiers between now and 2020.

The main hope for significant progress between now and 2020 may be in the application of neuro-engineering to advanced prosthetic devices such as limbs that incorporate fine movement control, machine intelligence, and interface with the nervous system to provide touch. This may be a good theme for a series of high profile X-Prize type of initiatives.

Advanced Prosthetics

Already two different types of artificial retina are commercially available for those who can afford them. A third model is close to FDA approval in the states and should become available some time soon. The technology is still quite primitive in the sense that the restored sight (though a big improvement) is not yet good enough to take the user over the threshold of legal blindness. But it is a start and three are many research projects underway around the world that aim to achieve and even to greatly exceed this goal. It is hard to claim that by 2020 this will be possible, but it is reasonable to assume that it will happen someday, and if not by 2020 perhaps by 2030. Until then many other strategies are worth trying to provide a blind person with the highest level of autonomy possible, for example strategies based on sensory substitution. Typically these strategies proceed by processing the image of the visual field and representing it using sound transmitted to the ears and vibration or small electrical currents to sensitive parts of the body. Some cars have safety features where the vibrations in the seat warn the driver of the direction of a possible hazard.

It is useful to note that there are still many things to do to improve the basic hearing aid or the cochlear implant. People who use cochlear implants can make out conversation but cannot hear music. Perhaps by 2020 this will be possible. A few thousand people have undergone experimental surgery that attempts to restore some hearing ability by transmit signals directly to the brain stem.

It has been very difficult to develop assistive technologies for people with speech impediments, mainly because of the difficulty attaching electrodes or electronics to the throat or near the voice box due to movement of the larynx and the intensity of vibration associated with human speech. Recent progress in the development of Epidermal Electronic Systems or electronic tattoos may result in progress in this domain.

The main area for progress in advanced prosthetic has been in the area of artificial limbs. Two of the top providers in the world are European – iLimb of Scotland and Ossur of Iceland. By 2020 it is reasonable to expect real progress in the development of artificial limbs that not only incorporate power, machine learning and intelligence, but which are also at least partially controlled by brain signals and which restore at least particle feeling in the extremities. One expects that high-end prosthetic limbs will be soft and life-like rather than hard and plastic. US surgeons already report a rise in requests for 'revisions'. In other words requests by people to have partial real limbs removed so that they can fit a fuller more functional prosthetic. By 2020 this could become a trend in Europe too.

Extending the Platform Approach beyond Mobile

Earlier we discussed how innovation happens in the mobile industry. In particular the power of corporate innovation systems based on a formula where a company develops a proprietary platform and facilitates the efforts of third party developers by absorbing the cost of development tools, provides them with access to the brand, distribution channels and infrastructure for basic business functions.

These models first appeared in the mobile industry in 2008. They have totally transformed the pace, structure and economics of innovation in the sector and are now being copied in other domains.

Aldeberan of France for example is pursuing this approach with its flagship social and companion robot called NAO. Many robots have been created by EC and other research programs for use as assistive devices either to help elderly people, those who are ill or those who work with them, their nurses and other carers. Many of these have not yet considered the platform approach to harnessing the power of open innovation. There is merit in going down this road. Not all robots may qualify as high potential platforms for further development, but the use of innovation prizes and grand challenge competitions is a promising mechanism to help identify solutions or systems worth developing as platforms associated to communities of developers and lead-user groups. There may be merit in initiative intended to complete existing robotic platforms with all of the tools and materials necessary to make them into platforms that a larger community of researcher and innovators can exploit.

The US army has adopted its platform approach to boost development of the DARPA developed Big Dog robot. Emotiv is doing the same with its EEG headset for recording brain-waves.

At least one engineer with a hearing impediment wants to implement an open platform approach to the development of hearing aids. This initiative is inspired by the efforts of the so-called "self-tuners". The self-tuners are good examples of lead-users in this domain and around which open innovation networks could be created.

In principle this approach could be applied to the various off-the-shelf retinal implants that are already available in the US and Europe, however it may take a while before the population of users of these devices reaches a level sufficient to sustain this kind of research and innovation community.

Platforming is a good way to discover un-anticipated uses for new technologies that may prove essential to their commercial development. It has helped the developers of EEG headset identify uses for the device making it a viable business even though it has so far failed to adequately address the problem for which it as originally conceived.

A platform approach to next generation web-enabled TV would also yield benefits for those with access needs. This is of particular importance as it is likely that for elderly user groups, even by 2020 the TV will remain the main media device and easiest point of access to more general web-enabled services. Makers of home electronics devices such as record players, CD players, radios and TVs are notorious for providing consumers with complex, hard-to-use systems, most of whose functions are entirely ignored by users who cannot find them, cannot use them and either give up or never bother to try. Voice interaction could change this, but user friendly design is an area where consumer electronics companies have generally fallen down.

The same has to be said for makers of ATM, vending or ticketing machines as well as Point of sale or store automation systems. Despite efforts to develop standards, compliance has been poor. People with disabilities are consistently under-served in these device categories. A legal approach based on regulation seems to have yielded little progress. Fresh thinking perhaps based on open innovation, UD or design4all concepts, as well as the adoption of lead-user and living lab models for the organization of research and innovation may provide a more effective path to progress on accessibility issues.

It is worth noting that a quiet revolution is happening right now in manufacturing. This is based on the idea of open source hardware and 3D printing. This could have an important role to play in many areas, assistive device in general, devices that need to be customized to the individual, devices such as companion and wearable robots, personal transport system and even wheelchairs. By 2020 one can reasonable hope to see the emergence of dynamic industrial eco-systems that include designers, lead–user groups and living labs, as well SW and technology companies, working together to develop a rich eco-system of assistive devices that we cannot even imagine today, due to the equivalent of the ideation bottleneck that exists in accessible mobile phones today and which we have discussed at some length earlier in this chapter.

Mainstreaming the Business Case for Compliance

Some applications, cherished by phone user who are blind, for example an application that recognizes voiced commands and content, are very ergonomic in their design and easy to use by people who are blind. The system recognizes that the user wants to make a note, it records the note, checks the content with the user, and when the user is ready sends it to outlook, synchronizing with other connected devices. Most mainstream users don't know about this application. They go through a tedious process of opening an application to write the note, making many errors while trying to type on the very small keyboard or touch screen. Then they have to close the file, give it a name and save it in a folder. Having done all of that, they must now open an email application. This means choosing the person to send it to, selecting the attachment, writing a subject line, sending it and closing the application.

If it is not obvious to mainstream users how the mobile phone can help deaf people, it is even less obvious that applications intended for deaf people could also help mainstream users. At a rock concert few people can hear what is said by someone beside us due to the overwhelming volume of sound. The same happens in factories or other noisy work environments, underwater, in a bulldozer or digger, on the street in traffic, in a crowded room or on a bus. In these environments we do not function as normal and in effect we become deaf. Solutions that work for people considered handicapped due to a hearing impediment can be of use to mainstream mobile phone users in each of the situations described above. The Universal Design philosophy urges that applications created for mainstream users should also be usable by people with disabilities, but this is not always possible and awareness among designers of the principle is in general quite low. The converse philosophy is to consider that tools created for people with disabilities can also be of use to mainstream users. This is what happened in the case of the TV remote control. This is also what happened in the case of the screen reader. When it happens it greatly expands the size of the market and totally changes the economic conditions for high impact innovation to take place. In future we may expect to discover other categories of software

which make the transition from niche market access SW to mainstream productivity software. It is possible to imagine this happening in areas such as voice interface or companion robotics.

The "accessible" ergonomically designed application considerably simplifies certain tasks such as making a note, in the process saving the user a great amount of time. People who are blind love it and use it because it is a necessity. Mainstream users don't know about to because they never look into applications intended for people with disabilities, they don't realize that these applications can also be of use to them, and they stay with old habits of work that were developed earlier when mobile technology was newer, less powerful and more costly. A small number of applications have escaped this trap, for example screen readers, but most have yet to realize their full potential, not just as access technologies aimed at people with disabilities, but as productivity tools for people with situational disabilities due to stress, complexity of work or the increasing demands on their time.

Funka Nu, a Swedish design company that specializes in mobile accessibility is emphatic that everyone is handicapped to some degree and in many more ways that they realize. To make the point Funka Nu goes even further to say that we have been handicapped by the mobile phone! Most adults have difficulty using the small keys of a mobile phone. Touch-screens could make things better but usually don't. Adults are even worse at using a small mobile touch screen than using the keyboard. When using mobile phones they effectively have problems with mobility and dexterity, it is as though they are wearing gloves. But when they do wear gloves or go out in the cold, performance at using the mobile phone is even worse again. Using a mobile phone while driving, something we should not do by law, but which many do anyway, their attention is divided and they effectively become cognitively impaired. Everyone is blind at night, when the light is too low or in strong sunlight, when an object is too far away or when the print is too small as it usually is on utility contracts or on the labels of food and household products. Everyone has a speech impediment when they are in a foreign country, in a meeting or in a place so noisy they cannot make themselves heard.

Microsoft has consistently made efforts to build accessibility into its products from the start. They are adamant that these features are of use to all users and have the potential to increase their productivity, enabling longer productive working lives, but they note that while the use of accessibility features is limited to people with disabilities, they are of considerable use to the general user. They advocate continuing research in this domain to measure the ways in which access features created, how much value it can create and the kind of work practices needed to realize the potential.

Filip Maertens, the CEO and founder of Argus Labs - a Belgian social media start-up, claims that we are increasingly handicapped by complexity, losing ourselves in the noise of Facebook, Twitter, Foursquare, Trippit. There is already a term for time wasted on social networks rather than on other more productive activities – this is nowadays referred to as "social notworking". Herman Konings a Belgian futurist, recently remarked that due to commuting and other factors we have on average 7.5 hours per week less time for ourselves compared to 20 years ago.

It seems that even though we may be living longer lives we have less time for living as we would like to. Despite the great advances that technology has provided us we have been handicapped by mobile phones, robbed of productive hours by social networks, and deprived of me time by commutes and other inefficiencies of daily living. Assistive technologies are required to regain this lost ground, not just for people with formally recognized disabilities but for everyone, in every role at every stage of their lives.

This is a very hopeful message in that it points the way to a greatly expanded market for access technologies and indicates how it may be possible to completely change the economics of innovation in this domain.

Compliance Activism

The European Disability Forum represents 80 million people across Europe. It is an important advocate for the rights of disabled people at EU level. It conducts political campaigns on pressing issues. It two main campaigns nowadays are on Web Accessibility and Freedom of Movement. Legislation with regard to disabilities is not uniform across Europe, but on both of these issues there is a major failing in compliance. New assistive technologies can help in at least two ways.

They can help people with disabilities whose needs are immediate and for whom, time is precious, to cope with situations of non-compliance, which do not or cannot change quickly enough. They can also help maintain pressure on those who can act to do so as quickly as possible. This subject is discussed in more detail in the chapter dealing with politics, citizenship and activism.

The essence is that technologies based on mobile phones equipped with cameras and GPS, are great ways for gathering evidence of compliance breakdown. Cold objective data is very useful to public authorities when it shows then how they can act and where. Early action saves money and this knowledge helps authorities understand how they can best deploy scarce resources.

Technology can bring together large communities of people allowing them to show the magnitude of their dissatisfaction with the state of affairs and the urgency of their need to have it addressed. On many issues people with disabilities have natural allies. On freedom off movement issues such as access to public transport, they have natural allies among mothers who travel with children and prams, people who use the route to bring home shopping or travel with baggage to the airport. Technology can help create these occasional and useful alliances intended to demonstrate solidarity and illustrate the magnitude of need created either by oversight or compliance failure.

Other measures reply on activities such as benchmarking, the encouragement of companies that practice CSR reporting, and the dissemination of good practice on inclusion on issues such as employment. Another issue is public procurement and the need to create sufficient competition in the provision of relevant services so as to bring costs down.

It is important to address these issues on many fronts. Legal options are available, as is advocacy at EU level, but clear local pressure from citizens also has a role to play as well. The regions of Europe have a role to play here to make their regions more citizen friendly, and to use regional innovation funding opportunities to pilot, demonstrate and implement the kind of e-democracy and e-administration initiatives that can have a high impact.

By 2020 one can hope for a large politically engaged citizenship that is active on its own behalf at local level, learning through exchanges of good practice across Europe.