Over the Horizon:

Potential Impact of Emerging Trends in Information and Communication Technology on Disability Policy and Practice

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Executive Summary

The technologies used in information and communication products are advancing at an ever increasing rate. Devices are getting smaller, lighter, cheaper, and more capable. Electronics are being incorporated into practically everything, making a wide variety of products programmable, and thus more flexible. Computing power is increasing exponentially. What requires a supercomputer one year can be done on a child's game player 15 years later.

There are many emerging technology trends that affect technologies used by people with disabilities. Four that will have particular impact on information and communication technologies (ICT) are:

- Increasing computational power, combined with decreasing size and costs;
- New interface research in areas such as virtual projected interfaces, speech input and output, direct brain interfaces, multi modal interfaces, and artificial intelligent agents that can act as mediators;
- Ubiquitous connectivity and network services, including the ability to be in constant connection with people or services that can provide assistance or augment a person's abilities – all with technologies that soon will be wearable or incorporated directly into clothing; and
- Creation of virtual places, service providers, and products that can enable a person to shop, explore, learn, travel, socialize, and work in "cyber space."

New Opportunities

These technical advances will provide a number of opportunities for improvement in the daily lives of individuals with disabilities, including work, education, travel, entertainment, healthcare, and independent living.

It is becoming much easier to make mainstream products more accessible. The increasing flexibility and adaptability that technology advances bring to mainstream products will make it more practical and cost effective to build accessibility directly into these products, often in ways that increase their mass market appeal. Although products have been getting progressively more complex for some time now, advances in key technologies will soon make it possible to reverse that trend and make products simpler. Improvements in connectivity and interoperability will enable individuals with severe or multiple disabilities, who could not operate the standard interface on universally designed products, to use products via a personal interface device that matches their abilities.

Less costly and more effective assistive technologies (AT) will also be possible as technology advances. More importantly, however, emerging technologies will enable the development of new types of AT, including technologies that can better address the needs of individuals with language, learning, and some types of cognitive disabilities. A potential for new "intelligent AT" is emerging that was previously not possible. Translating and transforming technologies will be able to take information that is not perceivable or understandable to many with sensory or cognitive impairments, and render it into a form that they can use. Human augmentation technologies will enhance some individuals' basic abilities, enabling them to better deal with the world as they encounter it. Advances in technology will also reduce the size and cost of products, making them easier to carry, wear, and, in some instances, replace. Assistive devices will be made available to and usable by those who would not have used them in the past out of a concern that they might lose them.

Barriers, Concerns, and Issues

Many of the same technological advances that show great promise of improved accessibility, however, also have the potential to create new barriers for people with disabilities. The following are some emerging technology trends that are causing accessibility problems.

- Devices will continue to get more complex to operate before they get simpler. This is already a problem for mainstream users, but even more of a problem for individuals with cognitive disabilities and people who have cognitive decline due to aging.

- Increased use of digital controls (e.g., push buttons used in combination with displays, touch screens, etc.) is creating problems for individuals with blindness, cognitive and other disabilities.

- The shrinking size of products is creating problems for people with physical and visual disabilities.

- The trend toward closed systems, for digital rights management or security reasons, is preventing individuals from adapting devices to make them accessible, or from attaching assistive technology so they can access the devices.

- Increasing use of automated self-service devices, especially in unattended locations, is posing problems for some, and absolute barriers for others.

- The decrease of face-to-face interaction, and increase in e-business, e-government, e-learning, e-shopping, etc., is resulting in a growing portion of our everyday world and services becoming inaccessible to those who are unable to access these Internet-based places and services.

In addition, the incorporation of new technologies into products is causing products to advance beyond current accessibility techniques and strategies. The rapid churn of mainstream technologies, that is, the rapid replacement of one product by another, is so fast that assistive technology developers cannot keep pace. Even versions of mainstream technologies that happen to be accessible to a particular group can quickly churn back out of the marketplace. To complicate the situation further, the convergence of functions is accompanied by a divergence of implementation. That is, products increasingly perform multiple functions that were previously performed by separate devices, but these "converged" products are using different (and often incompatible) standards or methods to perform the functions. This can have a negative effect on interoperability between AT and mainstream technology where standards and requirements are often weak or nonexistent. Thus, without action, the gap between the mainstream technology products being introduced and the assistive technologies necessary to make them accessible will increase, as will the numbers of technologies for which no accessibility adaptations are available.

Another concern is that technology advances are causing functions and product types to develop beyond the scope of existing policy. For example, when telephony moved from the public switched telephone network (PSTN) to the Internet, the accessibility regulations did not keep pace. The FCC determined that the Internet was information technology, and that the access regulations apply only to telecommunications, even though people were using the same phones and the same household wiring to make phone calls to the same people, many of whom were on the PSTN. Although the FCC has recently applied some telecommunications policies – namely those requiring E-9-1-1 call handling, electronic surveillance, and contributions to the Universal Service Fund – to some IP services, most of the remaining telecommunications regulations, including those requiring accessibility, have not been applied to these new technologies. Internet Protocol Television (IPTV) manufacturers are now talking about including conversation capabilities in their base technologies, again raising the question as to whether telecommunication accessibility will apply to these "phone calls." When accessibility is tied to technologies that become obsolete, often to be replaced by multiple new technologies, the accessibility requirements are often late or deemed not applicable. The shift of education, retail sales, etc. to the Internet after the ADA was drafted resulted in the Internet versions of these activities not being specifically mentioned in the law. This is another example of policy not keeping pace with technology. The evolving technology(s) involving copyright and digital rights management is another example.

The issue of policy not keeping pace with technology and product advances, however, goes beyond accessibility regulations. It can also apply to funding and eligibility issues. Often, the result is that people with disabilities become trapped, using old technologies that no longer work in their environment and activities.

Finally, there should be a broader recognition of the importance of having a "business case" for accessibility. This report focuses on new technologies and how they can benefit people with disabilities. None of these technologies will benefit people with disabilities unless they are built into products, made available, and supported. And none of that will occur in any reliable and sustainable fashion unless individuals within companies can make a business case for each new feature. Net profit is the primary reason products make it to the marketplace and remain there, and the primary reason ideas carry forward from one version of a product to other products. This is not specific to disability issues. It applies to all products. If a goal of our society is to have products that are accessible to and usable by people with disabilities, then mechanisms are needed to make accessible products generate significantly more net revenue for a company than products that are not accessible.

When accessibility features or capabilities have significant mainstream market appeal, and their incorporation will result in greater return on investment than would expending the same effort on something else, market forces alone can cause these features or capabilities to be incorporated into products and services. These instances should be identified and encouraged. Other accessibility features, however, no matter how low their cost, have not and will not occur in mainstream products without some induced effect on net profit. Regulations can be used to inject social values into the profit equation, but only if the regulations are enforced in a fashion that impacts profits positively if products are accessible, or negatively if they are not. “Pull” regulations (i.e., regulations that create markets and reward accessibility) generally work better than “push” regulations (i.e., regulations requiring conformance with regulatory standards), but both have a place in the development of public policies that bring about access and full inclusion for people with disabilities. Neither type of regulation works if it is not enforced. Enforcement provides a level playing field and a reward, rather than a lost opportunity, for those companies that work to make their products accessible. For enforcement to work, there must be accessibility standards that are testable and products that are tested against them.

Issues for Action

Seven general action items are advanced and discussed to address these issues:

#1 - Maximize the effectiveness of assistive technologies and lower their cost – in order to maximize people's general abilities and independence. Key strategies: Foster results-oriented R & D all the way to commercial availability.

#2 - Maximize the accessibility of mainstream information and communication technology products, so that people with disabilities and seniors can use standard products as they encounter them. Key strategies: Increase funding for research, proof of concept, and commercial hardening of approaches to accessible design of mainstream products to advance understanding in this area; craft accessibility regulations so as to help employees build business cases.

#3 - Ensure that access to the Internet and other virtual environments is provided, as it has been to physical places of public accommodation.

#4 - Address new barriers to the accessibility of digital media caused by digital rights management (DRM), including when visual and audio rights are sold separately.

#5 - Base all policy regarding information and communication technology (ICT) accessibility on a realization of the importance of the business case. Where a solid business case cannot be built based on market forces alone, create accessibility regulations and effective enforcement mechanisms that provide a clear profit advantage to those who comply and a disadvantage to those who do not.

#6 – Create accessibility laws and regulations that are not technology specific, but are based on the functions of a device. Provide clear guidance as to what is sufficient to meet the standard, and allow requirements to index themselves to technologies, as they evolve, using baselines. To the extent possible, harmonize laws and regulations with those of other countries for products that are sold internationally.

#7 – Ensure that up-to-date information about accessible mainstream technology (AMT) and assistive technology (AT) is available to and being used by the public.

Introduction

Information and communication technologies are changing at an ever-increasing rate. What used to be multi-year product life cycles have now decreased in many instances to life cycles of less than a year. Previous accessibility strategies involving the development of adaptive technologies, or accessible versions of new technologies, are failing due to this rapid turnover.[1] This is exacerbated by the fact that it is not just products that turn over, but the underlying technologies as well. For example, analog cell phones were made accessible just as they were being replaced with digital cell phones. Now some digital phone formats (e.g., TDMA) are being phased out in favor of newer technologies.[2] This same technology churn, however, is also opening up new opportunities for better assistive technologies and more accessible mainstream technologies.

The National Council on Disability undertook this project to explore key trends in information and communication technology, highlight the potential opportunities and problems these trends present for people with disabilities, and suggest some strategies to maximize opportunities and avoid potential problems and barriers. Many of the changes in technology are evolutionary, but some revolutionary changes are also ahead. Several of these changes may even cause a re-thinking of concepts and the definitions of such terms as “disability,” “assistive technology,” and “universal design,” or how these terms are used.

Several technology trends discussed in this paper present opportunities for universally designed products, and for improved availability, usability, and affordability of assistive technology that can have significant impact on the quality of life for individuals with disabilities. the more reliant society becomes on technology to perform fundamental aspects of every-day living, how we work, communicate, learn, shop, and interact with our environment , however, the more imperative it is that individuals with disabilities have access to that same technology, and the more costly will be the consequences of failure to ensure access. As the rate at which technology evolves increases exponentially, so does the potential for an unbridgeable technology divide. The policies we adopt today will determine whether the technology of the future empowers individuals with disabilities, enabling them to work, learn, communicate, shop, and live independent, productive lives as full and equal members of society.

Technological Advances that are Changing the Rules

In order to understand how technological advances can lead to the need to re-think technology and disability funding and policy, it is important to understand just how fundamentally things are changing. Four key technology trends have been selected for discussion in this report. Opportunities and barriers created by these advances follow in the next sections.

Some things in the discussion below challenge the imagination. Yet, except where indicated otherwise, everything discussed is already commercially available or has been demonstrated by researchers. This section is based on a more comprehensive and periodically updated list, complete with references and links, which can be found at www.trace.wisc.edu/tech-overview.

Trend 1: Ever-Increasing Computational Power Plus Decreasing Size and Cost

Computational power is growing at an exponential rate. At the same time, the size of electronic components is shrinking, decreasing product size, power consumption, and cost. Raymond Kurzweil helped to make this growth real to those not used to dealing in exponentials, with the following: In 2000, $1,000 could buy a computer that had the computational power of an insect. By 2010, $1,000 will purchase the computational power of a mouse. By 2020, $1,000 will purchase the computational power of the human brain. By 2040, $1,000 will purchase the computational power of all the brains in the human race.[3] Kurzweil has also “projected 2029 as the year for having both the hardware and software to have computers that operate at human levels.”[4]

Personal digital assistants have shrunk from the size of paperback books to credit card size, and now to a function that runs in the back of a cell phone.[5,6] Cell phones have shrunk from something just under the size and weight of a brick to cigarette-lighter size, most of which is occupied by the battery. Multiple Web servers can fit on a fingernail (sans power supply), and RJ45 (Internet) cable jacks are available that have Web servers built directly inside the jack.[7]

Researchers have created gears the diameter of a human hair,[8] motors that are a hundred times smaller than a human hair,[9] and are now exploring tiny cellular-scale mechanisms that would use flagella to move about in the blood stream.[10] The entire field of nanotechnology is taking off, supported by major federal funding.

Although very expensive technologies are needed to create these devices, the cost per device is dropping precipitously. Sensors that were once hand-assembled are now created en masse, and sometimes even created in a "printing-like" process.[11] The cost of computing drops by a factor of 10 approximately every 4-5 years. It is not uncommon to find children's video games that have more computing power than supercomputers of just 10-15 years prior. Scientists are now turning to light instead of wires in microchips to keep up with the speed.[12]

This trend towards more computational power, with decreased size and cost, can make possible improved and entirely new types of assistive technology. This trend is also providing capabilities in mainstream technologies that can enable them to more easily and effectively meet the needs of people with disabilities.

Trend 2: Technology Advances Enabling New Types of Interfaces

The human interface is one of the most important determinants of whether a technology product can be used by people with disabilities. Advances in interface technology are creating new opportunities for better assistive technologies, more accessible mainstream technologies, and entirely new concepts for controlling both.

Projected Interfaces. Using a projector and camera, companies have created products that can project anything from a keyboard to a full display and control panel onto a tabletop, a wall or any other flat surface. People can then touch the "buttons" in this image. The camera tracks movements, and the buttons or keys operate as if they really existed.[13] One device is pocket-sized, projects a keyboard onto the tabletop, and allows users to enter data into their PDA by typing on the image of the keyboard on the tabletop.[14, 15] Other projected interfaces use sound waves.[16]

Virtual Interfaces. Going one step further, researchers have demonstrated the ability to project an image which floats in space in front of a person. With this glasses or goggle-based system, only the user can see the image floating there.[17] Some systems project the image directly onto the retina.[18] A pocket controller or gesture recognition can be used to operate the controls that float along the display. Motion sensors can cause the displays to move with the user's head, or stay stationary.

Augmented Reality. Researchers are also using this ability to project images to overlay them with what a person is seeing in reality, to create an "augmented reality." One project envisions travelers who can move about in a city in a foreign country by wearing a pair of glasses that automatically recognizes all of the signs and translates them. Whenever foreign travelers look at a sign, they would see a translation of that sign (in their native language) projected over the top of the sign.[19] [20]

Virtual Reality. Research on ultra high resolution displays has a target of being able to display images that appear with the same fidelity as reality. Researchers look forward to the day when the resolution and costs drop to the point that entire walls can be "painted" with display technology, to allow them to serve as "windows," work spaces, art work, or entertainment, as the user desires. Introducing three-dimensional viewing and displays that work in 360 degrees, researchers have a goal of eventually creating walls or environments that are indistinguishable from reality.

Realistic imaging technologies are already being used in classrooms, primarily to teach science. The ability to virtually "shrink oneself" can be used to explore things that would otherwise not be visible or manipulable by humans. The ability to zoom out can provide more global perspectives. The ability to carry out virtual chemistry experiments can allow students to conduct the experiments that are most interesting or educational, rather than those that are the safest (from poisoning or explosion) or cheapest (not involving expensive chemicals or elements). Time can also be expanded or compressed as needed to facilitate perception, manipulations or learning.[21]

Hands-Free Operation and Voice Control. There are already hands-free telephones. New phase-array microphones have been developed that can pick up a single person's voice and cancel out surrounding sounds, allowing communication and voice control in noisy environments.[22] There are cameras that can self-adjust to track a user's face, allowing face-to-face communication for those who cannot reach out to adjust cameras.[23] Rudimentary speech recognition is available on a $3 chip,[24] and speech recognition within a limited topic domain is commonly used. IBM has a "superhuman speech recognition project," the goal of which is to create technology that can recognize speech better than humans can.[25]

Speech Output. The cost to build speech output into products has plummeted to the point where speech can be provided on almost anything. All of the common operating systems today have free speech synthesizers built into them or available for them. Hallmark has a series of greeting cards with speech output that, at $3.99, are just 50 cents more than paper, non-electronic cards. Recently a standard cell phone that had been on the market for a year received a software-only upgrade and became a talking cell phone, with not only digitized speech talking menus, but also with text-to-speech capability for short message service (SMS) messages. The phone, with all speech functionality, sold for $29 with a service contract.[26]

Natural Language Processing. The capability of technology to process human speech continues to evolve. Although full, open topic natural language processing is not yet available, natural language processing for constrained topics is being used on the telephone and soon may allow people to talk successfully to products.

Artificial Intelligent Agents. Websites are available that allow users to text chat with a virtual person, who will help them find information on the site.[27] Research on task modeling, artificial intelligence, and natural language are targeted toward creating agents users can interact with, helping them find information, operate controls, etc. Often the subject of science fiction, simple forms of intelligent agents are reaching the point in technology development of becoming a reality in the home.

Microprocessor Controlled User Interfaces. When products are controlled by microprocessor running programs as they are today, they can be programmed to operate in different ways at different times. The use of more powerful processors, with more memory, is resulting in the emergence of new devices that can be controlled in many different ways and can be changed to meet user preferences or needs.

Multi-Modal Communication. There is a rapid diversification taking place in the ways people can communicate. Video conferencing allows simultaneous text, visual, and voice communications. Chat and other text technologies are adding voice and video capabilities. In addition, the technology to cross-translate between modalities is maturing. The ability to have individuals talking on one end and reading on the other is already available using human agents in the network.[28] In the future, the ability to translate between sensory modalities may become common for all users.

Direct Control from the Brain. External electrodes in the form of a band or cap are available today as commercial products for elementary control directly from the brain.[29] Research involving electrode arrays which are both external and embedded in the brain have demonstrated the ability to interface directly with the brain to allow rudimentary control of computers, communicators, manipulators, and environmental controls.

Trend 3: Ability to be Connected Anywhere, Anytime – With Services on Demand

New advances will soon enable people to be connected to communication and information networks no matter where they are. People can leave caretakers and still be a button-press away. Everything in the environment will be connected, most often wirelessly, allowing people to think about communication, control, and “presence” in entirely new ways. Individuals who have trouble with wires and connectors will not need them. Network based services can provide assistance, on demand, to people wherever they are. These advances will create opportunities for whole new categories of assistive technology.

Wireless Electronics – Connected World. There are already wireless headsets, computer networks, music players, and sensors. New technologies, such as ZigBee, will allow for devices that are very small, wirelessly connected, and draw very little power.[30] Light switches, for example, could run off a small ten-year battery and have no wires coming to or from them. People would simply place a light switch on the wall where it was convenient, at a convenient height. Flipping the switch would control the lights as it does now. If someone else needed the light switch in a different place, they would simply move it by pulling it off the wall and replacing it where desired, or placing an additional switch wherever they liked, including on their wheelchair or lap tray.

High speed wireless networks are also evolving, and costs are dropping. No wires will be needed between televisions, video recorders, or anything else (except sometimes the wall, for power). A person in a power wheelchair could have an on-chair controller connected to everything in the house, and yet still be completely mobile.

Virtual Computers. Computers may disappear, and computing power will be available in the network. Wherever a person is, he or she will be able to use whatever display is convenient, e.g., on the wall or in a pocket, to access any information, carry out computing activities, view movies, listen to music, etc. Instead of making each product accessible, things would exist as services and capabilities, which could be accessed through a person's preferred interface.

Control of Everything from Controller of Choice. New universal remote console standards have been developed that would allow products to be controlled from other devices.[31] Products implementing these standards could be controlled from interfaces other than the ones on the product. A thermostat with a touchscreen interface, or a stove with flat buttons, for example, could be controlled from a cell phone via speech, or from a small portable Braille device.

Location Awareness. GPS (Global Positioning System) devices enable people to determine their position when outside, and are already small enough to fit into cell phones and large wristwatches. Other technologies, such as RFID (Radio Frequency Identification) and devices that send signals embedded in the light emitted from overhead light fixtures, are being explored to provide precise location information where GPS does not work.

Object Identification. Tiny chips can be embedded into almost anything to give it a digital signature. RFID chips are now small enough that they are being embedded inside money in Japan.

Assistance on Demand – Anywhere, Anytime. With the ability to be connected everywhere comes the ability to seek assistance at any time. A person who doesn't understand how to operate something can instantly involve a friend, colleague, or professional assistant who can see what he or she is looking at and help work through the problem. Someone who needs mobility assistance could travel independently, yet have someone available at the touch of a button. These assistants could help think something through, see how to get past an obstacle, listen for something, translate something, or provide any other type of assistance, and then "disappear" immediately.

Wearable Technology. Today there are jackets with built-in music players, with speakers and microphones in the collar.[32,33] There are keyboards that fold up, and circuitry that is woven into shirts and other clothing. There are now glasses and shoes with a built-in computer that can detect objects within close proximity through echo location and then send a vibrating warning signal to the wearer. The shoes also will use a GPS System to tell the wearer where they are and which direction they are going.

Implantable Technology. There are cochlear implants to provide hearing. Heart and brain pacemakers are common. Increasing miniaturization will allow all types of circuits to be embedded in humans. In addition, research is continuing not only on biocompatible materials, but also on biological "electronics."

Trend 4: Creation of Virtual Places, Service Providers, Products

Possibly one of the most revolutionary advances in information and communication technologies has been the development of the World Wide Web. Although the Internet had been around for a relatively long time by the 1990s, Web technologies allowed it to be approachable and usable by people in a way not previously possible. It has not only given people new ways of doing things, but has fostered the development of entirely new social, commercial, and educational concepts. It also has allowed for virtual "places" that exist only in cyberspace. This includes virtual environments, virtual stores, virtual community centers, and complete virtual communities. E-travel is allowing people to go places and see things that once were only possible through books or documentaries. Electronic re-creation can allow people to explore real places, as if they were there, and at their own speed. They could wander a famous museum, for example. The Web also provides an array of products and services that is unmatched in physical stores in most localities.

New Opportunities

Advances in information and communication technology will provide a number of new opportunities for improvement in the daily lives of individuals with disabilities, including work, education, travel, entertainment, healthcare, and independent living. There is great potential for more accessible mainstream technology with less effort from industry. There is also great potential for better, cheaper, and more effective versions of existing assistive technology (AT), and entirely new types or classes of AT.

Opportunity 1: More Accessible Mainstream Products (Simpler, More Adaptable, More Mainstream Benefit)

Some of the changes that will result from mainstream product design are evolutionary continuations of current trends. Other changes will be revolutionary, changing the nature of mainstream technologies and their usability by people with different types of disabilities. Some examples:

Potential for more built-in accessibility. Almost everything today, including cell phones, alarm clocks, microwaves, ovens, washers, and thermostats, is being controlled by one or more microcomputers. Even small devices like TV remote controls have a microcontroller inside. Because most everything is and will increasingly be controlled by programs running on increasingly powerful microprocessors, it is now possible to design products that will follow different instructions and behave differently for different users. Many products can already be adjusted to accommodate disabilities. For example, cell phones have a large print setting. Computers can be adjusted to work for people who have tremors. People can now watch television programs with or without captions. The Automated Postal Centers at many post offices offer touchscreen or tactile buttons and voice output. The ability to create a much broader range of products for the home, workplace, or public that can adapt to meet users' needs is continually increasing, and the cost is dropping. For example, speech is no longer a significant cost factor and can be added with little or no hardware costs.

Products that are simpler to use. Although the trend today is toward products that are ever more complex, we are on the cusp of a revolution in human interface. The ability for *unrestricted* voice recognition and natural language processing will come further in the future, and the ability to use these in practical ways in limited domains (e.g., controlling household appliances) is already emerging. When it arrives, the ability to simply tell products what should be done (e.g., “cook this at 450 for an hour,” or “record *Wild Kingdom*,” or “wake me at 8:30”) will be a tremendous advance for individuals with cognitive disabilities or people who, for any reason, are unable to effectively use knobs, buttons, and menus on products. The mass market appeal of such a capability is enough to drive this into the marketplace on its own as soon as it is ready. For individuals who cannot speak, text input or an aid with speech output could be used.

Interoperability: to reduce the need for built-in direct access. Direct access is the ability of a user to operate a product without the need for assistive technology. Building direct access into products is generally the most effective, least stigmatizing, most available, and least expensive method of providing access to people with some types of disabilities. For people with other types of disabilities, particularly those with multiple and severe disabilities, it is sometimes not practical to build direct access into mainstream products. The types of interfaces required, such as dynamic Braille displays, electrodes, sensors mounted on the wheelchair, etc., typically cannot be included as standard parts for mainstream products. For these people, the best approach may be to access mainstream products by controlling them with special AT interfaces via a standard interconnection/control method. This would require these users to have a special AT interface device.

The new and emerging wireless interconnectivity technologies and universal remote console standards discussed earlier will enable people needing a special interface to approach a device, link to it, and operate it from their own interface. This could include most any device in the home, work, or community, from a thermostat to office equipment. Universal remote controllers could include any of the current and future types of AT, including devices with Braille displays, sip and puff controls, natural language interfaces, or some day, even direct-brain interfaces. This type of connectivity in mainstream products also has the mass market application of enabling control of products with voice or intelligent agents.

Flexible “any-modality” communication. The trend toward multi-modal communication (voice, video, chat) all using the same device, can be a boon for individuals with sensory disabilities, especially individuals who are deaf, hard-of-hearing, deaf-blind, or speech-impaired. If “any-modality” communication can be implemented in mainstream technologies with the same ubiquity as captions are on televisions, individuals who are deaf or hard of hearing will be able to use almost any phone. People who are deaf can use text mode. Those who are deaf but can speak can use speech to talk, and then read the display on the phone for text coming back to them. People who are hard of hearing can listen, and have text displayed in parallel, or when they cannot understand. Individuals who sign can use sign language, and individuals with cognitive disabilities can use gestures and visual cues to facilitate communication. If the evolving translation capabilities are added, services in the network can change communication modality as needed. Communicating with someone at a distance may be easier than communicating face-to-face. Building these capabilities into mainstream technologies also may greatly assist in the adoption and use of these modalities by individuals who acquire disabilities as they age, by reducing the stigma that would ordinarily be associated with using *special* technologies.

Where these advances have demonstrable mainstream benefit, adoption will be easier and faster. And, like closed captioning, will gain universal acceptance and consumer demand. Only some accessibility features, however, will have enough mainstream benefit to be introduced and be maintained. For the rest, support and/or incentives must be provided.

Opportunity 2: Better (Cheaper, More Effective) AT and New Types of AT

Technology advances will result in the improvement of current assistive technologies and the introduction of entirely new types of AT. Some of these technologies are realizable today. Some will emerge in the future. But all should be considered when setting policy today – due to the very slow pace at which policy changes as compared to technology.

Cost, size, and power. The rapid advances being made every year in reducing the size and increasing the power of electronic devices is leading to smaller, less expensive, and more intelligent products. This provides for a greater opportunity to create assistive technologies that previously would have been too big or required too much power.

Inexpensive technologies. One concern regarding the use of personal technologies by people with cognitive disabilities is the risk that the products will be lost or stolen. With core functions being implemented as services on the network, and technology costs dropping precipitously, portable devices that could support cuing and other AT functions for those with cognitive disabilities will soon be so inexpensive that they can be easily replaced if lost. To reach these price points, however, the devices will have to be based on common mainstream devices. As speech and natural language-enabled technologies and intelligent agent software improve, mainstream products that could be used in these ways may be possible within the next decade.

Wearable technologies. The trend toward wearable technologies will obviate the need for people with disabilities to carry devices, leaving their hands free for other tasks. This will be particularly helpful for people who use canes, walkers, and service animals, and generally already have at least one hand in use. People who have a cognitive disability that makes it difficult to remember such devices, and who might therefore leave them behind, will also benefit from wearable technologies. Network-based services can further reduce costs by putting the intelligence and memory in the network and allow a new device to pick up where the last one left off, without any need for reprogramming. Very sophisticated communication and health-monitoring technologies can now be worn on the wrist or woven into clothes, making them less likely to be left behind. The trend is toward less expensive products with more functions.

Translating and transforming AT. Information throughout the environment is presented at a wide range of levels of complexity, which can create difficulties for people with cognitive disabilities. As researchers master the ability to create technology that can translate between languages, including translation between more complex and simpler languages, they are developing many of the tools needed to translate between different levels of complexity and vocabularies within the same language. These language translation technologies could be adapted to translate between sign languages and spoken languages.

A potential for new intelligent AT. With rapidly shrinking technologies, it will not be long before it is possible to implant imaging devices into contact lenses, so that even individuals with good vision could have enhanced vision, automated or human-based cuing on demand, text that could be read aloud by looking at it, etc. Such capabilities could be a boon to individuals with language, learning, or cognitive disabilities. Already, there are cameras that will read text when it is photographed, and concept glasses with built-in cameras that perform face recognition of whomever a person looks at. With the use of heuristics with increasing computing power, it is also possible to begin thinking about assistive technologies that would take in a complex display of information (e.g., all of the text visible down the corridor at the shopping mall) and present it to a person in a coherent way.

Human augmentation. In addition to making the world more usable by people with disabilities, advances in technology can also help enhance the overall abilities of people with disabilities to better interact with the world as they encounter it. Cochlear implants have been available for some time, as have prosthetic limbs. Research is progressing on artificial retinas. Advances in electronic imaging, robotics, and computer processing promise advances in all of these areas, enhancing people's basic abilities to access the world as they encounter it.

These new imaging and processing technologies also open the door for providing individuals with new and different ways to mitigate their disability. For example, an artificial eye might be able to provide enough vision for basic mobility, but not enough to read 10-point type. The same artificial eye, however, could have a processor and optical character recognition capability built in that could read any text the person looked at. The text could be read, changed to speech, and transmitted to a tiny earpiece. The person could then see a piece of paper well enough to pick it up, use their residual vision to direct the "reading" of the text, and have the text read into their ear. Using network connectivity, they could also have it translated, enhanced, or explained if needed. Combining technologies that mimic human abilities and provide enhanced super-human function in a single implantable prosthesis raises new opportunities and potentials for restoring function that go beyond the ability to restore natural vision.

Technologies that allow the unimaginable. Individuals are already using direct-brain control for rudimentary communication and manipulation activities. However, this currently requires that the skull be opened up and electrode arrays inserted. In the future, with advanced signal processing, it may be possible to read the signals from outside of the skull. Or, tiny sensors smaller than a blood cell might be injected into the bloodstream. Under computer control, they would be directed to swim to the brain, where they would position themselves, forming a sensor net powered by body processes or radiated power. They would provide a map of brain activity and feed it to an external sensor worn on glasses or earpieces and connect to a network, enabling the user to control the environment, drive a wheelchair, communicate, look up information, etc. No surgery would be required, and a device could fail without disrupting the network.

Opportunity 3: Decrease net cost while increasing quality of life.

Although the cost of technologies is continually decreasing, the cost is not zero. Some assistive technologies may in fact be expensive. The cost for some types of specialized technology could run to $10,000 or more (much more if it needs to be surgically implanted). The cost for failing to make technology accessible to people with disabilities, however, can be even higher. The 2005 average cost of nursing home care, for example, was over $60,000 a year for a semi-private room.[34,35] That leaves quite a margin for technologies that would delay entry into a nursing home by even 6 months or that could allow a person to live in a semi-dependent living situation.

Barriers, Concerns, and Issues

Rapidly advancing technologies provide a host of new opportunities. However, they raise a number of issues and concerns as well. If not addressed, technology advances can pose new barriers to people with disabilities, including loss of access to products they had access to before the advances in technology.

1) Technology Trends That Move Away From Accessible Interfaces Toward Inaccessible Interfaces

Many of the same technological advances that show great promise of improved accessibility also have the potential for making previously accessible products less accessible. The following are some emerging technology trends that are causing accessibility problems.

Increasing complexity of devices and user interfaces. Products continue to have new functions, capabilities and accompanying interface complexity added to them. A recent industry survey showed that the rate at which consumers are returning new products has been increasing, with the “No Defect Found” return rate running 50 percent to as high as 90 percent + (depending on product category).[36] These data are for mainstream customers, but the impact of increasing complexity of products on individuals with cognitive disabilities is even greater. As a result, people with cognitive disabilities, including many seniors with cognitive disabilities, are finding it increasingly difficult to find appliances or products they can operate.

The trend toward digital controls. One problem for people with severe visual disabilities is the use of touch screens, soft keys, and display-based interfaces. Instead of knobs or dials that have a fixed function, the functions of the knobs or buttons may change from one moment to the next. The current function controlled by the button is usually displayed on the screen near the control. The use of scrolling cursors on on-screen menus is increasing. Products are becoming more complex, requiring individuals to think in terms of hierarchical menus. This type of product interface also requires users to operate controls with one hand while they are watching the display, which is difficult for those with certain cognitive disabilities and those without good motor control. In addition, these types of products provide an absolute barrier to individuals who are blind. Many people who are blind, who have used their own home appliances independently, are suddenly losing the ability to use their stove, washer, or dryer, as old models have to be replaced, and the only products now available use digital displays instead of tactile controls.

Devices too small and closed to physically adapt. The move toward miniaturization and device consolidation is leading to devices that are increasingly difficult to handle and operate. For example, where once there were a few very small phones, now most phones are very small and are harder to pick up and operate. Even the remote controls on televisions and audio equipment are getting smaller. Some have buttons that are very close together or have flat, tactilely featureless surfaces. While some people may prefer small products, the problem arises when there is neither an alternate way to operate these products nor alternate versions of the products that can be handled and used more easily.

Closed/Locked systems. Problems also arise from closed systems that do not provide any alternate control mechanism. Increasingly, concern about security and/or digital rights management is resulting in products that are physically closed and have closed software. That is, the products cannot be opened, and no hardware or software can be added to them. E-book readers that do not allow access to the book text (so that it can be read by screen reading software) and that allow publishers to turn off the native text reading capabilities of the e-book readers is one example.[37] AT cannot read the text, and the e-books' built-in reading feature is purposely disabled by the book publisher. The result is that, for those who cannot see or read well enough to read the visual text, access (built-in or AT) is denied. Computers in libraries and other shared use locations are another example of a closed system barrier to access. The personal computer is ordinarily thought of as being open, but it is typically "locked down" in a library so that users are not able to add software, peripherals, etc. Systems that are closed must have built-in accessibility or provide some mechanism for access through an alternate interface. The same problem exists in university computer labs. Information Services departments that do not want any foreign software installed, or hardware attached to machines, because of the risk of virus or security breaches, are yet another common example.

The trend toward automated and self-service devices in public places. The trend toward replacing ticket agents, cashiers, information personnel, and salespersons with less expensive ticketing, vending, cash, and information kiosks will continue as such terminals become more intelligent. In some cases these information-transaction machines operate alongside their human counterparts. In other cases, humans are completely removed from the scene and replaced by such information-transaction machines. For obvious reasons these machines are designed so that users cannot modify them. Automatic, self-service technology must be designed with a wide range of disabilities in mind, or people with disabilities no longer will have access to these ticketing, vending, cash or information services. NCD’s 2006 position paper, *Access to Airline Self-Service Kiosk Systems*, describes the current problems people with vision impairments are experiencing in air travel due to inaccessible self-service ticket kiosks. [38]

The trend away from face-to-face interaction. This trend takes two forms. The first is the replacement of information and support people with automation. Interactive voice response systems (IVRs), Internet help pages that replace product support, and the above-mentioned information and transaction machines are examples of the move away from face-to-face customer service. Such systems are usually designed for individuals who do not have disabilities, and do not accommodate the variations that people with disabilities present. Interactive voice response systems (IVRs), for example, often are not operable in text mode. And if the person who is deaf accesses them through a relay operator, the additional communication delays often cause the IVRs to time out. Inaccessible Web pages can cause a similar problem for individuals who must rely upon technical support available solely through this medium, with no way to contact a human being.

The move away from face-to-face interaction is not occurring solely in information services. Education, commerce, work, and even social interaction are moving to the Web and to computer-mediated telecommunication forms. Universities are offering increasing numbers of educational programs via the Internet. Companies allow or require people to work from their homes or remote offices. Even when people are on the same campus, interactions and some types of work activities may be available only via computers and intranets. Some stores have been closed and moved to the Web. Some stores and businesses exist only on the Web.

The fact that all of these activities are now computer mediated can potentially be a great benefit to individuals who have disabilities. Computer mediation of the information and interactions makes it easier to translate the information into forms that people with sensory or learning disabilities can use. Such systems can also be far more usable by those with mobility impairments. However, if these systems and services are not accessible, many important aspects of society, such as education, work, and activities of daily living, will become inaccessible. Moreover, as things such as technical support and certain products and services become available exclusively via the Internet, they become unavailable to those unable to access those websites.

2) Technology Advancing Into Forms Not Compatible with Assistive Technology

The second major concern is that the incorporation of some new technologies into products is causing the products to advance and change so fast that current accessibility techniques and strategies cannot keep pace. The rapid churn of mainstream technologies is faster than assistive technology development, and even mainstream technologies that are inherently accessible to a particular group can quickly churn out of the marketplace. To complicate the situation further, the convergence of functions is being accompanied by a divergence of implementation. The same functions are being implemented on different products using different technologies and/or standards, and interoperability between AT and mainstream technology exists only in a few areas and is not strong even there. Thus, the gap between the mainstream technology products being introduced and the availability of assistive technologies necessary to make them accessible will be increasing, as will the number of technologies for which no accessibility adaptations are available.

Convergence of function, but divergence of implementation. Much is said about the convergence of technologies, such as the melding of IT and telecommunications functions into a single device. However, a seldom-discussed issue is that the technologies, and standards used to implement them, are diverging. Different industries are creating converged technologies, but each is implementing them in different, and not always compatible, ways. For example, telephony, music, messaging, and television used to be four separate industries, each with its own technologies. Now all four industries are morphing into the others – but using different technologies to do so. Cellular telephones began with voice, and then text messaging was added. The ability to play music and share pictures came next. And now, with phones, users can download and watch television programs or pick up broadcasts.

Instant message software began with text messaging, and then voice was added, using a different technology than in cell phones or in VoIP phones. Video was then added, again using a different standard. New functions continue to be added.

Music players originally played only music, but now, using a variety of formats, they have branched into downloading and playing television programs. Voice communication is soon to follow, although it will probably use existing cell phone standards or perhaps VoIP. Messaging will likely accompany voice communication, using one of the several incompatible text protocols.

Internet Protocol Television (IPTV) began as simply Internet-based television. However, it, too, is rapidly expanding into music and telecommunications. If one is developing technologies on the Internet for broadcasting voice and video, why not also do point-to-point voice and video, or video phone calls? This is currently being developed within the IPTV structure – using yet another, different set of technologies and standards.

Even though what stands out at first glance is the convergence of functions into single devices, a more careful look reveals the divergence. For example, different methods, technologies and standards are being developed for voice communication. The result is an ever-increasing variety of technologies being used for voice, video, text, music, and delivery of television programs. However, few of these interoperate, and often the only common point they have is that the voice call function will work with the PSTN (public switched telephone network). Even within each of these domains there are competing standards. Those forms that are critical for mainstream use (voice, and perhaps video) will interoperate due to market pressures (i.e., any voice networks that are formed will interoperate because hearing people insist on being able to call each other). However, individuals who are deaf do not have the same degree of market clout, and have fewer choices about how they communicate with others. They may even be limited to communications only with others who have the same type of technology, or even the same device. Accessibility provisions designed for one medium (text communication on phones, captions on television) may be different or not extend to the same functions on other technology.

Lack of interoperability. The ability to patch mainstream technology (with modifications or AT) is limited both by the very fast churn rate and the increasingly closed nature of mainstream technology. Two strategies for access should therefore be increasingly relied upon: built-in accessibility and built-in interoperability. If mechanisms that allow the substitution of other interfaces are provided, systems that are otherwise "closed" can still be "open" for accessibility. For example, products with USB connectors that can be used to connect generic USB "human interface devices" (HID) interfaces, such as keyboards and mice, allow users to easily substitute alternative keyboards or mice. Moreover, these USB interface devices work across hardware and operating systems. For anyone who needs more interface modification than this, however, interoperability standards are non-existent, weak, or not supported. Several interoperability standards efforts have been launched but have faded and disappeared. One new interoperability standard is the universal remote console (URC) framework, which has been adopted as a family of ANSI standards (ANSI/INCITS 389-2005 through 393-2005) and is currently being developed as an ISO standard (ISO 24752). The standard allows for the operation of electronic products (even “closed” products) via other devices, which can present an alternate, accessible interface. However, concern by companies over product identity (the interface is what the person sees every day and develops a loyalty to) may hamper the adoption of such "alternative interface" standards in mainstream products.

Delay in accessibility when new technologies are announced. The lack of any systematic accessibility guidelines creates problems whenever any new technology is announced. Guidelines that are technology-specific will not be applicable to new technologies. Some recent examples:

> CAPTCHA – When SPAM first started invading computer systems, CAPTCHAs were developed to help distinguish the software visitors from real visitors. Unfortunately, the initial and most common form was a visual character identification task that inadvertently prevented individuals who are blind from accessing any site that is protected by them. Only much later were alternatives developed.

> DVD Menus – DVDs may contain movies with audio descriptions. However, audible access to the menus must also be provided in order for a user to take advantage of the audio description. Currently, for most DVDs, the user must have vision to be able to select the audio description from the menu.

CITRIX – This was an NT terminal service that allowed people to run software on thin client workstations. Used in the workplace, it lowered costs but provided no access for screen reader users, since all images and text on the screen were bitmapped images.

Cell Phones – These have quickly evolved from simple phones to devices with extensive menu-based functions. However, if people who are blind have no access to the menus, they cannot tell when they are making a free call or roaming at $1 a minute, and are unable to determine the battery charge or signal strength. The phones have had all of the hardware necessary for voice output, but it was not implemented, even as an option, until a complaint was filed with the FCC. The software was then changed in a phone that had already been on the market for over a year and the same phone with talking menus and text-to-speech reading of messages became available for $29.95 if a service plan was also being purchased.[39]

Hearing Aid Compatibility and Cell Phones – When the Hearing Aid Compatibility Act of 1988 was passed, an exception was made for cell phones because they were little used at the time. As digital phones were introduced they created severe interference for hearing aid users. Because of the 1988 exception, industry did not do anything to make these phones compatible during the initial stage of design. Although some research was conducted after consumers filed an FCC petition in 1995 to require hearing aid compatibility, the lack of progress on this issue over the next five years prompted consumers to return to the FCC in 2000 with urgent pleas for corrective action. Progress on compatibility did not begin until 2003, long after the introduction of digital phones, when the FCC approved a schedule by which certain percentages of wireless phones would have to be hearing aid compatible. By this time 88 percent of all wireless telephone subscribers used digital services.

History Repeated. As we move forward, the same pattern is being repeated. New technologies, without accessibility, are being introduced. Only when their use becomes widespread do we require accessibility. However, by then, retrofitting accessibility is more complicated, more expensive (sometimes ***much*** more expensive), and often less effective than if accessibility had been included in the original design and specifications.

The same pattern is being repeated in digital homes, biometrics, e-government, VoIP, digital rights management (DRM) in digital media, Web 2.0, Next Generation Network (NGN), and digital television (beyond captions and audio descriptions).

3) Technology Advancing Into Forms Not Covered by Accessibility Rules

Another barrier is created when a type of product is covered under accessibility laws, but the product or product function evolves into a new technology and accessibility provisions no longer apply or are no longer effective. Some examples of the ways this can happen are:

Technology changing faster than regulations that govern it. Current legislative and regulatory framework is structured around particular types of technology. Rules apply to the built environment, transportation, telecommunications, and information technology. It is now becoming clear that the lines between these technologies are blurring. If two people make a phone call using the phone in their kitchen, and one is connected to the PSTN while the other is connected via the Internet, is it a phone call? High speed broadband Internet services were ruled by the FCC to be information services and generally not covered under telecommunications laws.

Recently, the FCC ruled that interconnected VoIP services (i.e., those that connect to the PSTN), must comply with certain telecommunications regulations, including those requiring emergency call handling and the submission of one's facilities to electronic surveillance. Most of the remaining telecommunications requirements, including those requiring accessibility, however, have not been applied to these new technologies, because the FCC has determined that VoIP is not a telecommunication service. People who switched from their local provider to their cable provider for phone service, using the same phones in their houses, suddenly were no longer covered by the telecommunications accessibility standards and protections. In the future, when people call family or colleagues using IPTV, and share with them video documents while they talk with them, will this be television, telecommunications, or information technology?

If classrooms with built-in tele-collaboration walls allow the class to take place in multiple locations, thus allowing better educational opportunities in rural areas, is this access to a built environment, information technology, or telecommunications?

Currently, there are gaps in our laws that require only certain things in certain environments to be accessible. These gaps will increase as new product types are developed. In addition, the shifting of functions into different technology types, such as phone calls now being made over the Internet and soon to be made using television sets, rather than just using the PSTN, will result in functions once protected by accessibility regulations, that are no longer protected. A model based on function versus technology and a model that is uniform across technologies is needed. For example, instead of regulations that apply only to telephones, access regulations should apply to any technology used for telecommunications.

Access requirements tied to technologies that become obsolete, with no requirements for access to new forms of technology. TTYs and captioning are two primary examples. The purpose of the TTY is to allow individuals who are deaf to communicate in text over phone networks. In IP networks, the TTY often doesn't work, and other IP text standards have been developed. However, without a requirement for text conversation technologies in IP-based voice telephony (VoIP), deaf people may be excluded from this communication modality as the world shifts from PSTN to VoIP. Perpetuation of the technology-specific TTY (Baudot code) will not serve them, because of connection, transport, and other problems. What is needed is a generic requirement for a reliable real-time text conversation capability wherever there is voice. This can then be combined with a requirement to interoperate with legacy PSTN text formats and with text in other interconnected voice and text conversation technologies. This would provide a requirement for the function desired without tying it to past technologies. Similarly, captions are currently encoded within the TV signal. However, that part of the signal would not exist on IPTV or when TV shows are downloaded or streamed from the Internet, so those regulations are ineffective. Restricting captioning requirements to one or a few particular transmission format(s) will result in growing gaps and for some - no coverage.

Funding for old paradigms implemented in new ways. Accessibility challenges can arise when there is a loss of funding for previously covered services as new technologies are utilized. For example, reimbursement for telemedicine can be problematic. Telemedicine holds great potential for individuals with mobility disabilities – particularly in rural areas. However, third party payers are not reimbursing for telemedicine services the same as for in-person medical services.

Another example is artificial personal assistants. As artificial personal assistants become real, effective, and cost-effective, will they be reimbursable? If people can live more independent, less expensive, and more productive lives with occasional tele-coaching or security monitoring, would artificial assistants be covered by private insurers or Medicare and Medicaid? Or would assistance and mentoring services not be reimbursed unless the person moves into a nursing home?

Another constraint can arise when funding for mainstream technologies is used to meet an AT need. If mainstream technologies can be repurposed to meet the needs of a person who has a disability better than purpose-built assistive technologies, will they be reimbursable to the same extent and in the same manner as purpose-built assistive technologies?

Open vs. content-constrained Internet connections. There is currently much debate about whether those who provide Internet connections to a house, or other location, should be able to control the types of information sent to the house, by whom, and at what level of quality connection. What if those who provide the connection are allowed to decide who will be able to provide information to the house (e.g., video and telephony) or are allowed to limit high performance connection to specific suppliers? If, for a given household, the access or performance preference is determined by the Internet provider to be Company A, and a person in that household who has a disability needs products from Company B (because Company B carries the accessible product), the person could be prevented from obtaining the Company B product by the Internet provider’s policy. Similarly, if the person needs to use an alternate technology provided by Company C, he or she may find its performance is degraded, causing accessibility problems or even blocked access. This problem is exacerbated by the fact that individuals may have to use their technologies from multiple locations and not just from their homes. Absent consumer choice, a person with a disability may not be able to call from any house but their own. Unless the Internet operates more like the public road system, where individuals are allowed to take any vehicle that meets safety standards onto the road, rather than having to drive only certain companies' vehicles on certain roads or to certain locations, individuals who must rely on accessible versions of technologies will run into problems.

Digital rights management (DRM). A very interesting sub-area in this discussion is digital rights management. While the need to protect the rights of those who publish things is critical, the ability to allow access for people with disabilities must be addressed as well. If content is to be locked so that it cannot be copied electronically, then some mechanism for rendering it in different forms should be built into the secure digital media players. For example, if a digital book can be presented visually but the text can not be read by the operating system (so that assistive technology such as screen readers could read it aloud), then a mechanism within the book player for enlarging it and reading it aloud should be provided. Technologically, this is not a problem, and voice synthesizers with speed control can be, and have been, built into the e-Book products directly. A marketing policy, however, whereby publishing companies sell the print (visual access) rights for a book to one distributor but the audio (spoken) rights for the book to another, has created an obstacle. Book player companies have been required to support a bit in their players that, when set by a book publisher, will prevent the voice output option in the book player from functioning. Thus, even though the book reader is capable of reading the book to the blind person, it will not perform that function if the book publisher sets the bit that tells the book reader to not read this book aloud. The same book is also protected so that it cannot be read by any other technology.

Interestingly, advances in optical character recognition and imaging technologies may cause a shift in digital rights management. However, if audio access is tied to marketing preferences, then the problem is likely to persist and must be addressed. This will be especially important with the rapidly aging population that has increasing difficulty seeing print media.

Assistive technologies that exceed human abilities. It is well known that although wheelchair users have trouble with stairs and other obstacles, they out-perform people who are walking on smooth surfaces. For example, in the Boston Marathon the women's wheelchair champion (1:43:42) was 20 percent faster than the men's running champion (2:07:14). And people who use power chairs and, sometimes, manual chairs, must travel more slowly when walking with someone who is on foot. We wouldn't think of only funding wheelchairs that went as fast as people walk, but funding limitations have been placed on the purchase of some communication and writing aids that went beyond basic speech or writing capabilities. For example, there have been cases in which a device that only provided speech output was reimbursable, but a general purpose laptop that was cheaper, and that also provided speech output was not reimbursable. How will this be dealt with when we get to human augmentation, artificial vision, etc.? Like the wheelchair, these technologies are likely to be inferior in some respects but superior in others. Will they be considered assistive technology or performance enhancement? In competitions, the answer is clearer, but, as we have seen with the ADA case involving whether a golfer with a mobility impairment could use a golf cart during competitions,[40]still tricky. The broader question will come with the provision of assistive technologies for activities of daily living, education, and work. If the devices restore function up to the level of that of people without disabilities, there would likely be no problem. But what if in providing devices to offset disability, the device gave super-human ability? Would this be covered by rehabilitation programs, government programs or insurance? What if someone with a disability wanted an enhancement in another ability, in order to be more employable? If this could be accomplished via training, would it be covered? Would it be covered if it were augmentation? How is it different? Why is it different? Should it be covered?

4) Definitions of Disability, Assistive Technology, and Universal Design

Rapidly evolving technologies might cause a rethinking of the definitions of disability, assistive technology, and universal design. At a minimum, they may change the way these words are used and how they are interpreted in legislation, regulation, and eligibility policy.

Definition of Disability. If a person is blind and gets an artificial retina/eye, is he or she no longer blind? Does it depend on quality of vision achieved? Would one qualify for training with the new eye if he or she can see fine but doesn't know how to interpret what is seen? Does the person qualify for accommodation? Other services? Can the person drive? Will new eye tests for driving be required? What if the eye fails a year later? Does the person qualify for a new eye? Or does the person have to wait for some period of months or years in a “blind” condition before again being classified as “disabled?”

A person may, in the future, be outfitted with a cybernetic eye, enabling the person to see general shapes for walking, to zoom in with image stabilization to read letters, and to employ OCR to read text. Assuming the person can now pass current eye tests and read any text, is the person blind? Can the person drive? Does the person qualify as blind? If the person qualified for government or insurance funding for the original cybernetic eye, and is now no longer “disabled” will the person qualify for an upgrade or replacement when it fails?

Definition of Assistive Technology (AT). Currently, there are many definitions for “assistive technology.” Some definitions focus on products that are purpose-built for people with disabilities. Other definitions refer to any technologies, including mainstream technologies that are used by a person with a disability to help offset the disability.

The definition is not always important, but may be in the case of deciding whether funding, tax breaks, or accommodations apply. Is an accessible mainstream product considered to be AT for this purpose? Is a feature in a mainstream product that makes things accessible considered to be AT or universal design (UD)? If there were an AT deduction for people who must buy AT to offset their disability, would mainstream technology that is accessible qualify? Some of it? All of it? None of it? If not and it does the same thing as an AT product would – why not?

Universal Design / Accessible Mainstream Technologies. Universal design is usually defined as a process, not as a thing or outcome. Universal design is the process of creating products that are usable by as wide a range of people as is commercially possible.

There is telecommunication legislation that requires products to be accessible when doing so is “readily achievable.” When doing so is not "readily achievable," the legislation requires that products be compatible with assistive technology if that is "readily achievable." So when is something directly accessible vs. accessible via AT?

Cell phones today have features such as ring-tones or special capabilities, such as GPS navigation, that can be selected and activated from a menu on the phone. Sometimes these features are already in the phone. Sometimes they are downloaded into the phone only when selected. Sometimes the user gets the feature for free (if included in the price of the phone and service). Sometimes the user pays for the features. Sometimes the feature is provided by the phone or service provider. Sometimes it is provided by a third party.

Now let’s assume that the feature in question is an accessibility feature.

- If it is in the phone – is it an accessible product (“built-in” accessibility)?

- If it is downloaded – is it built-in or AT?
- If the user can't tell that it is downloaded and it is free – isn’t it “built-in” for all intents and purposes?
- If the user has to pay for it – isn’t it then AT? No matter who provides it? (It is an add-on that must be purchased separately to make the phone accessible.)
- What if other people also have use of it – but have to pay for it? Would people with disabilities also have to pay for it? Is it AT then? Is it just another product that happens to be accessible? Is that true even if it is only a convenience for others but it is the only way that a user with a disability can use the phone?

If these questions are examined carefully, one can see that the same feature on the same product might be considered AT or accessible design depending on who uses it, how they use it, and who has to pay for it.

Why do we Care? Definitions are academic unless they are used to legislate, to regulate, or to fund. Unfortunately, all of the above terms are used in all of these ways (e.g., program eligibility, funding, tax breaks, etc.).

No ready solution presents itself for this problem except perhaps to move away from a model that focuses on types of devices and categorization and toward a model based on function and the role of devices.

Part of the solution may be achieved by defining terms in a way that is specific to the context rather than expecting a “one definition fits all” approach for each concept.

5) Central Role of the Business Case

Finally, there should be a broader recognition of the importance of the “business case.” This report focuses on new technologies and how they can benefit people with disabilities. None of these technologies will benefit anyone unless they are built into products, made available, and supported. And none of that will occur in any reliable or sustained fashion unless individuals within companies can make a business case for each feature.

Net profit is the primary reason products make it to the marketplace and remain on the market, and the primary reason ideas carry forward from one version of a product to other products. This is not specific to disability issues. It is true of every aspect of every product. It is often remarked that the problem is that companies care about nothing but profit– usually with a negative connotation. It is important to note that almost all of the companies involved in information and communication technologies are publicly traded companies, and the "owners who care about nothing but profit" are the public stockholders. Those who own stocks or have pensions usually ask nothing of their stock or pension managers except that they maximize return (profit, pension value, etc.). Environmental and sweatshop issues may sometimes impact shareholders' decisions, but there are no stakeholder directives to companies to "make accessible products" or "do good things for people who have disabilities." Profit, therefore, should be viewed in the same way one views gravity. It is neither good nor bad. It simply is. It is a force, and a very critical force, that drives industry and makes our economy work.

If a goal of our society is to have products that are accessible to and usable by people with disabilities, then some way must be found to make products that exhibit these characteristics generate significantly more net revenue for a company than products that do not. Business cases come from significant market demand or significant, enforced regulation – both of which affect the bottom line or net profit.

In some cases, more accessible and usable products will have a large enough market to generate their own business case. Where the technologies or techniques can be demonstrated to industry and shown to be more profitable than other design options or investments, the features or capabilities will become available through natural market forces. For a large portion of the population with disabilities, however, natural market forces have not and will not result in accessibility features in mainstream products over time.[41] [42]

Regulation is society's way of injecting social value into the business equation.[43] [44] Regulations can make it more profitable to create accessible products by rewarding accessibility with sales. No regulations are effective, however, without enforcement. Without enforcement there is no economic incentive to follow accessibility guidelines. In fact, there is a disincentive because companies that focus on accessibility worry that, while they are spending time and effort on accessibility, their competitors are spending their resources on other activities.[45] Enforcement of accessibility regulations has the effect of leveling the playing field. Companies that invest in accessibility know that their competitors must also be focusing on accessibility. Laws and regulations such as Section 508, when enforced, provide a competitive advantage to those who have more accessible products.

Section 508 has had a decided and positive, if somewhat limited effect on accessibility of electronic and information technology (E&IT) and on the willingness of E&IT companies to work with assistive technology vendors. However, the lack of enforcement of Section 508, the inability of purchasing agents to be able to judge the relative accessibility of the various products in the market, and the lack of any certification of compliance by companies have greatly reduced the potential impact of Section 508. The current voluntary product accessibility template (VPAT) does not provide a reliable way to determine conformance to 508, since purchasing agents cannot tell the difference between a VPAT that has been filled out with carefully considered information, and those that have not. Even when accurate, the VPAT only provides information that “relates” to each provision, but does not certify that the product meets any of the 508 provisions. This is left to the purchasing agents who do not have the time or the training to determine 508 compliance for each product type they procure. As a result, the primary enforcement agent (the purchasing agent) does not have the information necessary to know for certain if a product meets (fully or partially) any of the Section 508 provisions. Some mechanism for providing the purchasing agent with reliable assertions of conformance to the individualism provisions of 508 is needed for the Section 508 to be effective.

Regulations that are subject to strict enforcement and that have significant impact also result in better compliance. Regulations that are not enforced have little or no effect. In the electronic and information technology field, one can watch the efforts and teams in companies grow and shrink regularly in direct proportion to enforcement or perceived or anticipated enforcement.

To have more accessible information and communication technologies, we should provide the means for building a solid business case for those companies and employees who want to have more accessible products. Strong enforcement is one key element for this.

Issues for Action

There are many recommendations that could be made to minimize barriers and maximize opportunities inherent in the technology trends discussed above. Most can be found in other reports on this topic from NCD and others, such as NCD's 2004 report, *Design for Inclusion: Creating a New Marketplace*[46] and *Within Our Reach: Findings and Recommendations of the National Task Force on Technology and Disability*.[47]

Seven key action items are highlighted here.

#1 - Maximize the effectiveness of assistive technologies and lower their cost – in order to maximize people's general abilities and independence. Key strategies: Foster results-oriented R & D all the way to commercial availability.

Advancing technologies provide an opportunity to improve existing assistive technologies and to create entirely new types of AT not previously possible. Where these assistive technologies can restore function and allow individuals to work or live independently, or live more independently longer, the benefits and cost savings both to the individual and to society can be very significant. With a rapidly aging society, improving access to technology is becoming increasingly important. Providing access is shifting from a social issue to an economic issue.

- An inexpensive hand-held text reader could be developed using the same technologies that are rapidly shrinking in cost and size. About the size of a candy bar, the text reader could be held or waved over any text that then would be read to the user in a logical fashion. A pill bottle could be scanned, enabling individuals with low vision to confirm the dosage and check that the medication is for them. Any printed text could be made accessible.
- Advanced GPS combined with RFID tags in the environment could be used by anyone wanting better navigation, even inside buildings. GPS can be found in cell phones that sell for $69 with phone plans. One can envision a cell phone that could be programmed to guide anyone, including those with vision or cognitive disabilities, directly to the door of an office.
- Many individuals who are deaf communicate primarily in sign language, which has syntax quite different from English syntax. As a result, the written text of some deaf people can

have grammatical mistakes much different than those of native English speakers. Grammar-checking software checks for common grammar errors made by people who speak. Development of a tool that will correct the written grammar of individuals who rely on sign language as their primary mode of communication would be a great educational aid, improve their written communication, and open up conversation with non-signing speakers.

- Practical devices to enhance the functioning of a person’s language, learning, and cognitive disabilities have been limited to date. However, the sheer processing power that will soon be available, together with the ability to always be connected, and the shrinking size of devices, may make possible completely new approaches to providing assistance in this area.
- When the FCC asked for comments on its proposal to provide additional spectrum for use by new medical devices, it noted: “Implanted or body-worn devices in the future could enable paralyzed individuals to control artificial limbs by thought, through wireless interfaces between brain, nerve and muscle. The vision-impaired might have some degree of visual ability restored with the help of a microchip placed in the back of the eye. Even today, implanted vagus nerve stimulators that send electric pulses to the brain are being used to treat severe chronic depression. Tremors related to Parkinson's disease are being treated with deep brain stimulation implants. With other new types of implants, such as insulin pumps, physicians could wirelessly retrieve data and then make operating parameter adjustments with greater ease and accuracy than with the more traditional wired connection technologies, and in some cases, changes can be effected immediately by computer control. For health care providers and patients, such wireless implant monitoring technologies have the potential to lower medical costs by extending the time between hospital visits and surgical procedures.”

Funding is needed to explore and develop emerging technologies that can be used to improve assistive technologies for people with disabilities.

Advances in AT make it possible for many more people to access the environment as they encounter it. This is particularly important for those with more severe or multiple disabilities, where creating accessible mainstream technology that addresses their needs is not always possible. Aids that can provide individuals with the ability to see, hear, read, navigate, and control things with their thoughts have all been demonstrated at least on a rudimentary level. Maximizing the abilities of people with disabilities will reduce the barriers encountered in the environment. This is particularly important for people with severe or multiple disabilities since building direct access into products for people with severe or multiple disabilities can often be a challenge.

#2 - Maximize the accessibility of mainstream information and communication technology products, so that people with disabilities and seniors can use standard products as they encounter them. Key strategies: Increase funding for research, proof of concept, and commercial hardening of approaches to accessible design of mainstream products to advance understanding in this area; craft accessibility regulations to help employees build business cases.

Although assistive technologies can enhance the abilities of some people to access and use the environment, the strategy of adapting individual mainstream technologies is limited to those technologies that are within an individual person's control. Even then the rapid rate of technology advancement is moving beyond the ability of AT to keep up in many or most areas. Far and away the most desirable situation would be for everyone to directly access and use mainstream technologies effectively and efficiently. People with disabilities and seniors want to use the same products that everyone else uses. They do not want to be limited to specialized products that are more costly and often, less functional. This isn't always possible, but it is the most economical mechanism for people who have limitations, and for society as a whole. In fact, given the aging population, this is not just a social imperative but an economic one as well. Additional funding is needed for research to develop better strategies for building accessibility into mainstream products and for quantifying when and where built-in accessibility can provide a significant return on investment.

Broad application and enforcement of existing accessibility standards, such as Section 255 of the Telecommunications Act of 1996 and Section 508 of the Rehabilitation Act of 1973, as amended, would result in the widespread adoption of universal design principles into the mainstream technology marketplace. This could be accomplished by lowering the hurdles to filing complaints, carrying out enforcement actions more quickly, and providing expert guidance and examples. The "sufficient techniques" approach discussed below is one way to provide such guidance and examples. One important step would be to move from a declaration to a certification model. That is, rather than companies simply stating what they have done to make their product accessible, without any warranty as to whether it meets the standards, companies would certify which accessibility provisions the product meets and which it does not. Purchasing agents and other customers are currently not able to evaluate whether products meet accessibility standards because different vendors now provide different types of information, using different terminology, to describe features on their products. They also use different standards for "meeting" a provision. As part of the design process, vendors should carefully evaluate their products against accessibility standards, and report which access provisions are met. This would make it much easier for purchasing agents to apply accessibility provisions in the purchasing process. Companies that can accurately evaluate the accessibility of their products should not be forced to use third-party certification services. As in many other areas, companies should be allowed to self-certify, provided they furnish supporting evidence and information sufficient to enable purchasers to know whether a product meets a particular access standard.

Purchasing requirements ("pull" regulations) seem to fit best with the business model. Expanding the use of Section 508-like purchase requirements into markets other than the Federal Government, could have a strong effect on the availability of mainstream products usable by people who have disabilities, including those who are seniors. Expanding beyond just E&IT is also important. Again, rather than mandating that all products manufactured must meet accessibility standards ("push" regulations), a better place to start might be with "pull" regulations, where products that are purchased for use in certain environments, such as for use by state and local governments, public schools, and entities that receive government financial assistance, would be required to meet accessibility regulations. This would motivate companies to add accessibility features to their products in order to better compete in these markets, but yet allows for the sale of products outside of these markets. A tipping effect can occur over time in a more natural fashion. This works better for mass market products where one product is manufactured and sold both to the government and to the public. It does not work as well for services or products that are built individually for different customers. It also does not work as well for products not used by governments, public schools, or by entities receiving government financial assistance. “Push” regulations would be required for markets not reached by "pull" regulations, or when “pull” regulations do not prove to be effective.

#3 - Ensure that access to the Internet and other virtual environments is provided, as it has been to physical places of public accommodation.

Because the Web as we know it did not exist when accessibility laws were written, this important area was not specifically mentioned in accessibility laws. Yet the world is changing rapidly and more and more education, socializing, daily living, commerce and employment are being carried out using network-based services. Some stores already appear exclusively on the Internet. Many specialty shops have disappeared altogether, especially in smaller communities. The only way to secure some types of products or services is over the Internet. Employees work remotely, connecting through the Internet. Colleges teach some courses in this fashion. Many other courses assume or require that students access information or carry out exercises via the Internet.

Since these virtual environments did not exist at the time the original accessibility laws such as the ADA were written, these technologies and environments were not mentioned specifically in the Act. NCD analyzed the issue of the ADA's applicability to the internet in its 2003 publication *Application of the ADA to the Internet and the Worldwide Web,*[48] and concluded that the ADA does apply to the internet.

Courts have not been consistent in their approach to this issue, however, and individuals with disabilities have had to resort to litigation for resolution of the matter. Some companies that have been sued for inaccessible websites argue that since these virtual environments did not exist at the time the original accessibility laws such as the ADA were written, the intent was to cover businesses’ physical facilities only, not their websites. One such suit is pending in the Ninth Circuit.[49] The Internet and other virtual environments that exist, or may evolve, such as intranets and other networks and virtual environments, are becoming central to almost every activity in life and a powerful tool in enabling individuals with disabilities to live productively and independently.

#4 - Address new barriers to the accessibility of digital media caused by digital rights management (DRM), including when visual and audio rights are sold separately.

We are moving toward digital publication of most of our information. This has great potential for increasing the accessibility of information through flexibility of presentation. However, the combination of digital rights management (an important reality), marketing practices, such as selling visual and audio rights separately, and the lack of built-in accessibility is causing severe access barriers. Mechanisms and/or legislative changes are needed to address these new barriers. Opening up media to allow it to be electronically read may introduce piracy issues; thus, requirements for access to be built into players may be necessary. However, allowing individuals who have disabilities to legally and effectively access digital media using their own tools would be more effective for some, especially individuals who are deaf, blind, or deaf and blind, where including access features like a Braille display into every player may not be practical. Working with vendors of mainstream DRM devices to allow access via those special assistive technologies may be a solution. The issue of publishers blocking access by permanently turning off built-in accessibility features (example: “reading aloud” features) on a book-by-book basis must also be addressed.

#5 - Base all policy regarding information and communication technology (ICT) accessibility on a realization of the importance of the business case. Where a solid business case cannot be built based on market forces alone, create accessibility regulations and effective enforcement mechanisms that provide a clear profit advantage to those who comply and a disadvantage to those who do not.

Encourage companies to build access into their products by highlighting instances in which accessible products lead to profit. Where it is not clear that accessibility will lead to profit, however, a different mechanism should be used to enable people within companies who want to make their products more accessible to build a business case for doing so. For features and products lacking a natural business case, society must create regulations and enforcement mechanisms that impact profit and provide profit advantage to those who comply and disadvantage to those who do not. Creating conformance assertion mechanisms to make it clear when and where a product has met individual regulatory provisions will be key to compliance.

#6 - Create accessibility laws and regulations that are not technology specific, but are based on the functions of a device. Provide clear guidance as to what is sufficient to meet the standard, and allow requirements to index themselves to technologies, as they evolve, using baselines. To the extent possible, harmonize laws and regulations with those of other countries for products that are sold internationally.

Regulatory standards should be based on principles rather than technologies or product categories. In the past, different guidelines have been written for different technologies. One set of guidelines was developed for telecommunications, another for ATMs, another for information technologies, etc. Guidelines were also written differently for categories such as "open" and "closed" information systems.

These distinctions are blurring with modern technologies. Given any set of definitions it is possible to identify many products that fall into gray areas. There are also products that perform various functions, leading to a situation where one set of guidelines would apply to one function of a product, and another set would apply to another function.

Guidelines should be function and performance based, as well as technology neutral. Although this has a tendency to make guidelines more abstract, which can make them harder to understand and apply, two concepts that can help address this issue are "baselining" and "sufficiency."

Baselines. Technologies today are advancing so quickly that the standards and regulatory processes cannot keep up. In particular, regulations should be stable over time, yet technologies are constantly changing. The challenge is to create accessibility regulations, which make sense today, and that will work for technology of tomorrow. On the other hand, accessibility standards and regulations cannot be written with only the future in mind. It is not useful to write accessibility standards that will generate products that will be accessible someday, but will not work with the technologies that people with disabilities have today.

By introducing baselines, standards can be indexed to account for technology changes over time. Essentially, baselines are sets of technologies or features that it has been established are compatible with assistive technologies that consumers use. Products must then be accessible using technologies or features in the baseline. Over time, the technologies the users have can change, allowing for a natural progression without the need to rewrite standards. The approach is also more predictable and is function-based rather than based on a particular solution.

Sufficiency. A challenge in using more function-based standards is that they lack specificity. Functional standards allow innovation but can make it harder to determine if the standard has been met unless one is an expert in the area. Another problem is the tremendous variety of technologies. Although the essential requirements for accessibility may remain the same, the actual techniques to implement them can vary widely from technology to technology. What works on a fare machine, may not work on a hand-held device. And what works on a personal workstation where software can be downloaded and installed, may not work on a shared public terminal, which cannot be modified by users.

With sufficiency, guidelines can be written in clear, testable form. Techniques which are "sufficient" at this point in time to meet the guidelines can then be established. As new techniques are created that are sufficient to meet the guidelines, they can be evaluated, documented, and added to the list of "sufficient" techniques without changing the guidelines. In this manner the list of techniques which are "sufficient" and the conditions under which they can be used can be periodically updated to reflect changing times and changing understandings without having to rewrite the fundamentals for accessibility.

Different sets of "sufficient" techniques could be identified for different categories of products. For example, techniques that involve the use of special technologies which might be installed on a product might be considered sufficient for a workstation, but would not be sufficient on a public information terminal where users are not allowed to install their own adaptive software. Using a "product line" approach may be sufficient if users are presented with the entire product line at the time of purchase, but not if they are only presented with a subset of the product line (not including the accessible versions) when they shop, nor would it be sufficient if these models were not included in special deals, or available as part of bundles. The use of "sufficient" techniques would not add or subtract from the guidelines, but can make it very clear to purchasing agents, manufacturers, and others, which techniques do or do not meet the guidelines, without the purchasing agents, manufacturers, and others having to be experts in the field.

The use of baselines and sufficiency can also foster the development of specific technologies, that, once available, can allow much more flexible techniques to be sufficient. For example, if new techniques for Web access are developed and incorporated into assistive technologies that could handle new Web technologies it would no longer be necessary to provide accessible alternatives to content presented using those technologies. That technology could then be added to the baseline. When and where all text phones can handle a new IPText format, (and all TTY text that remains is translated into the new IPText format) then IPText support alone could be sufficient. This approach can also facilitate international harmonization where different levels of AT may exist for different languages or cultures.

If done properly, even the questions of open and closed technologies can be addressed in a way that minimizes gray areas, and when gray areas are encountered, the impact on the consumers of a decision either way would be minimal. That is, in those “gray” cases where it becomes unclear whether A or B situation applies, either one would lead to a reasonable accessibility outcome and could be chosen.

Need for harmonization. Key to the effectiveness of any accessibility standards and regulations in this global economy is harmonization. It is difficult for companies that develop a product for multiple countries to create a single product line that addresses conflicting regulatory standards. The key word here is “conflicting.” Standards can be different and still be harmonized. For example, one standard could ask for noise to be 15 decibels down from the signal and another could ask for it to be 20 decibels down. These two are harmonized, because creating products 20 decibels down would meet both standards. Harmonization does not mean that the standards must be the same, only that they must not conflict. It must be possible to meet all of the standards at the same time. But it is not necessary for all countries to have the exact same standards or regulations. Requiring that all standards or regulations be identical would be unfair to developed countries (holding them back) as well as developing countries (forcing them to adopt standards they might not be able to meet). However, it should be possible to design products that are marketed and sold in identical form internationally in a way that would fall within the accessibility standards or regulations for all of the countries, with only reasonable localization issues. It will be advantageous to all if agencies setting accessibility policy draw on each other and use similar language or criteria. In the area of interoperability, however, a higher level of compatibility is required. Interoperability standards must do more than “not conflict,” they must also work with each other and allow international interoperability, especially in the communication technologies.

#7 - Ensure that up-to-date information about accessible mainstream technology (AMT) and assistive technology (AT) is available to and being used by the public.

Although most of this report is focused on advances in science and technology and how these advances will make possible the creation of new tools, as well as the need to create these new tools, it is important to remember that current technology is underutilized. This underutilization applies to accessible mainstream technologies and assistive technologies. In some cases this is because the tools are large, costly, or not very effective. Research and development should address these issues.

In other cases the stigma of using these technologies prevents people from using them. The incorporation of these features into mainstream technologies and the creation of better, smaller, less obtrusive technologies will help address these barriers to utilization.

In some cases, underutilization is due to the cost of the products. The creation of newer, less expensive technologies will help to address this issue. Some people with disabilities have no funding source for assistive technologies. Certain technologies might always cost more than most people can afford. In this case there is a need to look beyond the technology to social funding mechanisms. Is accessible technology something that society should provide to people with disabilities in order to improve quality of life? Is it something that society should provide in order to decrease cost to society?

Many times, however, people don't use AT simply because they don't know that such things exist. Currently, most assistive technologies are purchased by people with disabilities or their families. Some do not buy AT because of cost, but a very large number simply do not know that there are technologies that could help them. They are not aware of the features that are already in products they are using that would make the products easier to use. They are not aware of features in products in the marketplace that would enable them to use mainstream products. Retail sales personnel, marketers, and advertisers are usually unaware of accessible features in mainstream products. Assistive technologies exist that would enable certain people with disabilities to garden, cook, write, read, or work, but most people do not know about these products. Information about the products may be on the Internet, and the products may not be hard to find, but most people don't look for them because they do not know they exist. Public service announcements and other mechanisms are needed to inform the public that:

1. Assistive technologies and accessible mainstream technologies exist;
2. AT and AMT can enhance abilities in school, employment and independent living;
3. For seniors, AT and AMT can make life easier, allow people to do more things (or resume doing them), and allow them to live at home longer with less dependence on family members;
4. Many people use AT and AMT;
5. A growing number of assistive technologies can be used fashionably; and
6. There are many places to look for AT and AMT.

If this information is common knowledge among people who have disabilities, their families, friends, caregivers, and medical and health professionals, the use of existing technology and the market for future technology will increase. The natural pressure for products that are more accessible and include built-in accessibility features will also significantly increase.

It should be noted that some types of assistive technology require assistance in selection and fitting by trained health personnel. At present, there is a shortage of individuals who are trained in the effective selection and fitting, and training in the use of, assistive technologies, primarily due to lack of funding. This should be addressed with third party payers, beginning with public payers such as Medicare and Medicaid. Services for which there is reimbursement, and long term market stability, will naturally lead to incorporation of these subject matters in medical and health service programs. This will, in turn, lead to more knowledgeable health service professionals.

Closing

Science and technology are moving forward, rapidly opening up new opportunities and posing new challenges. In many cases, they will redefine both the problem being addressed and the fundamental tools to address them. Current solution strategies may no longer work and the current way of classifying things and defining terms may, in fact, need to be reexamined. Since public policy often moves much more slowly, it is very important that, as new policies are created, including accessibility standards and regulations, they are based on functional specifications instead of being technology-specific. We should also move aggressively to capitalize on the new opportunities that science and technology are creating. This is important not only because of the benefit for people with disabilities, but also because of the potential to increase the market for technology products. Where this can be done in a profitable way, the private sector can be depended upon to do this. Studies are needed to identify and quantify those areas that are profitable and get this information to industry where it is not already active. For other important areas, there must be clear and enforced accessibility policy. This policy should encourage all to create accessible products (push), and reward those who practice accessible design (pull) by providing them with a level playing field or commercial advantage. Technology is not the answer to disabling conditions, but it is a powerful, underutilized tool for increasing independence and reducing costs. And, its potential to be a benefit, or to be a barrier, is steadily increasing.

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[37] As we go to press, the U.S. Copyright Office has issued new rules that authorize the breaking of locks on electronic books so that blind people can use them with software and hardware that will read the books aloud. This does not address the problem of book readers that are capable of reading specific books aloud, but are disabled because of a publisher setting a "do not read aloud" flag for the book. It would however allow the encryption to be broken so that a person who is blind could use his or her own software to read the book aloud. The new rules expire in three years.

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[39] LG VX4500 from Verizon Wireless offers latest in voice command and text-to-speech features. (2004). Retrieved October 24, 2006 from http://news.vzw.com/news/2004/11/pr2004-11-29.html.

[40] In Martin v. PGA Tour, Inc., 204 F.3d 994 (9th Cir. 2000), the Ninth Circuit Court of Appeals held that the Americans with Disabilities Act (ADA), 42 U.S.C. (sec)12101 et seq., permits a golfer with a disability to use a golf cart during a tournament.

[41] Trace R&D Center. (2000). Universal design research project final report: Understanding and increasing the adoption of universal design in product design. University of Wisconsin-Madison: Trace R&D Center.

[42] Peltz Strauss, K. (2006). A new civil right : telecommunications equality for deaf and hard of hearing Americans. Washington, D.C.: Gallaudet University Press.

[43] Vanderheiden, G. C. (2003). Access to voice-over-internet protocol (“VoIP”). Washington, D.C.: New Millennium Research Council. Vanderheiden Digital millennium paper.

[44] Vanderheiden, G. C. (2003). Transcript of comments at the FCC's VoIP forum on December 1, 2003. Retrieved October 25, 2006 from http://trace.wisc.edu/docs/2003-12-1-FCC-VoIP-Forum/transcript.htm

[45] Vanderheiden, G., & Tobias, J. (1998). Barriers, incentives and facilitators for adoption of universal design practices by consumer product manufacturers. Proceedings of the Human Factors and Ergonomics Society, 1, 584-588.

[46] http://www.ncd.gov/newsroom/publications/2004/publications.html

[47] National Task Force on Technology and Disability, supra note 1.

[48] http://www.ncd.gov/newsroom/publications/2003/adainternet.htm

[49] *National Federation of the Blind v. Target Corp*, 452 F. Supp.2d 946 (N.D. Cal. 2006).