Design for Inclusion: Creating a New Marketplace

National Council on Disability

October 28, 2004

National Council on Disability
1331 F Street, NW, Suite 850
Washington, DC 20004

Design for Inclusion: Creating a New Marketplace

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NATIONAL COUNCIL ON DISABILITY

An independent federal agency working with the President and Congress to increase the inclusion, independence, and empowerment of all Americans with disabilities.

October 28, 2004

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

On behalf of the National Council on Disability (NCD), I am submitting a report entitled, *Design for Inclusion: Creating a New Marketplace.* This report aims to educate designers and manufacturers about the way electronic and information technology (E&IT) intersects with the needs of individuals with disabilities, and how designing with access in mind can significantly increase the size of targeted markets for E&IT.

Designing with access in mind can be accomplished through Universal design. Universal design is a process to ensure that electronic and information technology is inclusive, accessible, and usable by everyone, including people with disabilities. Incorporating universal design processes when developing E&IT is one solution to accommodating people with disabilities that also improves the usability of the products for the rest of the population. NCD's research attempts to understand the market for universally designed mainstream consumer products and services, document successful universal design development processes, understand consumer needs, understand universal design facilitators and barriers, and identify and address current issues in universal design.

This research falls at a time when understanding and incorporating universal design into the development process are most crucial. We are in the window of opportunity for implementing Section 508 of the Rehabilitation Act of 1973 (as amended). Section 508 requires the Federal Government to purchase accessibly designed E&IT. If progress is not made quickly in improving the skills of government and industry employees on accessibility issues, the window will soon shut with little having been accomplished.

Progress must be made now, and the purpose of this report is to present the information and recommendations that will guide this progress.

Sincerely,

Lex Frieden

Lex Frieden
Chairperson

(The same letter of transmittal was sent to the President Pro Tempore of the U.S. Senate and the Speaker of the U.S. House of Representatives.)

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Dedication

This National Council on Disability report is dedicated to Ronald Mace, "a nationally and internationally recognized architect, product designer, and educator whose design philosophy challenged convention and provided a design foundation for a more usable world. He coined the term 'universal design' to describe the concept of designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life" (Center for Universal Design).

Acknowledgments

The National Council on Disability (NCD) wishes to express its appreciation to W. Bradley Fain of Georgia Tech Research Institute (GTRI), who was the principal investigator for this project. Researchers in GTRI's Electronic Systems Laboratory performed the work documented in this report. NCD acknowledges the contributions of Steve Jacobs of the Ideal Group, who performed the market definition and research for this report. NCD also acknowledges the participation of the industry partners that supported the industry study portion of this research. The industry partners provided invaluable insight into the impact of section 508 on business and the barriers and facilitators relating to the adoption of universal design principles. NCD also acknowledges the donation of equipment and services utilized during the user study portion of the research. The following companies provided products and services, at no cost to the project, for user testing: HP, Nokia, and SENCORE Electronic Test Equipment.

NCD would also like to acknowledge the efforts of Gerry Field, WGBH Boston, for providing the closed-captioned test stream used in user testing.

Contents

List of Tables

Executive Summary

Designing with access in mind can significantly increase the size of targeted markets for electronic and information technology (E&IT). Good business practice dictates that designers and engineers avoid *unintentionally* excluding large populations of consumers from accessing and using the E&IT they develop and manufacture. People with disabilities are at the highest risk of exclusion. Other consumer groups are also at risk. They are—

- Individuals 65+ years old
- Consumers living in low-bandwidth information infrastructures
- People who never learned to read
- Users of English as a Second Language (ESL)
- Tourists and people living in multilingual societies
- Consumers living in high-density populations

Designing with access in mind can be accomplished through universal design (UD). Universal design is a process to ensure that E&IT is inclusive, accessible, and usable by everyone, including people with disabilities. Accessible design is a step forward when developing E&IT products, but it tends to lead to technologies that will be used separately, or in addition to, the main E&IT product, which diminishes the effectiveness of designing for all. Incorporating UD processes when developing E&IT is one solution to accommodating people with disabilities that also improves the usability of the products for the rest of the population.

The National Council on Disability (NCD) undertook this research to understand the market for universally designed mainstream consumer products and services, document successful UD development processes, understand consumer needs, understand UD facilitators and barriers, and identify and address current issues in universal design. This research comes at a time when understanding and incorporating UD into the development process are most crucial. We are in the window of opportunity for implementing section 508. If progress is not made quickly in improving

the skills of government and industry employees on accessibility issues, the window will soon shut with little having been accomplished. If industry does not see that federal agencies are serious about implementing section 508 in a consistent manner, companies will shift the monetary and human resources needed for improving accessibility to product development opportunities that offer a higher return on investment. Progress must be made now, and the purpose of this report is to present the information and recommendations that will guide this progress.

Through this research, NCD aims to educate designers and manufacturers about how electronic and information technology intersects with the needs of individuals with disabilities. In addition to providing knowledge about disabilities, we see the importance here and now of educating individuals on universal design. Currently, many business people have never heard of UD, and many of those who have do not understand that it is more than just a design for disability. This research aims to provide businesses with the knowledge of UD methods they need to clearly see how their complex products can be made accessible in a cost-effective way.

As part of this research, six product lines were analyzed from the telecommunications, software, consumer electronics, and digital services industries for both accessibility and usability. We estimated how useful these products are to people with disabilities and whether the products conformed to section 508 standards and section 255 guidelines. We were able to present recommendations for improving such products. At a time when the incorporation of universal design is crucial, NCD hopes that the information provided in this report will motivate and drive the development of more universally, accessibly designed E&IT.

Important Findings and Recommendations

User Study. The purpose of the user study was to document and understand user experiences with the six product lines under study. The experiences and thoughts of the consumer with a disability provided important insight into the future design of accessible products and can potentially influence the universal design process. The key findings of the user study are as follows:

- Users with disabilities are often asked to pay high prices for phones with feature sets that are not useful to them.
- Rapid changes in technology often cause decreases in accessibility.
- Users are reluctant to adopt technologies that have proven frustrating in the past.
- Users have difficulty finding devices that match their functional capabilities because of the lack of familiarity sales associates have with accessibility features.
- Users are reluctant to invest in technologies that have an unproven accessibility record.
- Accessibility solutions must consider the needs of the individual with disabilities.

Substantial increases in accessibility will be required before increased sales to members of the disability community are realized.

Product Analysis. A detailed product line analysis was conducted for each of the product lines selected for study. The purpose of this research was to document accessibility issues that prevent people with disabilities from fully accessing the selected products and to document accessibility features that either are currently offered or could be offered by manufacturers. The end result of this product analysis was the assignment of an accessibility grade to each product line for each disability group. These grades may be useful to designers and manufacturers to identify the target populations that should be consulted during the design process so that more accessible design features are incorporated into new products.

Industry Study. The purpose of the industry study was to document UD practices within industries represented by the six product lines selected for study. Five categories of facilitators and barriers to accessible design were examined: design, organizational, informational, financial, and legal. A discussion of these barriers and facilitators as experienced by the six companies is included in this section.

In addition, 11 business concerns were identified as having an influence on UD practices within an organization. Each business concern had a different level of influence, depending on the

strength of the other factors. The factors influencing the adoption of UD practices included the business case, strategy and policy, demand and legislation, marketing and sales, research, design, testing, resource allocation and funding, organization and staff, training, and the customer and consideration of people with disabilities.

All the companies that participated in the industry study have made strategic decisions to address the accessibility of their products and services. A few of the companies had long-standing accessibility programs that were reinvigorated by the technical requirements of section 508. Other companies initiated their accessibility activities while planning for their response to section 508. In both cases, section 508 clearly has had an impact on the way accessibility and UD are being addressed by industry. The industry study found that the most common approaches to addressing accessibility issues are—

- Increasing awareness of employees
- Integrating accessibility requirements into the design process
- Performing accessibility verification testing
- Establishing an accessibility program office

Discussion. Through this research, we have come to better understand the market for universally designed mainstream consumer products and services, documented successful universal design development processes, achieved a better understanding of consumer needs, analyzed UD facilitators and barriers, and identified and addressed current issues in universal design. This research program has found that—

- A market for universally designed products and services exists.
- UD principles can be easily incorporated into current design practices.
- Products designed to be accessible sometimes do not meet the needs of users.
- Legislation is currently both a facilitator and a barrier to UD.

- Many barriers to UD remain and must be addressed before significant progress can be made.

Several important recommendations can be made from this research for designers, developers, federal agencies, and companies striving to incorporate universal design into their development process:

Strategies for Government and Industry to Promote Universal Design

Recommendation #1. Use standards (government or industry) to prohibit nonessential features that pose accessibility problems unless an alternative interface that solves the problem is provided.

Recommendation #2. Use standards (government or industry) to eliminate interoperability problems that create accessibility problems.

Recommendation #3. Use market forces to regulate features that pose intermediate levels of accessibility problems. Require labeling and other information to be provided, and allow recourse through tort (warranty) as well as through general demand, as reflected in consumer purchases.

Recommendation #4. Develop training materials and educational articles documenting the market potential for UD products and services.

Strengthening the Impact of Section 508

Section 508 was developed to govern the purchase of accessible electronic and information technology purchased by the Federal government. Despite having been in place for nearly three years, section 508 has yet to reach its potential. One of the greatest shortfalls of Section 508 is the lack of understanding of and attention to the functional performance requirements.

Recommendation #5. Institute procedures designed to ensure that due diligence is given to section 508 procurement requirements. Perform an internal analysis of the impact of section 508 on the procurement of actual products. Publish the results of

the analysis as a way of convincing industry that the Federal Government is committed to section 508.

Recommendation #6. Consider requesting supporting evidence for claims made on voluntary product accessibility templates (VPATs) from all vendors responding to bid proposals.

Recommendation #7. Develop a quick accessibility checklist for specific product lines likely to be procured by the Federal Government. The quick accessibility checklist would assist procurement officials in market research by providing them with a list of items that they can inspect themselves when procuring products. The checklist would be tailored to specific product lines and would not require detailed expertise to evaluate.

Recommendation #8. Develop guidance for reporting conformance with functional performance criteria guidelines.

Recommendation #9. Support the coordination of state and local government adoption of section 508 technical requirements. Provide state and local governments with documents and training programs designed to ensure unification of technical requirements.

Recommendation #10. Study and document the nontechnical aspects of accessibility, including social, psychological, and organizational accessibility. Promote UD solutions that consider all aspects of accessibility.

Promoting the Inclusion of Universal Design in Industry Practices

Companies are not aware of the design process modifications needed to incorporate universal design principles. The Federal Government should support the refinement of specific design process interventions that can easily be incorporated.

Recommendation #11. Develop, test, and disseminate methodologies for integrating UD into existing design practices.

Recommendation #12. Support the development of university-level training materials that could be incorporated into the curriculums of existing design-oriented degree programs. The training materials should include awareness-expanding videos and other teaching resources that illustrate the potential impact of key design process interventions on the lives of people with disabilities and other beneficiaries of UD.

Recommendation #13. Develop, test, and disseminate design reference users to illustrate the range of functional capabilities and limitations typical among people with disabilities. Design reference users (popular in specifying the target population in Department of Defense acquisitions) is a set of descriptions of prototypical users who, taken together, express the range of functional capabilities and limitations of the population that must be accommodated by the design project. The use of design reference users would greatly simplify the need for designers to research and integrate information pertaining to the functional limitations and capabilities of people with disabilities.

Recommendation #14. Develop a standard methodology for testing accessibility and comparing the accessibility of similar products.

Recommendation #15. Coordinate with industry to promote the integration of accessibility concepts, principles, and guidelines into the development tools used by designers to develop products.

Creating a New Marketplace

Consumers with disabilities find many E&IT products to be inaccessible. A sizeable un-tapped market for universal design products and services exists. However, few companies appreciate the size of the market or know how to tap its potential.

> **Recommendation #16.** Develop an information clearinghouse where users can obtain information about accessibility issues and the features designed to address the issues for specific product lines. Educate consumers on how to shop for UD products and services. List vendor resources where consumers can obtain more information about UD products.
>
> **Recommendation #17.** Develop marketing strategies and approaches that will facilitate a connection with people with disabilities.
>
> **Recommendation #18.** Train people with disabilities to become subject-matter experts for the purpose of participating in design focus groups and accessibility evaluations.
>
> **Recommendation #19.** Create job-related outcomes for bulk purchasers for the successful procurement of products and services with UD features.

Conclusions

People with disabilities want to use the same products that everyone else uses. They do not want to be limited to specialized products that are more costly. Implementation of UD is the best way to satisfy this desire of people with disabilities, while also providing more cost-effective products for all users. While it is impossible to satisfy the needs of all users, products and services that come closer to accommodating a variety of physical and cognitive differences will benefit both users and companies.

I. Introduction

The explosive development of information technology is rapidly changing the way we work, shop, communicate, and play. In the 19th and early 20th centuries, our grandparents saw America change from an agrarian society to an industrial one. We are now in the middle of a second transformation, from an industrial society to an information society, sparked by the development of information science, microprocessors, and wireless technology. Information technology and telecommunications are now relied upon for routine daily activities that contribute to overall quality of life, such as making doctor's appointments, obtaining directions, and purchasing goods and services. Companies are increasingly expanding their presence into emerging markets. As the National Council on Disability (NCD) points out, "Companies are serving populations they have never before served" (NCD, 2002).

Every consumer is different. No two people have the exact same set of learning styles, abilities, experiences, and educational background. What used to be one market of billions of consumers is evolving into billions of markets of one consumer, as computer technology makes it economical for products to be customized to meet the user's needs. This marketing shift is a dramatic change from a few short years ago. To remain competitive, companies must learn to develop products that accommodate the wants, needs, and preferences of as many individual consumers as is *technically possible* and *economically feasible*.

Designing with access in mind can significantly increase the size of targeted markets for electronic and information technology (E&IT). Good business practice dictates that designers and engineers avoid *unintentionally* excluding large populations of consumers from accessing and using the E&IT they develop and manufacture. People with disabilities are at a high risk of exclusion. Other consumer groups are also at risk. They are—

- Individuals 65+ years old
- Consumers living in low-bandwidth information infrastructures
- People who never learned to read

- Users of English as a Second Language (ESL)
- Tourists and people living in multilingual societies
- Consumers living in high-density populations

Universal design (UD) has been proposed as a means to meet needs of consumers, including those with special needs, while maximizing a company's potential to develop a marketable, easy-to-use product. The purpose of this research program is to understand the market for universally designed mainstream consumer products and services, document successful UD development processes, understand consumer needs, understand UD facilitators and barriers, and identify and address current issues in universal design.

The future of design for inclusion is in jeopardy. We are in the window of opportunity for implementing section 508. If progress is not made quickly in improving the skills of government and industry employees on accessibility issues, the window will soon shut with little having been accomplished. If industry does not see that federal agencies are serious about implementing section 508 in a consistent manner, companies will shift the monetary and human resources needed for improving accessibility to product development opportunities that offer a higher return on investment. Progress must be made now, and the purpose of this report is to present the information and recommendations that will guide this progress.

Through this research, NCD aims to educate designers and manufacturers about how electronic and information technology intersects with the needs of individuals with disabilities. In addition to providing knowledge about disabilities, we see the importance here and now of educating individuals on universal design. Currently, many people business people have never heard of UD, and many of those who have do not understand that it is more than just a design for disability. This research aims to provide businesses with the knowledge of UD methods they need to clearly see how their complex products can be made accessible in a cost-effective way.

This study examined the philosophical, economic, and technological rationales that currently drive the development of UD and identified specific barriers to increased implementation, while also addressing commonly held assumptions about universal design. Six product lines were analyzed from the telecommunications, software, consumer electronics, and digital services industries for both accessibility and usability. We estimated how useful these products are to individuals with disabilities and whether the products conform to section 508 requirements and section 255 guidelines. In doing so, we were able to present recommendations for improving such products. This report aims to aid industry in adopting UD practices by using the information obtained on current industry practices, barriers, and facilitation factors to investigate methods for motivating companies to incorporate UD methods in product development.

At a time when the incorporation of universal design is crucial, NCD hopes that the information provided in this report will motivate and drive the design for more universally designed E&IT.

Definition of Universal Design

Universal design, or design for inclusion, is a process to ensure that E&IT is inclusive, accessible, and usable by everyone, including people with disabilities. Accessible design is a step forward when developing E&IT products, but it tends to lead to technologies that will be used separately, or in addition to, the main E&IT product, which diminishes the effectiveness of designing for all. Incorporating UD processes when developing E&IT is one solution to accommodating people with disabilities that also improves the usability of the products for the rest of the population.

The above definition encapsulates what it means to design with universal access in mind. UD has been referred to as many things and has been defined in many ways and with many perspectives. Despite the differences in interpretation and definition, one thread that ties the perspectives together is that all people, young and old, with and without disabilities, can have access to the same opportunities. Some alternative terms that have been used to refer to UD are *inclusive design, design for inclusion, lifespan design, transgenerational design, barrier-free design,*

design-for-all, and *accessibility*. The first four terms have their roots in accomplishing social inclusion, the next two have their roots in design of the built environment, and the last is linked to legislated requirements for accommodation (Ostroff, 2001).

The term *universal design* was originally coined in the 1970s by Ronald Mace.

> Ron Mace was a nationally and internationally recognized architect, product designer, and educator whose design philosophy challenged convention and provided a design foundation for a more usable world. He coined the term "universal design" to describe the concept of designing all products and the built environment to be aesthetic and usable to the greatest extent possible by everyone, regardless of their age, ability, or status in life (Center for Universal Design, n.d.).

Other characteristics of UD are summarized, in part, from interviews with visionaries regarding accessibility and UD (Fain et al., 2001). The visionaries talked about including a wide range of individuals in all stages of the design process; integrating accessible features so they don't stand out (resulting in social integration); and creating things so that they can be made available "out of the box," enabling as many people as possible to use them. It is considered a design methodology and an extension of the user-centered design process. Additional variations include the following:

> …[T]he practice of designing products or environments that can be effectively and efficiently used by people with a wide range of abilities operating in a wide range of situations (Vanderheiden, 1997, p. 2014).

> …[B]uilding products that are robust and accommodating. Universal designs take account of differences in sight, hearing, mobility, speech, and cognition. Universal design helps not only people with disabilities, but also any of us when we're tired, busy, or juggling many tasks (Francik, 1996).

> …[T]he design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. The intent of universal design is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. Universal design benefits people of all ages and abilities (Center for Universal Design, n.d.).

A much greater awareness of disabilities has evolved in the last century, in part as a result of a significant increase in the human lifespan. The general population has had greater exposure to human limitation as the people around them have aged and developed limitations, while at the same time living outside institutions and becoming more independent. This exposure has increased awareness of limitations that can impede the average individual and has led to design changes in products to help overcome these limitations. Initially, these design changes were implemented as special features that added to the cost and stood out as features for people with special needs. Over time, designers began to recognize that many design changes could be made on a larger scale, reducing the cost and benefiting a larger portion of the population (Center for Universal Design, n.d.). Research led to the formulation of design principles that describe the objectives of UD.

In 1997, North Carolina State University's Center for Universal Design documented and published seven Principles of Universal Design (1997):

- Equitable Use: The design is useful and marketable to people with diverse abilities.
- Flexibility in Use: The design accommodates a wide range of individual preferences and abilities.
- Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
- Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
- Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.
- Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue.

- Size and Space for Approach and Use: Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility.

These principles serve as guidelines for the designers of accessible products. If these principles are incorporated into and considered during the design process, the result will be products that are accessible to a wide range of users. In addition to principles such as the ones mentioned above, standards have been and will continue to be developed that serve as guidelines for designers and manufacturers. These standards mandate that products, services, or places are accessible to particular groups of people and provide requirements that must be met. Universal designers must incorporate these principles and standards and use them for guidance when developing products and services to be accessible to the wide population.

The definition of UD must address the population it is intended to benefit. Consideration must be given to various disability groups—blind, low vision, deaf, limited hearing, limited manual dexterity, limited cognition, and lack of reading ability—keeping in mind that these limitations may result from situational constraints rather than a formally defined disability, as defined below:

> OPERABLE WITHOUT VISION = is required by people who are ***blind*** – and – people whose ***eyes are busy*** (e.g., driving your car or phone browsing) or who are ***in darkness.***
>
> OPERABLE WITH LOW VISION = is required by people with ***visual impairment*** – and – people using a ***small display*** or in a ***smoky environment.***
>
> OPERABLE WITH NO HEARING = is required by people who are ***deaf*** – and – by people in ***very loud environments*** or whose ***ears are busy*** or are in ***forced silence*** (library or meeting).

OPERABLE WITH LIMITED HEARING = is required by people who are ***hard of hearing*** – and – people in noisy ***environments.***

OPERABLE WITH LIMITED MANUAL DEXTERITY = is required by people with a ***physical disability*** – and – people in a ***space suit*** or ***chemical suit*** or who are in a ***bouncing vehicle.***

OPERABLE WITH LIMITED COGNITION = is required by people with a ***cognitive disability*** – and – people who are ***distracted*** or ***panicked*** or under the ***influence of alcohol.***

OPERABLE WITHOUT READING = is required by people with a ***cognitive disability*** – and – people who just ***haven't learned to read this language***, people who are visitors, people who left reading glasses behind (Vanderheiden, n.d.).

While there is no strong basis for characterizing UD and discriminating UD products from non-UD products, a few sets of evaluation criteria have been identified. The Center for Universal Design has developed two versions of Universal Design Performance Measures. The consumer version helps guide personal purchasing decisions. The designer's version "…provides a good relative assessment of universal usability, but the measures are not an absolute tool for achieving universal design" (Story, 2001). These measures consider questions for phase of use of commercial products: packaging, instructions, product installation, use, storage, maintenance, repair, and disposal. In addition, Vanderheiden (2001) has identified three levels for evaluating products. Level 1 is assigned for features that, if not implemented, will cause a product to be unusable for certain groups or situations. Level 2 is assigned for features that, if not implemented, will make the product very difficult to use for some groups and situations. Level 3 is assigned for features that, if implemented, will make the product easier to use but do not make it usable or unusable.

Now that UD definitions, principles, and evaluation techniques have been discussed, the question becomes, "What is the reality of UD?" In other words, "Is UD achievable?" The answer to this question depends, in part, on how UD is defined. On the one hand, there is Ronald Mace's definition, which indicates that people from all walks of life should have the same opportunities. At some level, this is achievable. Consider the curb cut. Curb cuts came about because of the Americans with Disabilities Act (ADA), but it turns out that they are beneficial to all of society: people pushing baby strollers or using roller blades, for example. The curb cut is most definitely considered to have achieved UD. On the other hand, one viewpoint of UD suggests the ideal that designs should be usable by individuals under every circumstance. While it's true that many things are usable by a range of individuals, not all of those things are designed in an ideal manner for those same individuals. It is not possible to account for every variation in human ability, need, and preference. As stated by Story, Mueller, and Mace (1998),

> It is possible to design a product or an environment to suit a broad range of users, including children, older adults, people with disabilities, people of atypical size or shape, people who are ill or injured, and people inconvenienced by circumstance. [Yet,] it is unlikely that any product or environment could ever be used by everyone under all conditions. Because of this, it may be more appropriate to consider universal design a process, rather than an achievement.

Role of Assistive Technology in Universal Design

According to the U.S. Assistive Technology Act of 1998,

> The term assistive technology means technology designed to be utilized in an assistive technology device or assistive technology service. The term assistive technology device means any item, piece of equipment, or system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities (Assistive Technology Act, 1998).

People with disabilities are commonly aided by the use of assistive technology (AT). Users with visual impairments may benefit from the use of the following ATs:

- Speech input and synthesized speech output
- Screen readers
- Screen magnifiers
- Screen projectors
- Signage and text printed in Braille and large letters with high contrast, standardized keyboards and keyboard layout with landmarks
- Visual, acoustic, and tactile feedback and alert signals
- Smart cards that provide a preferred user interface and output
- Audio recorded information

Users with hearing impairments may benefit from the use of the following ATs:

- Text telephones
- Nonverbal information
- Visual, acoustic, and tactile feedback and alert signals
- Adjustable signal level and tone on audio devices
- Adjustable temporal and spatial resolution in visual communications
- Volume control
- Additional earpieces
- Provisions for inductive coupling to hearing aids

Users with mobility impairments may benefit from the use of the following ATs:

- Tilting keyboards and keypads
- Hands-free data entry and response selection
- Speech input

- Intelligent word prediction software
- Alternative pointing devices, such as mouth sticks
- Keyboard controllers
- Body position switches
- Book holders and page turners
- Arm supports
- Touchscreens
- Remote switches

Users with cognitive disabilities may benefit from the use of the following ATs:

- Standardized icons
- Tactile cues
- Landmarks, both visual and tactile
- Speech-synthesized output
- Speech input
- Visual examples using drawings and icons for help systems

Some of these assistive technologies can be designed into the product lines themselves; others must be used externally to the device. There is an ongoing debate regarding the role of AT in universal design. At the core of the issue is whether the capabilities of AT should be built into mainstream products (those designed for the general public) or whether they should be separate products that can be used with mainstream products by those who need them. There are three schools of thought regarding the use of AT:

1. AT should be the primary solution to providing people with disabilities access to E&IT.

2. E&IT manufacturers should enhance the accessibility of their products to extents that are technically possible and economically feasible. Beyond this, AT should be used.

3. E&IT manufacturers should make all their products accessible by everyone, under all circumstances, in any situation.

While it is clear that a single design cannot accommodate all individuals in all contexts (Stephanidis, 2001; Vanderheiden, 1990), an inclusive design can accommodate a larger number of people than one designed for the "average" user. In addition, ATs themselves cannot readily accommodate the needs of all users, and it is burdensome and costly for AT to keep up with changing mainstream technologies. On the other hand, AT developers have detailed knowledge about the needs of users with various functional limitations, and they can develop better products if they can focus on the needs of their target users.

Some believe that the solution is for AT developers to develop better products rather than mainstream developers trying to design products that are useful to everyone. However, with this approach, people who need assistive technology are required to purchase AT products in addition to the mainstream products. They must also carry their AT device around so that they always have the capability to use a product. The best solution is, perhaps, a middle ground, keeping in mind that part of UD is ensuring compatibility with some types of AT (e.g., touchsticks), but UD doesn't have to require the use of AT.

> …[U]niversal design in [information technology and telecommunications] IT&T products should not be conceived as an effort to advance a single solution for everybody, but as a user-centered approach to providing products that can automatically address the possible range of human abilities, skills, requirements, and preferences (Stephanidis, 2001).

Assistive technology development, whether or not it is integrated in mainstream products, is critical. The Assistive Technology Act of 1998 (P.L. 105-394) provides federal support for research and promotion of AT; Title II specifically relates to coordinating research for assistive technology and universal design (U.S. Department of Commerce, 2003).

There are a number of arguments against the design of AT as separate products:

- AT requires added cost on top of the mainstream products and is affected, in part, by insurance reimbursement policies (U.S. Department of Commerce, 2003).
- AT is sometimes prohibitively expensive, even without the cost of the mainstream products.
- It is not always possible for a person to carry around all necessary AT products.
- AT is focused on a limited audience.
- Different AT is needed to accommodate different functional limitations.
- The economics of ATs are such that the limited market and limited purchasing power of the market will likely limit the abilities of AT companies to keep up with the pace of mainstream technologies.
- Often when an innovation in mainstream technology takes place, an update in the AT is required; this results in extra cost for the person requiring AT or, at the very least, introduces risk. For example, installation of a new software product may interfere with the operation of existing AT. Technology is changing so rapidly that once an access problem is solved, it is common for a new access problem to surface (Stephanidis, 2001; Emiliani, 2001).
- While ATs can be portable, security concerns may prohibit their use; for example, a library may prohibit the installation of a screen magnifier on a public computer.
- AT companies do not have the resources needed to work closely with companies to ensure compatibilities with their products or to do product testing (U.S. Department of Commerce, 2003).
- AT companies often do not share the features they have planned for their products with other companies until the AT is released. While industry would like to have the data sooner, AT companies are reluctant to promise technologies that they might not be able to deliver.

Arguments favoring the design of ATs as separate products include the following:

- AT allows companies to focus on the development of their specialized products, thus resulting in a better job of handling the accessibility issues to meet the needs of people with disabilities.
- It is possible for AT to become so mainstream that it is no longer considered AT. Eyeglasses, for example, are no longer thought of as assistive technology, and closed-captioning and voice recognition software are becoming more commonplace.
- AT is better equipped to handle specialized or rare needs of people with disabilities, and there will likely always be a need for some forms of assistive technology. In addition, AT can be tailored to address unique needs (U.S. Department of Commerce, 2003).

Arguments for integrated AT and UD include the following (Vanderheiden, 1990; Winograd, 1997):

- Many product adaptations necessary to accommodate some functional limitations can be implemented in mainstream products at little or no extra cost.
- Many product adaptations necessary to accommodate some functional limitations can also facilitate use by the general population (e.g., the curb cut). Some benefits of implementing accessibility features that have a more global benefit include lower fatigue, increased speed, and lower error rates.
- AT cannot accommodate the needs of the many individual subgroups that have special needs (e.g., mild versus severe hearing loss).
- Special features can be integrated into mainstream products so they are transparent to users who don't need them (e.g., "sticky keys").

Regardless of how people with disabilities use the technology, it will have a large impact on their independence and ability to fully participate in society, resulting in an added cost benefit to society as a whole (Vanderheiden, 1990). The population of people who may require some sort of

accommodation is ever-growing with the increase of the elderly population, so much so that the term "general population" possibly should be redefined in the minds of designers. Although the market potential for products is great, the limited population for any given AT creates financial constraints for small companies that focus on AT development. Large companies typically have the finances but not the expertise to address a wide range of needs (AAATE, 2003). Complications stem not only from the wide variety of functional limitations but also from the ever-increasing need for rapid configuration of technologies to accommodate environmental and other contextual needs. The increasingly mobile society, for example, may mean that individuals need specialized accommodation over a period of a day or even hours, while a more fixed environment may require little variation in configuration. "…[I]n the context of the emerging distributed and communication-intensive information society, users are not only the computer-literate, skilled, and able-bodied workers driven by performance-oriented motives, nor do users constitute a homogeneous mass of information-seeking actors with standard abilities, similar interests, and common preferences with regard to information access and use" (Stephanidis, 2001, p. 6). The AT industry alone cannot address the variable contexts that create a need for more customized situational technologies.

If products are not going to be designed with AT built in, they need to be designed from the ground up to be fully compatible with AT, and AT needs to be designed so well that people with disabilities no longer have accessibility issues with products. If products are designed with UD principles in mind, they will likely be accessible to a large number of people with disabilities without the use of AT. Regardless of the resolution to this debate, if any, AT and mainstream developers must work together to achieve the greatest accommodation possible and to develop adaptors, when necessary. "The use of an adaptor is appropriate when two systems cannot otherwise accommodate each other; this is the case when accessibility problems are alleviated by the choice of alternative input/output devices or by communication via an alternative modality" (Benyon, Crerar, and Wilkinson, 2001). Thus, there is a place in society for both integrated AT and UD, as well as for separate AT products.

Research Process

An extensive research program was conducted to complete each of the research activities documented in this report. This research program was conducted by examining the roles and perspectives of industry, Federal Government, and consumers with respect to the six product lines that are important to people with disabilities. The six product lines studied were automated teller machines (ATMs), cellular phones, distance learning software, personal digital assistants (PDAs), televisions, and voice recognition technologies. For more information about the research process undertaken in preparing this report and additional information, please consult the online version of the report at http://www.ncd.gov.

II. Market Definition and Research

Electronic and information technology is driving the creation of new communities that are forever changing the way people live, learn, work, and play. Companies are increasingly expanding their presence in emerging markets. Businesses are serving populations they have never served before. Every consumer is different. No two people have the same set of characteristics, learning styles, abilities, experiences, or educational backgrounds. Developing products that accommodate the wants, needs, and preferences of as many individual consumers as is technically possible and economically feasible can greatly enhance a company's competitive advantage.

Designing with access in mind can significantly increase the size of E&IT markets on a global basis. Good business practices dictate that designers and engineers avoid excluding large groups of consumers from accessing and using E&IT. Groups at the highest risk of unintentional exclusion are—

- People with disabilities
- Individuals 65+ years old
- Consumers living within low-bandwidth information infrastructures
- Users of English as a Second Language (ESL)
- Tourists traveling to nonnative language destinations
- Consumers living in high-density populations

This market analysis examined many aspects of manufacturing "more accessibly designed" E&IT. This analysis was intended to help answer questions such as the following:

- Is there a market for more accessibly designed products?
- Does the capacity exist to develop more accessibly designed products in each of the presented product lines?

- What factors influence the market for more accessibly designed products for each of the product lines presented?

All the product lines reviewed in this report are manufactured by members of the E&IT industry. Naturally, in order for these products to be manufactured, the E&IT industry must exist. In order to exist, it must be profitable. A question often asked by the disability community is, "How can we ensure that the E&IT products and services being manufactured are accessible to people with disabilities?" E&IT manufacturers pose a similar question. They ask, "How can we ensure that the E&IT products and services we manufacture are accessible and usable by as many people as is technically possible and economically feasible without the need for customization?" The questions are different. The motivations are different. The market drivers are different. The solutions can be remarkably similar.

Definition of the Market Environment

Historically, the primary forces driving the manufacture of more accessible E&IT products and services have been legal, moral, social, and ethical. The assumption was that if legal, moral, social, and ethical issues no longer existed, the motivation to manufacture more accessible E&IT would all but disappear. The next two sections discuss the reasons why nothing could be further from the truth.

In contrast to the historical notion of what the primary forces driving the manufacture of accessible E&IT are, in actuality a majority of the forces driving demand for more accessibly designed E&IT fall into the following five categories:

- Market forces
- Local environment
- Human condition
- Legal framework
- Standards and guidelines

Market Forces

Market forces consistently drive the demand for more accessibly designed E&IT. Market forces include the need to respond to consumer behavior, the work of federal agencies, legislation mandating developments in the accessibility of E&IT, changing marketing philosophies (from mass marketing to a one-on-one marketing philosophy), competition within the market, emerging technology trends, and economic expansion. These market forces are discussed below in terms of how they drive the markets for more accessibly designed E&IT products.

Consumer Behavior

E&IT is prevalent in schools, libraries, individuals' homes, work environments, places of recreation, banks, and even supermarkets. It is because of this widespread presence that consumers are more technically literate than they were five years ago. Devices such as cell phones, PDAs, voice recognition systems, and the wireless Web enable us to carry our offices with us when we travel. We are more mobile now than ever before. Consumers have become accustomed to getting the information they need *when* they need it and *where* they want it. This has created an expectation of immediacy. When consumers don't get what they want quickly, they become impatient. E&IT designers need to respond to consumer behavior by providing products and services that not only meet but exceed the high expectations of a technically literate, mobile consumer base. Increasing the accessibility of information services and mobile technologies increases access to the information demanded by consumers with high expectations.

Federal Government

The Federal Government serves as a catalyst for more accessibly designed E&IT products through its buying power, the development of legislation, and the support of AT accommodation labs. Section 508 of the Rehabilitation Act amendments of 1998 mandates the purchase of accessibly designed E&IT. As a result, all federal agencies appointed section 508 coordinators (Section 508, 2003). Those coordinators are responsible for organizing and supporting the implementation of section 508 in their respective departments and agencies, and they serve as the central point of contact for information concerning accessibility issues and solutions. In addition

to section 508, other legislation provides guidelines for designing more accessible E&IT. The Architectural and Transportation Barriers Compliance Board (Access Board) developed the ADA Accessibility Guidelines for Buildings and Facilities (ADAAG), and the Telecommunications Act Accessibility Guidelines (section 255) mandates the design of more accessible E&IT products and services. There are also presidential initiatives driving the design of more accessible E&IT. These initiatives include the President's New Freedom Initiative (White House, 2001), the No Child Left Behind Initiative (U.S. House of Representatives, 2002), and the disabilityinfo.gov Web site (DisabilityInfo.gov, 2003).

In addition to these acts and initiatives, many federal agencies have created AT accommodation labs. These labs serve as focal points for information regarding accommodations, disabilities, and assistive technology. These resources include the following:

- Department of Agriculture's TARGET Center
  http://www.usda.gov/oo/target
- Department of Education's Assistive Technology Program
  http://www.ed.gov/offices/OCIO/programs_services/assistive_technology/index.html
- Department of the Interior's Accessible Technology Program
  http://www.doi.gov/atc
- Department of Transportation's Disability Resource Center
  http://www.drc.dot.gov
- Department of Labor's Job Accommodation Network
  http://www.jan.wvu.edu
- The National Institute on Disability and Rehabilitation Research, U.S. Department of Education's ABLEDATA database of assistive technologies
  http://www.abledata.com
- Department of Veterans' Affairs Adaptive Training Program
  http://www.va.gov/oirm/itss/itc/brochsb.htm

- General Services Administration's Center for Information Technology Accommodations (CITA) http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentId=9815&contentType=GSA_OVERVIEW

Clearly, the Federal Government is an important market force for driving accessibility requirements.

Marketing Philosophies

Marketing philosophies have changed radically over the past 35 years. The marketing philosophy of the 1960s was mass marketing (Mass Marketing Definition, 2003), in which the seller views the market as a homogeneous whole and, therefore, has only one marketing program (the same product, the same price, the same promotion, and the same distribution system) for everyone in the population. This type of marketing is also referred to as unsegmented or undifferentiated marketing.

Marketing philosophies of the 1970s included product line extension (Product Line Stretching Definition, 2003) and market segmentation (Market Segmentation Definition, 2003). Product line extension adds depth to an existing product line by introducing new products in the same product category. Market segmentation is the division of a totally heterogeneous market into groups or sectors with relatively homogeneous needs and wants.

In the 1980s, the marketing philosophy shifted to one of niche marketing (Niche Marketing Definition, 2003). Niche marketing or concentrated marketing is a marketing segmentation strategy in which the firm focuses all its efforts and resources on serving one segment of the market.

In the 1990s, value-added marketing became popular. Value-added marketing is a strategy in which a company buys products, customizes them for a particular application, and then resells them. There was also a shift toward marketing to individual customers rather than to the larger

mass. Don Peppers and Martha Rogers invented the phrase “one-to-one” marketing (Peppers and Rogers, 1997) to illustrate the revolutionary concept of treating different customers differently. One-to-one marketing supports the establishment of permanent relationships with your customers. One-to-one subscribes to providing products and services to customers according to their individual wants, needs, and preferences. “Share of customer” replaces market share. The marketing focus shifts from institutions to individual consumers.

Once a company acquires the knowledge and experience required to manufacture more accessibly designed E&IT, it can take an asset marketing approach (Asset-Based Marketing Definition, 2003) to providing its E&IT products globally. Asset marketing uses the knowledge and skills a company has already developed as the basis for growth. For example, a company that is skilled in developing kiosks that are accessible to people who are blind can market kiosks designed in a similar manner to countries that have high populations of people who have never learned to read. This global marketing (Global Marketing Definition, 2003) philosophy enables companies to sell the same, or very similar, products to world markets with essentially the same promotion. This marketing approach is also commonly referred to as international marketing.

Competition

Competition in the E&IT industry is fierce. The industry is constantly looking for ways to increase efficiency, competitive advantage, sales, market shares, and profitability. It is also looking to cut costs. Businesses are constantly developing new and innovative products and services with the hope of achieving these objectives, and adding functionality that enhances the accessibility and usability of a product can be very beneficial. In extremely competitive markets, several companies have correctly identified UD as a potential market discriminator. When highly similar product lines are all competing for the same customer, a product designed with access in mind may have the needed advantage required to outbid the competitors.

Technology Trends

A variety of rising mainstream technology trends fuels the need for more accessibly designed E&IT. The functionalities of multiple individual devices are now being integrated into a single device, including pagers, cell phones, PDAs, palmtop computers, smart phones, MP3 players, and so on. This trend is creating a dependence on one device to accomplish multiple functions. Thus, if not more accessibly designed, this multiple functionality precludes the use of such devices by certain segments of the population, for example, people 65+ years of age. Developing and manufacturing an accessible interface for a device that provides multiple functions is less expensive than developing and manufacturing an accessible interface for multiple single-function devices.

Decreasing costs are making E&IT devices more affordable to emerging markets, which have the greatest concentration of individuals with low income and a greater concentration of individuals who are unable to read and write. E&IT manufacturers need to move into emerging markets in order to increase sales and gain competitive price advantage through economies of scale.

Increasing processing power, disk storage, memory capacity, and battery life are enabling developers to integrate advanced access technologies (speech recognition, text-to-speech synthesis, projected displays, etc.) into devices where it had not previously been technically possible to do so. In addition, the Internet and the World Wide Web are now being used as a primary infrastructure for education, government services, news, and business. Customers' technical knowledge and expectations are constantly increasing, along with the use of wireless Internet appliances and wireless infrastructures. Legal mandates to manufacture more accessibly designed E&IT in support of people with disabilities are a driving force behind these technological trends.

Economic Expansion

The strength of our global economy is, to a great extent, the result of the investment in and application of new technologies by governments, businesses, and individuals. Technology is the

foundation upon which developing countries can build thriving, financially independent, self-sufficient economies. The technologies that build this foundation include computers, networks, ATMs, wired and wireless information infrastructures, wireless handheld Internet appliances, and cellular telephones, to name a few. Applications include online banking, distance learning, e-government, and e-commerce (World Information Technology, 2003).

Local Environment

Another force that drives the market for accessibly designed E&IT is local environments. The following is a discussion of two environmental factors: variances in bandwidth and tourism.

Bandwidth

As of May 2004, more than half (51.39 percent) of home Internet users in the United States relied on dial-up modems of 56Kbps or less. Of all U.S. home Internet users, 42.53 percent used 56Kbps modems, 6.52 percent used 28/33.3Kbps modems, and 2.34 percent used 14.4Kbps modems (Nielsen/NetRatings, 2004).

Computers using dial-up connections cannot handle graphics as quickly and efficiently as computers connected via broadband. It is for this reason that dial-up users surf the Internet with graphics turned off. They do this to speed up downloads. Low-bandwidth connections do not lend themselves to a lot of graphic images, video-based information, or streaming audio. Multimedia content can be problematic for users with slower connections. Wireless devices communicating with the Internet at slow connect speeds can also be a source of accessibility and usability problems.

There are solutions to these problems. Some companies have the ability to control the settings on the browsers used on their employees' PCs. When available corporate Intranet bandwidth is at a premium, these companies can simply issue a central command to turn off graphics on all client PC browsers. This can immediately free up as much as 80 percent of available bandwidth. Designing Web sites for low-bandwidth access tends to increase accessibility for users with

disabilities. For example, a graphics- or animation-intensive site often requires high bandwidth and is inaccessible to those who are blind. In contrast, a text-based site loads quickly and is accessible to screen readers. Dial-up environments will continue to drive the development of more accessible E&IT in the foreseeable future.

Tourism

During the first quarter of 2004, the United States welcomed 8 million international visitors. This was an increase of 12 percent compared to the first quarter of 2003.

Visiting tourists often make use of ATMs, self-service kiosks, ticketing kiosks, and other tourism-related information technologies. Many tourists use English only as a second language. Content written in simplified English is more understandable to users of ESL. Simplified English content has other significant benefits. For example—

- It reduces the cost of language translation.
- It reduces ambiguity.
- It speeds reading.
- It reduces liability associated with misunderstandings.

The use of simplified content was originally included in various accessibility design guidelines in support of people with cognitive reading disabilities. Using simplified language has now evolved into a market force driving the design of more accessible E&IT.

Human Condition

Aside from forces stemming from the market and the environment, many of the forces driving the accessible design of E&IT fall under aspects of the human condition. E&IT products must be designed with people of different disabilities, various age groups, various levels of literacy, various languages, different learning styles, and different experience levels with activities such as using the Internet in mind. These aspects of the human condition bring with them the demand for

accessible E&IT products that cater not just to one category but to many different types of users. Below is a summary of the forces that drive the demand for E&IT that is accessible to a wide range of users.

Disability

Census 2000 counted 54 million people in the United States with some type of long-lasting condition or disability (NCD, 2004). These individuals represented 19.3 percent—nearly one in five people—of the 257.2 million people age five and older in the civilian, noninstitutionalized population. Their conditions included a wide range of disabilities, not all of which precluded the use of E&IT. Within this population, Census 2000 found—

- 9.3 million (3.6 percent) with a sensory disability involving sight or hearing
- 21.2 million (8.2 percent) with a condition limiting basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying
- 12.4 million (4.8 percent) with a physical, mental, or emotional condition causing difficulty in learning, remembering, or concentrating
- 6.8 million (2.6 percent) with a physical, mental, or emotional condition causing difficulty in dressing, bathing, or getting around inside the home
- 18.2 million of those age 16 and older with a condition that made it difficult to go outside the home to shop or visit a doctor (8.6 percent of the 212.0 million people this age)
- 21.3 million of those ages 16 to 64 with a condition that affected their ability to work at a job or business (11.9 percent of the 178.7 million people in this age group)

E&IT products and services that are accessible to people with disabilities appeal to the wider population as well. Accessible design can significantly enhance the sales of a product. For example, all of the following products were first developed in support of people with disabilities and are now used by the wider population:

- Auto-dialers

- Flatbed scanners
- Microphones
- Speech recognition
- Speech synthesis
- Talking ATMs
- Talking caller ID
- Vibrating pagers

Age

There are 36 million consumers 65 years of age and older living in the United States (Population, 2003). People 65+ years of age are often not able to see, hear, think, or move about as easily as they did when they were younger. In order to enable people 65+ years of age to access and use E&IT, these differences must be accommodated. In addition, 52 percent of people 65+ years of age have some type of disability. Thirty-three percent of persons 65+ years of age have a severe disability.

By 2030, there will be about 70 million older persons, more than twice the number in 2000. People 65+ represented 12.4 percent of the population in the year 2000, but are expected to grow to 20 percent of the population by 2030 (Administration on Aging, 2002). Furthermore, individuals who are accustomed to operating E&IT will demand accessible E&IT as their functional capabilities diminish.

Language

Language is certainly a driving force in today's market for more accessible E&IT. According to Global Reach, there are 262 million English-speaking people online. Non-English-speaking populations online are 474 million. By the end of 2005, the ratio of English-speaking to non-English-speaking users will decrease significantly (Global Reach, 2003).

Sixty-four percent of people who visit the Internet seek sites in languages other than English (Global Reach, 2003). In a world where International Data Corporation (IDC) predicted that Internet spending outside the United States will have exceeded $914 billion in 2003, effective Web site globalization is the next imperative of Internet enterprises (IDC, 2000). Despite the vast international opportunities projected, few U.S. companies appear poised to take advantage of them. More than half (55 percent) of U.S. companies do nothing to customize their Web sites for foreign visitors; less than one-quarter even allow a choice of language, according to recent IDC Internet Executive ePanel research. With such minor globalization efforts, it is not surprising that 72 percent of U.S. companies that are online currently draw only 10 percent or less of their e-commerce revenue from outside the United States. To increase their e-commerce revenue, companies must strive to design Web sites that are accessible to the non-English-speaking population.

Learning Style

There are three major types of learning styles (Live Text, 2000). They are visual, auditory, and kinesthetic. Visual learners need to see a person's body language and facial expression to fully understand the content of what is being said. They tend to prefer sitting at the front of a classroom, play, or lecture hall to avoid visual obstructions (e.g., people's heads). They may think in pictures and learn best from visual displays, including diagrams, illustrated textbooks, overhead transparencies, videos, flipcharts, and handouts. During a lecture or classroom discussion, visual learners often prefer to take detailed notes to absorb the information. Auditory learners learn best through verbal lectures, discussions, talking things through, and listening to what others have to say. Auditory learners interpret the underlying meanings of speech through listening to tone of voice, pitch, speed, and other nuances. Written information may have little meaning until it is heard. These learners often benefit from reading text aloud and using a tape recorder. Tactile/kinesthetic learners learn best through a hands-on approach, actively exploring the physical world around them. They may find it hard to sit still for long periods and may become distracted by their need for activity and exploration. Enabling people to acquire

information in the manner most appropriate to their learning style(s) enhances the effectiveness of E&IT and accommodates users with sensory disabilities.

Experience Level

Many people who are learning to use an application on the Web for the first time want all the help they can get. There will come a time, however, when the extra help is no longer needed or desired. One of the benefits of accessible design practices is having the ability to customize user interfaces based on the wants, needs, and preferences of individual users.

Legal Framework

The following is a summary of key laws, statutes, and standards that have improved accessibility for individuals with disabilities in this country. Each law is summarized, followed by a discussion of who is primarily affected by the law and the law's approach toward addressing accessibility issues. These laws and standards are a driving force in the market for accessibly designed products, as they set the standards and guidelines for what must be done by the government and industry to accommodate the needs of individuals with disabilities.

Section 508 of the Rehabilitation Act

Section 508 of the Rehabilitation Act of 1973 requires that when federal agencies develop, procure, maintain, or use E&IT, they must ensure that individuals with disabilities have access to and use of information that is comparable to the access and use by federal employees who do not have disabilities, unless an undue burden (significant expenses or difficulties) is imposed on the agency. The law also requires that individuals with disabilities in the general public seeking information or services from a federal agency have access to information and services comparable to that provided to individuals without disabilities, unless undue burden is imposed on the agency. When compliance does impose an undue burden, agencies must still provide disabled individuals with the information and data by allowing them to use it by an alternative means of access (e.g., captioning, audio description).

Section 508 covers E&IT such as computer hardware, software, networks, ancillary equipment, firmware, technology services, telecommunications products, information kiosks and transaction machines, World Wide Web sites, multimedia, and office equipment such as copiers and fax machines. Section 508 does not cover equipment that contains embedded information technology that is used as an integral part of the product but the principal function of which is not the acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information (e.g., HVAC equipment and medical equipment). As a guideline, E&IT systems can be considered to be accessible to individuals with disabilities if they can be used in a variety of ways that do not depend on a single sense or ability.

Section 508 has the potential to greatly improve accessibility to E&IT for individuals with disabilities. The Federal Government will likely become a better employer to the many people with disabilities who work for it, as well as a model employer for industry. In addition, members of the public with disabilities will have greater accessibility to government information and services related to technology.

Those affected directly by section 508 include federal departments and agencies and vendors that serve the Federal Government. The initial impact is at the procurement stage. Section 508 must be integrated into the procurement process by determining which technical provisions from section 508 apply in a given situation, performing market research to determine the availability of products and services that meet the applicable technical provisions, deciding which technical provisions, if any, do not apply due to an exception, and submitting technical specifications and minimum requirements to a contracting officer.

Private companies and software developers are also affected by section 508. Although section 508 does not require private companies to alter their products, full implementation of the law may provide an incentive for companies that want to do business with the government to build better accessibility features into their products. Currently, however, there is a perception by some

in industry that section 508 conformance is being "rubber stamped" by procurement officials and that the content of documents describing section 508 conformance, such as voluntary product accessibility templates (VPATs), is not important as long as it is merely offered. If section 508 is fully addressed by procurement officials, accessibility will become a key discriminator for federal sales. Increased competition will raise the bar for hardware and software vendors that want to create new and innovative solutions to addressing accessibility issues. Software developers are affected by section 508 in that they are now trying to integrate the applicable section 508 provisions into their entire software development life cycle. Developers are faced with the challenge of either making their software compatible with assistive technology or making software products accessible without the aid of other AT.

In contrast to other federal laws that take a "push" approach toward improving the accessibility of E&IT by mandating that new, better technologies are manufactured and adopted, section 508 does not explicitly require manufacturers to make their products more accessible. Rather, section 508 uses a "pull" approach, in which the federal agencies are responsible for seeking better products to address accessibility problems by procuring products that comply with the provisions when such products are available in the commercial marketplace or when such products are developed in response to government solicitation.

Section 255 of the Telecommunications Act

Section 255 of the Telecommunications Act of 1996 requires that telecommunications products and services be accessible to people with disabilities, to the extent that such access is readily achievable. If manufacturers cannot make their products more accessible, they must design products to be compatible with adaptive equipment used by people with disabilities when it is readily achievable to do so.

Telecommunications products covered under this Act include wired and wireless telecommunication devices such as telephones, pagers, and fax machines; products that have a telecommunication service capability such as computers with modems; and equipment that

carriers use to provide telecommunications services, which includes the software integral to that equipment. Also covered are basic and special telecommunication services, including regular telephone calls, call waiting, speed dialing, call forwarding, computer-provided directory assistance, call monitoring, caller identification, call tracing, repeat dialing, interactive voice response systems, and voice mail.

The implementation of section 255 of the Telecommunications Act stands to improve access and the number and range of accessible products in the telecommunications industry. Companies that manufacture telecommunications products or provide telecommunications services are expected to shift toward a more universal, inclusive design process in the development of new products and services. Those affected by section 255 include manufacturers of telecommunications equipment and customer premises equipment as well as the providers of telecommunications services. Companies must research ways to make their products more accessible and provide training for their staffs on accessibility. Manufacturers must modify their design processes to ensure that accessibility and usability are considered in the earliest design phases of a product. The law has been beneficial to manufacturers and service providers because they have found that by making products easier to use for people with disabilities, the products often are easier for everyone to use.

Section 255 takes more of a push approach toward improving accessibility by establishing a set of guidelines that manufacturers in this industry must follow in designing new products and services. Companies are advised to use these guidelines and implement training procedures as specified by the law. Section 255 is related to section 508 of the Rehabilitation Act in that the U.S. Access Board has incorporated the language of the guidelines specified in section 255 into the 508 standard. This consistent language has enabled companies to develop products that meet both the design requirements of the manufacturers and the procurement requirements of the federal agencies.

Hearing Aid Compatibility Act

The Hearing Aid Compatibility (HAC) Act of 1988 requires that the Federal Communications Commission ensure that all telephones manufactured or imported for use in the United States after August 1989, as well as all "essential" telephones, are hearing aid compatible. "Essential" telephones have been defined as coin-operated telephones, telephones provided for emergency use, and other telephones frequently needed for use by persons with hearing aids. This includes telephones in the workplace, in confined settings such as hospitals or nursing homes, and in hotel and motel rooms.

Telephone manufacturers are directly affected; they must design phones with volume control and other features for users with hearing aids. Owners of hospitals, hotels, and other places with "essential" telephones must ensure that the telephones they purchase for their buildings are hearing aid compatible. Employers must ensure that all telephones in both common and noncommon areas in their workplaces are hearing aid compatible and that any new telephones they purchase are hearing aid compatible.

Unlike section 255 of the Telecommunications Act, in which companies must ensure that their products are accessible to hearing aid users only if it is readily achievable for them to do so, under the HAC Act this requirement is absolute. Like section 255 of the Telecommunications Act, section 255 takes a push approach, mandating that corporations and business owners purchase telephones that are hearing aid compatible and that the Federal Communications Commission (FCC) ensure that all essential telephones and telephones manufactured or imported for use in the United States are hearing aid compatible.

Americans with Disabilities Act

The Americans with Disabilities Act (ADA) of 1990 recognizes and protects the civil rights of people with disabilities. It provides protection from discrimination against individuals on the basis of disability. Covered under the ADA are a wide range of disabilities, and a person with a disability is defined as anyone with a physical or mental impairment that substantially limits one

or more major life activities. These include physical conditions that affect mobility, stamina, sight, hearing, and speech, as well as emotional illnesses and learning disorders. The ADA addresses access of individuals with disabilities to the workplace (Title I), state and local government services (Title II), and places of public accommodation and commercial facilities (Title III). In addition, phone companies are required, under the ADA, to provide telecommunications services for people who have hearing or speech impairments (Title IV).

Title I, which deals with employment of individuals with disabilities, requires that employers do not discriminate against qualified individuals with disabilities and that they reasonably accommodate the disabilities of qualified applicants and employees by modifying work stations and equipment, unless undue burden should result. Title II, which deals with public services, requires that state and local governments do not discriminate based on disability and that they ensure that their buildings are accessible, that new and altered streets and pedestrian walkways contain curb cuts at intersections, and that each service or program is operated so that it is readily accessible to and usable by individuals with disabilities. In addition, this title requires that transit facilities, buses and rail vehicles, key stations in rail systems, Amtrak stations, and vehicles for demand response systems be made accessible, unless certain exceptions apply. Title III, which deals with public accommodations, requires that restaurants, hotels, theaters, shopping malls, retail stores, museums, libraries, parks, private schools, and day care centers, among other places of public accommodation, do not discriminate based on disability. Any alterations to existing places of public accommodation are required to be done in an accessible manner. Moreover, new busses for specified public transportation must be accessible, and elevators must meet certain conditions. Title IV, which covers telecommunications, states that telephone companies must provide telecommunications relay services for hearing-impaired and speech-impaired individuals 24 hours per day.

The ADA has had a significant impact on American society, allowing individuals with disabilities to pursue opportunities that were not available to them in the past. One of the largest groups affected by the ADA is employers, who must both reasonably accommodate the needs of

employees with disabilities and refrain from discriminating against them. If an employer fails to comply with the ADA, the employee can sue, forcing the company to comply or pay damages. In addition, state and local government bodies, educational institutions, and virtually any place of public accommodation or employment are directly affected by the ADA and must comply with the regulations.

The Annenberg Washington Program, a nonprofit institute in communication studies, met in 1994 and expanded upon a previously published white paper in which it stated its initial findings that the average cost of most ADA accommodations was approximately $36, a much lower amount than many anticipated. The program found that the impact of the ADA on American businesses did not create onerous legal burdens, as many believed would be the case, but rather has provided a framework for employers and employees for dispute avoidance and resolution. Overall, the ADA has had a positive impact on society.

The ADA has also taken a push approach toward addressing issues of accessibility. The push is for the businesses and organizations themselves to devise solutions based on the requirements set forth in the ADA.

Electronic Industries Alliance (EIA) Standards: EIA- 608 and EIA-708

The EIA-608 standard specifies the use of closed-captions in analog TV signals. EIA-608 addressed the lack of standards for Line 21 closed-captioning, to ensure that new decoders would all work the same way and that captioners could create captions that would appear in a consistent and predictable manner on every TV set. The Television Data Systems Committee of the EIA enhanced the Line 21 system by adding new characters and assigning codes that would allow the center of the screen to be used for captioning. They also allowed roll-up captions, for the first time enabling real-time captions to be placed somewhere other than the bottom of the screen. This work became known as the EIA-608 standard, and all captioning software and all TV receivers built after July 1993 were required to comply with it.

When digital television (DTV) was developed, a new need arose for the ability to change the size of the caption display—making the captions larger and more readable or smaller and less obtrusive. The conversion of closed-captions for service with digital was necessary. This need could not be accommodated in the EIA-608 standard, and thus the EIA-708 standard was introduced. The current version, EIA-708B, covers two areas. It defines how captioned data are to be encoded and transmitted (known as the transmission protocol or transmission layer). It also defines where in a DTV signal the caption data are to be placed, the bandwidth allocated, and the format of the data. The second area is the display protocol, which determines how captions are displayed on the screen of a DTV. The 708 captioning format was designed to allow for the use of the entire unicode set, which includes every character in the alphabet in any language plus the complete range of symbols. Almost any program can thus be captioned.

Many groups are affected by the introduction of the EIA-708 standard. Manufacturers are affected because the Decoder Circuitry Act of 1990 states that "[d]igital television receivers and tuners must be capable of decoding closed-captioning information that is delivered pursuant to the industry standard EIA-708-B." This Act requires the FCC to update its rules for decoders as new technologies such as DTV are developed. Television broadcasters are also largely affected by the new 708 captioning format, because the pressure is building to produce new programming with digital closed-captions based on this standard. Broadcasters and producers must begin devising plans to make this move and invest in the equipment they will need to do so. Also significantly affected are the viewers with auditory impairments who will benefit from much greater flexibility and a higher quality of captioning with the EIA-708 standard.

A push approach toward the development of a new standard has been taken in the movement from EIA-608 to EIA-708 captioning. After developing the new standard, the EIA put the responsibility on the broadcasters and producers to comply with these standards in their captioning. This push to move from EIA-608 (analog) to EIA-708 (digital) has brought many improvements to closed-captioning. Television viewers can now control the size of the caption text. In addition, EIA-708 offers more letters and symbols, supports multiple fonts and text and

background colors, and allows the viewer to replace the traditional black-box background with a colored box or do away with it entirely. Also, EIA-708 increases the data rate by 16 times over that provided by EIA-608, allowing DTV captions to contain much more information. However, most DTV content currently still relies on the EIA-608 standard captions that have been converted to the EIA-708 format, because the consumer base of DTV receivers is not yet high enough to justify the added expense of native EIA-708 encoding.

Individuals with Disabilities Education Act

The Individuals with Disabilities Education Act (IDEA) was first enacted in 1975. The Act was passed to ensure that students with disabilities receive free, appropriate public education and the related services and support they need to achieve in the least restricted environment appropriate to their individual needs. IDEA was created to help states and school districts meet requirements for educating children with disabilities and to pay part of the expenses of doing so. IDEA consists of three parts: Part B provides grants to states for services for preschool and school-age children, Part C funds early intervention services for infants and toddlers, and Part D supports national activities to improve the education of children with disabilities, including research and professional development programs.

IDEA covers children with disabilities until they graduate from high school or until they are 22 years of age if graduation is delayed. Students who may have a covered disability must be evaluated. If it is determined that the student does have a disability covered by IDEA, the school is required to annually develop an individualized education program (IEP) for the student and place him or her in a regular classroom setting when possible. Amendments to the Act adopted in 1997 have shifted the focus of IDEA from merely providing children with disabilities access to an education to improving results for all children in the education system.

The primary group affected by and benefiting from IDEA are children with disabilities. As a result of IDEA, students with disabilities now learn among their peers. U.S. Senator Jim Jeffords reports that since the initiation of IDEA, dropout rates for students with disabilities have

significantly declined and graduation rates have gone up. The percentage of college freshman with disabilities has tripled as a result of the improved education children with disabilities have available to prepare them for college. Teachers and parents of children with disabilities are also significantly affected by IDEA. These two groups play a large role in the development of a child's IEP. Teachers have had to adjust to having children with disabilities in the same classroom as children without disabilities, learning together. Others involved in the public education system are certainly affected as well.

The enactment of IDEA has followed a push approach in requiring that public schools make free education that adheres to the provisions set forth in the Act available to students with disabilities. The legislation places the responsibility upon the schools and provides them with the requirements they must meet, while providing some financial assistance.

Instructional Material Accessibility Act

The purpose of the Instructional Material Accessibility Act of 2003 (IMAA) is to improve access to printed instructional materials used by students in elementary and secondary schools who are blind or have other visual disabilities. The Act creates an efficient system for the acquisition and distribution of instructional materials in the form of electronic files suitable for conversion into a variety of specialized formats. IMAA requires one national file format and a single national repository for files, which simplifies the process of obtaining materials for students with disabilities. Having a national file format will make the conversion process for producing specialized formats more efficient by reducing the amount of human intervention necessary. Having one national file format will make it easier for states, publishers, Braille software developers, and Braille transcribers to work with files. Braille transcribers will have more time to use their expertise in formatting and proofing files, leading to high-quality Braille. Students will directly benefit because the national file format will eliminate needless steps in scanning and reformatting files. Teachers will benefit, as well, by having materials available in specialized formats for their students who have disabilities at the same time they are available to their other students.

State and local education agencies that receive federal funding under IDEA are responsible for developing a statewide plan within two years of the enactment of IMAA to ensure that printed materials required for classroom instruction in elementary and secondary schools are available in specialized formats to individuals with disabilities at the same time they are made available to students without disabilities.

This Act is a push approach toward improving access to printed instructional materials for visually impaired students. IMAA requires all the states to adopt the national file format.

Video Description Restoration Act

The Video Description Restoration Act (VDRA), which is pending in Congress, would restore the FCC's video description rules that were overturned in federal court on November 8, 2002. The Act would guarantee TV access for individuals who are blind or visually impaired through video description. The FCC would be expressly granted authority to restore its minimum requirements, with increased access over time. Those minimum requirements mandated that the major networks and cable channels in the top 25 television markets present at least four hours of described programming per week and that video-described programs be made available in smaller markets where TV stations have the equipment to do so. VDRA has been rigorously supported by the American Council for the Blind and other blind and deaf organizations, because they feel that video description will achieve for people who are blind what closed-captioning does for individuals who are deaf.

The community of people who are blind or visually impaired would benefit from VDRA by once again having video description available to them, affording them the same access to information on television as sighted viewers. Also affected would be the television program providers and owners who would be required to offer video description for a portion of their programming. VDRA permits an exemption if the provision of video description would be unduly burdensome to the provider or owner, or if video description is not necessary to achieve video programming accessibility by persons who are blind or otherwise visually impaired.

VDRA would restore the FCC's rule for the minimum requirements major networks and cable channels must meet in terms of the amount of video description they provide. This push approach taken by the FCC would ensure that at least a portion of programs would be made available for the visually impaired through video description. The number of hours of video description mandated by the FCC may grow larger, leading to increased access to television programming for the visually impaired over time.

Standards and Guidelines

In addition to the laws mentioned in the previous section, standards and guidelines exist that drive more accessibly designed E&IT. These are discussed below.

ADA Accessibility Guidelines

The Access Board's guidelines, issued under the Americans with Disabilities Act, are to be completely updated and revised. The ADA Accessibility Guidelines (ADAAG) cover the construction and alteration of facilities in the private sector (places of public accommodation and commercial facilities) and the public sector (state and local government facilities). The accessibility guidelines issued under the Architectural Barriers Act (ABA) primarily address facilities in the federal sector and other facilities designed, built, altered, or leased with federal funds. The guidelines under both laws are being updated together in one rule that contains three parts: a scoping document for ADA facilities, a scoping document for ABA facilities, and a common set of technical criteria that the scoping documents will reference. As a result, the requirements for both ADA and ABA facilities will be more consistent. The guidelines also include new scoping and technical provisions for accessible housing that derive from requirements for "Type A" dwelling units contained in the 1998 edition of the ICC/ANSI A117.1 standard, "Accessible and Usable Buildings and Facilities." Of specific interest is 4.34.5 Equipment for Persons with Vision Impairments. Instructions and all information for use must be made accessible to and independently usable by persons with vision impairments.

Telecommunications Act Accessibility Guidelines

On February 3, 1998, the Access Board issued its final guidelines for the accessibility, usability, and compatibility of telecommunications equipment and customer premises equipment covered by section 255 of the Telecommunications Act of 1996 (Telecommunications Act Accessibility Guidelines, 1998). The Act requires manufacturers of telecommunications equipment and customer premises equipment to ensure that the equipment is designed, developed, and fabricated to be accessible to and usable by individuals with disabilities, if readily achievable. When it is not readily achievable to make the equipment accessible, the Act requires manufacturers to ensure that the equipment is compatible with existing peripheral devices or specialized customer premises equipment commonly used by individuals with disabilities to achieve access, if readily achievable.

Web Content Accessibility Guidelines 1.0

These guidelines explain how to make Web content accessible to people with disabilities (Web Content Accessibility Guidelines 1.0, 1999). The guidelines are intended for all Web content developers (page authors and site designers) and for developers of authoring tools. The primary goal of these guidelines is to promote accessibility. However, the adoption of these guidelines will also make Web content more available to all users, no matter what user agent they are using (e.g., desktop browser, voice browser, mobile phone, automobile-based personal computer) or constraints they may be operating under (e.g., noisy surroundings, under- or over-illuminated rooms, in a hands-free environment). The adoption of these guidelines will also help people find information on the Web more quickly. These guidelines do not discourage content developers from using images, video, and so on, but rather explain how to make multimedia content more accessible to a wide audience.

Authoring Tool Accessibility Guidelines 1.0

This specification provides guidelines for Web authoring tool developers (Authoring Tool Accessibility Guidelines 1.0, 2000). Its purpose is twofold: to assist developers in designing authoring tools that produce accessible Web content and to assist developers in creating an

accessible authoring interface. Authoring tools can enable, encourage, and assist users ("authors") in the creation of accessible Web content through prompts, alerts, checking and repair functions, help files, and automated tools. It is just as important that all people be able to create content as it is for all people to have access to it. The tools used to create this information must therefore be accessible. Adoption of these guidelines will contribute to the proliferation of Web content that can be read by a broader range of readers and authoring tools that can be used by a broader range of authors.

User Agent Accessibility Guidelines 1.0

This document provides guidelines for designing user agents that lower barriers to Web accessibility for people with visual, hearing, physical, cognitive, and neurological disabilities (User Agent Accessibility Guidelines 1.0, 2002). User agents include HTML browsers and other types of software that retrieve and render Web content. A user agent that conforms to these guidelines will promote accessibility through its own user interface and through other internal facilities, including its ability to communicate with other technologies (especially assistive technologies). Furthermore, all users, not just users with disabilities, should find conforming user agents to be more usable. In addition to helping developers of HTML browsers and media players, this document will also benefit developers of assistive technologies because it explains what types of information and control an AT may expect from a conforming user agent. Technologies not addressed directly by this document (e.g., technologies for Braille rendering) will be essential to ensuring Web access for some users with disabilities.

XML Accessibility Guidelines

This document by the World Wide Web Consortium (W3C) provides guidelines for designing Extensible Markup Language (XML) applications that lower barriers to Web accessibility for people with visual, hearing, physical, cognitive, and neurological disabilities (XML Accessibility Guidelines, 2002). XML, used to design applications such as XHTML, SMIL, and SVG, provides no intrinsic guarantee of the accessibility of those applications. This document explains how to include features in XML applications that promote accessibility.

Customer Analysis

The purpose of this section is to highlight the consumer markets targeted by the industries being studied. A more detailed customer analysis can be found in the appendix to the online version of this report.

People with Disabilities

Estimates vary greatly on the number of persons with disabilities living within the United States and worldwide. The latest Census Bureau disability statistics report, *Characteristics of the Civilian Noninstitutionalized Population by Age, Disability Status, and Type of Disability: 2000,* estimates that there are 49.7 million people with disabilities living in the United States (Age Structure, 2003). Applying the disability percentages presented in this report to the age structures categorized by the *World Factbook* (including populations less than five years of age), results in a figure of 54 million, which is often cited as the actual number of people with disabilities living in the United States. This is the figure reported by the NCD (2004). Comparing the U.S. disability statistics with those of other countries indicates that China, India, Russia, Mexico, and Turkey have greater instances of disabilities for any age category because they have poorer health care than the United States. The market for universally designed products and services seems clear when global disability statistics (498 million people) are analyzed for these countries, which currently have the top five emerging markets. A detailed look at these emerging markets can be found in the appendix to this report online.

The specific customer populations of interest for the purpose of this study are people with the following disabilities or conditions:

- Low vision
- Blind
- Hard of hearing
- Deaf

- Upper-mobility impaired
- Lower-mobility impaired
- Cognitive

Each of the above conditions is defined in terms of a loss of functional capability that may be temporary or permanent or may develop as a natural part of the aging process. The functional limitations may be caused by genetics, disease, traumatic injury, aging, environmental or situational factors, or some combination of multiple factors. In other words, the analysis is not restricted to functional limitations resulting from what is traditionally termed a disability. This approach, espoused by the functional model of disabilities (Kaplan, n.d.), allows us to consider a wide segment of the population who could truly benefit from universal design.

It is important to understand the functional capabilities and limitations, as well as alternative strategies of access, of the target population in order to properly assess the impact of various accessibility features on mainstream products. Each of the target populations has different functional capabilities and limitations and thus experiences different issues with the product lines under study.

Visual Impairments

In general, people with impaired vision may have difficulty perceiving visual detail, focusing on objects either close up or at a distance, separating objects that do not have sufficient contrast, perceiving objects in both central and peripheral vision, perceiving color and contrast brightness, adapting to different light levels, tracking moving objects, and judging distances (Story, Mueller, and Mace, 1998).

Hearing Impairments

In general, people who are deaf and hard of hearing may have difficulty localizing the source or direction of sound, filtering out background sound, perceiving both high- and low-pitched sounds, and carrying on a conversation (Story, Mueller, and Mace, 1998).

Mobility Impairments

In general, people with impaired mobility may have difficulty with tasks requiring range of motion, coordination, strength, and balance. More specifically, difficulties may be apparent in the following areas: reaching, pushing, pulling, lifting, lowering, carrying, grasping, squeezing, rotating, twisting, and pinching (Story, Mueller, and Mace, 1998).

Cognitive Disabilities

In general, people with cognitive disabilities may have difficulty "…receiving, comprehending, interpreting, remembering, or acting on information" (Story, Mueller, and Mace 1998). More specifically, difficulties may be apparent in the following areas: beginning a task without a prompt or reminder, responding within an appropriate time frame, concentrating, comprehending visual or auditory information, understanding or expressing language, following procedures or doing things in order, organizing information, remembering things, making decisions and solving problems, and learning new things and doing things a new or different way (Story, Mueller, and Macel, 1998).

Other Customer Markets

In addition to people with disabilities, other customer markets targeted in this study include the following. A discussion of each of these customer populations can be found in the appendix to the online version of this report.

- Individuals 65+ years of age
- Consumers living in low-bandwidth information infrastructures
- People who have never learned to read
- Users of ESL
- Tourists
- Consumers living in high-density populations

- Consumers in situations that reduce sensory or visual capabilities

Analysis of Market Trends

The market for E&IT products is constantly changing and evolving as new product trends arise. New trends in cellular phones, ATMs, PDAs, televisions, speech recognition technology, and distance learning are changing the way we learn, do business, store data, bank, communicate with others, and entertain ourselves. There are many market forces that reflect the desires of the E&IT industry (such as gaining a competitive advantage and complying with U.S. laws) and of the consumer (such as wanting easy-to-use products that are efficient and increase the user's safety). These forces create the demand for more accessibly designed products. New products are consistently emerging with the aim of serving a wider population of users, including users with various disabilities, and increasing the overall ease of use for everyone. Current trends in the industries for the six product lines presented in this report are discussed below, along with the market forces that create the demand for those products. Information in this section of the report comes from many different sources, all of which are cited in the text.

Cell Phones

Scarborough Research, the nation's leader in local, regional, and national consumer information, estimates that "almost two-thirds (62 percent) of American adults own a cell phone" (McFarland, 2002). Most cell phones are used to make telephone calls, surf the Web, and receive messages. Cell phones are invaluable in an emergency. They have helped save people's lives, whether assisting in locating people involved in an airplane crash or enabling people to call for help when faced with a medical emergency. Many people use them for long-distance calling instead of signing up for a long-distance plan through their home telephone service provider. Cell phones give people the ability to surf the Web without a computer, take a photo and immediately send it to someone else, and receive messages, stock quotes, news, and other information anywhere, anytime.

Market Forces Creating Demand for More Accessibly Designed Cell Phones

1. The desire on the part of the E&IT industry to achieve competitive advantage and increase profits. Desire on the part of consumers to purchase the most convenient and easy-to-use cell phone. Examples of these market forces include the following innovations:

   — **Easier data entry:** The desire to enter text into a cell phone easily was a major market driver in making cell phones more accessible. Until recently, entering a single character (i.e., A–Z) into a cell phone required up to *six key presses*. For example, you would have to press the #2 key six times and then the #key to select and enter a capital C. Here is, in order, what each key press would do: First press = a, second press = A, third press = b, fourth press = B, fifth press = c, sixth press = C, and # enters the character. Consumer demand led to the development of new cell phone keypads. For example, the Fastap™ keypad is an extremely simple, intuitive, and powerful computer interface that fits in a small mobile phone. Modern phones offer a lot more than just voice communication. Mobile phones are data devices with the ability to write messages, collect and store information, and buy things. They are essentially networked computer terminals. Alphanumeric keypads make a cell phone easier to use for people with low vision (Fastap, n.d.).

   — **Voice dialing:** Voice dialing is a common feature on most digital cell phones. The technology has gone even further. iVoice, Inc., recently released a new hands-free feature to its Speech Enabled Auto Attendant that allows outbound callers to speak the number they wish to dial (iVoice, Inc., 2003).

   — **Talking caller ID:** Most people would like to know who is calling them before answering their cell phone, especially if they are occupied in an eyes-busy, hands-busy, environment. Lucent Technologies offers talking caller ID in support of helping wireless network operators rapidly deploy new features and generate new revenues (Cambridge Telecom Report, 2000).

— **Automatic ring mode adjustment:** A cell phone that is aware of where it is and adjusts its ring mode accordingly is being patented by IBM's research lab in Winchester, MA. The new system uses global positioning system (GPS) technology to switch the phone's ringing modes. In "region definition" mode, the phone stores its current GPS coordinates while the owner tells it whether to ring loudly, quietly, vibrate, or divert to an answering service. This can be done separately in several locations—home, work, church, and your favorite bar, for example—so the phone knows exactly how to behave at that location. (Note: The cell phone industry is already building GPS receivers into handsets so that emergency services can locate callers.)

— **Large fonts:** Samsung's SCH-T300 can display numbers in a large font. (Samsung, n.d.).

— **Bluetooth communications:** Bluetooth comes built into products consumers use every day—like cell phones, headsets, PDAs, laptops, and, yes, even cars—and it allows devices that have Bluetooth built in to "talk" to each other without a wire connection. If a cell phone and headset both have Bluetooth built in, the user could put the headset on and leave the phone in his or her pocket. Bluetooth can also connect a car to the driver's Bluetooth-enabled cell phone. The phone in this scenario connects to the car's audio system, and dash-installed controls take over the function of the phone. Calls are made and retrieved using voice recognition, and the user never has to touch the actual phone (Auto Channel, 2003).

2. The desire on the part of the E&IT industry to comply with federal laws. The desire on the part of consumers to be safe, get help in case of an emergency, and maintain contact with young children, aging parents with Alzheimer's, or others at risk. Examples of these market forces include the following advancements:

— **Global positioning system feature:** Facing a federal requirement to provide location data to 911 dispatch centers by 2005, cell phone carriers have developed a GPS system to track wireless calls. A special chip in the phone times the signals from three satellites to calculate its position, which is relayed to the nearest 911 center (LaGeese, 2003). GPS-equipped cell phones can also be used to maintain contact with young children, aging parents with Alzheimer's, or others at risk, or to find out if your children are where they say they are when you call them.

— **Cellular phone with built-in optical projector for display of data:** A patent for a cellular phone that is compact in size and weight includes a mechanism for displaying received wireless data in its original page format, as sent from the original source. This allows for viewing each original page as a whole page, rather than as a series of partial pages. The phone also allows the display of received wireless visual data with characters in their true original size, thus allowing for ease of reading and use.

Market Forces Reducing the Accessibility of Cell Phones

1. The desire on the part of the E&IT industry to achieve competitive advantage through innovation. Desire on the part of consumers to purchase distinctive cell phones suited to a personal sense of style. Examples include the following:

— **Miniaturization.** Many cellular phones are being designed to be more portable and less obtrusive. As a result, keypads have shrunk, making it difficult for users who are blind to tactilely identify keys. In addition, users without fine motor control skills have difficulty activating the smaller keys.

— **Nonstandard keypads.** Some stylized phones have keypads arranged in a circular pattern or other nonstandard layout. Users who are blind find it difficult to identify the keypad keys because they are not arranged in the familiar layout.

2. The desire on the part of the E&IT industry to achieve competitive advantage and increase profits. Desire on the part of consumers to purchase the most advanced, feature-rich cell phone. The following is an example:

   — **Smart phones.** There is a trend to integrate PDA functionality with cellular phones. The complexity of the user interface and the dexterity required to operate the smart phone may place the phone beyond the capabilities of some users.

ATM Machines

The classic definition of an automated teller machine (ATM) is an unattended machine, external to a bank, that dispenses money when a personal coded card is used. There are more than 200 million users of ATMs in the United States. Billions of transactions are processed in the United States yearly. According to Grant Thornton LLP, there are 350,000 ATMs in the United States; 250,000 are in nonbank locations, and 150,000 of these ATMs are owned by nonfinancial companies (Grant Thornton, 2003).

ATMs have revolutionized the way most people do their banking. Customers can take care of financial transactions at any time of the day or night without having to go to a bank building per se, since ATMs are readily available at supermarkets, convenience stores, shopping malls, hotels, and many other public places. ATMs are used for cash withdrawals, transferring money between accounts, looking up account balances, depositing cash and checks, purchasing money orders, obtaining credit-card advances, and purchasing stamps. Talking ATMs have enabled people who are blind to experience the convenience of anytime banking. In the future, ATMs will be able to send person-to-person "cash" payments, cash checks, deposit cash immediately into your account, and be accessed by a cell phone or PDA.

Market Forces Creating Demand for More Accessibly Designed ATMs

1. The desire on the part of the E&IT industry to comply with U.S. and international laws. Examples of legal requirements that have prompted accessibility include the following:

— **United States:** ADA Accessibility Guidelines for Buildings and Facilities (ADAAG) as amended through September 2002: Section 4.34 Automated Teller Machines [4.34.5] Equipment for Persons with Vision Impairments states, "Instructions and all information for use shall be made accessible to and independently usable by persons with vision impairments (Access Board, n.d.).

— **United States:** Section 707 of ICC/ANSI A117.1 Standard on Accessible and Usable Buildings and Facilities is entitled "Automatic Teller Machines (ATMs) and Fare Machines." Although the 2003 version of this document has not yet been finalized or published, the following is an example of preliminary wording (in part): "Speech Output Machines shall be speech enabled. Operating instructions and orientation, visible transaction prompts, user input verification, error messages, and all displayed information for full use shall be accessible to and independently usable by individuals with vision impairments. Speech shall be delivered through a mechanism that is readily available to all users including, but not limited to, an industry standard connector or a telephone handset. Speech shall be recorded or digitized human, or synthesized" (International Code Council, n.d.).

— **Australia:** The Australian Bankers' Association (ABA), the Human Rights and Equal Opportunity Commission (HREOC), and the Accessible E-Commerce Forum worked with representatives from member banks, other financial institutions, community groups, suppliers and retailers, and the National Office for the Information Economy's (NOIE) Access Branch to develop a set of voluntary industry standards to improve the accessibility of electronic banking (Australian Bankers' Association, n.d.).

— **United Kingdom:** Access to ATMs: UK Design Guidelines provides research-based information to ensure that ATMs meet the needs of all users. The guidelines are based on ergonomic research and testing, offering design principles and guidance for those who design, manufacture, install, and maintain ATMs. The 2002

edition reflects and builds on the experience gained from advances in the design of ATMs and the practical application of the 1999 edition (Feeney, 2003).

2. The desire on the part of the United Nations and the World Bank to reduce poverty in developing countries by helping those countries grow and prosper. The desire on the part of the E&IT industry to achieve competitive advantage and generate revenue from emerging markets. The desire on the part of consumers in developing countries to have the basic necessities of life. Examples of these market forces at work include the following:

   — **The unbanked:** ATMs can be a channel for the flow of money that is being kept "under the pillows" of billions of people living in emerging market areas who do not have a bank account. There also are about 11 million consumers in the United States who do not have bank accounts (Cipherwar.com, 2000). Delton Yuen, NCR's vice president, Financial Solutions Division, Asia-Pacific, stated, "If every household saves money in pillowcases or a cookie jar, the economic system is going to have less money to go around to fund capital investments. For countries to ensure that the economy grows, they need capital. And when the money within a country is not channeled into the financial system or banking system, that capital is circulating less and less" (McGill, 2002).

   — **Talking ATMs:** Although these devices are being developed for people who are blind, they can also accommodate people who cannot read. There are 440 million people who cannot read living in the top five emerging markets.

Personal Digital Assistants

PDAs store, analyze, and retrieve needed information on demand, anytime and anywhere. A PDA can be used as a calculator, address book, calendar, memo pad, expense tracker, and an electronic information storage device. They serve as portable personal computers and augmentative communications devices. Some of the many industries using PDAs are health care,

building/construction, engineering, restaurant, and sales. PDAs are useful for dispatching crews and managing mobile personnel. While they are particularly useful in the business world, they are excellent memory aids for individuals. Information can be transferred between the PDA and a personal computer, providing portable access to information. PDAs are also being used for leisure-time activities. They can provide golfers with distance measurements and scorecards. It is also possible to watch a movie on your PDA. Gartner Group predicted worldwide PDA revenue would be $3.53 billion in 2003, or approximately 10 million new units shipped worldwide (Directions Magazine, 2003a).

Market Forces Creating Demand for More Accessibly Designed PDAs

The primary force is the desire to minimize the cost of doing business. PDAs are now replacing what were once expensive, proprietary, industry-specific telecommunication devices. Another force is the desire of consumers to maximize the ease of use of PDAs in eyes-busy, hands-busy environments. Professionals using PDAs in eyes-busy, hands-busy environments are likely to find PDAs more user-friendly and easier to use if they are equipped with voice recognition and text-to-speech technologies. Examples of improvements resulting from these market forces include the following:

- **Health care:** Wireless-equipped PDAs have been embraced by the medical community to access medical records, write electronic prescriptions, and use as a portable nursing-unit terminal. PDAs are also replacing high-cost medical devices. CardioNet developed a proprietary PDA-type electrocardiogram monitoring device connected to electrodes on a patient's chest. The PDA receives signals from the electrodes and transmits data to the PDA device (CardioNet, n.d.).
- **Public safety:** Field officers use Internet-ready PDAs to access remote records from management databases. This helps to improve the efficiency of creating incident reports. It also optimizes the transfer of queries and responses (Directions Magazine, 2003b).
- **Workforce management:** Cobb EMC is an electric cooperative serving more than 170,000 customers in five metropolitan Atlanta counties. Cobb EMC uses PDAs to

dispatch crews. The cooperative claims that this has helped to streamline work processes and increase service reliability (Directions Magazine, 2003c).

- **Military:** Applications and devices developed for use by the military include the V3 Rugged PDA; industry-leading handheld capabilities; integrated Bluetooth for wireless link to phones, printers, and PCs; TFT screen with 64K colors; Windows CE-based Pocket PC with IBM ViaVoice, MS Pocket Office, and other applications (General Dynamics, n.d.).
- **Multimedia industry:** Pocket PC Films, in Sherman Oaks, California, uses PDA technology to distribute video content for Pocket PC and Palm OS devices. Film fans can buy CD-ROM titles, load them on their computers, and sync them into their handheld devices. Pocket PC Films now distributes 25,000 titles. The huge potential market to use PDAs to view high-quality multimedia has led manufactures to equip them with high-quality audio capabilities. For more information, access the following Web site: http://store.yahoo.com/pocketpcfilms/xsxtremwinsp.html.
- **Assistive technology industry:** In order to reduce the cost of their products, several AT vendors are replacing their proprietary augmentative communications device hardware with PDAs. The touchscreen, text-to-speech, and voice recognition capabilities of PDAs make this possible. Two vendors in particular are pioneering this trend. They are Enkidu Research with its Palmtop Portable and Saltillo with its ChatPC.
- **Simplified writing interfaces:** Written Chinese has 6,000 characters. A computer keyboard has 47 character keys. Chinese data entry is so difficult that there is an entire industry of people who make their living as typists. Someone who is really good with the Chinese version of Microsoft Word (which takes the simplified "pinyin" transliteration and guesses at the character the writer means) can type maybe 20 words a minute. Until, that is, PDA manufacturers started to equip PDAs with better chips and faster algorithms. Voice interfaces are becoming so powerful that the Mandarin PDA-based language recognizer can distinguish about 40,000 words and still not tax the memory or processing power of the PDA (Kumagai, n.d.).

Televisions

A television is technically described as a telecommunication system that receives, decodes, and displays images and plays audio of objects, stationary or moving, broadcast from a separate transmitter. Television is the medium that entertains, informs, and educates; it can also serve as a companion to people who, because of circumstances beyond their control, are confined to their homes. Traditionally, people have used TVs to get news reports and watch movies, sports events, and sitcoms. Cable TV is a telecommunication system that receives, decodes, and displays images and plays audio of objects, stationary or moving, broadcast over cable directly to the receiver. With cable TV, people have many more options of channels to watch, some devoted to a particular subject of interest, such as HGTV for the home and garden enthusiast or news broadcasts 24 hours a day. In addition, movies can be purchased on a pay-per-view basis. Technologically advanced TV systems allow viewers to play interactive games, take a distance learning course, send instant messages, surf the Web, send an email, and shop for and purchase products, including movie tickets and CDs from talk shows and concerts.

HDTV (high-definition television) is a system that has more than the usual number of lines per frame, resulting in pictures that show more detail. Interactive television (iTV) provides richer entertainment, interaction, and more information pertaining to the shows, props, and people involved in its creation. In a sense, it combines traditional TV viewing with the interactivity enjoyed by those communicating through a network, such as the Internet. According to Disney, its iTV program, "Disney Active Portal on Sky Digital," is a major step forward. It offers Disney more flexibility and control of its interactivity in terms of design and dynamic update. The new application empowers kids, giving them the opportunity to participate in shows while still being able to watch the action on screen.

Market Forces Creating Demand for More Accessibly Designed Televisions

1. The desire on the part of the E&IT industry to comply with U.S. laws. Examples of how these market forces resulted in enhanced products and services include the following:

— **Emergency programming:** FCC rules require broadcasters and cable operators to make local emergency information accessible to persons who are deaf or hard of hearing and to persons who are blind or have visual disabilities. This means that emergency information must be provided both orally and in a visual format. Video programming distributors include broadcasters, cable operators, satellite television services (such as DirecTV and the Dish Network), and other multichannel video programming distributors (FCC, 1999).

— **Captioning:** Congress first instituted the requirement that television receivers contain circuitry designed to decode and display closed-captioning. As of July 1993, the FCC required that all analog television sets with screens 13 inches or larger sold in the United States contain built-in decoder circuitry that allows viewers to display closed-captions. Beginning July 1, 2002, the FCC also required that digital television (DTV) receivers include closed-caption display capability. As part of the Telecommunications Act of 1996, Congress instructed the FCC to require video program distributors (cable operators, broadcasters, satellite distributors, and other multichannel video programming distributors) to phase in closed-captioning of their television programs. In 1997, the FCC implemented rules to provide a transition schedule for video program distributors to follow in providing more captioned programming. The rules require that distributors provide an increasing amount of captioned programming according to a set schedule. All English language programming prepared or formatted for display on analog television and first shown on or after January 1, 1998, as well as programming prepared or formatted for display on digital television that was first published or exhibited after July 1, 2002, is considered "new programming" and must be captioned according to benchmarks set by the FCC. The following benchmarks establish how much new programming must be captioned each calendar quarter:

> January 1, 2000, to December 31, 2001: 450 hours of programming per channel per quarter

> January 1, 2002, to December 31, 2003: 900 hours of programming per channel per quarter

> January 1, 2004, to December 31, 2005: 1350 hours of programming per channel per quarter

> January 1, 2006, and thereafter: 100 percent of all programming, with some exemptions

— **Digital television TV mandate:** The FCC has issued a ruling that requires DTV licensees to simulcast 50 percent of the video programming of their analog channel on their DTV channel by April 1, 2003. This requirement increases to 75 percent on April 1, 2004, and 100 percent on April 1, 2005. The simulcasting requirement was intended to ensure that consumers enjoy continuity of free, over-the-air video programming service when the analog spectrum is reclaimed at the end of the transition. With digital transmission, a TV broadcaster will be able to

> Send multiple programming at the same time over the same channel

> Improve the quality of the transmission with options not available with analog transmission

> Offer digital data services, which will allow the TV broadcaster to send out virtual newspapers and other types of services directly to your TV

2. The desire on the part of the E&IT industry to achieve competitive advantage and generate revenue.

— **Word-search videos using closed-captions:** The need to produce just-in-time news stories used to cause problems for broadcasters. When a major event occurred, news programs would have to scramble around looking for some footage that supported the subject of the news story. For example, when an entertainer passes away, news programs might show a clip or two of the last interview with that individual. It could be very time-consuming to search through logs and libraries to find the appropriate footage. That is, until broadcasters gained the ability to both

store digital copies of their broadcasts on computers and conduct word searches on them using the captions. Captioning their programming has enabled many news broadcasters to achieve a competitive advantage in the marketplace by being the first to announce a breaking event with the appropriate video content.

Voice Recognition

Voice recognition technology (VRT) by itself is neither accessible nor inaccessible. It is the integration of VRT into other products and services that can help to make those products and services more accessible and usable. VRT, also referred to as speech recognition technology (SRT), provides telecommunications and computing devices with the ability to recognize and carry out voice commands or take dictation. VRT is generally identified as either being speaker dependent or speaker independent. Speaker-dependent systems recognize only a particular individual's voice and are often used in dictation products. Speaker-independent systems can recognize multiple voices. Speaker-dependent systems are better able to process an individual's quirky speech patterns, but they can take a significant amount of time to train. There are also continuous versus discrete speech recognition systems, in which, respectively, the user can talk at a normal rate or is required to talk with pauses between words.

Voice recognition enhances quality of life and independence for many people. Users do not have to use their hands when operating a telecommunications device that incorporates VRT. This technology is also useful in a hands-busy environment, such as when a radiologist analyzes x-rays by holding them up to the light and verbally dictates the results to a computer. It is also helpful when operating small devices such as cell phones and PDAs.

Many industries are adding VRT to their communication systems as a way to lower operational expenses by cutting the costs of call handling. In 1996, Charles Schwab became the first major consumer company to offer voice recognition for its customers to get stock quotes and other information at the customer's convenience. In addition to brokerage houses, the banking, health

care, law enforcement, travel, transportation, and entertainment industries, to name just a few, are also incorporating VRT.

The Market Forces Creating Demand for More Accessible and Usable VRT

1. The desire on the part of the E&IT industry to achieve competitive advantage. The desire of consumers to purchase easy-to-use and convenient products. The following is an example of an innovation resulting from these market forces:

    — **Voice dialing:** People trying to operate a cell phone in an eyes-busy, hands-busy, environment might experience difficulty. This market factor led to the incorporation of VRT into cell phones and the development of hands-free accessories for cell phones. People with upper mobility disabilities, people with low vision, and many senior citizens can also benefit from voice dialing. Voice dialing is a common feature on most digital cell phones. PCS-Direct, an Internet-based phone store, carries nine different cell phones equipped with voice dialing (PCS-Direct, n.d.).

2. The desire on the part of the E&IT industry to reduce cost and employee turnover. The desire on the part of call-center agents to make their jobs as pleasant and nonrepetitive as possible. Examples of innovations resulting from these market forces include the following:

    — **Interactive voice response (IVR) systems:** To date, companies have attempted to handle interactions with their customers using touch-tone IVR systems, but customers are not entirely satisfied with this form of interaction. Touch-tone interfaces are both frustrating and ineffective. In order to support customer interactions more quickly and efficiently, companies are beginning to move to speech recognition systems. Many call centers use systems that combine digitized speech and speech recognition. Using IVR systems costs much less than using call-center agents. Thanks to IVR, customer requests can be handled with little human intervention. Call-center agents can then become more productive doing other

things. Another benefit of IVR is that agents no longer need to repeat the same information to each caller, over and over again. This tends to increase employee satisfaction and reduce turnover. “Following this, the market is believed to be on its way to being worth $43 billion by 2007” (Telecomworldwire, 2002).

— **Web-based voice portals:** VRTs can be used to enable people to access a Web site using a telephone. Extending access to a commercial Web site by telephone can attract new customers who may not be in a position to use a computer connected to the Internet. There are many instances of this use. For example—

> People operating from within low-bandwidth infrastructures

> People who never learned to read

> Mobile professionals who need quick access to information while on the go

> Senior citizens who recognize the value of the Internet but are simply more comfortable using a telephone

> People who are blind or visually impaired

> People who are traveling and don’t have access to their PCs

— **VoiceXML standards:** The VoiceXML Forum is an industry organization established to promote VoiceXML as the universal standard for speech-enabled Web applications. The VXML Forum “aims to drive the market for voice- and phone-enabled Internet access by promoting a standard specification for VXML, a computer language used to create Web content and services that can be accessed by phone.” Following standards breeds success and enhances the compatibility and interoperability of your system with others. Systems that have been developed according to standards are easier and less expensive to maintain.

— **Dictation, voice recognition, and transcription:** Many professions require the transcription of voice-recorded data. These professions include law enforcement, medicine, and the legal profession. The financial pressures to drive transcription

costs down and productivity rates up helped to fuel the $8 billion speech recognition industry.

Distance Learning

"Distance learning is used in all areas of education, including pre-K through grade 12, higher education, home school education, continuing education, corporate training, military and government training, and telemedicine" (USDLA, n.d.). Students participating in distance learning can use the learning style of their choice. Audio-based classes can consist of recordings, synthesized speech, and audio-conferencing. Video-based learning includes video and videoconferencing and Webcasting. Print-centered techniques include online texts, books, and handouts. Employers also benefit when their employees participate in distance learning courses. "Travel expenses are reduced or eliminated, there is increased productivity as employees don't need to leave the office for extended periods of time, teams are brought together without restrictions on schedule or location, and it provides the ability to reach geographically dispersed populations with a uniform and consistent approach" (Thunderbird, n.d.). Also, higher education facilities are finding that distance learning is less expensive to support than traditional classroom learning.

The types of technologies for implementing distance learning include "two-way video with two-way audio (two-way interactive video), one-way video with two-way audio, one-way live video, one-way prerecorded video (including prerecorded videotapes provided to students and TV broadcast and cable transmission using prerecorded video), two-way audio transmission (e.g., audio/phone conferencing), one-way audio transmission (including radio broadcast and prerecorded audiotapes provided to students), Internet courses using synchronous (i.e., simultaneous or real-time) computer-based instruction (e.g., interactive computer conferencing or Interactive Relay Chat), Internet courses using asynchronous (i.e., not simultaneous) computer-based instruction (e.g., e-mail, listservs, and most World Wide Web-based courses), CD-ROM, multimode packages (i.e., a mix of technologies that cannot be assigned to a primary mode), and other technologies" (Tabs, 2003, p. 11). Online education is now offered at more than 56 percent

of the nation's two- and four-year colleges and universities, with distance learning beginning to extend to high schools and lower.

Market Forces Creating Demand for More Accessibly Designed Distance-Learning Technology

1. **The World Bank and its members want to reduce poverty and strengthen emerging economies:** American businesses have invested more than $250 billion in the top 15 emerging markets with the sincere belief that they will yield significant returns on their investment. Distance education is a critical success factor in human development in emerging markets. Some call it the foundation of business success in emerging markets. Education provides the high-level skills necessary to establish a growing, self-sustaining E&IT labor market. It can also provide the training required by engineers, doctors, teachers, nurses, business entrepreneurs, social scientists, and many other professionals critical to the success of maturing a developing economy.

   The information infrastructures supporting a majority of distance learning activities in emerging markets are low-bandwidth environments. Many of their resources will need to operate over wireless devices. This means that the content will need to be developed in an accessible manner.

   Billions of workers live in emerging markets. They are the individuals who ultimately benefit from an effective distance-learning infrastructure. However, in the top five emerging markets, there are 440 million people who can't read. In order to benefit from distance learning, the materials need to be provided in alternate formats.

2. **Corporations want to educate their employees more effectively and less expensively:** Distance learning produces a 60 percent faster learning curve than traditional instruction. More than 6,000 U.S. companies offered distance learning courses to their employees in 2003, up from 391 in 1998. The U.S. corporate skills business training market is projected

to reach $18.3 billion by 2006 (compounded annual growth rate [CAGR] of 13.3 percent). Worldwide, the distance-learning IT education and training market is projected to reach $28.6 billion by 2006 (CAGR of 7.1 percent).

3. **Universities want to reduce costs, increase enrollment, and still offer a quality education.** Conservatively, there are 45 million users of online higher education. By 2025, the global demand for online education is forecast to reach 160 million students. For every foreign student studying in the United States, there are three to five students who would access U.S. education online if they could (Moe, 2002).

4. **The law:** Many countries have policies relating to Web accessibility. They are Australia, Canada, Denmark, Finland, France, Germany, Hong Kong, India, Ireland, Italy, Japan, New Zealand, Portugal, Spain, the United Kingdom, and the United States of America. The European Union also has Web-access policies. Distance learning usually takes place via the Web (Web Accessibility Initiative, n.d.). Several countries have detailed policies that specifically apply to education, as described here:

   — Australia has a Disability Discrimination Act (1992) that applies to education.

   — Canada's Charter of Rights and Freedoms guarantees the basic rights and freedoms important to Canada as a free and democratic society. The Canadian Government has also established a Common Look and Feel for Canadian Government Web sites, which includes accessibility provisions.

   — The UK's Special Educational Needs and Disability Act took effect on September 1, 2002. The Act removes the previous exemption of education from the Disability Discrimination Act (1995), ensuring that discrimination against students with disabilities will be unlawful. Institutions incurred additional responsibilities in 2003, with the final sections of legislation coming into effect in 2005.

The following U.S. policies make accessibility a requirement for distance learning:

— ADA and section 504: Two federal laws govern accessibility of education: Title II of the ADA and section 504 of the Rehabilitation Act of 1973 (as amended in 1998). All elementary, secondary, and postsecondary educational institutions are regulated under these laws. A useful legal analysis of the requirements is provided in the California Community Colleges' Distance Education Access Guidelines (California Community College, 1999).

— Section 508: To ensure that its technology is accessible to its own employees and to the public, the Federal Government has created regulations based on section 508 of the Rehabilitation Act that require that E&IT developed, procured, maintained, or used by the Federal Government be accessible to people with disabilities. These regulations apply to all federal purchases of technology. Requirements in section 508 may also affect state colleges and universities, pending policy decisions from the Department of Education's Office of Civil Rights.

— California higher education requirements: The California Community College system has released Distance Education Access Guidelines and Alternate Media Access Guidelines. The Alternate Media Access guidelines serve as a guide for the implementation of California Law AB422, requiring publishers to provide textbooks in electronic format to the three systems of higher education in California (the University of California, the California State University, and the California Community Colleges). The Distance Education Access Guidelines include a summary of legal requirements as well as access guidelines for specific modes of distance education instructional delivery. These documents and other resources are available from the High Tech Center Training Unit of the California Community Colleges.

— Texas K-12 textbook adoptions: Texas has for several years been studying the issue of access to electronic books and educational software for students with disabilities. Two reports, one issued in 1997 and one in 1999, provide information on how educational materials can be made accessible. Texas requires publishers to provide electronic files for adopted print materials and is in the process of incorporating the federal section 508 requirements as an optional part of its adoption process for interactive educational software and electronic textbooks. Further information about Texas textbook accessibility is available from the Texas School for the Blind and Visually Impaired.

III. Product Analysis

This section documents the primary findings of a detailed product line analysis for each of the product lines selected for study. The purpose of this research is to document accessibility issues that prevent people with disabilities from fully accessing the selected products and to document accessibility features that are either currently offered or potentially could be offered by manufacturers. For a more detailed discussion of the product line analysis, including a discussion of the product lines broken down according to different disability types, consult the appendix to the online version of this report at http://www.ncd.gov.

The accessibility of a given product is based primarily on a determination of access to core features of the product, with some consideration for additional features that enhance the product but are not necessary for use of the product for its primary purpose. For this research, both accessible and UD features are considered. Accessible design is defined as the design of products that makes them accessible to people with disabilities without requiring the purchase of additional equipment or specialized training. Universal design, or design for inclusion, is the design of products and environments to make them usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. A disability is considered any restriction or lack of ability, resulting from an impairment, to perform an activity in the manner or within the range of activity considered standard for a human being.

Under section 508, each federal department or agency, including the U.S. Postal Service, when developing, procuring, maintaining, or using E&IT, must ensure that the E&IT allows—

- Federal employees with disabilities to have access to and use of information and data comparable to the access to and use of information and data by federal employees who do not have disabilities.
- Individuals with disabilities who are members of the public seeking information or services from a federal department or agency to have access to and use of information and

data comparable to the access to and use of information and data by members of the public who are not disabled.

Section 508 applies without regard to the medium of the technology. However, section 508 permits exceptions if an undue burden would be imposed upon the agency or department.

In general, section 508 requires that products be—

- Usable by people who are blind
- Usable by people with low vision without relying on audio
- Usable with little or no color perception
- Usable by people who are deaf
- Usable by people with limited hearing
- Usable by people with limited manual dexterity, reach, and/or strength
- Usable with time-dependent controls or displays
- Usable by people without speech
- Usable by people with limited cognitive or memory abilities
- Usable by people with language or learning disabilities
- Available with audio cutoff (private listening)
- Designed to prevent visually induced seizures
- Available with biometric identification/activation bypassing
- Usable by people with upper extremity prosthetics
- Hearing aid compatible
- Usable from a wheelchair or similar personal vehicle

Also, section 508 requires compatibility with peripheral devices and that accessibility of information, documentation, labeling, and support be provided to customers. Section 508 provides guidelines for software applications and operating systems, Web-based Internet information and applications, telecommunications products, video and multimedia products, self-contained closed products, desktop and portable computers, and functional performance criteria.

Product designers should consider features that facilitate the following capabilities: Users with visual impairments need to be able to identify, differentiate, and operate all controls and displays, without accidentally activating undesired controls; they should be able to detect control activation and outcome; they should not be required to depend on color to differentiate control and display states to successfully use the device. Users with hearing impairments need to be able to acquire information via a nonauditory format, detect control activation and outcome, and use assistive listening devices. Users with mobility impairments need to be able to view, reach, and activate all controls and displays; manipulate levers, drawers, panels, and all controls; activate controls without accidentally activating adjacent controls; activate controls with the use of an assistive device; and have sufficient time to enter commands. Finally, users with cognitive disabilities need to be able to understand the controls and displays and have sufficient time to enter commands.

Product Line Assessment Methodology

The product line assessment provides an identification of accessibility issues within each product line and an assessment of accessibility features designed to address specific issues. The assessment of accessibility issues involves the calculation of an “impact score” for each issue and target population. The impact score is an estimation of the affect of a particular accessibility issue on a particular target population. The score is calculated at the task level based on two separate dimensions. The first dimension, task priority, is defined as a measure of task importance. High-priority tasks are those that are essential to the device, while low-priority tasks are defined as those that are not essential or would not be expected to be performed by the end-user. The second dimension, accessibility, is defined as an estimation of the ability of a user with a given set of

functional capabilities and limitations to satisfactorily complete a given task. Accessibility is classified at three levels: little or no difficulty, some difficulty, or great difficulty. After impact scores are calculated from the priority and accessibility level for each task, they are used to assign an accessibility grade to each product line for each target population.

Product Line Assessments

The sections below describe the results of the product line assessments. Each product line section is organized as follows: background, accessibility features, compliance with government regulations, and conclusions.

Part of the product line assessment included conducting a task-based accessibility analysis for each product line. A detailed discussion of this task-based accessibility analysis is available in the appendix to the online version of this report. The task-based accessibility analysis consists of identifying the core functionality (tasks) for the product line, identifying the priority level for each task, and assigning a task-accessibility estimation for each task. The task-accessibility score is derived from expert evaluations, a Georgia Tech survey on universal design, and user testing. The combination of the task-priority levels and the task-accessibility estimation is used to calculate an impact score, which is then used to create an accessibility grade for the product line. These accessibility grades appear at the conclusion of this section of the report.

Please note that reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply endorsement by the National Council on Disability.

ATM Machines

Despite their popularity and capabilities, ATMs are not accessible by everyone. People who have visual disabilities may have difficulty reading the display and providing accurate inputs. People who have a mobility disability may have difficulty approaching the device, reaching the controls, and reading the display. People who have cognitive disabilities may have difficulty reading the

display and understanding the options. Each of these challenges can be overcome, to some extent, through proper design.

Task-Based Accessibility Analysis

The core functionality considered necessary to effectively use an ATM consists of the following:

- Locating an ATM
- Locating an accessible ATM
- Inserting the bank card
- Remembering a personal identification number (PIN)
- Entering a PIN number
- Making a cash withdrawal
- Making a deposit
- Checking account balances
- Transferring money
- Printing a statement
- Retrieving a receipt
- Retrieving the bank card
- Reading a receipt

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, or the design of the ATM. Accessibility issues for the disability population were identified, along with an impact rating for each issue. The disability populations include people who have an impairment resulting from environmental or situational factors. The issues identified and impact ratings

assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various ATM manufacturers' marketing data produced a number of features identified as accessible design components. Each of these components is listed, along with a description of the component and an assessment of the usefulness of the feature for disability groups. Some of these features may have been designed with a particular disability population in mind; others may have been designed simply as desirable features. In many cases, the accessibility features benefit or are used by a variety of people, and they may be considered to provide universal access.

Large sunlight-readable color display: ATM displays can be very difficult for the average person to use simply because of lighting issues, natural or otherwise. Sunlight often creates glare on electronic displays, sometimes making it impossible to even discern that any text appears on the display. In some cases this can be overcome by shifting the viewing orientation, but this is not an option for all people. Sunlight-readable displays can increase accessibility by preventing glare. With the exception of people who are blind, this will have a medium impact for all users and will help solve the problem of not being able to receive visual information.

Touchscreen display: Touchscreens provide the manufacturer with a method of creating a dynamic display, providing more information in less space. Touchscreens can be designed with large, high-contrast buttons or icons that can provide an alternative solution for those with partial visual impairment or motor disabilities. Selection via large touch areas on the screen may be preferable to some users as an alternative to keyboard or function key input. Additionally, for users with complete vision loss, touchscreen functions can be mapped—or directed—

down to the tactile keyboard. But unless the functions are mapped in this way, or an alternative audio interface is provided, touchscreens are not accessible to people who are blind and will have a negative impact. If keyboard mapping is implemented or an alternative audio interface is provided, touchscreens will have no impact on people who are blind. They will have a medium impact for those with low vision and mobility impairments if implemented with large touch areas and text or graphics. If good graphical metaphors are used, touchscreens will have a medium positive impact for the cognitively disabled. They will help solve the problem of making inputs and possibly of receiving and interpreting visual information.

Talking ATM: A talking ATM is one with voice displays. Talking ATMs are useful in circumstances in which it is difficult to read the text display because of a visual impairment, low reading ability, significant glare on the screen, or possibly having to view the screen from a seated position. Inclusion in design will have a high impact for those who are blind, a medium impact for those with low vision or cognitive disability, and a low impact for all other users. It will help solve the problem of receiving and interpreting visual information.

Private headphone jacks for talking ATM: Voice instructions can be provided publicly, or privately through the use of headphones. Voice instructions can help guide the user through the transaction and provide information such as feedback on keypress entries and account balance (things that would typically be presented visually). This would allow a person who is blind to perform an ATM transaction independently, although it is likely that audio feedback would not be available for PIN entry for security reasons. This would probably be an inconvenience for the user but would not prevent use of the ATM. Implementation in design will have a high impact for people who are blind, a medium positive impact for users with low

vision, and a neutral impact for other users. Choice of private audio will help solve the problem of not being able to receive auditory or visual information.

Mapping function keys to the keypad: This is a software feature that allows the function keys at the side of the ATM display to be mapped, or directed, down to the keyboard. This means that the user can perform the entire transaction from the keyboard, which minimizes the distance a user has to stretch to reach the keys. It also helps people who are blind by providing a more familiar key layout to use for input. Function key mapping will have a medium impact for people who are blind and people who have upper or lower mobility impairments, and a neutral impact for all others. It will help solve the problems of not being able to locate or identify controls and not being able to make inputs.

Raised tactile symbols: Raised tactile symbols help those with visual impairments, particularly if they are blind, distinguish keys that most people differentiate through a text label or graphic. In some cases, these symbols may include a Braille keypad, although Braille proficiency is not widespread. Other alternatives include protruding keytips, which enable the visually impaired to feel the edge of individual keys and so determine the end of one key and the start of another, and increased character size, to assist those with visual impairments. Implementation in design has a neutral impact for most users, but a medium impact for those who are vision impaired. It will help solve the problem of not being able to locate and identify controls.

Raised area (nib) on the "5" key: A nib is a raised area that helps users identify the location of the center of the keypad so they can then determine the position of the remaining keys. Given a standard telephone keypad layout with the addition of nonnumeric keys, the nib helps the user (particularly the user with a visual impairment) find the "5" key, from which the remaining numeric keys can be

easily identified. Inclusion in design will have a high impact for users who are blind, a medium impact for those with low vision, and a neutral impact for other users. It will help solve the problem of not being able to locate and identify controls.

Keys on the keypad that are discernible by touch: Tactile separators typically provide either raised or indented spaces between controls to assist in tactile differentiation of numeric keys from other keys. Inclusion in design will have a high impact for those who are blind, a medium impact for those with upper mobility impairments, and a low impact for all others. It will help solve the problems of not being able to locate and identify controls and not being able to make accurate inputs.

Tactile feedback keypad: Tactile feedback results from the keys springing back to position once pressed, indicating that a key has been pressed and input accepted. Touchscreens, for example, do not have tactile feedback. Inclusion in design will have a high impact for people who are blind, a medium positive impact for those with low vision, and a low impact for other users.

User-controllable playback speed: User-controllable speed allows the user to make adjustments to auditory output to meet information processing needs. Visual output tends to be available until the next selection is made, but auditory output is temporal, and user control allows review of information as needed. This is particularly beneficial to people who are blind and perhaps to some users with low vision or cognitive disabilities. Implementation in design will have a medium positive impact for people who are blind and a low impact for other users. It will help solve the problem of difficulty receiving auditory information.

User-controllable volume: Volume control allows the user to make adjustments to auditory output to meet sound level needs, particularly in noisy environments. This is particularly beneficial to the hard of hearing. Implementation in design will have a high positive impact for the hard of hearing and a low impact for other users. It will help solve the problem of difficulty receiving auditory information.

Visual alert: Visual alerts may be in the form of a change in text display or a light. They serve as an alternative or supplement to vibrating and auditory alerts. Visual indicators are particularly beneficial for people who are deaf or hard of hearing. Inclusion in design will have a high impact for users who are deaf, a medium impact for those who are hard of hearing, and a low impact for all others. They will help solve the problem of not being able to receive auditory information.

Pause control for talking ATM: Pause control allows the user to pause the verbal output from the device. This is helpful to give one time to write something down or to think about what option might be desired. Inclusion in design will have a medium impact for users who are blind and a low impact for all other users. Pause control will help solve the problem of not being able to read text on the screen.

Replay control for talking ATM: Replay control allows the user to listen to a message more than once. This is helpful if the voice output was not understood or could not be heard over environmental sounds. Inclusion in design will have a medium impact for users who are blind or hard of hearing and a low impact for all other users. Replay control will help solve the problem of not being able to read text on the screen.

Voice recognition for talking ATM: Voice recognition allows a user to speak in his or her voice to make inputs to the device. This is particularly useful for those who cannot physically activate the controls or who cannot tactilely differentiate the

controls to know, for example, which button to press. Inclusion in design will have a high impact for users who are blind, a medium impact for users with low vision and upper mobility impairments, and a low impact for all others. Voice recognition will help solve the problems of not being able to locate, identify, and activate the controls.

ATM that can be controlled by a cell phone or PDA: External control of the ATM allows individuals to use their own personal accessible device to interact with an ATM that may not otherwise be accessible for a particular disability type. Inclusion in design will have a medium impact for users who are blind, have low vision, or have an upper mobility impairment and a low impact for all other users. PDA or cell phone control will help solve the problems of not being able to read text on the screen or to locate, identify, and activate the controls.

Large keys for the keypad: Large keys on the keypad increase the ability to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have poor fine motor control and a low impact for all other users. It will help solve the problem of having difficulty making accurate inputs.

Large fonts on the display: Large fonts on the display increase the text size for circumstances in which small text is difficult to read. Inclusion in design will have a high impact for those with low vision, a low impact for users who are blind, and a medium impact for all other users. It will help solve the problem of not being able to read text on the screen.

Large display screen: Large display screens reduce screen clutter and increase the space available for larger text and graphics. Inclusion in design will have a medium

impact for low-vision users and a low impact for all others. It will help solve the problem of not being able to read text on the screen.

High-contrast display: High contrast provides the option for users to adjust the color or brightness of the foreground and background colors so that the text stands out from the background, increasing readability. Inclusion in design will have a high impact for those with low vision and most users under very bright- or low-light conditions. It will have a low impact for other disability populations. High contrast will help solve the problem of not being able to receive visual information.

Ability to request additional time: Ability to request additional time allows the user to complete a transaction despite the need to use more than the normal amount of allotted time to complete individual transaction components. Inclusion in design will have a high impact for most users, depending on the output mode (visual or auditory) from the device. Additional time will help solve the problems of not being able to receive visual or auditory information, not being able to reach controls, and not being able to grasp objects.

Graphical instructions: When good metaphors are used and display resolution is sufficient, graphical instructions may be easier to see than text instructions, particularly if the font size for text is small. Inclusion in design will have a medium impact for those who have low vision and a low impact for all other users. Graphical instructions will help solve the problem of not being able to read text on the screen.

Text equivalents for auditory information: Text equivalents are a means of providing redundant information so that someone who has difficulty with one sense (in this case, hearing) has an alternative method of obtaining the information being provided (in this case, through eyesight). Inclusion in design will have a high

impact for those who are deaf or hard of hearing and a low impact for all other users. Text equivalents will help solve the problem of not being able to receive auditory information.

Detachable controls: Detachable controls provide the option for individuals to place the control panel in their laps, for example, limiting the amount of reach required to activate the control, increasing the ability to support the hand and arm, and possibly making the difference between being able to use the device or not. Inclusion in design will have a high impact for those with those with a lower mobility impairment or any user operating the ATM while seated in a wheelchair, and a low impact for all other users. Detachable controls will help solve the problem of not being able to reach the controls from a seated position.

More space between keys on the keypad: More space between the keys increases the ability to differentiate the keys by touch and to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. It will help solve the problem of having difficulty locating controls and making accurate inputs.

Concave keys on the keypads: Concave or curved-inward keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. This type of key also increases the ability to differentiate the keys from each other and from the surrounding area on the device. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Concave keys will help solve the problem of locating controls and making accurate inputs.

Keys that can be operated without human contact: Some individuals use pointing devices or other mechanisms to help them reach or activate controls. Some devices require moisture content or heat (characteristics of touch) to activate the controls; these devices cannot be used by someone who needs to use an alternative input device. Controls that are operable without physical human contact will have a high impact for someone with an upper mobility impairment and a low impact for all other users.

Rubberized keys: Rubberized keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. Textured keys also help the user differentiate the key itself from the surface of the device, particularly if the keys are not raised sufficiently. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Rubberized keys will help solve the problem of locating controls and making accurate inputs.

Additional features that may enhance accessibility include the following:

Type of card reader—swipe, dip, or motorized: These are typically accompanied by tactile indicators and flashing lights to assist in card insertion. People with different capabilities may benefit more from one type of reader than another. For example, a vertical card swipe may be difficult for someone with limited reach. It may be difficult for users without fine motor control to retrieve a fully inserted card (dip card reader) from the device. Users who are blind may have difficulty finding the card reader or determining the proper orientation of the card. Implementation of a certain style will have a high impact for users who are blind or have upper mobility impairments. Use of a motorized reader or a horizontal swipe with tactile cues will help solve the problem of having difficulty inserting the ATM card into the machine.

Customer telephone: This can be used to acquire human assistance if the customer has difficulties using the ATM. A customer telephone will have a low impact for all users. It can help solve the problems of not being able to receive visual information or not being able to locate and identify controls.

Digital video camera: This can be used in conjunction with the customer telephone to allow the customer service representative to see the customer's difficulty. A digital video camera will have a low impact for all users. This can help solve the problems of not being able to receive visual information or not being able to locate and identify controls.

Multilingual capability: Multilingual capabilities will help those who have difficulty operating the ATM because of unfamiliarity with the language. This will have a medium impact for users with cognitive disabilities. It may help solve the problem of not being able to interpret visual information.

LED indicator: LEDs provide a visual indication of status information, or they may provide guidance on what to select next or where to insert an object. They serve as an alternative or supplement to vibrating and auditory alerts. Visual indicators are particularly beneficial for people who are deaf or hard of hearing. They will have a low impact for all other users, and will help solve the problem of not being able to receive auditory output.

User manuals in alternative formats: Alternative formats include large print, Braille, and audio. Inclusion in design will have a high impact for users who are blind or have low vision and a neutral impact for other disability populations. It will help solve the problems of not being able to read or handle printed materials.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to ATMs address self-contained, closed products (1194.25); functional performance requirements (1194.31); and documentation (1194.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another.

The following section 508 regulations are seen as issues for ATMs:

- Verify that all controls and keys are tactilely discernible without activating the controls or keys. Some ATMs only use touchscreens, which are counter to this regulation.
- Verify that at least one mode of operation and information retrieval is provided that does not require user vision or, alternatively, that support is provided for assistive technology used by people who are blind or visually impaired. The majority of ATM information is provided through a text display, which cannot be seen by a user who is blind.
- At least one mode of operation and information retrieval that does not require visual acuity greater than 20/70 must be provided through audio and enlarged print output working together or independently; otherwise, support for AT used by people who are visually impaired must be provided. ATMs do not always provide voice output and often use font sizes smaller than 14 points, which is inadequate for someone with low vision.
- At least one mode of operation and information retrieval that does not require fine motor control or simultaneous actions and that is operable with limited reach and strength must be provided. ATMs are often mounted at a height that is difficult or impossible for people in a seated position to access. The level of the display and control panel varies from one ATM to the next, and some are better suited to individuals in wheelchairs than others.

Cell Phones

Despite their popularity and their capabilities, cell phones are not accessible to everyone. There are limitations that make cell phones either inaccessible or difficult to use (and, therefore, possibly undesirable). People who have visual impairments may have the most difficulty reading

the display and accessing visual information. People who are deaf or hard of hearing may have difficulty carrying on a verbal conversation and detecting auditory alerts. People with a mobility disability may have difficulty making accurate inputs and simultaneously handling the phone and manipulating the controls. People who have cognitive disabilities may have difficulty understanding metaphors that are used and remembering how to access information. Each of these problems can be overcome, to some extent, through proper design.

Background

Digital cellular telephone service is growing rapidly in the United States because of the advantages it offers over older analog service. Digital service allows for more users, less expensive service, higher sound quality, more features, and better security. There are different types of digital cellular technology, including code-division multiple access (CDMA) and several varieties of time-division multiple access (TDMA), global system for multiple communications (GSM), and integrated digital enhanced network (iDen). The particular type of digital technology in use varies by service provider.

The introduction of digital cellular telephone service in the mid-1990s also introduced a new access barrier for people who wear hearing aids. Analog systems work fairly well with teletype devices (TTYs). Some phones have built in modular jacks into which a TTY can be plugged; other phones can be used with an adapter. Initially, digital systems did not work well with TTYs. Digital wireless transmissions inherently contain errors, but error correction techniques can reduce the problem for speech. Digital networks are less forgiving in the case of the tones generated by TTY devices, however, and the transmission errors can cause characters to be lost or changed, resulting in unintelligible messages.

When digital cellular telephones are in close proximity to hearing aids, interference may be heard through the hearing aid. The interference may be perceived as a buzzing, humming, or squealing inside the hearing aid. This interference does not occur with all combinations of telephone, hearing aid, and cellular service; but when it does occur, it can make use of the telephone

annoying, difficult, or impossible. In general, older, larger hearing aids are more susceptible to interference than newer models. Studies have shown that a distance of one to two feet between the phone and the hearing aid will reduce or eliminate the interference in most cases.

The electromagnetic field surrounding the antenna of the telephone is the primary source of interference. Moving the antenna farther from the hearing aid may reduce or eliminate interference. The loudness of the interference also depends on the power of the transmission, which in turn varies with the distance from the telephone to the cellular base station. "Flip phone" designs may reduce interference by placing the antenna farther from the hearing aid and by shielding the hearing aid from the antenna. But the antenna is not the only source of interference; internal telephone electronics, such as the back light on the screen, can also cause interference.

Possible solutions from the cellular industry may include reducing the required transmission power by adding more base stations, improving antenna technology and shielding the telephone, and providing accessories such as neckloops that induce sound into the T-coil of hearing aids without requiring proximity of the telephone to the hearing aid.

Possible solutions from the hearing aid industry include increased shielding of hearing aids and modification of the circuitry and design of hearing aids to minimize interference.

Digital Cell Phone Compatibility with TTY

In 1996, the FCC issued a requirement that wireless carriers be capable of connecting 911 calls over a digital wireless network for callers using a TTY. The deadline for compliance was extended repeatedly as various wireless carriers worked to provide a solution.

Since September 1997, the TTY Forum (sponsored by the Alliance for Telecommunications Industry Solutions, or ATIS) has worked to develop technically feasible solutions that will enable TTY users to make TTY calls over digital wireless systems. The TTY Forum is composed of

various stakeholders, including wireless carriers, wireless handset manufacturers, wireless infrastructure manufacturers, manufacturers of TTYs, 911 and telecommunications relay service providers, and consumer organizations representing people with hearing and speech disabilities.

In January 2000, Lucent Technologies announced a solution for TTY access using digital cellular telephones. The solution was developed by the Bell Labs Speech and Audio Processing Technologies group; it involves upgrading software in both the network and the handset. The software detects the TTY characters being sent and repeatedly transmits those characters to the receiving end, allowing the receiving end to correctly regenerate the tones corresponding to the characters.

At its meeting on June 4, 2002, the TTY Forum announced that many wireless service providers were prepared to meet the FCC's June 30, 2002, deadline for TTY compatibility, and that testing had shown that digital wireless TTY consistently performed better than TTY over analog circuits. To enable the TTY calls over digital voice channels, digital wireless handsets and networks had to be redesigned to accommodate the speed and tone of TTY Baudot signals. Numerous problems had to be overcome, including setting standards for the interface between TTY devices and digital wireless mobile phones operating with several different digital standards.

However, while wireless TTY compatibility services work well for nonemergency communication, at the time of the announcement there were some remaining issues for emergency situations. Wireless 911 TTY calls may suffer high character error rates when received by some public service answering points (PSAPs). Test results from the ATIS-sponsored TTY Technical Standards Implementation Incubator show that the problem encountered may be related to older and nonstandardized TTY equipment or software used by some PSAPs. The wireless telecommunications industry performed due diligence to ensure that the digital network would be capable of transmitting TTY calls by the June 30, 2002, deadline and was committed to continue to work to provide access to 911 for its customers using TTYs. There is some indication that wireless networks now support digital TTY with compatible

phones, but this cannot be verified since it is illegal to test 911 services. A number of carriers petitioned the FCC for an extension to the 911 requirements.

Hearing Aid Compatibility with Cellular Telephones

The Hearing Aid Compatibility Act of 1988 (HAC Act) required the FCC to ensure that all telephones manufactured or imported for use in the United States after August 1989, and all "essential" telephones, were hearing aid compatible. Secure telephones and mobile telephones were exempt from the HAC Act, however.

In November 2001, the FCC released a Notice of Proposed Rulemaking to reexamine the exemption of mobile phones from the requirements of the HAC Act. On August 14, 2003, the FCC released a Report and Order modifying the exemption for wireless phones under the HAC Act to require that digital wireless phones be capable of being used effectively with hearing aids.

The FCC ruling requires digital wireless phone manufacturers to make available within two years at least two HAC-compliant handsets with reduced radio frequency (RF) emissions for each air interface (e.g., CDMA, TDMA, GSM) they offer. It also requires each carrier providing digital wireless services, except for nationwide (Tier I) wireless carriers, to make available to consumers within two years at least two HAC-compliant handset models with reduced RF emissions for each air interface it offers.

Nationwide (Tier I) wireless carriers must offer within two years two HAC-compliant handset models with reduced RF emissions for each air interface they employ or ensure that one quarter of their total handset models are HAC-compliant with reduced RF emissions within two years, whichever option yields a greater number of handsets.

Digital wireless phone manufacturers must make available to carriers within three years at least two HAC-compliant models with telecoil coupling for each air interface they produce, and each

carrier providing digital wireless access must make available to consumers within three years at least two HAC-compliant handset models with telecoil coupling for each air interface it offers.

Further, one-half of all digital wireless phone models offered by a digital wireless manufacturer or carrier must be compliant with the reduced RF emissions requirements by February 18, 2008. Manufacturers must label packages containing compliant handsets and must make information available in the package or product manual. Service providers must make available to consumers the performance ratings of compliant phones.

In addition, the FCC established an exemption for digital wireless manufacturers and carriers that offer a minimal number of handset models. The FCC encourages digital wireless phone manufacturers and service providers to offer at least one compliant handset that is a lower-priced model and one that has higher-end features, and encourages hearing aid manufacturers to label their precustomization products according to the American National Standards Institute (ANSI) standard.

On September 5, 2003, ATIS established the ATIS Hearing Aid Compatibility Incubator. The ATIS HAC incubator consists of a diverse mix of wireless service providers, wireless manufacturers, hearing aid manufacturers, and other parties. The mission of the HAC incubator is to investigate performance between hearing aids and wireless devices to determine methods of enhancing interoperability and usability for consumers with hearing aids.

On October 1, 2003, DAMAX, a manufacturer of cellular telephone antennas, announced a line of directional antennas that show promise for improving the hearing aid compatibility of existing handsets.

Task-Based Accessibility Analysis

The core functionality considered necessary to effectively use a cell phone consists of the following:

- Locating the cell phone
- Identifying the current state of the phone: on or off
- Turning the phone on and off
- Locking the phone
- Unlocking the phone
- Dialing numbers on the keypad
- Storing a phone number
- Recalling a stored phone number
- Receiving a phone call
- Receiving caller-ID information
- Accessing voice mail
- Attaching a headset
- Using a headset
- Determining battery status
- Determining signal strength
- Detecting when the phone is in roam mode
- Receiving a text message
- Sending a text message
- Charging the phone

Additional functionality that is typically inherent in cell phone design includes the following:

- Using a calculator
- Playing games

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, and the design of the phone. Accessibility issues for each disability population were identified, along with an impact rating for each issue. The disability populations include people who have an impairment resulting from environmental or situational factors. The issues identified and impact ratings assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various cell phone manufacturers' marketing data produced a number of features identified as accessible design components. Each of these components is listed, along with a description of the component and an assessment of the usefulness of the feature for disability groups. Some of these features may have been designed with a particular disability population in mind; others may have been designed simply as desirable features. In many cases, the accessibility features benefit or are used by a variety of people, and they may be considered indicative of universal access.

Loopset for hearing aids: A loopset is an accessory that increases clarity and reduces background noise when translating from sound over the telephone line to a hearing aid device. Inclusion in design will have a high impact for users who are hard of hearing and who use T-coil equipped hearing aids and will help resolve the issue of not being able to receive verbal information. Availability of loopsets will have no impact for other disability populations.

Voice dialing: Voice dialing provides users with the option to speak the name of the person they want to call rather than using numeric dialing or accessing a name from the directory. Inclusion in design will have a high impact for people who are blind and a medium positive impact for users with low vision and upper mobility impairments. It will have a low impact for other disability groups. All users (except

perhaps the speech impaired) may find the feature useful. Although voice dialing is not likely to increase accessibility under general circumstances, it will in some situational contexts in which the user's hands are unavailable. This is an example of a feature that is nearly universally usable, but it should not replace traditional dialing methods; voice dialing may be problematic for people without speech, people with laryngitis, or in noisy environments. Voice dialing will help resolve the issues of not being able to locate or identify controls and not being able to make accurate inputs.

Adjustable contrast: Adjustable contrast provides the option for users to adjust the color or brightness of the foreground and background colors on the display screen to increase clarity and readability. Inclusion in design will have a high impact for those with low vision and most users under very bright- or low-light conditions. It will have a low impact for other disability populations. Adjustable contrast will help resolve the issue of not being able to receive visual information.

Roller key: The roller key provides an alternative to successive button presses, allowing the user to slide the thumb or finger over a roller in order to scroll through contents on a screen. This is an example of a feature that is nearly universally usable, but it should not replace traditional navigation methods. Inclusion in design will have a low impact for all disability groups.

User manual in alternative formats: Alternative formats include large print, Braille, and audio. Inclusion in design will have a high impact for those who are blind or have low vision and a neutral impact for other disability populations. It will help resolve the issues of not being able to read or handle printed materials.

One-touch dialing: One-touch dialing provides the option to map phonebook entries to numeric keys. Once programmed, the key can be pressed for an extended

period of time to dial the phone number rather than dialing in full or navigating through the phonebook. This is a desirable feature for all people, regardless of disability. Inclusion in design will have a high impact for people with upper mobility impairments (if they can sustain the key press) and visual impairments and a low impact for all other users. It will help resolve the issues of locating or identifying controls and making accurate inputs.

Customized ring tones/alerts: Ring-tone options provide the user with a choice regarding the ring sound that is heard when there is an incoming call. In some cases, the phone can be set to ring differently for different callers. Customized alerts provide the user with a choice of the sound or tone that is heard when different alerts (e.g., reminders) are triggered. This user profiling is particularly useful for individuals who are blind who may not otherwise be able to determine the source of an incoming call, and inclusion in design will have a medium-high positive impact. Certain ring tones may be more perceptible than others for the hard of hearing, and inclusion of ring-tone options in design will have a medium impact for this group and will help resolve the issue of not being able to receive acoustic alerts and signals. While inclusion for other disability groups does not affect accessibility, ring-tone options are a highly desirable feature. Different ring tones also help users distinguish their own cell phone ring from someone else's.

Text-based functionality: Similar to sending email, text messaging via cell phone provides a mobile communication mechanism and has become highly popular. It allows individuals to communicate in noisy environments and when verbal conversations are inappropriate. It is particularly beneficial for people who are deaf or hard of hearing, who may not be able to hold a verbal conversation. Cell phones with text messaging and dedicated text messaging devices are very popular among users who are hearing impaired. However, text messaging is a somewhat slower communication method, and it is difficult to share and perceive emotion accurately

from text messaging. Inclusion in design will have a high impact for people who are deaf or hard of hearing and low impact for other population groups. Text messaging will help resolve the issue of not being able to receive auditory information by providing a viable alternative.

Vibrating alerts and visual indicators: Vibrating alerts are an alternative to auditory alerts. Vibrating alerts are valuable for all users in various situational contexts, such as a business meeting; but they really enhance accessibility for people who are hard of hearing and deaf, who may not otherwise be able to detect an incoming call. Inclusion in design will have a high impact for users who are deaf, a medium impact for users who are hard of hearing, and a low impact for all other users. Vibrating alerts will help resolve the issue of not being able to receive auditory information. Visual indicators may be in the form of a change in text display or a light. They serve as an alternative or supplement to vibrating and auditory alerts. Visual indicators are particularly beneficial for people who are deaf or hard of hearing . Inclusion in design will have a high impact for users who are deaf, a medium impact for those who are hard of hearing, and a low impact for all others. Visual indicators will also help resolve the issue of not being able to receive auditory information.

Cradle that attaches to mobility aid: A mobile holder is a mounting mechanism that can be attached to a wheelchair or other mobility aid or installed in a car to provide a consistent, secure place to store the cell phone. It also facilitates one-handed dialing by eliminating the need to simultaneously hold the phone and manipulate the controls. Mobile holders are particularly useful for people with upper mobility impairments. Inclusion in design will have a high impact for this group and a low impact for other groups, and it will help resolve the issue of not being able to lift and hold the device.

Raised area (nib) on the "5" key: A nib is a raised area that helps users identify the location of the center of the keypad so they can then determine the position of the remaining keys. Given a standard telephone keypad layout with the addition of nonnumeric keys, the nib helps the user (particularly the user with a visual impairment) find the "5" key, from which the remaining numeric keys can be easily identified. Inclusion in design will have a high impact for users who are blind, a medium impact for those with low vision, and a neutral impact for other users. It will help resolve the issue of not being able to locate and identify controls.

Keypress feedback: Tactile feedback results from the keys springing back to position once pressed, and it is typically accompanied by a clicking sound. Both feedbacks are indicators that the key has been pressed and input accepted. Touchscreens lack both tactile and tonal feedback. Inclusion of keypress feedback in design will have a high impact for those who are blind, a medium impact for those with low vision, and a low impact for other users.

TTY compatibility: A TTY is a small device with a keyboard that allows the user to type input rather than speak. This is then transmitted to the person on the other end of the line, who must also have a TTY device or use a relay service to translate from text to voice. Inclusion of TTY compatibility in design will have a high impact for people who are deaf or hard of hearing and a neutral impact for other users. It will help solve the issue of not being able to receive auditory information. Text messaging is a good alternative to TTY if all parties have access to it.

Voice tag for menu navigation: Voice tags are spoken commands that can be used to bypass keypress inputs to control the phone. Voice tag use is quite common, though it is most beneficial for those with vision and mobility impairments who might otherwise not be able to make accurate inputs. Inclusion in design will have a high impact for these groups and a low impact for all others. It

will resolve the issues of not being able to locate and identify controls, not being able to receive visual information, difficulty with inputting information, and difficulty finding desired features.

Zoom display: A zoom display provides the option to increase the text size, reducing the number of lines of text available at any given time. Inclusion in design will have a medium impact for users with low vision and a low impact for others. It will help resolve the issue of not being able to receive visual information.

Brightly backlit display: Backlighting provides the option to adjust the screen lighting to accommodate low-light conditions. This is useful for all individuals in some contexts and is useful for users with low vision in a wider variety of conditions. Inclusion in design will have a medium impact for users with low vision and a low impact for all other users. It will help resolve the issue of not being able to receive visual information.

Adjustable volume: Volume control is important for both auditory alerts and conversation. It is particularly important for hard-of-hearing people, but it is useful for all. Inclusion in design will have a medium impact for hard-of-hearing people and a low impact for all other users. It will help resolve the issue of not being able to receive auditory information.

Icon/graphic menu: Pictorial representations as text alternatives generally allow for more information to be presented on a single screen. They are particularly useful for people who might have a reading impairment. They also provide the opportunity to declutter the screen, which is useful for users who have low vision or cognitive disabilities (if good metaphors are used). Inclusion in design will have a medium impact for users with low vision and users with cognitive disabilities (unless implemented with poor metaphors, in which case it may have a negative

impact for users with cognitive disabilities). This will help resolve the accessibility issue of difficulty interpreting textual information.

Audio cue capability: Audio alerts are typically used to identify conditions such as a low battery. They are most useful for those with vision impairments and others in low-light conditions. Other people enjoy auditory displays and will use them, though they do not enhance their accessibility. Inclusion in design will have a high impact for people who are blind, a medium impact for those with low vision or upper mobility and cognitive disabilities, and a low impact for all others. It will help resolve the issue of not being able to receive visual information.

External audio output (via headset): External audio output allows the user to carry on a conversation without needing to hold the phone. Amplified headsets enhance the sound output to increase the clarity of the information. Amplification is not strictly volume level, but more an intensity of different signals. Headsets help to concentrate the sound at the ear while blocking out some environmental noises. External audio is particularly useful for people who have upper mobility disabilities; if implemented in design, it will have a high impact. If the headset is amplified, it will have a high impact for hard-of-hearing users and will help resolve the issue of not being able to understand speech information. It will have a low impact for other users.

Keys on the keypad that are discernible by touch: Tactile separators typically provide either raised or indented spaces between controls to assist in tactile differentiation of numeric keys from other keys. Inclusion in design will have a high impact for those who are blind, a medium impact for those with upper mobility impairments, and a low impact for all others. It will help resolve the issues of not being able to locate and identify controls and not being able to make accurate inputs.

Voiced menu options: Voiced menu options provide verbal output of the different menu screens, allowing the user to make appropriate inputs without having to see the display. This greatly increases the number of features that benefit a visually impaired user, in particular. Inclusion in design will have a high impact for those who are blind or have low vision, a medium impact for those with upper mobility impairments, and a low impact for all others. It will help resolve the issues of not being able to read text on the screen or to locate and identify controls.

Screen magnifiers: Screen magnifiers increase the size of the text on the display. Inclusion in the design will have a high impact for those who have low vision and a low impact for all other users. It will help resolve the issue of not being able to read text on the screen.

Larger keys on the keypad: Larger keys on the keypad increase the ability to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have poor fine motor control and a low impact for all other users. It will help resolve the issue of having difficulty making accurate inputs.

More space between keys on the keypad: More space between the keys increases the ability to differentiate the keys by touch and to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have an upper mobility impairment and a low impact for all other users. It will help resolve the issue of having difficulty locating controls and making accurate inputs.

Talking battery-level indicators: Talking battery-level indicators provide users who cannot see the screen with necessary information about the need to charge the phone. Inclusion in design will have a high impact for those who are blind and

have low vision and a low impact for all other users. It will help resolve the issue of not being able to read the display.

Talking signal-strength indicators: Talking signal-strength indicators provide users who cannot see the screen with necessary information about the availability of coverage to successfully make and receive calls. Inclusion in design will have a high impact for those who are blind and have low vision and a low impact for all other users. It will help resolve the issue of not being able to read the display.

Talking caller-ID: Talking caller-ID provides users, particularly those with visual impairments, with information about an incoming call. Caller-ID allows users to identify the caller before answering the phone, permitting the user to decide not to answer without worrying about missing an important call. Inclusion in design will have a high impact for those who are blind or have low vision and a low impact for all other users. It will help resolve the issue of not being able to read text on the screen.

Large fonts on the display: Large fonts increase the text size on the display. Inclusion in design will have a high impact for those with low vision, a low impact for users who are blind, and a medium impact for all other users. It will help resolve the issue of not being able to read text on the screen.

Large display screens: Large display screens reduce screen clutter and increase the space available for larger text and graphics. Inclusion in design will have a medium impact for low vision users and a low impact for all others. It will help resolve the issue of not being able to read text on the screen.

Simplified connector for power: Simplified connectors for power allow the user to use a single hand with minimal pinching or grasping to connect the power cord to the device. Simplified connectors are not limited to insertion in a single

orientation. Inclusion in design with have a medium impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users.

Simplified connector for headsets: Simplified connectors for headsets allow the user to use a single hand with minimal pinching or grasping to connect the headset cord to the device. Simplified connectors are not limited to insertion in a single orientation. Inclusion in design with have a medium impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users.

Hearing aid compatibility: Hearing aid compatibility includes both the ability for someone using a hearing aid to use the cell phone without interference and the ability to be in proximity of someone else using a cell phone without experiencing interference. Inclusion in design will have a high impact for users who are hard of hearing and a low impact for all others. Hearing aid compatibility will help resolve the issue of not being able to receive auditory information.

Concave keys on the keypads: Concave or inwardly curved keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. This type of key also increases the ability to differentiate the keys from each other and from the surrounding area on the device. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Concave keys will help resolve the issue of locating controls and making accurate inputs.

Keys that can be operated without human contact: Some individuals use pointing devices or other mechanisms to help them reach or activate controls. Some devices require moisture content or heat (characteristics of touch) to activate

the controls; these devices cannot be used by someone who needs to use an alternative input device. Controls that are operable without physical human contact will have a high impact for someone with an upper mobility impairment and a low impact for all other users.

Rubberized keys: Rubberized keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. Textured keys also help the user differentiate the key itself from the surface of the device, particularly if the keys are not raised sufficiently. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Rubberized keys will help resolve the issues of locating controls and making accurate inputs.

Speakerphone: A speakerphone allows the user to carry on a conversation without needing to hold the phone. This is particularly useful for people who have upper mobility disabilities; if implemented in design, it will have a high impact. It will have a low impact for other users. A speakerphone will help resolve the issue of not being able to receive auditory information.

Additional features that may enhance accessibility are described in this discussion of an accessible phone: http://www.trace.wisc.edu/docs/phones/tcrd1/summary/index.htm. These features include:

Key shape: Keys can be shaped to be associated with their function. This can help someone relying on the tactile sense to better differentiate keys and may help those with cognitive disabilities to learn the appropriate use of various controls. Inclusion in design will have a high impact for people who are blind, a medium impact for people who have cognitive disabilities, and a low impact for all others.

Help request key: A help request key allows the user to press a designated key and then press another key to get information (verbal output), such as the status of a function or the function name for the selected key. Implementation in design will have a medium impact for those who are blind and a neutral impact for all other users. It will help resolve the issues of not being able to locate and identify controls or not being able to receive visual information.

Key confirmation: Key confirmation provides feedback about the selected option before activation of the control. It then requires the user to confirm the selection to implement activation. Key confirmation helps to prevent accidental activation, which is especially common for those who are blind or have upper mobility impairments. Implementation in design will have a medium impact for both of these groups and a neutral impact for others. (If key confirmation is not optional, it might have a negative impact for other users by slowing their transactions.) It will help resolve the issue of having difficulty locating controls and making accurate inputs.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to cell phones address telecommunications (1194.23), self-contained closed products (1194.25), functional performance requirements (1194.31), and documentation (1194.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another.

The following section 508 regulations are seen as issues for cell phones:

- TTY compatibility.
- Verify that all controls and keys are tactilely discernible without activating the controls or keys. Many of the keys on cell phones do not have adequate tactile separators or a sufficient nib on the "5" key to facilitate tactile differentiation.

- The status of all locking or toggle controls or keys must be visually discernible and discernible either through touch or sound. The status of the phone when it is locked is available only visually.
- When products provide auditory output, the audio signal must be provided at a standard signal level through an industry standard connector that will allow for private listening. Some cell phones use proprietary connectors.
- Verify that at least one mode of operation and information retrieval is provided that does not require user vision or, alternatively, that support is provided for assistive technology used by people who are blind or visually impaired. The majority of information is provided through a text display on the cell phone, which cannot be seen by a user who is blind.
- At least one mode of operation and information retrieval that does not require visual acuity greater than 20/70 must be provided in audio and enlarged print output, working together or independently, or support for AT used by people who are visually impaired must be provided. Cell phones do not provide voice output, and they typically do not use more than a 10-point font, which is inadequate for someone with low vision.
- Where audio information is important for the use of a product, at least one mode of operation and information retrieval shall be provided in an enhanced auditory fashion, or support for assistive hearing devices must be provided. While many cell phones are designated as hearing aid compatible and loopsets are available for some phones, they do not work for all people with hearing aids. Some cell phones also provide insufficient volume control to assist those with hearing impairments.

Distance Learning Software

Distance learning is an excellent option for people with limited mobility or restricted schedules and those not near an educational provider. There are some human limitations, however, that make distance learning either inaccessible or difficult to use. People who have visual impairments may have difficulty accessing visual information and making accurate inputs.

People who are deaf or hard of hearing may have difficulty accessing auditory information. People who have a mobility disability may have difficulty making accurate inputs and responding quickly enough to prompts. People who have cognitive disabilities may have difficulty understanding the language and responding quickly enough to prompts. Each of these challenges can be overcome, to some extent, through proper design (Tabs, 2003).

Streaming media are audio and video distributed in real time over the Internet. "Streaming" means the file can be viewed and heard before it is fully downloaded. An initial portion of the file is downloaded, or buffered, and begins playing, while the remainder of the file arrives in a continuous stream. Streaming media often refers not only to media distributed in real time, but to any media downloaded from the Internet.

In general, two sets of users will benefit most from streaming video that is accessible: people who are deaf or hard of hearing, and those who are blind or have low vision. People who are deaf or hard of hearing rely on captions to understand the audio content. People who are blind or have low vision rely on an audio description of the video content. However, as with all universal design, everyone benefits when streaming media is made accessible, even the provider of the streaming media. For example, captions can be made searchable, allowing for a much more elaborate video clip search and retrieval system. Captions also make streaming media more accessible for individuals who do not speak English, those for whom English is their second language, and those for whom printed English is more accessible than spoken English. Captions have also been shown to consistently improve reading retention of presented material.

Background

There are two main pieces of legislation that dictate accessibility of streaming media. The most obvious is the Americans with Disabilities Act of 1990, which requires that all public programs and services be accessible to people with disabilities. The second and most relevant piece of legislation is section 508, which was signed into law in August 1998 and became effective in June 2001. Section 508 requires that E&IT used by the Federal Government be accessible by

people with disabilities and that accessibility must be comparable to that provided to the public without disabilities.

The provision of captioning for Internet video streams is still in its infancy when compared to the captioning of television programming. In some ways, captioning video streams is a more challenging problem because of the number of different video formats that must be considered. There is not at present any single, predominant standard for the captioning of Internet video streams. Several similar but distinct techniques are used; the techniques that are available depend on the format of the video stream. Three major formats are Apple's Quicktime, Microsoft's Windows Media, and Real's RealPlayer. Each format has software bugs and some level of unreliability with respect to captioning.

Windows Media

Windows Media Player adds captions using Microsoft's Synchronized Accessible Media Interchange (SAMI). SAMI is an extensible markup language (XML) based text language. SAMI files contain the actual captions, as well as information about when and how the captions should display. SAMI is structured very similarly to hypertext markup language (HTML), and many HTML formatting tags are allowed in SAMI. Broadly speaking, SAMI files consist of caption text with tags specifying the appearance of the text and time tags that control when each caption should be displayed (in terms of elapsed milliseconds from the start of the media file). SAMI files can be created in any text editor, though using a captioning program such as MAGpie to enter caption times simplifies the process.

There are two ways of adding captions to a media file. If the media file is embedded in a Web page (a practice that is not recommended for accessibility), code can be added to the Web page to display the captions along with the video. The recommended method involves creating a third file, called an active streaming XML (ASX) file. The ASX file is a pointer file that contains details about the media presentation and tells Windows Media Player which files (media and captions) to retrieve and play.

RealPlayer

RealPlayer uses the Synchronized Multimedia Integration Language (SMIL), developed by the World Wide Web Consortium (W3C), to choreograph the presentation of video and captions. SMIL is written as an XML application.

To caption a RealPlayer file, a RealText file containing caption text, timing, and formatting information is created. The RealText file can be created in any text editor, but using a captioning program such as MAGpie to enter caption times simplifies the process. Next, an SMIL file must be created that links the video (RealPlayer) file and the caption (RealText) file, and creates the screen regions in which the video and caption files will be played. Links to the SMIL files must be provided in the form of real audio movie (RAM) files. The link points to the RAM file, which in turn points to the SMIL file, which in turn points to the RealPlayer and RealText files. The video file can also be embedded in a Web page, but this practice is not recommended because of the accessibility problems it creates.

Quicktime

There are two methods for captioning Quicktime movies. The first involves creating a Quicktime text track and making it a part of the Quicktime movie. The result is a single file that contains audio, video, and captions. Quicktime Pro is required for this method. The second method involves creating a text track movie as a separate file, which is then synchronized with the movie with SMIL (as described above for RealPlayer).

In either case, a caption file must be created. This file can be created using any text editor or by using MAGpie. In the first method, Quicktime Pro is used to convert the caption file to a text track and merge it with the video file. In the second method, a separate SMIL file is created. There are a number of ways to access captioned Quicktime movies. If the captions are embedded in the movie, a direct link to the movie can be provided. Quicktime movies (or SMIL files) can be embedded into Web pages; this is an accessible option for Quicktime, because there is an

option to make the control bar visible on the screen. Code can also be included in a Web page that will open a Quicktime movie or SMIL presentation in the Quicktime player.

Task-Based Accessibility Analysis

The core functionality considered to be necessary to effectively use distance learning programs consists of the following:

- Logging in to the system
- Navigating the system
- Obtaining content—text, auditory, visual (graphics, videos)
- Filling out forms
- Reading email messages
- Using Instant Messaging software
- Reading documents in Microsoft Word format
- Reading documents in Adobe PDF format
- Viewing presentations in Microsoft PowerPoint format
- Using chat software

Additional functionality that is typically inherent in distance learning design includes the following:

- Participating in audio or video conferencing

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, and the design of the system being used. Accessibility issues for each disability population were identified, along with an impact rating for each issue. The issues identified and the impact ratings

assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various distance learning providers' marketing data produced features identified as accessible design components. Each of these components is listed, along with a description of the component and an assessment of the usefulness of the feature for disability groups. Some of these features may have been designed with a particular disability population in mind; others may have been designed simply as desirable features. In many cases, the accessibility features benefit or are used by a variety of people, and they may be considered to provide universal access. Each of the accessibility features listed below is a function of the distance learning software as well as the content developed by an administrative user of the software. Each of the features has the capability to be implemented in distance learning if the content developers include it in the course materials. Distance learning vendors provide guidance for course developers that addresses many of these issues.

> **Use of alt tags:** Alt tags provided with images allow screen reader users to obtain information about the images that are present on the page. Without alt tags, a blind person using a screen reader may know only that an image is present but will have no idea what it represents. In addition, alt tags can be used as a means to ignore images that exist for aesthetic reasons and do not provide important information by providing blank or null alt text for the image, which simplifies the process of obtaining information through a screen reader. Implementation in design will have a high impact for those who are blind, a medium impact for those who have low vision, and a low impact for all others. It will help resolve the issue of being unable to receive important visual information, and in some cases, of having difficulty interpreting visual information.

Synchronized multimedia: Multimedia can consist of text, video, audio, and other content. Sometimes multiple sensory outputs are provided but not directly in parallel, which can be confusing for the individual performing multiple sensory processing. Multimedia should be synchronized with the material, or there should be linked multimedia files containing synchronized equivalent alternatives to assist those who may benefit from redundant information sources. Synchronized multimedia will have a medium impact on most users.

All information conveyed with color is also available without color: Color is a very good tool for grouping controls or identifying important information, as long as the viewer can see and differentiate color. Color provides a means to create contrast, code objects, and provide meaning without words. However, some people with visual impairments cannot benefit from the use of color, and the meaning may be lost to some people with cognitive disabilities. Therefore, while color is useful and should be used, it should not be the only means to differentiate objects, provide structure, or present useful information. Anything represented with color should also be available without color. Following this guideline in design will have a high impact for users who are blind or have low vision, a medium impact for users with cognitive difficulties, and a low impact for other users. Ensuring that no information is conveyed with color alone will help resolve the issues of not being able to receive important visual information and not being able to interpret some visual information.

Documents are organized so they are readable without requiring an associated style sheet: When documents require style sheets, individuals may not be able to control the appearance (font size, etc.) of the information on the page or to use their own customized style sheet. This may create problems for those who use screen readers. Implementing pages that are readable without style sheets will

have a high impact for those with visual impairments. It will help resolve the issue of not being able to receive visual information.

Only client-side image maps are used (or, redundant text links are provided for each active region of a server-side image map): Client-side image maps make information available to people browsing with nongraphical user agents and offer immediate feedback as to whether or not the pointer is over an active region. Implementation of only client-side image maps in design will have a high impact for users who are blind and a medium impact for those with low vision. There will be a low impact for all other users. It will help resolve the issue of not being able to receive visual information.

Row and column headers are provided for data tables in order to take advantage of newer screen reader capabilities to process this additional information: Tables that are not constructed in an organized fashion with headers to describe the row and column contents are very difficult to interpret for someone relying on a screen reader. Headers can help the individual determine the organization of the information being presented. This facilitates navigation through the table and comprehension of the information contained in the table. Implementation in design will have a high impact for those who are blind, a medium impact for those who have low vision, and a neutral impact for all others. It will help resolve the issue of not being able to receive visual information.

Framesets are titled to facilitate identification and navigation: Frame titles let users know, for example, whether they are in the navigation frame or the content frame. Providing titles helps a person using a screen reader distinguish the organization of the information and facilitates navigation. Implementation in design will have a high impact for people who are blind and a low impact for all

other users. It will help resolve the issue of not being able to receive visual information.

Pages are designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz: Some flicker frequencies can induce visual seizures. Flicker is most often an issue for animations, and pages should be designed so that only appropriate animations are used. Moving content can cause difficulty for people with low vision and cognitive disabilities, particularly if they must react at the same speed to click an object, for example. In addition, screen readers cannot read moving text. Implementation in design will have a high impact for those who are susceptible to visual seizures; a medium impact for those who have low vision, cognitive disabilities, or upper mobility impairments; and a low impact for other users. It will help resolve the issues of not being able to receive visual information, having difficulty interpreting visual information, and having difficulty making inputs, particularly when there is a time constraint.

Dynamic scripting is not used for content presentation: Dynamic scripting can be problematic for screen readers, sometimes providing an inaccurate description of the page content and preventing the user from receiving the same information that can be obtained visually. Implementation in design will have a high impact for users with no vision, a medium impact for users with low vision, and a neutral impact for other users. It will help resolve the issue of not being able to receive visual information.

Plug-ins are supported as embedded content or as automatically launched files: Some plug-ins that require interaction will only work with mouse input, which excludes a large number of users. Appropriately applied plug-ins implemented in design will have a high impact for those who are blind or have upper mobility impairments, a medium impact for those with low vision, and a

neutral impact for the remainder of users. They will help resolve the issue of not being able to receive visual information and make appropriate inputs.

Form labels are placed next to the form input elements that are referenced, including input boxes and radio buttons: This allows screen reader users to appropriately associate labels with the form elements. A user should be able to fill out the form with either keyboard or mouse input. Implementation in design will have a high impact for those who have visual or cognitive disabilities and a low impact for all other users. It will help resolve the issues of not being able to receive visual information and of having difficulty interpreting visual information.

For navigation links located in the body of the main content page, code exists to allow screen readers to detect and skip the navigation links: When navigation links are in the main content page, they are read each time the page is accessed. This can be very time-consuming and unnecessary for someone using a screen reader to find or review a part of the page. Providing a means for the user to skip over the navigation links allows the user to read through the page and get to the needed information more easily and quickly. Implementation in design will have a high impact for those who are blind and a medium impact for those with low vision. It will help resolve the issue of not being able to receive visual information.

Session timeout settings can be modified by the system administrator to allow for more time, if necessary: Some systems require an input within a certain amount of time before they end the session; this provides security and helps free up access to others. However, some people cannot respond in appropriate time limits because they are using a screen reader, which takes longer than expected to process the page; they themselves are slow to process the page content; or they have difficulty with fine motor control and making appropriate inputs. If time-dependent

settings can be controlled as needed for individuals, it will have a high impact for those who are blind or have cognitive disabilities or upper mobility impairments. It will help resolve the issues of not being able to receive visual information and having difficulty making inputs.

Online help documentation is provided describing layout, context, functionality of each feature, and instructions for using the features: Some systems may use functionality that is atypical or not intuitive, particularly for those who cannot visually explore the contents. Implementation of online help documentation will have a medium impact for those with visual or cognitive disabilities and a low impact for all other users.

Additional features we feel would make a distance learning program accessible include the following:

Screen reader compatibility: Screen readers allow users to obtain information without visually perceiving it. Visual information is translated into auditory output that is read to the user. The most common users of screen reading technology are those who are blind or have low vision. Implementation in design will have a high impact for those who are blind, a medium impact for those with low vision, and a neutral impact for all others. Screen reading compatibility will help resolve the issue of not being able to receive visual information.

Printed materials available in alternative formats: Alternative formats include large print, Braille, and audio. They mostly benefit users with visual impairments, providing a high impact for that user group. Distribution of documents in an accessible electronic format that is convertible is often preferred. It will help resolve the issue of not being able to receive visual information.

Uncluttered pages, pages that are well organized, and pages that don't have backgrounds that interfere with processing foreground information: Pages with a lot of information, colors, patterns, and movement can be very difficult for some people to process. Avoiding these things in design will have a medium impact on those with low vision and cognitive disabilities. It will help resolve the issues of having difficulty receiving and interpreting visual information and having difficulty finding desired features.

Consistent layouts from page to page: Information that is organized in a similar fashion from one page to the next helps the user to quickly find items of interest. Implementation in design will have a medium impact for those who have a cognitive disability and a low impact for all other users. It will help resolve the issues of having difficulty receiving and interpreting visual information and having difficulty finding desired features.

Closed-captioned video: Videos, audio clips, and live presentations naturally have audio output, but they do not readily have comparable visual output available. Graphics and text to describe the audio information, particularly direct transcriptions, can greatly enhance the accessibility of this information for those with hearing impairments, having a high impact for this population of users. It will help resolve the issue of not being able to receive auditory information.

A text-only page, with equivalent information or functionality, should be provided when accessibility cannot be achieved in any other way: The content of the text-only page should be updated whenever the primary page changes. This will have a high impact for those who are blind, a medium impact for those with low vision, and a low impact for other users. It will help solve the issue of not being able to receive visual information.

User manuals in alternative formats: Alternative formats include large print, Braille, and audio. Inclusion in design will have a high positive impact for users who are blind or have low vision, possibly the same for those with hearing impairments (depending on the original format), and no impact for other disability populations. It will help resolve the issue of not being able to receive visual (and possibly auditory) information.

Screen magnifier compatibility: A screen magnifier increases the size of the display and button labels to enhance the readability for those with low vision. It is an alternative, particularly if adjustable screen resolution and font size are unavailable. Implementation in design will have a medium impact for those with low vision and a neutral impact for other users. It will help resolve the issues of not being able to receive visual information and not being able to locate and identify controls.

Adjustable font sizes: Small fonts are very difficult to read for users with low vision, who typically need to squint or use a magnifying glass to read them. They are also more difficult to read under low-light conditions and when users are fatigued. Implementation in design of adjustable font sizes will have a high impact on users with low vision and, with the exception of people who are blind, a low impact on all other users. It will help resolve the issue of not being able to receive visual information.

Adjustable contrast: Adjustable contrast provides the option for users to adjust the color or brightness of the foreground and background colors to increase clarity. Inclusion in design will have a high impact for those with low vision and most users under very bright- or low-light conditions. It will have a low impact for other disability populations. Adjustable contrast will help resolve the issue of not being able to receive visual information.

Graphics that are described in detail: Graphics may be impossible to see for a person who is blind, difficult to see and interpret for those who have low vision, and difficult to understand for those who do not learn well from pictures. Inclusion of detailed descriptions will have a high impact for those who are blind or have low vision, and a low to medium impact for all other users. Described graphics will help resolve the issue of not being able to receive visual information.

Video that is described in detail: Video may be impossible to see for a person who is blind and difficult to see for those who have low vision or are limited to small video screens with insufficient resolution. Inclusion of detailed descriptions will have a high impact for those who are blind or have low vision, and a low impact for all other users. Described video will help resolve the issue of not being able to receive visual information.

Adjustable volume: Volume control is important for auditory information and alerts. This is particularly important for hard-of-hearing people, but it is useful for all. Inclusion in design will have a medium impact for hard-of-hearing people and a low impact for all other users. It will help resolve the issue of not being able to receive auditory information.

Ability to request additional time: Ability to request additional time allows the user to be able to complete a transaction despite the need to use more than the normal amount of allotted time to complete individual transaction components. Inclusion in design will have a high impact for most users, depending on the output mode (visual or auditory) from the device. Additional time will help resolve the issues of not being able to receive visual or auditory information and having difficulty with control inputs.

Voice recognition: Voice recognition allows the user to provide inputs verbally rather than through mechanical keypresses. Voice recognition is particularly useful for those who cannot see to make the correct inputs or cannot reach or have difficulty activating mechanical controls. Implementation in design will have a high impact for those who are blind, a medium impact for those who have low vision or an upper mobility impairment, and a low impact for other users. It will help resolve the issues of having difficulty entering/inputting information, difficulty making accurate inputs, difficulty lifting and holding the device, and possibly difficulty finding desired features and interpreting visual information.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to distance learning address software applications and operating systems (1194.21), Web-based Intranet and Internet information and applications (1194.22), video and multimedia products (1194.24), functional performance requirements (1191.31), and documentation (1191.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another.

The following section 508 regulations are seen as issues for distance learning:

- Sufficient information about a user interface element, including the identity, operation, and state of the element, must be available to assistive technology. When an image represents a program element, the information conveyed by the image must also be available in text. The creators of distance learning content do not always provide text equivalents for graphical information. Some features of the software interface are not recognized by screen readers.
- A text equivalent for every nontext element must be provided (e.g., via “alt,” “longdesc,” or in-element content). The creators of distance learning content do not always provide text equivalents for graphical information.

- Equivalent alternatives for any multimedia presentation must be synchronized with the presentation. Equivalent alternatives are often not provided and are typically not synched when they are available.
- At least one mode of operation and information retrieval must be provided that does not require user vision or, alternatively, that support for assistive technology used by people who are blind or visually impaired is provided. Much content is provided in a graphical fashion that cannot be seen by those with visual limitations and that cannot be read by a screen reader.
- At least one mode of operation and information retrieval that does not require user hearing must be provided, or support for AT used by people who are deaf or hard of hearing must be provided. Distance learning content is often provided in an auditory fashion without closed-captioning or text to accompany the output.

Personal Digital Assistants

Despite their popularity and their capabilities, PDAs are not accessible to everyone. There are some human limitations that make PDAs either inaccessible or difficult to use (and therefore perhaps undesirable). People who have visual impairments may have difficulty accessing visual information and providing accurate inputs. People who are deaf or hard of hearing may have difficulty detecting auditory alerts. People who have a mobility disability may have difficulty simultaneously handling the PDA and manipulating the controls. People who have cognitive disabilities may have difficulty understanding metaphors and jargon and remembering how to access information. Each of these challenges can be overcome, to some extent, through proper design.

Background

Personal digital assistants are popular for both personal and business use. There are thousands of applications available for PDAs, many of them free, that support a wide range of activities. PDAs have the potential to provide benefits to individuals with disabilities, but they are not currently

accessible to all users. Users generally interact with PDAs by use of a small stylus for input and a small screen for output, producing barriers for users with visual or mobility impairments in particular.

Text Input and Output

To assist people who are unable to use the stylus, nearly all PDAs support the attachment of various types of keyboards, including those that support one-handed typing such as the halfkeyboard.

The AlphaPad is a software application for PalmOS and Window CE that uses a 12-key keyboard along with word prediction software. The keyboard is displayed on a touchscreen, so fine motor control is necessary, but it could be useful for low-mobility users. Thumbscript is another text-entry system that uses gestures on a nine-button grid to produce characters. It is compatible with any device having eight actuation points arranged radially around a center and may be useful for users with mobility impairments. There are a number of other variations on stylus-based text entry, as well.

Several products provide some degree of voice interaction with PDAs. IBM has released a version of its ViaVoice application for Pocket PCs. This application serves as a text-to-speech screen reader and also allows user input utilizing a limited command vocabulary. ScanSoft's Dragon PDsay provides similar functionality for Pocket PCs. Both of these products are command-based and don't support dictation or application-specific functionality beyond a basic core set of popular applications.

Display Features

TealMagnify is a screen magnifier for PalmOS that may be of use to people with visual impairments, although it requires users to touch a button on the PDA to activate it and apparently produces rather pixilated results.

For users with low vision, many PDAs are now available with bright color displays. Palm claims that some (but not all) of its color models provide a variety of color and contrast adjustments for users with visual impairments, and there are a number of third-party applications that allow customization of display colors. Pocket PCs apparently can also be modified to provide a higher contrast color scheme.

PDAs Designed Specifically for Users with Disabilities

Enkidu makes a line of portable communication devices known as the IMPACT family that is designed specifically for users with various disabilities. These devices provide speech output and support input via touchscreen, integrated buttons, keyboard, or external switches.

Task-Based Accessibility Analysis

The core functionality considered to be necessary to effectively use a PDA consists of the following:

- Locating the PDA
- Turning the PDA on and off
- Storing an appointment
- Recalling an appointment
- Viewing the calendar
- Using the calculator
- Making and retrieving a memo or notes
- Storing contact information
- Recalling contact information
- Reading/composing/sending email
- Making and retrieving a TO DO list entry

- Syncing with a computer
- Adjusting screen contrast
- Adjusting font sizes
- Receiving an alert
- Detecting battery status
- Charging or replacing batteries
- Installing software

Additional functionality that is typically inherent in PDA design includes the following:

- Tracking expenses

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, and the design of the PDA. Accessibility issues for each disability population were identified (taken in part from www.techdis.ac.uk/PDA/front.htm), along with an impact rating for each issue. The disability populations include people who have an impairment resulting from environmental or situational factors. The issues identified and the impact ratings assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various PDA manufacturers' marketing data produced few features identified as accessible design components. Each accessibility feature is listed, along with its description, a determination of availability in the product line, and an assessment of whether the feature actually improves accessibility.

> **Screen reader compatibility:** Screen readers allow users to obtain information without the need to perceive it visually. Visual information is translated into auditory output that is read to the user. The most common users of screen reading

technology are people who are blind or have low vision. Implementation in design will have a high impact for these groups and a neutral impact for other groups. It will help resolve the issue of not being able to receive visual information. Jaws and other screen readers are not available for mainstream PDAs. ViaVoice is available, but it is designed more for voice input than output, and output is very limited. ViaVoice provides some options for a person who is blind trying to use a PDA, but it is not a substitute for a screen reader.

Additional features that would make a PDA accessible include the following (taken in part from www.techdis.ac.uk/PDA/front.htm):

Adjustable display resolution: Display resolution affects the quality of the visual images provided as well as the amount of information that can be seen at a single time. Someone with low vision, for example, may need a lower display resolution, which increases the size of the images, in order to clearly interpret the information provided. Thus, allowing the display resolution to be adjusted enhances the accessibility for various individuals. If implemented in design, it will have a high impact on those with low vision and, with the exception of people who are blind, a medium impact on other users. It will help resolve the issue of not being able to receive visual information.

Adjustable font size: Small fonts are very difficult to read for users with low vision, who typically need to squint or use a magnifying glass to read them. They are also more difficult to read under low-light conditions and when users are fatigued. Implementation in design of adjustable font sizes will have a high impact on users with low vision and, with the exception of people who are blind, a low impact on all other users. It will help resolve the issue of not being able to receive visual information.

Adjustable contrast control: Adjustable contrast provides the option for users to adjust the color or brightness of the foreground and background shades to increase clarity. Ease of contrast adjustment, for example, through a hardware control, greatly improves the accessibility for many individuals, but it could mean the difference between being able to use the PDA and not for a low-vision user. Inclusion in design will have a high impact for those with low vision and most users under very bright- or low-light conditions. It will have a low impact for other disability populations. Adjustable contrast will help resolve the issue of not being able to receive visual information.

Ability to adjust screen colors: Adjustable color provides the option for users to adjust the color or brightness of the foreground and background colors to increase clarity. Inclusion in design will have a high impact for those with low vision and for most users under very bright- or low-light conditions. It will have a low impact for other disability populations. Adjustable color will help resolve the issue of not being able to receive visual information.

Good screen lighting: Adjustable screen lighting accommodates low-light conditions. This is useful for all individuals in some contexts and can also be useful for users with low vision in a wider variety of conditions. Inclusion in design will have a medium impact for users with low vision and a low impact for all other users. It will help resolve the issue of not being able to receive visual information.

Buttons with good tactile quality: Buttons that have texture and are not slick are easier to distinguish by feel and to use without slipping and accidentally activating an adjacent control. Implementation in design will have a medium impact on those who are blind and those with upper mobility impairments. It will help resolve the

issues of having difficulty locating and identifying controls and difficulty making accurate inputs.

Adequately sized button labels and symbols: Users with low vision may have difficulty reading small labels or interpreting small symbols, particularly under low-light conditions. Implementation in design of adequately sized text and graphics on buttons will have a high impact on users with low vision and, with the exception of people who are blind, a low impact on all other users. It will help resolve the issues of not being able to receive visual information and not being able to locate and identify controls.

Voice recognition: Voice recognition provides the option to provide inputs verbally rather than through mechanical keypresses. This is particularly useful for those who cannot see to make the correct inputs or cannot reach or have difficulty activating mechanical controls. Implementation in design will have a high impact for those who are blind, a medium impact for those who have low vision or an upper mobility impairment, and a low impact for other users. It will help resolve the issues of having difficulty entering/inputting information, difficulty making accurate inputs, difficulty lifting and holding the device, and possibly the difficulties of finding desired features and interpreting visual information.

Screen magnifier compatibility: An external screen magnifier increases the size of the display and button labels to enhance the readability for those with low vision. It is an alternative, particularly if adjustable display resolution and font size are unavailable. Implementation in design will have a medium impact for those with low vision and a neutral impact for other users. It will help resolve the issues of not being able to receive visual information and not being able to locate and identify controls.

Good use of visual metaphors; simple graphical navigational aids: Graphics are very useful for people who have difficulty reading text. Graphics can help declutter a display by reducing the need for text. Implementation in design will have a high impact on the cognitively disabled, a medium impact for those with low vision, a neutral impact for people who are blind, and a low impact for all other users. It will help resolve the issues of not being able to receive or understand visual information and not being able to find desired features.

Clear menu structures: Simple menus and information organization help all users find the information they are looking for in a timely fashion. They require fewer inputs, which can be very beneficial for those who have trouble finding or manipulating controls. Implementation in design will have a high impact for all users. It will help resolve the issues of not being able to receive or understand visual information and not being able to find desired features.

Auditory, visual, and vibrating alerts: Alerts provided in a redundant fashion assist users with specific physical impairments as well as those who encounter a situation in which the normal alerting mode is insufficient. Implementation in design will have a high impact for users who are visually or hearing impaired and a medium impact for all other users. It will help resolve the issue of not being able to receive visual or auditory information.

Use of simple language (not PDA-specific technical jargon): Some individuals may have difficulty using a device simply because they do not understand the terms that are used to refer to various features. Implementation of simple language will have a high impact on users who have a cognitive disability and a medium impact on all other users. It will help resolve the issues of not being able to respond in the allotted period of time or not being able to interpret visual information.

Minimal force requirement for activating controls: The effort required to activate a control may be more than an individual can provide, preventing that individual from using the device. Implementation of minimal force will have a high impact for users with upper mobility impairments and a low impact for all other users. It will help resolve the issue of not being able to make inputs.

Input alternatives other than stylus and touchscreen controls (e.g., keyboard): Users who cannot see or who have difficulty controlling certain input devices benefit from having an alternative input mechanism. Implementation in design will have a high impact for users who are blind, have low vision, or have an upper mobility impairment. It will have a low impact for all other users. It will help resolve the issue of not being able to provide inputs.

Choice of stylus size and style: A stylus is typically a very thin, smooth-surfaced pointing device, which can be difficult for some individuals to hold onto. Implementation of choice of styli will have a high impact on those with upper mobility impairments and a neutral impact on all other users. It will help resolve the issue of not being able to make accurate inputs.

PDA cases designed with materials that increase friction and grip: A PDA case typically houses the PDA device, even while in use. The case adds to the size and potentially awkward shape of the device, which can be cumbersome for some users. Implementation of friction in design will provide a medium impact for users with upper mobility impairments and a neutral impact for all other users. It will help resolve the issue of not being able to lift and hold the device.

An overall shape and size (weight) that allows the device to be comfortably held in the average adult hand: The shape and size of a PDA can affect the ability to hold the device and, specifically, to hold and manipulate the device

simultaneously. A lightweight contoured shape will have a high medium impact on users with upper mobility impairments and a low impact on all other users. It will help resolve the issue of not being able to lift and hold the device.

The availability or feasibility of mounting brackets for use with a desk or wheelchair or in a fixed location: A mobile holder is a mounting mechanism that can be attached to a wheelchair or other mobility aid or installed in a car to provide a consistent, secure place to store the PDA. When using a PDA, people often hold the device with one hand and make inputs with the other. This is problematic for people who may be unable to hold and manipulate the device simultaneously. However, if the device were constructed so it could be secured to another surface to handle the "holding component" of using the PDA, it would increase the accessibility for those with an upper mobility impairment. If implemented in design, this feature will have a high impact for those with upper mobility impairments and a low impact for other groups. It will help resolve the issue of not being able to lift and hold the device.

Adjustable zoom: A zoom display provides the option to increase the text size predefined amounts, reducing the number of lines of text available at any given time. Inclusion in design will have a medium impact for users with low vision and a low impact for others. It will help resolve the issue of not being able to receive visual information.

Availability of user-defined alerts: Auditory alerts sometimes accompany visual alerts, which can help differentiate one from another. For those who cannot see, however, or for people who are hard of hearing, a way to make the alerts more distinct and meaningful for will increase the user's ability to process and make use of the auditory alerts by themselves. Implementation in design will have a high impact for those who are hard of hearing or have visual impairments and a low

impact for all other users. It will help resolve the issues of not being able to receive visual information and difficulty receiving auditory information.

User manuals in alternative formats: Alternative formats include large print, Braille, and audio. Inclusion in design will have a high impact for users who are blind or have low vision, a medium impact for users with upper mobility impairments, and no impact for other disability populations. It will help resolve the issues of not being able to read or handle printed materials.

Large fonts on the display: Large fonts on the display increase the text size for circumstances in which small text is difficult to read. Inclusion in design will have a high impact for those with low vision, a low impact for users who are blind, and a medium impact for all other users. It will help resolve the issue of not being able to read text on the screen.

Large display screens: Large display screens reduce screen clutter and increase the space available for larger text and graphics. Inclusion in design will have a medium impact for low vision and cognitively disabled users and a low impact for all others. It will help resolve the issue of not being able to read text on the screen.

High-contrast displays: High contrast provides the option for users to adjust the color or brightness of the foreground and background colors so that the text stands out from the background, increasing readability. Inclusion in design will have a high impact for those with low vision and most users under very bright- or low-light conditions. It will have a low impact for other disability populations. High contrast will help resolve the issue of not being able to receive visual information.

Large keys: Large keys on the keypad increase the ability to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have poor

fine motor control, and a low impact for all other users. It will help resolve the issue of having difficulty making accurate inputs.

More space between keys: More space between the keys increases the ability to differentiate the keys by touch and to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. It will help resolve the issue of having difficulty locating controls and making accurate inputs.

Keys that are discernible by touch: Tactile separators typically provide either raised or indented spaces between controls to assist in tactile differentiation of numeric keys from other keys. Inclusion in design will have a high impact for those who are blind, a medium impact for those with upper mobility impairments, and a low impact for all others. It will help resolve the issues of not being able to locate and identify controls and not being able to make accurate inputs.

Simplified connector for power: A simplified power connector allows the user to use a single hand with minimal pinching or grasping to connect the power cord to the device. Simplified connectors are not limited to insertion in a single orientation. Inclusion in design will have a medium impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users.

Simplified connector for headsets: A simplified headset connector allows the user to connect the headset cord to the device with a single hand with minimal pinching or grasping. Simplified connectors are not limited to insertion in a single orientation. Inclusion in design will have a medium impact for users who are blind,

have low vision, or have an upper mobility impairment, and a low impact for all other users.

Adjustable timeouts: Adjustable timeouts allow the individual to set the amount of time for features that have timeout settings. This accommodates those who may be slower in making inputs or who prefer to minimize the number of inputs, which may increase when a setting times out. Inclusion in design will have a medium impact for those who are blind, have low vision, or have upper mobility impairments. Adjustable timeouts will help resolve the issues of not being able to receive visual information or to respond within an allotted period of time.

Ability to request additional time: Ability to request additional time allows the user to complete a transaction despite the need to use more than the normal amount of allotted time to complete individual transaction components. Inclusion in design will have a high impact for most users, depending on the output mode (visual or auditory) from the device. Additional time will help resolve the issues of not being able to receive visual or auditory information, not being able to reach controls, and not being able to grasp objects.

Adjustable volume: Volume control is important for auditory alerts. It is particularly important for hard-of-hearing people, but it is useful for all. Inclusion in design will have a medium impact for hard-of-hearing people and a low impact for all other users. It will help resolve the issue of not being able to receive auditory information.

Concave keys on the keypads: Concave or inwardly curved keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. This type of key also increases the ability to differentiate the keys from each other and from the surrounding area on the device. Inclusion in design

will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Concave keys will help resolve the issue of locating controls and making accurate inputs.

Keys that can be operated without human contact: Some individuals use pointing devices or other mechanisms to help them reach or activate controls. Some devices require moisture content or heat to activate the controls; these devices cannot be used by someone who needs to use an alternative input device. Controls that are operable without physical human contact will have a high impact for someone with an upper mobility impairment and a low impact for all other users.

Rubberized keys: Rubberized keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. Textured keys also help the user differentiate the key itself from the surface of the device, particularly if the keys are not raised sufficiently. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Rubberized keys will help resolve the issue of locating controls and making accurate inputs.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to PDAs address self-contained closed products (1194.25), functional performance requirements (1191.31), and documentation (1191.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another.

The following section 508 regulations are seen as issues for PDAs:

- Verify that all controls and keys are tactilely discernible without activating the controls or keys. Since the PDA system is primarily touchscreen-based, it is not possible to have tactilely discernible controls unless they are redundant with hardware controls.
- Verify that this self-contained product is usable by people with disabilities, without requiring the end-user to attach assistive technology to the product. There is very little a user who is blind can accomplish with a PDA without the assistance of voice output. Unfortunately, screen reader software is not yet available for a PDA.
- Verify that at least one mode of operation and information retrieval is provided that does not require user vision or, alternatively, that support for AT used by people who are blind or visually impaired is provided. As indicated above, there is very little a user who is blind can accomplish with a PDA without the assistance of voice output. Unfortunately, screen reader software is not yet available for a PDA.
- Provide at least one mode of operation and information retrieval that does not require visual acuity greater than 20/70 in audio and enlarged print output, working together or independently, or provide support for AT used by people who are visually impaired. PDAs do not provide voice output, and they typically do not use more than a 10- or 12-point font, which is inadequate for someone with low vision. Increased font size is available only for a limited application set.

Televisions

There are some human limitations that make TVs either inaccessible or difficult to use. People who have visual impairments may have difficulty perceiving visual information and providing accurate inputs. People who are deaf or hard of hearing may have difficulty perceiving auditory information. People who have a mobility disability may have difficulty activating controls. People who have cognitive disabilities may have difficulty understanding control options.

Background

Television is the medium that entertains, informs, and educates; it can also serve as a companion to people who, because of circumstances beyond their control, are confined to their homes. Traditionally, people have used TV to get news reports and watch movies, sports events, and sitcoms. However, televisions are not currently accessible to all users. Certain services have become available to make television more accessible to users with disabilities. Closed-captioning and real-time captioning for live broadcasts have made televisions more accessible to users with hearing impairments by allowing them to understand the auditory portion of television programs. Descriptive video services have increased accessibility for users with visual impairments by allowing them to better understand the visual portion of television programs. New challenges to accessibility have been posed with the rise of digital television and interactive services, but accessible design solutions have been proposed to overcome the barriers associated with this new technology.

Closed-Captioning

In 1970, the National Bureau of Standards began investigating the possibility of using a portion of the network television signal to broadcast time information in a part of the signal not used for picture information. The American Broadcasting Company (ABC) network took part in this project; and although the project didn't work, ABC suggested that it might be possible to send captions in the unused bandwidth.

In 1971, two captioning technologies were demonstrated at the First National Conference on Television for the Hearing Impaired. A second demonstration was held at Gallaudet College on February 15, 1972. In the second demonstration, ABC presented closed-captions embedded in the normal broadcast of *The Mod Squad*. The Federal Government agreed to fund the development and testing of captioning.

In 1973, engineers at the Public Broadcasting System (PBS) started working on the project under contract to the Bureau of Education for the Handicapped of the Department of Health, Education,

and Welfare. The closed-captioning system was successfully tested that year in Washington, D.C., with the captions being broadcast using Line 21 of the vertical blanking interval. In 1976, the FCC set aside Line 21 for the transmission of closed-captions in the United States.

The first closed-captioned television series was broadcast on March 16, 1980. In 1982, the National Captioning Institute (NCI) developed real-time captioning for use in newscasts, sports events, and other live broadcasts.

NCI partnered with the ITT Corporation in the late 1980s to develop the first caption-decoding microchip that could be built directly into new television sets in 1989. In 1990, the Television Decoder Circuitry Act was passed. This Act mandated that, by mid-1993, all new television sets 13 inches or larger manufactured for sale in the United States must contain caption-decoding technology.

Also in 1990, the Americans with Disabilities Act was passed. Title III of the ADA requires that public facilities, such as hospitals, bars, shopping centers, and museums (but not movie theaters), provide access to verbal information on televisions, films, or slide shows. (Captioning is considered one way of making this information available.) Federally funded public service announcements must also be captioned.

To implement the closed-captioning requirements of the Telecommunications Act of 1996, the FCC established rules and implementation schedules for the captioning of television programming. These rules went into effect on January 1, 1998, and established an eight-year transition period for new programming. (At the end of the transition period, 100 percent of nonexempt new programs must be captioned.) A similar schedule was established for the captioning of Spanish-language programming.

Section 508 of the Rehabilitation Act, as strengthened by the Workforce Investment Act of 1998, requires that federal agencies make their E&IT accessible to people with disabilities, including employees and the general public. The requirements of section 508 apply to an agency's

procurement of E&IT, as well as to the agency's development, maintenance, or use of E&IT. All training and informational video and multimedia productions that support the agency's mission, regardless of format, must be open- or closed-captioned if they contain speech or other audio information necessary for the comprehension of the content. All training and informational video and multimedia productions that support the agency's mission, regardless of format, must include an audible description of the video content if they contain visual information necessary for the comprehension of the content.

By 1998, new standards for captioning in high definition television (HDTV) were being created. These new standards greatly expanded the capabilities of captioning for HDTV, including—

- Variable-size captions
- Multiple fonts and colors
- Different font and background styles
- More information bandwidth
- A larger symbol set

In addition to the obvious benefits to deaf and hard-of-hearing persons, captioned television is a valuable tool for young children who are learning to read, illiterate adults who are learning to read, children and adults with learning disabilities, people in public places, and people learning English as a second language.

Descriptive Video Service

Descriptive video information or descriptive video service (DVS) enables visually impaired people to better understand the visual portions of television programs. A TV program with DVS has an additional audio track with a narrator describing the setting, what actions are taking place, who is talking, and any other important information that a visually impaired person would not be able to see. The narration is timed so that the narration does not interfere with dialog.

The roots of DVS date back to the 1960s, when some attempts were made to fill in the gaps for *Star Trek* episodes through audio cassettes. In the 1970s, a former radio broadcaster began describing movies on a radio station in Philadelphia. In 1981, Margaret Pfanstiehl began describing live theatrical performances in Washington, D.C., and later developed descriptive techniques and described some programs that were broadcast over the radio reading service.

In 1985, stereo television broadcasting began. WGBH, a Boston public television station, began exploring possible ways to use the secondary audio program (SAP) audio channel to carry narrated descriptions of a program's key visual elements. The goal was to eliminate the need for a specially developed assistive device in order to receive the descriptions.

In 1988, the Corporation for Public Broadcasting awarded WGBH a grant to develop a complete business and operational plan for the permanent establishment of DVS. At the same time, WGBH funded all aspects of a national test of the service that was conducted in conjunction with PBS and other groups.

In 2000, spurred by the major networks' failure to voluntarily offer DVS, the FCC mandated the provision of DVS by broadcasters; but various groups (including the National Association of Broadcasters, the Motion Picture Association of America, and the National Cable and Telecommunications Association) challenged the mandate in court. They claimed that the FCC exceeded its authority and, by compelling speech, violated the First Amendment. The core of the issue appeared to be one of cost.

Under the FCC measure, network affiliates would have to offer four hours a week of prime time or children's shows by June 2002; cable and satellite operators would have a similar requirement for top networks. Certain programming, including live news, sports, and talk shows, would be exempt.

There were a number of legal decisions between 2000 and 2002, with courts variously upholding and overturning the FCC mandate. In mid-June 2003, Senator John McCain introduced a bill (S.

1264, FCC Reauthorization Act of 2003) that would reinstate the FCC mandate. The bill was approved by the Senate Committee on Commerce, Science, and Transportation and is now awaiting approval by the full Senate. There is no House bill as of this printing.

The application of DVS is still somewhat limited compared to closed-captioning, consisting mainly of programming on PBS and a few other networks. Certain movies for which descriptions have been developed are available by direct mail, in libraries, and in video rental stores.

Real-Time Captioning

In 1982, NCI developed real-time captioning, a process for captioning newscasts, sports events, specials, and other live broadcasts as the events are being televised. In real-time captioning, court reporters who have been trained as real-time captioners type at speeds in excess of 225 words per minute to give viewers instantaneous access to live information. The viewer sees the captions within two to three seconds of the words being spoken, with the delay resulting from the time it takes the captioner to hear the words spoken and then key the words, and for the captions to be encoded.

Real-time captioners write what they hear phonetically, using a stenotype machine (also known as a shorthand machine), which has only 24 keys and a number bar. The basic concept behind machine shorthand is phonetic, where combinations of keys represent sounds, but the theory is much more complex than straight phonics. Multiple keys can be depressed simultaneously on steno machines to create different word combinations. No two captioners write exactly the same way, so each has a custom dictionary (typically containing 50,000 to 100,000 entries) composed of the phonetics and their corresponding English that the captioner uses to build words and create punctuation. The steno then goes into a computer system, where it is translated into text and commands. The captioning software on the computer formats the stream of text into captions and sends them to a caption encoder.

Accessibility of Digital Television and Interactive Services

Interacting with a modern television set, even for an action as basic as selecting a program, has become far more complex with the advent of digital television. The digital set-top boxes (STBs) used to access digital programming offer access to a large amount of information, entertainment, and services via electronic program guides (EPGs), which require users to scroll through lots of on-screen text and graphics to select programs or access advanced features such as parental controls and advance scheduling. The highly visual nature of this style of interface has created serious barriers for consumers who are blind or have low vision.

These barriers are similar in nature to those that were created by graphical user interfaces for computer operating systems and by the rise of the World Wide Web. Over time, screen readers and other technologies emerged to provide access to these environments, but so far those solutions have not been applied to STBs for digital television. The automatic conversion of EPGs to synthesized speech has proven problematic.

In February 2001, the National Center for Accessible Media (NCAM) at Boston public broadcasting station WGBH partnered with America Online to explore ways to make interactive TV accessible to audiences who are blind or visually impaired, focusing initially on making the EPG more accessible. The assumption was that the majority of the solutions required to make the EPG accessible will also apply to making other content accessible with the STB. Funding for the research was provided by the National Institute on Disability and Rehabilitation Research.

In August 2003, NCAM published *A Developer's Guide to Creating Talking Menus for Set-top Boxes and DVDs* (NCAM, 2003). This document discusses the accessibility problems posed by the EPG and presents possible technological solutions to the problems and guidelines for content development.

According to the *Guide,* there are challenges in finding the best strategy for translating on-screen visual information into a spoken equivalent, and there are also technological challenges in actually delivering the spoken information. The primary technological challenges result from the

operating constraints of current STB hardware. The computers inside American STBs are too primitive to support the additional capability needed to provide voice output.

The *Guide* states that speech synthesis is a far more feasible solution than the use of prerecorded speech, because the number of audio samples that would be required in the latter case would be unworkable. A system could be designed where the synthesized speech is provided from a central server along with the current program guide information, but the bandwidth and storage requirements of this approach make it unfeasible. The STB itself could perform the speech synthesis, which is a trivial task for most modern computers, but until the computing power of STBs catches up with that of desktop systems, this approach is not possible.

Some other alternatives include using a more powerful third-party STB—such as a TiVO or other personal digital recorder—to do the speech synthesis, or to dispense with the STB altogether and route the cable signal through a desktop computer.

For users with low vision and/or other disabilities, the ability to adjust various aspects of the display (such as font sizes and text/background contrast settings) would be beneficial. In the article "Interactive Digital Television Services for People with Low Vision," Sylvie Perera (n.d.) advocates the use of a smart card identification system to allow low-vision users to set personal preferences for such features as text size, content layout, speech output, audio description, color combinations, timeouts, reminders, and alerts. This scheme could also be extended to assist users with other disabilities by allowing the smart card preferences to include subtitles, signing, and other features.

Task-Based Accessibility Analysis

The core functionality considered to be necessary to effectively use a TV consists of the following:

- Turning the TV on and off

- Changing the input source
- Changing the channel
- Adjusting the volume
- Activating closed-captioning (CC)
- Accessing the EPG
- Activating DVS
- Adjusting picture quality settings
- Using picture-in-picture (PIP) features

Additional functionality that is typically inherent in TV design includes the following:

- Setting the time
- Automatically or manually adding/deleting channels
- Setting the TV to turn on and off automatically

In many cases, these functions require or are facilitated by use of the remote control.

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, and the design of the TV. Accessibility issues for each disability population were identified, along with an impact rating for each issue. The disability populations include people who have an impairment resulting from environmental or situational factors. The issues identified and the impact ratings assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various TV manufacturers' marketing data produced a single feature identified as an accessible design component. This component is listed, along with a description of the

component and an assessment of the usefulness of the feature for disability groups. While this feature was designed with a particular disability population in mind, it turns out that it benefits and has been used by a much wider variety of people than anticipated and may be considered a universal design feature.

> **Closed-captioning:** Information can be obtained from TV both visually and auditorily, but the visual information is very limited for something like a news show, for example, which inhibits hearing-impaired people from benefiting from the TV as an information source. The Television Decoder Circuitry Act of 1990 requires decoder chips in U.S. TVs; as of 1993, all 13-inch or larger TVs were required to have decoder circuitry built in to provide CC. A phase-in is under way to make CC available for all TV programming. In addition to helping people who are deaf or hard of hearing, CC benefits those whose native language differs from the programming language and children or others who are learning to read (http://www.fcc.gov/cgb/consumerfacts/closedcaption.html). CC has greatly enhanced the accessibility of TV for people who are deaf or hard of hearing, having a high impact if implemented in design, and serves as a useful feature with low impact for the population as a whole. It helps resolve the issue of not being able to receive auditory information.

Additional features that would make a TV more accessible include the following:

> **Selection of SAP via a dedicated button on the remote control:** SAP is an often-used feature, most commonly used for translation of English programming into Spanish or, less commonly, to provide sign language interpretation. Access to this programming option is often nonintuitive and cannot be done quickly. Access through a dedicated remote control button would greatly enhance accessibility for those challenged by sound or cognition, having a medium impact for these groups

if implemented in design and a neutral impact for other users. It will help resolve the issue of not being able to interpret auditory or visual information.

Selection of DVS via a dedicated button on the remote control: Access to DVS is typically through a menu structure that is often nonintuitive and cannot be done quickly. Access through a dedicated remote control button would greatly enhance accessibility for those who are blind or have low vision, having a high impact for these groups if implemented in design and a neutral impact for other users. It will help resolve the issue of not being able to interpret visual information.

Selection of CC via a dedicated button on the remote control: Access to CC is typically through a menu structure that is often nonintuitive and cannot be done quickly. Access through a dedicated remote control button would greatly enhance accessibility for those challenged by sound, having a medium impact for this group if implemented in design and a neutral impact for other users. It will help resolve the issue of not being able to interpret auditory information.

Vivid picture for clarity of CC: CC is typically provided in all capital letters, which is harder to read than mixed capital and lowercase letters. In addition, the readability varies with the quality of the television on which it is viewed. For example, HDTV sets offer a higher resolution image and typically greater clarity of CC material. Good picture quality can greatly enhance accessibility of information provided textually. Implementation in design will have a high impact for those with visual and hearing impairments and a low impact for all others. It will help resolve the issues of not being able to receive auditory and visual information.

High-quality audio system: For those people who depend on the auditory output of the TV to obtain information, quality of audio output can have a large impact on ability to accurately perceive information, especially for those who have a visual

disability and cannot benefit from the redundancy provided by the images. Implementation in design will have a high impact for those who are hard of hearing and a medium impact for all other users, with the exception of those who are deaf. It will help resolve the issue of having difficulty receiving auditory information.

User manuals in alternative formats: Alternative formats include large print, Braille, and audio. Accessible electronic formats are also often acceptable. Inclusion in design will have a high impact for users who are blind or have low vision and a neutral impact for other disability populations. It will help resolve the issues of being unable to read or handle printed materials.

Voice-activated remote controls: A voice-activated remote control will allow the user to provide all inputs via voice rather than through mechanical key presses. If implemented in design, this will have a high impact for people who are blind and those with upper mobility impairments, a medium impact for those with low vision, and a neutral impact for other users. It will help resolve the issues of not being able to locate or identify controls, not being able to lift and hold the remote control, and not being able to make accurate inputs, and it may help with not being able to find desired features or respond within the allotted time.

Talking remote controls: A talking remote control is one with voice displays. Talking remote controls are useful in circumstances in which it is difficult to make control inputs or read the text display because of a visual impairment, significant glare on the screen, or possibly having to view the screen from a seated position. Inclusion in design will have a high impact for those who are blind, a medium impact for those with low vision, and a low impact for all other users. It will help resolve the issue of receiving and interpreting visual information.

Large buttons on the remote: Large keys on the keypad increase the ability to accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have poor fine motor control, and a low impact for all other users. It will help resolve the issue of having difficulty making accurate inputs.

More space between keys on the remote: More space between the keys increases the ability to differentiate the keys by touch and accurately press the desired key without inadvertently pressing any adjacent keys. Inclusion in design will have a medium impact for those who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. It will help resolve the issue of having difficulty locating controls and making accurate inputs.

DVS: DVS provides auditory output of key visual elements in visual programming. Inclusion in design will have a high impact for those who are blind or have low vision and a low impact for all other users. It will help resolve the issue of not being able to receive visual information.

Voiced on-screen menus: Voiced on-screen menus provide verbal output of the visual displays from the TV, allowing a user to become familiar with the menus without having to see them. On-screen menus are used for functions such as controlling TV features (such as CC or DVS) and setting up a VCR to tape a program. Inclusion in design of voiced menus will have a high impact for those who are blind or have low vision and a low impact for all other users. Voiced menus help resolve the issue of not being able to receive visual information.

Voiced program guides: Voiced program guides provide verbal output of the programming available on the TV. Inclusion in design of voiced program guides will have a high impact for those who are blind or have low vision and a low

impact for all other users. Voiced program guides help resolve the issue of not being able to receive visual information.

Ability to adjust program guide font size: Adjustable font size allows the user to set the size of the program guide lettering so that it is comfortable to read. Font size can be an issue for those with visual disabilities and for anyone who is seated at a fair distance from the TV. Inclusion in design will have a high impact for those who have low vision and a low impact for all other users. Adjustable font size will help resolve the issue of not being able to receive visual information.

Ability to adjust program guide font color: Adjustable font color can be used to increase contrast for text information. Inclusion in design will have a high impact for those who have low vision and a low impact for all others. Adjustable color will help resolve the issue of not being able to receive visual information.

Ability to adjust program guide background color: Adjustable background color can also be used to increase contrast for text information. Inclusion in design will have a high impact for those who have low vision and a low impact for all others. Adjustable color will help resolve the issue of not being able to receive visual information.

Ability to adjust CC font size: Adjustable font size allows the user to set the size of the CC lettering so that is comfortable to read. Font size can be an issue for those with visual disabilities and for anyone who is dependent on using CC. Inclusion in design will have a high impact for those who are deaf and hard of hearing, a medium impact for those who have low vision, and a low impact for all other users. Adjustable font size will help resolve the issue of not being able to receive visual or auditory information.

Ability to adjust CC font color: Adjustable font color can be used to increase contrast for text information. Inclusion in design will have a high impact for those who are deaf and hard of hearing, a medium impact for those who have low vision, and a low impact for all other users. Adjustable font size will help resolve the issue of not being able to receive visual or auditory information.

Ability to adjust CC background color: Adjustable background color can also be used to increase contrast for text information. Inclusion in design will have a high impact for those who are deaf and hard of hearing, a medium impact for those who have low vision, and a low impact for all other users. Adjustable CC background color will help resolve the issue of not being able to receive visual or auditory information.

Ability to adjust CC display rate: Adjustable display rate allows the user to set the speed at which CC is displayed. All people read at different rates, and those who have a visual impairment in addition to a hearing impairment may need some additional time to process the CC information. Inclusion in design will have a high impact for those who are deaf or hard of hearing, a medium impact for those who have low vision, and a low impact for all other users. Adjustable CC display rate will help resolve the issue of not being able to receive visual or auditory information.

Concave keys on remote control: Concave or inwardly curved keys help prevent fingers from slipping off the keys, which often results in inadvertent activation of adjacent keys. This type of key also increases the ability to differentiate the keys from each other and from the surrounding area on the device. Inclusion in design will have a medium to high impact for users who are blind, have low vision, or have an upper mobility impairment, and a low impact for all other users. Concave keys will help resolve the issue of locating controls and making accurate inputs.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to TVs address video and multimedia products (1194.24), self-contained closed products (1194.25), functional performance requirements (1191.31), and documentation (1191.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another. The following section 508 regulation is seen as an issue for TVs:

- At least one mode of operation and information retrieval that does not require user hearing must be provided, or support for assistive technology used by people who are deaf or hard of hearing must be provided. Not all programs are captioned, and there are many inaccuracies and lapses in captioning when it is available.

Voice Recognition Software

There are some human limitations that make voice or speech recognition software either inaccessible or difficult to use (and therefore, perhaps, undesirable). While there are very few limitations for any one disability population, all groups may be challenged by getting the software trained, making accurate inputs, overcoming problematic voice characteristics, and dealing with noisy environments. Some of these issues can be overcome through proper design.

Task-Based Accessibility Analysis

The core functionality considered to be necessary to effectively use speech recognition programs consists of the following:

- Using automatic voice recognition phone attendants
- Understanding computerized voices
- Using your voice to control your computer
- Using voice recognition software in public settings
- Using voice recognition software over a headset

- Activating voice input
- Providing appropriate voice input (consider training, vocabulary, speech characteristics)
- Correcting errors

People may have difficulty accomplishing these basic tasks, depending on functional limitations resulting in an impairment, environmental or situational factors that create barriers, and the design of the voice recognition software. Accessibility issues for each disability population were identified, along with an impact rating for each issue. The disability populations include people who have an impairment resulting from environmental or situational factors. The issues identified and the impact ratings assigned for each disability group can be found in the appendix to the online version of this report.

Accessibility Features

A review of various speech recognition software manufacturers' marketing data failed to identify any features as accessible design components. Features that would make speech recognition accessible include:

> **Automatic suggestion of alternatives for voice recognition errors:** A dictionary is available from which words can be suggested that resemble those that are not understood by the software. If the software is capable of providing good alternatives, this prevents the user from having to continue to attempt the speech input. Implementation in design will have a high impact for people who have cognitive disabilities and a medium impact for all other users. It will help resolve the issue of having difficulty entering information.
>
> **Ability to filter out background noise:** Noise filters help prevent accidental and perhaps inappropriate input that may go undetected or may cause the user to enter a different mode than desired. Implementation in design will have a high impact for

all users and will help resolve the issues of not being able to receive visual or auditory information.

Availability of macros: Macros can be used to enter groupings of information that are often used as input, such as name and address. One voice command is used to cue the system to enter the data set, greatly reducing the amount of verbal input required and reducing error. Implementation in design will have a high impact for all users.

Readback options: Readback allows the user to get feedback on how the voice input has been interpreted. It may be provided as each input is given or after multiple inputs to allow for more continuous data entry. Implementation in design will have a high impact for those with visual impairments and a neutral impact for other users. It will help resolve the issue of not being able to receive visual information.

User manuals in alternative formats: Alternative formats include large print, Braille, and audio. Inclusion in design will have a high impact for users who are blind or have low vision, a medium impact for those who have an upper mobility impairment, and a neutral impact for other disability populations. It will help resolve the issue of not being able to read or handle printed materials.

Ability to pause voice messages: Pause control allows the user to pause the verbal output from the device. This is helpful to give some time to write something down or to think about what option might be desired. Inclusion in design will have a medium impact for users who are blind and a low impact for all other users. Pause control will help resolve the issue of not being able to read text on the screen.

Ability to replay voice messages: Replay control allows the user to listen to a message more than once. This is helpful if the voice output was not understood or

could not be heard over environmental sounds. Inclusion in design will have a medium impact for users who are blind and hard-of-hearing users and a low impact for all other users. Replay control will help resolve the issue of not being able to read text on the screen.

Adjustable volume: Volume control is important for auditory alerts. It is particularly important for hard-of-hearing people, but it is useful for all. Inclusion in design will have a medium impact for hard-of-hearing people and a low impact for all other users. It will help resolve the issue of not being able to receive auditory information.

Ability to change voice types: Voice types may consist of male or female, for example. Some voices are more comfortable for a user to listen to; some are better understood by one user than by another. Inclusion in design will have a medium impact for all users. It will help resolve the issue of not being able to receive auditory information.

Ability to adjust the speed of voice messages: A speed that is too slow can negatively affect productivity, but a faster speed may not be well understood by all users. Adjustable speed of voice messages allows the user to set the level that is comfortable for him or her. Inclusion in design will have a medium impact for all users. It will help resolve the issue of not being able to receive auditory information.

Ability to request additional time: Ability to request additional time allows the user to complete a transaction despite the need to use more than the normal amount of allotted time to complete individual transaction components. Inclusion in design will have a high impact for most users, depending on the output mode (visual or auditory) from the device. Additional time will help resolve the issues of not being

able to receive visual or auditory information, not being able to reach controls, and not being able to grasp objects.

Headset compatibility: Headsets provide privacy for the user and reduce distraction to neighboring individuals. Headsets also help to control environmental noises that may be misinterpreted by the voice recognition software. Inclusion in design will have a high impact for all users.

Adjustable microphone: Adjustable microphones allow users to reposition the microphone so that the device is at a comfortable level for the user. Users with lower mobility impairments will benefit from the design.

Wireless microphone: Wireless microphones allow users to move about without being directly attached to the device that is being controlled. Users with lower mobility impairments will benefit from the added freedom of movement.

Compliance with Government Regulations

The primary parts of section 508 that are applicable to voice recognition software address software applications and operating systems (1194.21), functional performance requirements (1191.31), and documentation (1191.41). Many of these regulations have an impact on all users; others have a larger impact on one disability group than another.

The following section 508 regulation is seen as an issue for voice recognition software:

- Verify that at least one mode of operation and information retrieval is provided that does not require user vision or, alternatively, that support for assistive technology used by people who are blind or visually impaired is provided.

Conclusions

The final result of the analysis of each product line is the accessibility grade. The overall accessibility grade for a product line is an index of the cumulative impact of all accessibility issues. The accessibility grade is a letter grade on the familiar scale of A, B, C, D, and F. The following definitions are offered for each grade:

> **A = Excellent accessibility.** Users with an impairment are generally able to make full use of the product, with few limitations.
>
> **B = Good accessibility.** Users with an impairment are able to make good use of the product, but some areas of product functionality are not accessible.
>
> **C = Fair accessibility.** Users with an impairment can access some of the functionality of the device, but many aspects of product functionality are not accessible.
>
> **D = Poor accessibility.** Users with an impairment can make use of a small proportion of the functionality of a device, but most aspects of product functionality are not accessible.
>
> **F = Accessibility failure.** Users with an impairment are generally not able to use the product.

The accessibility letter grades are assigned according to the impact scores calculated for each target population. Details on how these grades were calculated and the task priorities, accessibility levels, and impact scores for each target population for each product line can be found in the appendix to the online version of this report. Accessibility grades may be useful to industry in prioritizing UD efforts and identifying what target populations should be consulted during the design process so that more accessible design features are incorporated into new products.

Table 1. Accessibility Grades for Each Target Population for the Six Product Lines

Target Population	Product Line					
	ATMs	Cell Phones	Distance Learning Software	PDAs	TVs	Voice Recognition Software
Low Vision	**C**	**C**	**C**	**C**	**B**	**C**
Blind	**D**	**F**	**F**	**F**	**D**	**D**
Hard of Hearing	**A**	**C**	**B**	**B**	**B**	**D**
Deaf	**A**	**D**	**D**	**B**	**B**	**F**
Upper Mobility	**C**	**C**	**C**	**D**	**A**	**A**
Lower Mobility	**C**	**A**	**A**	**A**	**A**	**A**
Cognitive	**C**	**C**	**C**	**C**	**A**	**C**

As these results indicate, certain product lines are very accessible to some target populations but largely inaccessible to others. It would be helpful in informing the UD process and developing products that are more accessible to people with disabilities if designers consulted the target populations for which a product line received accessibility grades of D or F during future product development. For ATMs, users who are blind will likely be unable to use an ATM or portions of the core functionality because of a lack of accessibility features; blind users should be considered in the design of new features for ATMs. Cellular phones are largely inaccessible to users who are blind and users who are deaf. Incorporating more features that make this product line more accessible to these users will expand the market for cellular phones. Distance learning software is largely inaccessible to users who are blind and users who are deaf. Adhering to accessibility regulations and guidelines for designing software will improve the accessibility of distance learning software for these user groups. PDAs are largely inaccessible to users who are blind and users with upper mobility impairments. Televisions were found to be most inaccessible to users who are blind because of an inability to locate, access, and read information, features, and controls. Voice recognition software is largely inaccessible to users who are blind, hard of hearing, or deaf.

IV. Industry Study

The purpose of the industry study was to document universal design practices within industries represented by the six product lines selected for study. Six different companies, representing each of the six product lines, were selected as industry partners. Selection of industry partners was primarily based on their leadership in the marketplace and their ability to deliver candid representations of their experiences with UD. During data collection, every effort was extended to foster an environment in which companies would be able to deliver documentation of actual processes and experiences.

Each company was individually approached by Georgia Tech and asked to participate in the research program. Nondisclosure agreements (NDAs) were signed to assure the companies that Georgia Tech would protect any proprietary data disclosed during the course of the study, as well as to foster a general environment of open and frank discussions. Full disclosure was critical to the success of the industry study, because it was important that actual experiences be documented, as opposed to ideal situations or marketing hype. The NDA restricts Georgia Tech from releasing any proprietary information belonging to the industry partners. Therefore, it is not the intent of this study to provide detailed descriptions of experiences recorded as part of the research. This section documents the general experiences of companies that are representative of the six product lines selected for analysis and provides a basis for identifying candidate interventions or approaches for the promotion of UD.

As part of the industry study, we investigated the presence of barriers and facilitators to accessible design. When an industry partner indicated experiences with a particular barrier, key personnel were interviewed to determine the policies and procedures that were used to overcome the barrier. Before interviewing the industry partners, we identified a candidate list of facilitator and barriers.

Analysis of Facilitators and Barriers to Accessible Design

Source materials, generated as part of the Information Technology Technical Assistance and Training Center (ITTATC), were reviewed to identify potential facilitators to accessible design. Facilitators are defined as concepts, procedures, or actions that can be employed by industry that might result in the development of accessible technologies. We read the needs assessment literature review, a survey of ITTATC National Advisory Committee participants, and a survey of accessibility visionaries in order to create the initial list of facilitators. The list was supplemented by our experience consulting with industry and our preliminary findings from the ITTATC case studies project.

The list of facilitators is divided into five categories: design, organizational, informational, financial, and legal facilitators. Design facilitators are methods or tools that can be implemented in the design process to possibly achieve a more accessible design. Organizational facilitators include augmentations to communications and infrastructure that may enhance the effectiveness of an accessibility program in a company. Informational facilitators address the lack of knowledge in accessible design and the continuation of common misperceptions. Financial facilitators include factors that make accessibility appear to be fiscally attractive. Finally, legal facilitators include legal positions that make accessibility easier to achieve.

Design Facilitators

- Integrate accessibility into engineering processes. Often accessibility of a product can be improved by integrating the consideration of the product's accessibility as a formal step in the engineering design process. The most desirable outcome is usually observed when accessibility is addressed very early in the design process.
- Develop standardized mechanisms for connecting assistive technologies. A common complaint from industry is that it is difficult to ensure that their products successfully interface with AT, because not enough is known about the detailed interface requirements of the variety of AT products on the market.

- Make technological advancements for handling adaptive devices and flexible design. For example, develop smaller components for connecting assistive devices so that products can be smaller and lighter.
- Develop innovative strategies to promote awareness and understanding of universal design issues. For example, a company could sponsor a design challenge contest to address a specific accessibility concern or award bonuses to those who significantly contribute to the design of a more accessible product.
- Share ideas, concepts, and research with other organizations, including encouragement of peer-reviewed research. Two possible means to accomplish this are by hosting a conference or publishing a journal of accessible design.
- Develop awareness of efforts in accessible design from competing companies.
- Develop accessible design standards and guidelines.
- Develop a tool to help individuals understand their role in universal design.
- Provide training for understanding accessible design, including demonstrations of why a particular approach may not work for an individual with a particular limitation. This will help the designers adjust their approach to thinking about accessible design and developing accessibility design practices in the early phases.
- Fund the acquisition of ergonomic and human performance data for people with disabilities.
- Develop methods for measuring accessibility and comparing the accessibility of two similar products. One approach to addressing these issues would be to start or participate in a working group to develop standardized measurement methods.
- Develop a working group to formulate a clear definition of design goals related to accessibility.
- Promote the benefits of UD. Accessible design is likely to benefit a much larger population than the target group.

- Perform accessibility evaluations on new and existing products and services.
- Include elderly individuals and individuals with disabilities in the design process. Get input from them early and recruit them to participate in evaluations. This can be done through prototype and product testing, focus groups, direct contact with the designers, discussion forums, and other mechanisms.
- Test for product compatibility with assistive technologies.
- Hire product designers with disabilities or with experience in creating universally designed products.
- Hire support personnel with disabilities to work directly with designers.
- Designate an accessibility coordinator to monitor accessibility issues and become familiar with related standards and guidelines.
- Provide concrete design examples of universally designed products.

Organizational Facilitators

- Share accessibility information companywide, and make it part of the culture. Ensure that all departments have the same understanding of accessibility requirements.
- Educate the company on the tangential benefits of accessible design. While most companies recognize that increased accessibility will result in an increase in the user base, some do not realize the benefit of UD for the existing user base.
- Increase diversity in the workforce.
- Develop brown bag and discussion groups regarding accessibility efforts so that upper management has the opportunity to learn about these efforts and factor this information into corporate decisions.
- Ensure that the personnel responsible for making marketing, product development, and design decisions are educated about accessibility and accessible design.

- Educate middle management on how accessible design can be made part of the design process without burdening schedule and budget requirements.
- Recognize accessibility as a necessity for the general population rather than as an exception.
- Incorporate accessibility standards into quality assurance programs.

Informational Facilitators

- Educate employees that people with disabilities have the same wants and needs as people without disabilities (e.g., communication, bill paying, travel). Remind them that the general population suffers from a number of temporary disabilities as well as disabilities related to aging.
- Recognize that relatively small changes can have a large impact on accessibility. Something as simple as reducing the force required to press a button can greatly increase the usability of a product for all potential users without taking away from design creativity.
- Provide accessibility training for managers, designers, sales representatives, customer service personnel, and any other groups that may benefit from the knowledge.
- Advertise accessibility features of products, and emphasize the benefits for everyone.
- Gather as much information about accessibility and disabilities as possible. Survey employees, canvas disability groups for information, hold community meetings to get direct input from people familiar with disabilities, and provide a Web link and/or phone number dedicated to obtaining feedback on product accessibility.
- Form partnerships/relationships with organizations devoted to promoting accessibility.
- Provide information to consumers about their rights under section 508 and section 255 and the company's efforts to comply with those regulations. Complete voluntary product accessibility templates (VPATs) for products so that consumers can make informed decisions.

- Purchase assistive technologies for designers to work with, and train them to use the devices properly.
- Increase exposure of engineers and designers to accessible design. Train them when they're hired, develop a short course that can be made available through local universities, and encourage someone in the company to teach at local universities to increase exposure at the university level.
- Recruit employees who have a background in universal design.
- Ask employees (particularly those with temporary or permanent disabilities) to comment on the usability of products they use and to provide design suggestions. Establish a mechanism for employees to provide feedback, and possibly develop a discussion forum from which additional informal feedback can be acquired. Use the people already in the company, as many of them may have experiences with others who have limitations.

Financial Facilitators

- Recognize accessibility as a product enhancement, not as a prohibitive-cost retrofit.
- Market products with accessible features to a large population, not just to the target market for which they are believed to be appropriate.
- Use employees to reduce costs associated with funding research in accessible design.
- Include accessible design as a regular part of the design process rather than as a feature that needs to be addressed separately at added cost.
- Factor accessibility upgrades into the cost of other important upgrades.
- Study the cost of not designing accessible products. For example, revenue may be lost because of the inability to effectively market to a federal customer.

Legal Facilitators

- Demonstrate efforts to comply with section 508. Create VPATs.

- Review consumer complaints received by legislators and industry.
- Designate an accessibility expert to monitor government regulations.
- Pressure the government for more detailed requirements that industry must meet or guidelines for satisfying the regulations.

The process used to identify candidate barriers was similar to the process used to identify candidate facilitators. Source materials, generated as part of ITTATC, were reviewed to identify potential barriers to accessible design. Barriers are defined as potential roadblocks to a successful accessibility program. We read the needs assessment literature review, a survey of ITTATC National Advisory Committee participants, and a survey of accessibility visionaries in order to create the initial list of barriers. The list was supplemented by our experience consulting with industry and our preliminary findings from the ITTATC case studies project.

Similar to the list of facilitators, the list of barriers is divided into five categories: design, organizational, informational, financial, and legal barriers. Design barriers are obstacles in the design process that may result in difficulty in achieving an accessible design. Organizational barriers include impediments to communications and infrastructure that may limit the effectiveness of an accessibility program in a company. Informational barriers have to do with the lack of knowledge about accessible design and the continuation of common misperceptions. Financial barriers include factors that make accessibility appear to be fiscally unattractive. Finally, legal barriers include factors that make accessibility difficult to implement because of litigation concerns.

Some of the barriers are merely *perceived* barriers, resulting from a lack of knowledge of or insufficient experience in accessibility. Other barriers represent more significant challenges to the accessibility community in general.

Design Barriers

- Marketing and technology trends sometimes run counter to accessibility requirements. For example, the cell phone industry has followed a trend in miniaturization that has resulted in the creation of a smaller keypad that is difficult to use for individuals with some types of upper mobility impairments. The font size used for the labels on these keypads has been reduced as well.
- There is a general lack of peer-reviewed research in accessible design. Many human factors professions complain of the lack of human performance research to support design in general. Even fewer studies focus on human performance issues for people with disabilities. In addition, little information exists about standard practices and methods of accessible design in the open literature. Designers simply do not have access to information they need to create accessible products.
- There is a lack of realistic standard guidelines and principles of accessible design.
- Designers lack an understanding of accessible design and what can be achieved if products are designed from the beginning with accessibility in mind. Very few commercially available products exist that represent successful exercises in accessible design.
- Designers do not have access to information about people with disabilities in a format usable to them. Designers often require human performance and ergonomic data in an easy-to-use format to support design decisions. Unfortunately, human performance and ergonomic data for special populations, including people with disabilities, are not a part of the standard data sets. Designers must consult outside sources and attempt to compile the necessary data from a wide variety of technical reports and published articles. The compilation of these data is extremely time-consuming and often unfeasible.
- A standard accessible design process has not been documented, tested, or verified.
- Implementation of multiple methods of display and control may make it difficult to create a streamlined user interface. Many feel that the addition of accessibility features creates an unwieldy user interface.

- There is no standardized method of measuring accessibility or comparing the accessibility of two similar products. Designers do not have a way of determining whether their designs have met their accessibility goals.
- Many feel that there is no clear definition of how accessible a product has to be in order to be considered an accessible design.
- Many designers equate accessible design with designing products for the lowest common denominator.
- Individuals with disabilities are not integrated into the design or evaluation process.
- There is a lack of tools and resources useful for efficiently creating accessible products.

Organizational Barriers

- Often there is a lack of communication across departments about accessibility requirements. A few pockets of accessibility awareness seem to exist in many companies, but there is a lack of structure integrating a comprehensive accessibility program.
- Many companies lack accessibility champions who are in a position to influence company decisions. In many cases, personnel responsible for a company's accessibility efforts come from human factors, usability, or disability support groups. In general, these groups do not have a large amount of input in corporate decisions.
- Often personnel responsible for making accessibility decisions have little knowledge about accessibility or accessible design.
- Middle management often perceives accessible design to be in direct conflict with schedule and budget requirements.
- Accessibility is often a minor concern compared with other corporate issues, especially in today's economy.
- There is a lack of infrastructure to support accessible design.

Informational Barriers

- Some view people with disabilities as not having the same wants and needs as people without disabilities.
- Sometimes designers fail to consider the possibility that someone with a disability would attempt to use the products they design.
- Sometimes accessibility features are poorly communicated to the consumers who require the features.
- Specific information about accessibility and disabilities, in general, is not easy to obtain.
- Companies often do not know how to market to people with disabilities.
- Consumers are not familiar with their rights under section 508 and section 255.
- Some designers do not have sufficient access to assistive technology interface requirements.
- Engineers and designers are not sufficiently exposed to accessible design at the university level.
- Accessibility is often interpreted narrowly to include only physical access to the technology.

Financial Barriers

- The cost of developing new technologies associated with accessibility is often seen as prohibitive.
- The target market for accessible design is not well understood or defined.
- There is a general lack of sources of funding for research in accessible design.
- Some people feel that the business case for accessibility is weak.
- It is difficult for companies to market to consumers with disabilities.
- The cost associated with retrofitting existing products is significant.

- The cost associated with purchasing accessible products is often not affordable by people with disabilities.
- The technology required to produce accessible products is not available at a reasonable cost.

Legal Barriers

- Some companies feel that they are under pressure to self-certify compliance with section 508 in order to compete.
- Some feel that federal regulation does not go far enough in detailing the requirements that industry must meet. Others feel that the regulations unnecessarily restrict creative design and innovation.
- Exploration of the federal requirements through litigation is both time-consuming and costly.
- Some companies believe their competition is incorrectly representing its product's accessibility.
- Procurement officials do not understand accessibility requirements to a sufficient degree. Officials may not be able to recognize when an accessibility claim is false.
- Section 508 is either not being adhered to or is being adhered to inconsistently.

Industry Study Data Collection Methodology

Six companies or industry partners were selected for participation in the study. Once the companies were identified and the points of contact (POCs) established, each was given a list of topics related to accessibility in the company. Georgia Tech requested initial reactions during preliminary phone interviews and then conducted onsite visits and in-person interviews with various individuals involved in the accessibility program. Some industry partners chose to provide detailed documentation and formal responses to our initial inquiries before the

interviews. The purpose of the in-person interview was to obtain additional information and documentation to enhance the initial responses provided on the topics of interest.

The data collected were based on a series of topics related to accessibility in each company. The type and format of data requested in response to each of the 10 topic areas is listed below:

1. Documentation of current design practices, with emphasis on user interface design and other aspects of products related to accessibility and UD.

2. Documentation of current product evaluation practices, with emphasis on accessibility and UD.

3. Key personnel who make decisions about product design, product selection, and/or marketing related to accessibility and UD.

4. Current products (fielded or in development) with specific accessibility features or other direct relationship to accessibility.

5. Lessons learned in developing accessible products. Focus on organizational barriers encountered, technical challenges, financial barriers, informational barriers, and legal challenges.

6. Company forecasts of demand and requirements for products with accessibility features.

7. Company training materials related to accessibility and UD.

8. Company-funded research into accessibility and UD.

9. Company contact with members of the disability community relevant to product accessibility and usability by individuals with disabilities.

10. Company position on product accessibility and UD.

Georgia Tech scheduled an initial meeting with the company POC, during which the industry study objectives and data requirements were reviewed in detail. Any readily available information was collected, and the company POC was charged with identifying sources for archival data and arranging personal interviews with individuals qualified to supply the required information. The information analyzed in this summary is based on materials provided directly from the company, notes from the in-person meeting, and publicly available materials.

Analysis of Industry Data: Factors Influencing Adoption of UD Practices

As defined by Tobias and Vanderheiden (1998), the primary factors that influence the adoption of UD principles are government regulation (or the threat of regulation) and profitability. The purpose of the industry study was to build upon previous work and understand how the perception of profitability affects UD. Eleven business concerns have been identified as having an influence on UD practices in an organization. Each business concern has a different level of influence, depending on the strength of the other factors. The factors influencing the adoption of UD practices include the business case, strategy and policy, demand and legislation, marketing and sales, research, design, testing, resource allocation and funding, organization and staff, training, and the customer and consideration of people with disabilities. Detailed descriptions of the impact of each business concern on UD are described below.

Business Case

The business case is the financial justification and plan for including accessibility in product design. Central to consideration of the adoption of UD principles for all six industry partners was the identification of a compelling business case to justify committing the required resources to the effort. Someone at a company wishing to add accessibility features to an existing product or to add schedule and budget to accommodate building accessibility into the design of a new product is often required to justify the added expense by producing either a formal or informal business case for accessibility.

There are several methods that might be used to construct a business case. Each method relies on the interpretation of market forecasts and sales data and is, therefore, somewhat subjective. For example, a senior manager might look at federal sales data and determine that the number of sales at risk because of the production of inaccessible products is negligible and therefore produce a very weak business case for accessibility. A second senior manager might look at the same data and see great potential for increasing the market share of federal sales by enhancing accessibility, therefore determining that the business case for accessibility is strong.

The industry study identified the following primary justifications for the business case for UD:

- Increase market share to include people with disabilities
- Increase federal sales market share
- Reduce risk of losing market share
- Increase overall usability of the product or service
- Reduce risk of costly legal action
- Increase status as a corporate citizen

While increasing market share in general is traditionally regarded as a strong justification for a business case, the potential to increase market share by extending the market focus to cover people with disabilities is often seen as a relatively weak business case, primarily for two reasons. First, the market for people with disabilities is highly segmented. The cost associated with developing a product for users with various disabilities and levels of functional capabilities is not justified by the potential of direct sales to people with disabilities. Second, the amount of disposable income available to people with disabilities is not perceived to be great. The additional cost associated with producing accessible products cannot be passed along directly to consumers with disabilities.

Companies do not appear to fully appreciate the potential value of extending their market share to nontraditional markets through UD. Universal design is generally associated with design for

inclusion of people with disabilities. The market analysis documented elsewhere in this report illustrates that this view of the market for UD products is unnecessarily restrictive. Companies representing the six product lines selected for analysis have failed to embrace the extended market perspective for UD products.

The introduction of section 508 of the Rehabilitation Act, requiring federal agencies to consider accessibility in the procurement of most products and services, should have had a direct impact on the calculation of the market size of UD products. Sales to the Federal Government represent a significant portion of sales for many companies producing E&IT products and related services. Based on the face value of section 508, businesses wishing to increase federal sales might do so by developing a more accessible product than the competition and using accessibility as a key discriminator on competitive bids. However, many of the industry partners failed to recognize the potential increase in federal sales as a strong business case, perhaps because of the perception that procurement officials are not consistent in enforcing section 508.

Perhaps more compelling than the potential increase in federal sales is the threat of loss of Federal Government market share to a competitor. A company that enjoys a large share of the federal market could lose market share if a competitor creates an accessible product that federal procurement officials choose over the traditional supplier in an effort to conform to the requirements of section 508. In reality, none of the companies participating in the industry study were aware of any lost sales that could be attributed directly to an attempt of a procurement official to conform to the requirements of section 508.

Business cases are sometimes generated in response to less tangible benefits and threats that are not directly related to a company's market position. For example, one of the companies in the industry study referred to corporate citizenship as a justification for research into accessibility and UD. Another company perceived accessibility as clearly being related to usability, which had been identified as a key market discriminator. Finally, one company mentioned a concern about avoiding future legal actions as a motivator for accessibility.

Strategy/Policy

Strategy is the high-level plan for UD or the implementation of accessible design features. A policy is a written a statement that is a reflection of corporate strategy. Most industry partners had an informal or formal policy statement approved by senior management; however, they differed widely in their content and implementation. External policy statements tended to be used primarily for marketing and had little overall impact on processes and procedures. When an internal policy statement was drafted and issued to employees, it usually had the effect of temporarily increasing awareness of accessibility; but a sustained, corporatewide commitment is rare without the dedication of resources. Internal policy statements that lack an associated commitment of resources are rarely enforced.

An effective policy must reach the level of a corporate instruction or directive and address inclusion of people with disabilities in design and evaluation of products, increased training, incorporation of documented standards and guidelines, increased research and development, increased marketing of accessibility features and efforts, and lowered costs for products with accessibility features. The policy must also be associated with an implementation plan and a commitment of needed resources.

Corporate culture had a strong influence on accessibility. In two of the six companies in the industry study, employees reported that the corporate culture was such that accessibility was expected to be considered when making design decisions. A strong corporate culture was generally associated with a strong customer voice requiring that accessibility be considered. Accessibility will be considered, independent of policy, if the customer demand is great. Policy tended to be more entrenched in corporate culture if someone from senior management experienced a disability or a close relationship with someone with a disability.

Resource Allocation/Funding

Resource allocation and funding was the single most frequently identified reason for the failure of accessibility policy. Four of the six companies had money earmarked for staffing accessibility

program offices; however, the program offices were often underfunded and did not have sufficient resources to effect change in the corporation. In some cases, the accessibility program office consisted of only one or two individuals who served as the focal point for accessibility concerns throughout the company. Only one company earmarked money specifically for accessibility research. Outreach to employees was also severely limited. The accessibility program offices often developed plans for implementing universal or accessible design but lacked funding to appropriately implement the plans.

At least one company that decided to commit to accessibility and establish an accessibility program office was reevaluating the commitment of resources because of an inability to demonstrate return on investment (ROI). The company cited a lack of impact of accessibility features on federal procurement decisions as the primary motivator for reconsidering its commitment to accessibility. Companies spending less money on accessibility were not perceived to suffer decreased sales as a result of section 508 procurement regulations.

Organization/Staff

Several methods of staffing for accessibility issues were observed. The most common staffing organization, used by four of the six companies, involved the development of an accessibility program office responsible for UD and accessibility issues throughout the corporation. The size of the accessibility program offices varied from a single member to a staff of five or six with a background in accessibility issues. In other cases, responsibility for accessibility was integrated into existing groups, such as marketing or human factors.

Two staffing trends were noted. First, the presence of a single accessibility champion or a small number of accessibility champions was very common among the industry partners. The success of the accessibility program in a company that must rely on the work of a very small number of accessibility champions was directly related to the workload or attrition of the champions. Loss of an accessibility champion could result in a major setback of accessibility objectives. Second, the accessibility program office may become a place to assign nonproductive personnel. While

the majority of accessibility program offices are staffed by competent individuals capable of advancing UD principles if given adequate resources, some companies have assigned accessibility to individuals who are either transitioning between departments or are experiencing difficulty marketing themselves within the company.

The mission of the accessibility program offices also varied widely. In some cases, the program offices were mostly reactive, responding to requests for information or to particular accessibility concerns. In other cases, the accessibility program offices were very proactive and focused on developing and testing new technologies that might be integrated into future products. In reality, a balanced approach is required. The group charged with accessibility should be able to respond to the immediate needs of the corporation as well as contribute to future planning and development of universally designed products.

Unfortunately, the accessibility program office in the four companies that had program offices demonstrated very little control over design decisions that directly affected the accessibility of the final product. The accessibility program office should be constructed to include groups (or individuals) who have decision-making responsibilities to influence product accessibility. This may include a human factors group or an accessibility group, or even an oversight group that can serve as a resource for other groups in the company. It also helps for accessibility awareness to be widespread throughout the company. One method of accomplishing this is to have staff in each group or available to each group who have more extensive training and who can advocate for inclusion of accessibility features.

Another staffing mechanism for enhancing accessibility practices in the company is to hire people with various disabilities and ensure that they are involved with the design and evaluation of products. However, this mechanism can be used inappropriately. For example, it would be inappropriate to send a new product to a single employee with a disability and ask the employee to quickly review the product rather than conducting more extensive product testing. This approach is especially problematic if the employee has other responsibilities, has little experience

with product evaluations, and is not prepared to comment on the accessibility of the product beyond his or her personal experiences.

Training/Awareness

Some corporate accessibility training was offered to employees; however, training relating to UD and accessibility is not widespread. The most common type of training was aimed at increasing employee awareness of section 508, accessibility policy, people with disabilities, and the specific accessibility issues associated with the products that the company produces. An important function of several accessibility program offices was to provide targeted training to key decision makers, as needed. The targeted training was largely informal and usually conducted on a rather limited basis. The training offered was generally focused on program managers and design teams. Very little training was offered to sales or marketing teams.

Typically, accessibility awareness is made available on an as-needed basis and is specific to a project. In some cases a brief introduction is provided to all employees regarding the importance of UD, but sometimes it is simply awareness through diversity training. Training materials may include an overview of the range of disabilities (including situational disabilities), assistive technologies, principles of UD, minimal design requirements, business and consumer arguments for addressing accessibility, consequences of not addressing accessibility, a review of accessibility features, legal requirements, and barriers and lessons learned.

Training of staff is one of the best mechanisms for getting accessibility included in product design. Often accessibility is overlooked because of a lack of awareness of the issues. People do not realize how inaccessible products can be to individuals with disabilities and they do not understand how much an individual's life can be improved with the availability of more accessible products. Training can greatly affect accessibility practices through increasing awareness of disability issues, increasing awareness of standards and guidelines, and providing tools (processes and checklists, for example) to facilitate accessibility implementation.

Companies should be aware of hidden messages in corporate training. For example, if a company emphasizes section 508 conformance over accessibility in general, employees may come to view UD and accessibility as a federal sales issue. Designers may choose to ignore accessibility requirements if they know that their product is not likely to be marketed to the Federal Government.

To be effective, training should be tailored for the decision makers who routinely affect accessibility in the corporation. Technical staff might like to consider the needs of people with disabilities, but they are junior staff members who do not have the power to implement major design decisions. Technical staff training is effective if concrete design examples and information about integrating UD guidelines into the design process are offered. However, changes to the design process are often resisted by middle managers, who argue that extra development time would be required, that money must be expended, or that these changes are not relevant to the target market. The key decision makers are the key product team members and the personnel who are responsible for defining the products' functional requirements.

One successful method of providing UD and accessibility awareness training is to incorporate basic constructs into employee induction training. Other successful training methods include alternative delivery methods, such as a video, on the importance of UD and the impact of inaccessibility on the lives of people with disabilities. Computer-based training materials have also been used to increase general awareness of accessibility issues.

Research

With one notable exception, the accessibility program offices of the four companies participating in the industry study were not directly linked with corporate research. One company was able to successfully integrate personnel with research experience into the accessibility program office. This integration allowed the program office to offer design solutions to the accessibility problems that it identified through testing. However, most accessibility program offices were not in a

position to influence research priorities or review research before it was integrated into a product development cycle.

Several companies successfully employed external consultants to assist with UD or accessibility research. However, externally funded research tended to be more exploratory in nature and less focused on design-oriented solutions.

Research into accessibility issues is dependent on available funding. Much design work is dependent on research of the best way to implement accessibility features, compatibility with assistive technologies, and development of emerging technologies. Advanced and ongoing research can influence accessibility implementation through identification of features that are useful for the disability community, cost-effective, and appealing to a wide population.

Design

In many cases, accessibility processes are in place for both design and quality assurance, including user-centered design, but are either not documented or not followed consistently. Accessibility requirements are not well integrated into existing design processes. For those companies that do include accessibility requirements in the design process, the requirements are typically tailored to the specific product line or range of product lines produced by the company.

Design decisions are made by a range of personnel. Industrial designers or design management teams typically handle display and control layout. Product managers or core team members detail the design and ensure manufacturability. Some design decisions are made at the engineering level. Typically, decisions about trade-offs are made at an upper-management level. Decisions about product requirements are typically handled at the marketing level. Accessibility champions can have some influence over the design, independent of the above-mentioned roles.

All six companies participating in the industry study adopted some variant of a product development or life cycle design process. However, the companies varied in the extent to which

they followed engineering process manuals. Smaller projects and internal research and development projects tended to operate outside the formally defined development process. None of the companies reported immediate changes to the development process in response to section 508. Rather, UD and accessibility requirements have slowly been integrated into the development process, mainly in response to efforts from members of the companies' internal accessibility program offices. Three of the six companies reported that accessibility was addressed in its formal engineering product manuals. However, two of those three companies reported that their formal engineering process simply required that accessibility be considered at some point in the design process. In general, detailed requirements or checklists relating to accessibility were not found in formal design documents.

The product life cycle design process is intended to manage the product from its inception through its retirement and eventual cessation of support. Although different companies have different names for their design processes, the processes all generally follow these steps:

- Product planning
- Requirements definition
- Product specification
- Development
- Verification and testing
- Manufacturing
- End-of-life management

In order for UD principles to be incorporated into the final product, the principles must be considered at the very beginning of design. Accessibility must be considered during product planning. Companies that relied solely on accessibility testing after product development were unable to have a substantial impact on the overall accessibility of the product. Product planners must decide very early whether accessibility will be considered in the design of the product and

to what extent the product will meet or exceed accessibility technical guidelines. Companies that failed to consider accessibility early in product development often failed to have a significant impact on the accessibility of the final design.

In the requirements-definition phase, it is important to define objectively testable requirements for accessibility. It is not sufficient to require that the product be accessible, because doing so provides little information to designers and prevents accessibility verification testing. Vague accessibility requirements are more likely to be ignored in both the development and the verification and testing phases of design. Proper accessibility requirements should be defined in the form of the incorporation of relevant section 508 technical requirements or specific functional performance requirements. For example, the requirements document could incorporate specific paragraphs from section 508 technical requirements that apply to the specific product under development, or it could require that specific user tasks must be able to be performed by a given population of users with specified functional capabilities and limitations.

During the product-specification phase, the functionality and appearance of the product is defined in accordance with the definition of product requirements. Personnel with expertise in UD must be available to assist in defining the specifications, reviewing the product specifications that affect accessibility, and determining whether the accessibility-related product requirements are met by the product specification. Major changes to the product design are unlikely after the product specification has been produced, so it is critical that accessibility be considered before moving on to the design phase.

During development, the design is conceptualized, produced, and prototyped. Typically, a project leader will arrange a multidisciplinary team that might involve members of engineering, computer science, industrial design, human factors, quality assurance, and marketing. At least one member of the development team should have an understanding of the accessibility issues related to the product under development. Iterative testing and development are important during this phase.

Testing

Companies participating in the industry study routinely performed usability testing, but they rarely included users with disabilities in usability testing and rarely conducted user testing for accessibility. Accessibility evaluations are different from standard usability evaluations in at least three ways. First, accessibility evaluations measure the degree to which a specific impairment restricts the operation of a device. In addition to measuring how effective a device is, usability evaluations also tend to measure customer satisfaction and efficiency. While satisfaction and efficiency data may be collected during an accessibility evaluation, this type of data is not the primary focus. A device that has usability issues may still remain accessible, as long as the usability problems do not disproportionably affect the ability of a user with an impairment to accomplish a given task. Second, accessibility evaluations are, in general, performance-based rather than subjective. The focus of an accessibility evaluation is generally on measuring functional performance. Finally, the primary motivation for performing an accessibility evaluation is compliance with government regulations. While technical standards and guidelines for usability certainly exist, there are few legal requirements that must be met in order for a device to be considered usable.

Federal procurement officers, in an attempt to comply with section 508, routinely request information about the accessibility of a product before a purchase. All the companies that participated in the industry study reported some level of UD or accessibility testing. However, the depth and breadth of the testing varied widely. Most testing was performed in order to fill out a voluntary product accessibility template. One company's engineering process required that a VPAT be constructed before launching the product. Although it is unlikely that an unfavorable evaluation would delay product launch, requiring the VPAT prior to launch does force the design team to consider accessibility. VPATs are often requested by federal procurement officers as part of their required market research. Two of the six companies performed quality assurance or requirements-verification testing as part of the normal design process.

Testing was generally restricted to an inspection for conformance with the technical requirements of section 508. Notably, the functional performance requirements of section 508 were often overlooked. The functional performance requirements are perceived as being difficult to test. The most effective method of testing these requirements involves user-in-the-loop testing with representative members of the disability community. Use of a task-based approach is critical to accurately measure accessibility and directly compare the accessibility of more than one similar product. None of the industry partners routinely performed user testing for the purpose of measuring conformance with the functional performance requirements of section 508.

The industry partners were split regarding a preference for internal or independent third-party testing. Three companies preferred to keep testing in-house, and three companies preferred to contract an independent lab to perform testing.

As with any kind of testing, accessibility evaluations are more effective if they are conducted in conjunction with an iterative design process. Testing can have the greatest impact on accessibility if people with disabilities are included in the evaluation process and have the opportunity to do early testing to facilitate design changes.

Demand/Legislation

Demand is affected by consumer needs and interest as well as legislation requiring accessibility. Demand can influence the presence of UD features in three ways. First, consumers may voice their interest in products with accessibility features. If customer demand is great enough, companies are likely to address accessibility issues. Second, some companies primarily market to other companies. For example, cell phone manufacturers market their products to cellular network providers. The purchaser—the cellular network provider in this example—is in a strong position to pass along requirements for UD to the manufacturer. Finally, if enforceable legislation requires the government to purchase accessible products or requires a minimal level of accessibility, industry will not be able to ignore the need to incorporate accessibility features into its products.

However, legislation has not been extremely effective in increasing demand for accessible products. Many problems stem from conflicting requirements. Local and global requirements may differ. The business customer's requirements may differ from other requirements that support accessibility for the end-user. In addition, the regulations do not change as quickly as technology does, limiting the development of enhanced capabilities. Not all consumers have the latest version or model, rendering some applications inaccessible for those using older technologies. To complicate the issues further, the federal requirements are too general to be extremely useful and lend themselves to various interpretations. Some companies even misrepresent accessibility of their products; they claim to be 100 percent accessible but fail to deliver an accessible product or deliver only a partially accessible product.

Marketing/Sales

One method of increasing demand involves adequate marketing of products with accessibility features. Often, companies develop products that have accessibility features, but they are not marketed as features that support the needs of a particular disability population. Unless the consumer does extensive research, it may not be evident that the features exist. Consumers do not always know what to ask for or how to ask, so unless the products are marketed appropriately or the sales staff are trained to identify features that may benefit a particular user, awareness of those features will remain low. Sales staff should be trained to discuss accessibility features with consumers, to spot consumers who may benefit from particular features, and to relay customer requests back to designers or another appropriate department in the company that will get those requests factored into design considerations.

Some companies do not have any forecasts for accessibility marketing. There is considerable recognition that the aging population is increasing and will need to be accommodated, though this is not addressed in the current marketing strategy. There is also increased recognition for accommodation of temporary disabilities resulting from a physical or mental impairment or from an environmental or situational limitation.

Customers/People with Disabilities

The final influences on accessibility are the customer—whether a business customer (for example, the carrier, in the case of cell phones) or the end-user. When a business customer is the major driver of product requirements, UD solutions are not likely to be integrated into a product if they are not requested.

End-users, including people with disabilities, can influence the design process by supporting companies in their efforts to generate products that include accessibility features. Customers can also influence the design process by making their problems and successes known to the companies so the designers can build on that knowledge and improve the process for future product development. However, there were few examples of customer feedback resulting in a change to the design of a product.

Many companies shy away from direct interaction with people with disabilities or disability advocacy groups. Companies often perceive that inclusion of people with disabilities is complicated, perhaps even aversive in nature. As an alternative, they sometimes have phone contact with accessibility organizations that assist them in understanding the needs of users with various functional limitations. The quantity and quality of the guidance received from the advocacy group is perceived to be largely dependent on who happens to answer the phone on a given day.

Companies are often hesitant about interaction with disability advocacy groups unless the technology they are developing is perceived to be accessible. Companies often seek an advocacy group's "stamp of approval" but rarely interact directly with the group to improve the accessibility of an inaccessible product. Some companies interact specifically with employees with disabilities but do not involve outside individuals. Other interaction is through conferences, workshops, and trade shows. Some companies perform user testing internally or through outside consultants, and this occasionally involves people with disabilities.

Analysis of the Industry Study Findings

All the companies that participated in the industry study have made strategic decisions to address the accessibility of their products and services. A few of the companies had long-standing accessibility programs that were reinvigorated by the technical requirements of section 508. Other companies initiated their accessibility activities while planning for their response to section 508. Regardless, section 508 has clearly had an impact on the way accessibility and UD are being addressed in industry. The most common approaches to addressing accessibility issues were—

- Increasing the awareness of employees
- Integrating accessibility requirements into the design process
- Performing accessibility verification testing
- Establishing an accessibility program office

All six companies in the industry study provided training, formally or informally, to a subset of their employees. Three of the companies have integrated accessibility guidance, particularly the technical requirements of section 508, into their design process. Four of the six companies performed accessibility verification testing for the purpose of generating a VPAT for federal procurement officials. Finally, three of the industry study partners established accessibility program offices to coordinate accessibility activities in the company.

The industry study has identified a number of situations in which UD principles have been successfully integrated into corporate culture; however, there are still numerous opportunities for improvement. First, government legislation has had an impact on the accessibility of E&IT but has fallen far short of its potential to inspire universally designed products. Second, the industry study identified a number of barriers to accessibility experienced by the study participants. Some issues were associated with specific industries; however, the vast majority of barriers are common to all industries represented by the six product lines selected for study. The potential to develop interventions that are likely to have a profound effect on a large number of companies producing E&IT products and services is significant.

A research project studying the barriers to UD was conducted from 1996 to 1998 by Dr. Pieter Ballon, Dr. Gerd Paul, Dr. Leslie Haddon, and Dr. Monique van Dusseldorp under the European Union's Telematics Applications for the Integration of Disabled People and the Elderly (TIDE) program. The team interviewed 68 managers from telecommunications, computer hardware, software, electronic commerce, public information services, Internet, broadcast, and interactive services firms. The interviewees were middle- and high-ranking managers from marketing, product management, design, and usability departments, primarily in the Netherlands, Germany, and the United Kingdom. Ballon's team found that there was a low awareness of UD among these upper- and mid-level managers. Few of them believed that UD would improve industry's development practices.

The researchers did find a number of positive factors. Many of the managers understood and appreciated the concept of UD, because it fit with their existing criteria for good design. At the same time, UD is compatible with trends in the IT industry to offer solutions that adapt to users' preferences, experience levels, and task requirements. Finally, the researchers found interest in the possibility of expanding markets to include older people and people with disabilities.

The researchers felt that the quality of marketing information concerning the needs of real and potential users was comparatively low in the E&IT industry compared with other, more mature consumer goods industries. In most E&IT industry sectors, information and guidelines on inclusive design are lacking. They found that larger companies have more means and procedures with which to consider the user and his or her needs in the design process than small enterprises, especially start-up firms in software and Web design.

The research identified nine types of barriers to the implementation of UD principles. At the most general level are barriers relating to a failure to sufficiently consider or involve any end-users in the design process. More important, companies fail to consider or involve older people and end-users with disabilities in the design process. Some general developments in the E&IT

industry also have a negative impact on implementation: the speed of product development, market trends, and industry organization.

For this industry study, a list of potential barriers to UD was reviewed with each of the industry partners. The industry partners were asked to comment on their experiences and to report methods, if any, that were used to overcome the barriers. The purpose of the study was to build upon the findings of the TIDE program by reviewing an extensive list of accessibility barriers with E&IT companies competing in the U.S. market. The following barriers were common to most of the companies participating in the industry study:

- Section 508 is either not being adhered to or is being adhered to inconsistently.
- Some people feel that the business case for UD and accessibility is weak.
- A standard accessible design process has not been documented, tested, or verified.
- There is a lack of realistic standards, guidelines, and principles for accessible design.
- There is no standardized method of measuring accessibility or comparing the accessibility of two similar products.
- Many feel that there is no clear definition of how accessible a product has to be to be considered an accessible design.
- Often there is a lack of communication across departments regarding accessibility requirements.
- Many companies lack accessibility champions who are in a position to influence company decisions.
- Middle management often perceives accessible design to be in direct conflict with schedule and budget requirements.
- Individuals with disabilities are not integrated into the design or evaluation processes.

Common barriers identified during the industry study are discussed in detail in the following paragraphs:

Section 508 is either not being adhered to or is being adhered to inconsistently. Inconsistent application of section 508 by federal procurement officials was the most commonly heard complaint among the industry partners. As might be expected, the industry partners that did not market to the Federal Government were less concerned about section 508 issues.

Two of the industry partners did not market to the Federal Government, and four of the partners produced products that were directly marketed to the Federal Government. The industry partner representing a distance learning software company markets its products mainly to universities. The company perceived that it must conform with the technical requirements of section 508 because its customers were demanding conformance; however, the company was technically not obligated to develop products in conformance with section 508. The company made a decision to design to section 508 because its customers incorrectly assumed that section 508 applied to them because they received federal funding as public universities. The company representing cell phone manufacturing had little experience with section 508, mainly because it marketed its products almost exclusively to the cellular network carriers and did not feel much pressure to conform to section 508 requirements.

The four remaining companies that did market to the Federal Government expressed discontent with the way federal procurement officials have procured products and services under section 508. In general, companies responded to section 508 in one of two ways. Some adopted a “wait and see” attitude while minimally responding to the requirements of section 508. Such companies might produce VPATs, but they were unlikely to invest resources in developing products

to conform to section 508 until the cost could be justified. Companies in this category have yet to experience either lost or increased sales to Federal Government customers because of section 508. There is a perception by some in industry that section 508 conformance is being "rubber stamped" by procurement officials and that the content of the VPAT is not important as long as a VPAT is offered.

Other companies have been very proactive in their response to section 508. Two of the companies in the industry study have incorporated section 508 requirements into their design process. However, at least one company is currently reconsidering its accessibility program investment in response to section 508 because it has not realized increased federal sales from its increase in overall accessibility. Furthermore, the company did not observe a reduction in federal sales for competitors that were perceived as producing less accessible products. In short, accessibility seems to have failed to become a key discriminator, as promised under section 508.

Some people feel that the business case for UD and accessibility is weak. All six companies reported that they struggled with the business case for universally designed products and services. Most companies could not report specific instances in which accessibility was a key discriminator in a federal procurement. In the absence of data suggesting that federal sales could be increased with UD or data suggesting that federal sales were at risk because of nonconforming products, companies were reluctant to use federal sales figures in developing a business case for UD.

A standard accessible design process has not been documented, tested, or verified. Several companies have attempted to integrate UD into their standard product development process. Process interventions typically include prompts to

consider accessibility during design, the addition of accessibility requirements to requirements-definition documents, and limited testing with users with disabilities. However, no one has been able to determine if the interventions are sufficient or if additional interventions are required to produce accessible products and services. The impact of the integration of candidate accessibility interventions into the design process has not been studied extensively.

There is a lack of realistic standards, guidelines, and principles of accessible design. Accessibility design guidelines that are currently available are not sufficiently detailed to have a profound effect on the overall accessibility of all E&IT products. Some guidance does exist, such as the technical requirements associated with sections 508 and 255; however, the guidance is sometimes ambiguous or subject to alternative interpretations.

There is no standardized method of measuring accessibility or comparing the accessibility of two similar products. The industry partners struggled with the issue of measuring accessibility of products or comparing the accessibility of two similar products. An industry agreed-upon accessibility metric does not exist. In addition, industry has not identified a standard method of measuring accessibility. Currently, accessibility is measured only in terms of section 508 conformance. The VPAT is currently the agreed-upon vehicle for reporting accessibility. It does not, however, necessarily reflect the actual accessibility of the product it was created for, nor does the VPAT allow procurement officials to directly compare the accessibility of two similar products.

Many feel that there is no clear definition of how accessible a product has to be to be considered an accessible design. Many people see UD as a goal. The goal is to create a product that is usable by as many people in as many situations as possible. Given that complete accessibility is either impossible or cost-prohibitive,

companies are struggling to determine just how accessible their products need to be to be considered accessible. The problem is compounded by the fact that companies do not have useful methodologies for measuring accessibility.

Often there is a lack of communication across departments regarding accessibility requirements. Communication between the accessibility program offices and other departments was limited by the resources of the program office. While some proactive outreach activities were observed, the accessibility program offices were generally reactionary in nature. Most of the decisions that affect accessibility take place within product design teams working on specific projects and outside the influence of the program office. Also, sales departments in two of the industry partners were not well connected with the personnel making decisions about new product development. In two companies, the demand for accessible products was great, but that demand was not communicated to the group defining the requirements for the next-generation products.

Many companies lack accessibility champions who are in a position to influence company decisions. Accessibility champions working within the companies participating in this study had diverse backgrounds and job responsibilities. The accessibility champion, to be truly effective, must be able to influence corporate decisions for the purpose of setting priorities and securing resources to further UD efforts.

Middle management often perceives accessible design to be in direct conflict with schedule and budget requirements. Project managers are responsible for making sure that a development project comes in on time and on budget. Because accessibility generally does not have a specific budget, the project manager perceives the research required to identify accessibility requirements and integrate them into the design as a threat to his or her objectives. If accessibility features can

be developed without adversely affecting budget or schedule, they have a chance of being integrated into the product; however, accessibility activities are often the first to be cut if budget or schedule is threatened.

Individuals with disabilities are not integrated into the design or evaluation processes. Many of the industry partners did not include people with disabilities in either the design phase or the testing and evaluation phase of product development. Tight schedules or limited resources were the most common reasons cited for lack of integration of people with disabilities into the design process. Other problems exist because of the accessibility barriers themselves. For example, it would be difficult to find a user who is blind who has extensive experience with computer-based training software if computer-based training software is generally inaccessible to users who are blind. Also, very few users with disabilities are experienced in participating in design focus groups or accessibility evaluations. Industry partners that perform user testing with people with disabilities typically perform only very limited or sporadic testing.

ATM Industry UD Barriers. The most important barriers to UD expressed by the industry partner representing the ATM industry were—

- A standard accessible design process has not been documented, tested, or verified.
- Sometimes accessibility features are poorly communicated to the consumers who require the features.
- The cost of developing and fielding new technologies associated with accessibility is often seen as prohibitive.
- Personnel responsible for making accessibility decisions often have little knowledge about accessibility or accessible design.
- Accessibility is often interpreted narrowly to include only physical access to the technology.

Barriers specific to the ATM industry identified during the industry study are discussed in detail in the following paragraphs.

A standard accessible design process has not been documented, tested, or verified. Factors beyond the immediate control of manufacturers of ATMs often affect the accessibility of ATMs. For example, while the manufacturer supplies guidelines for placement of the ATM, the purchaser of the ATM may choose to install the ATM in an inaccessible location. Furthermore, the purchaser often insists on loading custom software onto the ATM that may or may not take advantage of the built-in accessibility features of the device.

Sometimes accessibility features are poorly communicated to the consumers who require the features. Some users may not be fully aware of the accessibility features available on ATMs. UD features may not be used if users are unable to identify ATMs that possess the features or understand how to use them. While manufacturers often create end-user instruction materials and product brochures, the applicability of the materials is limited by the extent of software customization performed by the purchaser.

The cost of developing and fielding new technologies associated with accessibility is often seen as prohibitive. ATMs represent a substantial investment for the purchaser. Replacement of ATMs is often cost-prohibitive or extremely difficult. Furthermore, the life expectancy of ATMs is such that they rarely need a full replacement. Product components are simply replaced as needed or as substantially upgraded functionality is made available. Accessibility enhancements are unlikely to justify replacement of an existing ATM or even provide justification for replacing key ATM components. However, if the accessibility enhancements are bundled with security or performance enhancements, purchasers may find the upgrade more attractive.

Personnel responsible for making accessibility decisions often have little knowledge about accessibility or accessible design. Banks may place the ATM in an inaccessible location, may design inaccessible screens, or may design the pathway to the ATM in such a way as to make it inaccessible.

Accessibility is often interpreted narrowly to include only physical access to the technology. During a normal design process, the total user experience is often considered; however, it may be overlooked when the design is focused on accessibility. For example, when addressing access issues for individuals in a seated position, the inability of the user to privately enter the user PIN is overlooked. A seated person cannot conceal the keypresses in the same manner as someone standing. Accessibility evaluations should address the total user experience and not just the physical access issues.

Cell Phone Industry UD Barriers. The most important barriers to UD expressed by the industry partner representing the cell phone industry were—

- Marketing and technology trends sometimes run counter to accessibility requirements.
- Sometimes accessibility features are poorly communicated to the consumers who require the features.
- Companies often do not know how to market to people with disabilities.
- The cost associated with purchasing accessible products is not affordable by people with disabilities.

Barriers specific to the cell phone industry identified during the industry study are discussed in detail in the following paragraphs.

Marketing and technology trends sometimes run counter to accessibility requirements. Several marketing trends run counter to UD in cell phones.

Miniaturization is currently driving the development of most cell phones. As the form factor of cell phones is reduced, the space available for both the display and the keypad is reduced. Users who have difficulty reading information on small displays or users who have difficulty selecting small keys have difficulty using small cell phones. In addition, there is a current trend to expand the capabilities of phones to include PDA functionality. The "smart phones" are controlled by complex menu structures that may be difficult for some users to navigate.

Sometimes accessibility features are poorly communicated to the consumers who require the features. Cell phone manufacturers build phones to the requirements specified by the carriers and often have little interaction with end-users. In general, the cellular network providers are the exclusive customers of the cell phone manufacturers. The cell phone manufacturers have little control over how their products are marketed to end-users. Therefore, accessibility features built into cell phones are often not communicated to the end-user.

Companies often do not know how to market to people with disabilities. In the cell phone industry, this issue applies to the cellular network providers rather than the manufacturers. The sales staff members of the cellular network providers are often not familiar with the accessibility features of the phones operating on their networks and are incapable of advising people with disabilities about their purchase decision.

The cost associated with purchasing accessible products is not affordable by people with disabilities. Accessibility features tend to be added to the high-end products, which are typically not subsidized by the carrier. Higher processing speeds and greater memory are often required to operate accessibility features such as voiced menu options. Phones containing adequate processing and storage resources tend to be relatively expensive. Customized third-party software

designed to increase the accessibility of programmable phones is also expensive and therefore out of reach of most users with disabilities.

Distance Learning Software Industry UD Barriers. The most important barriers to UD expressed by the industry partner representing the distance learning software industry were—

- Designers lack an understanding of accessible design and what can be achieved if products are designed with accessibility in mind from the beginning.
- There is a lack of tools and resources useful for efficiently creating accessible products.
- The amount of time required to produce accessible products is prohibitive.

Barriers specific to the distance learning software industry identified during the industry study are discussed in detail in the following paragraphs.

Designers lack an understanding of accessible design and what can be achieved if products are designed with accessibility in mind from the beginning. Although developers of the core distance learning software seem to understand and design for accessibility, the developers of course content may not have the same appreciation for UD. Professors, teachers, instructors, and teaching assistants are responsible for the development of the vast majority of distance learning course content. The content may consist of videotaped lectures, audiotapes, transcripts of lectures, PowerPoint presentations, PDF documents, multimedia presentations, streamed video, and electronic texts. Each content type is associated with very specific accessibility issues. For example, streamed video should be closed-captioned and, in some cases, audio described in order to be considered accessible. Unfortunately, few content providers are able to commit the necessary resources required to develop fully accessible content.

There is a lack of tools and resources useful for efficiently creating accessible products. The tools available to content providers offer little assistance in creating

accessible content. Often content must be recoded manually in order to be accessible. For example, the effort required to design and develop an accessible slide presentation is often many times greater than the effort required to create the presentation without the accessibility features. Presentation software such as Microsoft's PowerPoint does not natively generate accessible content. Therefore, the content provider must work outside the presentation software to develop an accessible HTML representation of the original presentation.

The amount of time required to produce accessible products is prohibitive. It can take an experienced professional as much as 14 hours to caption 1 hour of video. Content providers simply do not have the time, resources, or tools to create fully accessible distance learning content.

PDA Industry UD Barriers. The most important barriers to UD expressed by the industry partner representing the PDA industry were—

- Marketing and technology trends sometimes run counter to accessibility requirements.
- Companies often do not know how to market to people with disabilities.
- The cost associated with purchasing accessible products is not affordable by people with disabilities.
- Designers lack an understanding of accessible design and what can be achieved if products are designed with accessibility in mind from the beginning.

Barriers specific to the PDA industry identified during the industry study are discussed in detail in the following paragraphs.

Marketing and technology trends sometimes run counter to accessibility requirements. The primary interface for most PDA devices, such as Palm OS or Pocket PC–based products, is a touch-sensitive stylus interface. The touch-

sensitive interface, like the touchscreen interface, is not accessible to people who are blind. Low-vision users may find it difficult to use assistive technologies, such as a magnifying lens, while holding the device and using the stylus. Users with fine motor control limitations will find it extremely difficult to select items from the on-screen menus because of the precise motor control movements required to use a touch-sensitive stylus interface. Although the potential for use of a PDA by people with disabilities is great, the technology is currently inaccessible to many users.

Many of the elements needed for the development of an accessible PDA are already embedded in existing products. Technologies for voice recognition interfaces—such as microphones, speakers, storage, and a sufficiently fast processor to process the voice recognition algorithms—are generally built into many PDAs. However, the software required to fully implement the technology in an accessible manner has not yet been developed. As an alternative to using the stylus interface, some programs support navigation using the hardware keys found on many PDAs. Keypress navigation is available for some applications, but adoption of the alternative navigation scheme is not widespread among software developers.

Companies often do not know how to market to people with disabilities. Perhaps because of the inaccessibility inherent to the touch-sensitive stylus interface, the accessibility of mainstream PDAs seems to have been overlooked. Therefore, PDAs are generally not marketed to people with disabilities, nor is the potential for PDAs to improve the lives of people with disabilities recognized.

The cost associated with purchasing accessible products is not affordable by people with disabilities. While the cost of PDAs has been reduced, they still represent a substantial investment for consumers. People with disabilities are reluctant, and rightly so, to invest in technologies with unproven track records on

accessibility. Accessible devices with PDA functionality, such as Freedom Scientific's PACMate, can cost up to 10 times the price of a standard PDA. Therefore, few people with disabilities are able to afford the devices without assistance.

Designers lack an understanding of accessible design and what can be achieved if products are designed with accessibility in mind from the beginning. Because of the touch-sensitive stylus interface, many see the PDA as inherently inaccessible, just as a digital camera is inherently inaccessible to a person who is blind. PDAs, particularly as storage capacities and processing power increase, are gradually becoming true handheld personal computers. It is reasonable to assume that a capable PDA could employ some of the same mechanisms for accessibility as personal computers. For example, voice displays used in conjunction with keypad navigation could be used in a similar manner to the way screen readers are used with personal computers. Voice recognition technologies could provide access to users who are unable to interact with the screen or keys. Screen magnifiers could be employed to assist users with low vision. Cooperation among hardware manufacturers, operating system developers, software application developers, and AT software developers will be needed to produce a fully accessible PDA. Currently, hardware manufacturers are reluctant to change their products unless the necessary accessibility features are built into the operating system and there is demand from software application developers.

Television Manufacturing Industry UD Barriers. The most important barriers to UD expressed by the industry partner representing the television manufacturing industry were—

- Personnel responsible for making accessibility decisions often have little knowledge about accessibility or accessible design.
- There is a lack of realistic standards, guidelines, and principles of accessible design.

Barriers specific to the television industry identified during the industry study are discussed in detail in the following paragraphs.

Personnel responsible for making accessibility decisions often have little knowledge about accessibility or accessible design. Accessibility of television sets depends on the cooperation of television manufacturers, content distributors, and content developers. Television manufacturers are responsible for developing hardware designs to take advantage of accessibility features, such as closed-captioning and descriptive audio, added by content developers. Content distributors must be aware of the accessibility features and deliver the content so it does not interfere with these features. Design decisions made by television manufacturers, content distributors, and content developers often are made for technological, financial, or creative reasons without consideration for accessibility.

There is a lack of realistic standards, guidelines, and principles of accessible design. While standards and guidelines exist for some aspects of television accessibility, such as closed-captioning, very little guidance is available for the accessibility of most television components. For example, little if any guidance is available for the accessibility of remote controls or on-screen menus.

Voice Recognition Software UD Barriers. The most important barriers to UD expressed by the industry partner representing the voice recognition software industry were—

- The technology required to produce accessible products is not available at a reasonable cost.
- The cost of developing and fielding new technologies associated with accessibility is often seen as prohibitive.

Barriers specific to the voice recognition software industry identified during the industry study are discussed in detail in the following paragraphs.

The technology required to produce accessible products is not available at a reasonable cost. Great advances in technology have improved both response time and accuracy of voice recognition software. However, frequent errors and recognition delays greatly affect the overall usability of voice recognition software. There are two basic types of voice recognition software. Natural language recognition software, such as Dragon Naturally Speaking or IBM ViaVoice, attempts to process and recognize a vast vocabulary of words. Such software can be used to navigate computer programs as well as produce text. In general, the user is required to tune the voice recognition software to the nuances of his or her voice in order to obtain acceptable levels of voice recognition accuracy. In contrast, limited vocabulary voice recognition software, such as an automated phone attendant, improves accuracy by constraining the number of words that the system can recognize. Limited vocabulary systems are speaker-independent and do not require tuning to the user's voice.

Natural language voice recognition software is still perceived as being too inaccurate and slow for use as an alternative to keyboard and mouse input. Users with disabilities who have used the technology in the past are reluctant to purchase additional software because of past disappointments. However, user perception of limited vocabulary voice recognition software is changing. Specialized voice recognition software can be embedded in common products such as digital copiers and public kiosks to provide access to a device that would otherwise be inaccessible.

The cost of developing and fielding new technologies associated with accessibility is often seen as prohibitive. Although the pathway to embedding voice recognition technology in common E&IT products is understood, implementation of the integration can be challenging. The embedded voice recognition system typically consists of a voice recognition algorithm, audio input

and output circuitry, a processor to execute the voice recognition algorithms, and a software vocabulary. The audio circuitry and processor represent a nontrivial production cost. The cost to develop the voice recognition algorithms (or to license existing ones) and capture needed samples of the vocabulary can also be high.

V. Discussion

The purpose of this research program is to understand the market for universally designed mainstream consumer products and services, document successful UD development processes, understand consumer needs, understand UD facilitators and barriers, and identify and address current issues in universal design. On the basis of the data collected during the market analysis, product assessment, industry study, and user study, certain conclusions can be drawn about the state of UD and the likely trends that will facilitate or inhibit the development of UD products and services.

First, a sizeable market for UD products and services exists. However, few companies appreciate the size of the market or know how to tap its potential.

Second, UD objectives can be achieved by making relatively minor modifications to the product design process currently used by manufacturers. The fact that companies can achieve UD objectives without changing their core design process is significant, because UD principles can be incorporated with minimal disruption. Furthermore, design process interventions, such as the adoption of accessibility requirements or the performance of user testing with people with disabilities, can be incorporated gradually as part of an organized, deliberate rollout of a UD program.

Third, our review of the state of UD indicates that products that are designed to be accessible sometimes do not meet the actual needs of the target population. Developers may not fully understand the needs of users with disabilities, because people with disabilities are not usually integrated into the design process, and information about the functional capabilities and limitations of people with disabilities is not available in a conveniently accessible format. Also, technical solutions to accessibility issues may be formulated in the absence of the total design or with little understanding of how the feature will be used.

Finally, the discussion section ends with an analysis of the barriers to the implementation of UD faced by industry and a discussion of possible facilitators for the adoption of UD principles. The following paragraphs discuss the major findings of the UD research project in further detail.

A Sizable Market Exists for Universally Designed Products and Services

The market analysis and focus group study results demonstrate that a market does indeed exist for UD products and services. E&IT is driving the creation of new communities that are forever changing the way people live, learn, work, and play. Companies are increasingly expanding their presence in emerging markets. Businesses are serving populations they have never served before. No two people have the same set of characteristics, learning styles, preferences, abilities, experiences, and educational backgrounds. The classes of people making up the market for UD products and services include—

- Users with disabilities
- Users with temporary disabilities
- Users with functional limitations due to situational factors
- Users with low literacy skills
- Users in low bandwidth areas
- Users desiring increased functionality and usability
- Users who do not speak English as their primary language
- Users in high-population-density areas
- Users who are elderly

Approximately 21.19 percent of the total U.S. population has a formally classified permanent disability (i.e., low vision, blind, hard of hearing, deaf, upper-mobility impaired, lower-mobility impaired, or cognitively disabled). When considered at a more global level, almost 500 million people in just the United States and the top five emerging markets have permanent disabilities.

Add to that number those people with permanent disabilities in all other parts of the world, as well as individuals who experience temporary or situational disabilities or an impairment resulting from one of the classifications listed above, and it is clear that accessible designs are critical to everyday functions.

In addition to the sheer numbers of people who can benefit from UD products and services, there are legal mandates to address the needs of people with disabilities. Legislation provides further justification for developing products and services that can be used by larger segments of the population. Technological advances are ever-increasing, which enhances our ability to provide products that are usable by more people. These products can also be provided more cheaply. Cost is a barrier that has been difficult to overcome in the past.

As previously specified, users with disabilities include those who have low vision; are blind, hard of hearing, or deaf; or have an upper- or lower-mobility or cognitive disability. Temporary and situational disabilities result in functional limitations that mimic those of permanent disabilities. People in darkness or an eyes-busy situation (e.g., driving a car) can benefit from the same tactile cues that people who are blind use. Low vision is created when someone has dilated pupils, is without his or her reading glasses, is in a smoky or low-light environment, or is presented with a small display using small fonts. Noisy environments create similar issues as for people who are hard of hearing. Very loud environments (e.g., a construction site) or forced-silence environments (e.g., a library or meeting) create a need for alternative means of communication, as for people who are deaf. Limited manual dexterity results if someone has a broken arm, arthritis, or hand tremors; is in a bouncing vehicle; or is wearing gloves. Finally, temporary limited cognition can result when individuals are distracted or panicked, under the influence of alcohol, or in an environment where their native language is not spoken.

Users with low literacy skills or who are in an environment where the native language is not their primary language (including tourists) can benefit from some of the same products and product features that help cognitively disabled individuals, including use of simple language, good

graphical metaphors, and redundant text and pictures. Users in low-bandwidth areas can benefit from some of the same products and product features that help people with low vision and users who are blind, including text alternatives for graphics and low-density displays.

The elderly population is ever-increasing, and many difficulties faced by people with various types of disabilities will become issues for the aging population as well. Products that can be developed for use by a variety of individuals will benefit people as they age. The elderly experience limitations to their sight, hearing, manual dexterity, and cognition. Many of these individuals are accustomed to having access to various technologies and have come to rely on them; they will expect to be able to continue to use these technologies, despite any age-associated limitations they may develop. They will not want to purchase new products to accommodate their developing limitations. This includes products that are easy to understand and use, that have adequately spaced and sized buttons, and that have sufficiently sized labels and display elements, to name a few features.

The final group is users who desire increased functionality and usability. For example, the cell phone used to be simply a voice communications device. Now many cell phones have text messaging as well. Text messaging is one feature that is particularly beneficial to people who are deaf or hard of hearing, but a large percentage of the population has adopted the technology for situations in which voice communication is inappropriate. Many product features, if designed with different user groups in mind, can benefit a large part of the population, satisfying the needs of many rather than just a few.

Universal Design Principles Can Be Easily Incorporated into Current Design Practices

The industry study included a review of the design practices of the industry partners. While different companies have different names for the individual design processes, the processes generally follow these steps:

- Product planning

- Requirements definition
- Product specification
- Development
- Verification and testing
- Manufacturing
- End-of-life management

The application of UD principles does not require a major modification to the way companies currently develop products. Minor changes in the way products are developed will lead to significant increases in accessibility. The most important modification to the design process occurs in the very first stage of design: product planning or product conceptualization. During this stage, the objectives of the design product are outlined and the high-level conceptualization of the product is developed. Accessibility must be considered during this stage. Companies that failed to consider accessibility in product planning often failed to have a significant impact on the accessibility of the final design.

The incorporation of UD principles at the product-planning stage involves expanding the user requirements to include people with disabilities and adapting to principles of UD in the conceptualization of the specific product being designed. For example, if a new copier is under development, product planners might consider early on that users who are blind should be able to complete all the primary tasks supported by the device. This consideration might lead product planners to conceptualize a copier with a user interface that is supplemented with a secondary, but integrated, user interface that is accessible to those who are blind. Users with disabilities should be consulted during the product-planning phase.

Slight modifications to the requirements-definition phase can also lead to significant improvements in accessibility. In the requirements-definition phase, it is important to define objectively testable requirements for accessibility. It is not sufficient to require that the product

be accessible, because doing so provides little information to designers and prevents accessibility verification testing. Vague accessibility requirements are more likely to be ignored in both the development and the verification and testing phases of design. Testable requirements that are tailored to the product being developed should be incorporated into the requirements definition of the product. Again, the addition of accessibility requirements does not change the way the product is designed. Rather, these requirements are simply added to the existing requirements-definition methodology. The same methods used for monitoring, tracking, and measuring standard product requirements can and should be applied to accessibility requirements.

During the product-specification phase, the functionality and appearance of the product is defined in accordance with the definition of product requirements. Personnel with expertise in UD must be available to assist in defining the specifications, reviewing the product specifications that affect accessibility, and determining if the accessibility-related product requirements are met by the product specifications. Given that most companies use some sort of integrated team development process during the product-specification and product-development phases, the addition of a team member with UD expertise is not likely to be disruptive. In fact, an existing team member can assume the role of the UD expert on the development team by becoming familiar with UD principles and understanding the functional limitations and capabilities of people with disabilities.

The product-development phase typically involves iterative design and testing of prototypes. The product-development test plan should be broadened to include users with disabilities and testing with common assistive technologies. Testing should be task-based. The outcome of testing should be determined by human performance rather than the subjective impressions of the users.

Products Designed To Be Accessible Sometimes Do Not Meet the Needs of Users

Manufacturers, sometimes with good intentions, often develop products that, while innovative, fail to meet the needs of the intended population. Occasionally, products are developed with

accessibility features that only partially meet the needs of users. For example, some cellular phones have been developed with auditory indicators for battery and signal strength; however, the user is required to operate a user interface that requires vision to properly activate and configure the additional features. In this case, the designers of the system were successful in developing a needed indicator for users who are blind, but they fell short of the solution the implementation of the feature set was developed to address. Occasionally, developers working on accessibility issues are segmented from the general design and must develop accessibility solutions independent of the main design path. This practice can lead to a failure to integrate accessibility into all aspects of the design process.

Occasionally, designers fail to fully appreciate the needs of users with disabilities. For example, an ATM developer may incorrectly assume that Braille labels on numeric keypads increase accessibility for people who are blind. In reality, most users who are blind are comfortable using a standard keypad. What users request most often is a standard keypad with raised buttons and a nib on the "5" key. The nib serves to quickly orient the user to the arrangement of the keypad and is much more useful than Braille labels on the keys. In fact, the Braille labels may interfere with the user's ability to quickly identify the "5" and therefore increase transaction times for users who are blind.

Failure to address the needs of users with disabilities typically results from a separation of the user from the design process or the separation of the designer of accessibility features from the mainstream design activities. Companies interested in developing universally designed products and services should consider consulting with people with disabilities or accessibility subject-matter experts when contemplating an addition of a design feature that is intended to increase the accessibility of the product. Furthermore, companies should consider mainstreaming accessibility-feature development as soon as practical so that the feature will be well integrated into the product and all aspects of the feature, such as configuration and activation, will be considered.

Legislation Is Currently Both a Facilitator and a Barrier to Universal Design

The Federal Government has a critical role to play in the promotion of UD. Accessibility-related legislation can affect businesses in several ways, some positive and some negative. Straightforward ways in which businesses can experience a direct positive impact from legislation include the following:

- Legislation can remove barriers that inhibit provision of accessible products and services. The primary method by which legislation can remove these barriers is to set standards for interoperability in a complex network of systems. The impact of such legislation can be to remove barriers that prohibit content providers from marketing accessible products because of infrastructure constraints. Such legislation can also allow infrastructure developers to invest in feasible technologies with the assurance that content providers will produce compatible products.
- Legislation can create new markets for accessible products and services. Legislation that creates new markets for accessible products or services also creates new ancillary opportunities for testing and marketing those products or services. These new markets can be pursued by all types of businesses.
- Legislation can alter the market dynamics for a given class of products, creating a new product attribute that can be used to gain market share. Legislation that alters the market dynamics in this way inherently creates a way for an incumbent business to lose market share to a competitor—thereby creating an incentive for the incumbent to improve the accessibility of products to guard against the loss of market share.

Straightforward ways in which businesses can experience a negative impact from legislation include the following:

- Legislation can add to the base cost of producing a product or providing a service, without creating a commensurate offset in (increased) price. This type of impact is particularly negative when different suppliers experience different impacts in costs—for example,

when some competitors are exempted from full compliance and thus do not experience the same cost increases as other competitors.

- Legislation can eliminate markets for certain existing or planned products. Products can be eliminated because they are noncompliant with requirements of the legislation and thus cannot be sold or because they are not compatible with a prescribed architecture for interoperability and thus cannot function properly in a network of systems.

The effects described above are direct impacts on the markets for products and services offered by businesses. Legislation can also have indirect effects on businesses that are positive or negative. These effects are called "indirect" because they are manifested in long-term trends in product development rather than in immediate effects on markets. Indirect effects on businesses that are positive include the following:

- Legislation can encourage businesses to invest in solving accessibility-related problems.
- Legislation can create an incentive for innovation in developing accessible products and services.
- By creating larger markets for accessible products, legislation can facilitate corporate strategies with respect to societal issues and corporate stewardship. For some businesses, the opportunities to contribute to the overall betterment of society (and to receive appropriate recognition for doing so) through improved accessibility of their products may fit well with their plans in such diverse areas as energy efficiency, environmental impact, and community investment.

Legislation can also have indirect impacts that are negative for businesses. Examples include the following:

- Legislation can set a minimum standard for acceptability that becomes the de facto maximum standard. Businesses may be unable or unwilling to justify developing improvements in accessibility because compliance is a simple binary judgment; improvements are not seen as economically justifiable.

- Legislation can create a regulatory environment in which the focus is on compliance with the regulations rather than on achieving the outcome sought by the regulations. Businesses may produce products that comply with the regulations but are not truly accessible. Businesses may choose to advocate interpretations of regulations that circumvent the intended outcome.
- Legislation can be used to advance or oppose political agendas with little regard for the actual outcomes that are influenced by the legislation. Businesses can be negatively affected by these political agendas. For example, a business might decide to oppose "government regulation" related to accessibility on ideological grounds, even though it may be in the best interest of that business (not to mention society at large) for the legislation to pass.

Government, Industry, and Consumers Have Important Roles To Play in Promoting Universal Design

Government, industry, and consumers can all have a hand in promoting the development of UD products. Users who participated in the study focus groups were asked to comment on what the Federal Government, manufacturers of products, and consumers could do to promote universal design.

Government Involvement. Focus group participants indicated the following:

- Government can fund research, similar to this project, in which consumers with disabilities are involved early in the process.
- Government can provide funding or tax breaks to encourage companies to develop some accessible products so that companies can see the value they can provide.
- Government can get consumer input and make the general public more aware of accessibility and disability issues, and can provide funding to make accessible products more affordable. Getting consumer input should include putting the question out to the disability community on how to improve the technologies, rather than making decisions for the disabled about their needs and desires.

- Government needs to continue to develop and enforce legislation and standards, without which industry is unlikely to act on the needs of special populations.
- Focus groups should be used in standards development and should include participation from a variety of consumers as well as individuals with technical knowledge; standards should be developed in conjunction with solutions to make them more realizable.
- Government should put a mechanism in place to force its entities to consider their technology purchases and the impact on different disability populations (e.g., the U.S. Postal Service purchase of touchscreen displays).
- Government is in a position to influence by example. If it is addressing UD-related issues and can demonstrate positive outcomes to industry and consumers, awareness will increase and others are likely to follow suit.

Industry Involvement. Industry can do similar things, as indicated by focus group participants:

- Industry can get consumers with disabilities involved early in the design process and conduct more focus groups.
- Industry should always consult the people they're designing for, whether through direct involvement or market research.
- Industry should hire people with disabilities, at least as consultants, to provide input throughout the design and development process. This would also assist in increasing awareness of the needs of people with disabilities.
- Industry spends millions in advertising dollars. It should put a portion of those funds toward designing for people with disabilities and funding research to assist those with disabilities.
- Industry need to make products more affordable and do extensive marketing so that people are aware that these products are available.

- Industry needs to consider the wider market that can benefit from products with accessibility features, as well as understand that there are people with disabilities that would like to use their products.
- Industry needs to recognize the advantage that can be had by building in UD from the beginning.
- Industry should provide a mechanism (e.g., an accessibility program office) for consumers to voice their concerns, and it should act more on the concerns that it hears about.

Consumer Involvement. Focus group participants indicated the following:

- Consumers can influence the development of UD products by participating in research studies, surveys, and product evaluations.
- Consumers can spend time talking to and educating product sales people about features that can benefit someone with a certain disability and about the lack of usefulness of some features for people with particular disabilities. This education can extend to other members of the community as well, to make people aware of the issues that affect people with various disabilities.
- They can speak up and contact companies directly to advocate for their disability community and provide suggestions for design improvements. Consumers need to be very specific when contacting manufacturers to complain about products that are not accessible. They should provide both positive and negative feedback. If companies know what they are doing right, their awareness will increase, and they will be likely to continue to implement designs they know are useful.
- In addition to contacting manufacturers, people with disabilities should contact government to voice their concerns and increase awareness of how many people with disabilities there are in the population.
- Consumers can donate their old accessibility aids to others who may benefit from them because they cannot afford the technologies themselves.

- Consumers should contact state agencies, which can communicate to the larger disability populations to inform them of accessible opportunities and products they may not know about. State agencies can serve as an information outlet to the disability community and as a means to help government and industry gather data they need to take steps to improve accessibility in all matters of life.
- Consumers can purchase the products they find most accessible. They should not purchase products from companies that fail to demonstrate an effort to address UD, and they should encourage others to do the same.

Industry and Consumers Would Benefit from Better Industry Coordination with AT Vendors

Assistive technology manufacturers possess the technical knowledge, experience, and talents that can help E&IT manufacturers succeed in selling E&IT into emerging markets. It is difficult for AT manufacturers to support the needs of E&IT manufacturers for many reasons. Most of the difficulty may be attributed to the differences in size and available resources between AT and E&IT manufacturers.

Randy Marsden, director of ATIA and president and CEO of Madentec (USA) Inc., uses the following analogy to paint a picture of what compatibility of AT and E&IT is all about:

> Owners of public buildings are obliged to make them accessible to everyone, including people with physical disabilities. They do this by focusing on providing wheelchair ramps, automatic door openers, etc., which are of limited value in and of themselves, unless there is also a wheelchair in the picture. But few building owners provide wheelchairs as part of the "accessibility package" of their building. Wheelchairs are usually a very personal item (size, weight, style, etc.). Instead, building owners make sure their ramps and doors are compatible with the wheelchairs on the market that are provided by specialized vendors.
>
> Continuing with the analogy, the building owner can do smaller things to help make their building more accessible themselves. For example, they could put larger door knobs and door pulls on their doors that make them more accessible to everyone. You wouldn't expect someone to bring their own door knob. But when it

> comes to major items, building owners focus on simply being compatible with the more specialized equipment that is provided by people who better understand the disability marketplace.

E&IT vendors are like the building owners. They have the ability to make their products compatible with AT products used by people with disabilities to the extent that is technically possible and economically feasible. While AT is not the primary approach to universal design, AT manufacturers do have a role to play in ensuring that E&IT is accessible.

At the lowest level, universal design of E&IT should mean that products and services should be developed so that they do not actively interfere with the operation of assistive technologies if the user chooses to use AT. For example, some software applications, when installed on a user's personal computer, may disable screen readers. While the software may not rely on AT for accessibility, it should at least ensure that use of the software does not interfere with AT that may be installed on the user's system. This implies that E&IT vendors should, at a minimum, have some understanding of AT and how it is used.

AT may also be used to enhance the user experience. While independent accessibility is an important UD goal, in some instances AT interoperability may be built into products for the mutual benefit of the developer of the technology and the user. For example, a software developer should not be required to reinvent screen reader technologies for every application. The developer should instead concentrate on ensuring that the software is interoperable with existing AT. Consumers benefit from the arrangement because they may rely on the user interface of a screen reader that is familiar and customized to meet their needs. Industry benefits because developers can focus on the development of the application user interface rather than the reinvention of solutions that have already been fielded.

Opportunities for enhancing the interoperability between AT and E&IT products include identifying reasonable, achievable, functional performance criteria and developing AT/E&IT interoperability specifications and interoperability testing procedures. Both AT and E&IT vendors would benefit from a clear understanding of requirements. Also, there is a need for AT

manufacturers to be active participants in the creation of interoperability specifications. Notice that the word "specifications" is used in a plural form, because there is not a single solution to interoperability. Instead, there is a need for ongoing cooperation between E&IT and AT manufacturers to continually define interoperability specifications on a product-by-product basis, acknowledging the fact that some products can be grouped into similar categories and a common interoperability solution can be applied.

E&IT manufacturers can actively support the AT industry by—

- Actively participating in creating interoperability specifications
- Adhering to interoperability specifications
- Assigning "point people" within each E&IT manufacturer to support AT manufacturers' efforts to achieve the highest levels of compatibility and interoperability and to answer highly technical questions about specific E&IT products
- Providing, at no cost, E&IT loaner products and possibly human resources for testing AT/E&IT interoperability

The Federal Government can support the AT industry by weaving the tracking of AT products into the fabric of the Department of Commerce's mainstream E&IT product research and continuing efforts in support of facilitating dialog between AT and E&IT vendors.

VI. Conclusions

Given the ultimate goal of promoting universal design in consumer products, policymakers are confronted with choices of strategies that will help further progress toward that goal. Two broad categories of strategies emerge: market-based strategies and rule-based strategies. Market-based strategies attempt to use market forces, which translate into supply and demand forces, to promote UD. A simple example of a market-based strategy is use of advertising to encourage consumers to purchase accessible products. If the advertisements are effective, demand for accessible products will increase, and the supply will increase to match the demand. Rule-based strategies attempt to use standards or regulations to encourage suppliers to develop and offer accessible products; latent demand for such products is expected to subsequently become manifest. Rule-based strategies can be based in industry-adopted standards, in government regulations and policies, or both. A simple example of a rule-based strategy is a regulation that all telephones sold in Australia must have a nib on the "5" key.

A hybrid strategy combines rule-based features and market-based features. A leading example is section 508 of the Rehabilitation Act, which seeks to create a bigger market for accessible products by regulating the purchases made by the Federal Government. For products purchased in significant quantities by the Federal Government, companies have an incentive to increase the accessibility of the products and thereby increase their sales. The rules regarding product features and capabilities only apply to federal purchases.

Rule-based strategies "push" UD forward; market-based strategies "pull" it forward. Some aspects of UD are better served by a push strategy, and other aspects are better served by a pull strategy. Delineating the mixture of push versus pull and the overall philosophy of when to use which strategy requires consideration of how purchase decisions are made and how production decisions are made.

Analysis of Purchase Decisions for Accessible Products

The decision to purchase an accessible product is first and foremost a decision to make a purchase. Whether the item is, in fact, accessible might not be known when the decision is made. Factors that influence the decision to purchase an accessible product are simply factors that influence a purchase decision—the accessibility of the product *cannot* influence this behavior. The three factors that primarily interact in a purchase decision are—

- The availability of resources to apply to the purchase.
- The perceived inherent value of the item.
- The properties of alternative purchases; in particular, the perceived values of these alternatives. Note that the alternatives could be products in the same class as the putative accessible product or could simply be something altogether different.

A full exposition of the complex topic of consumer choice is well beyond the scope of this exercise. Central to this exercise, however, is consideration of the primary contributors to a purchase decision.

The accessibility of a given product can only affect the purchase decision if it affects the inherent perceived value of that item. There are two broad categories of factors that can affect the perceived inherent value of an item:

- Actual experience with the item or highly similar items
- Presence of discriminators that predict eventual experience with that item

The purchaser's "actual experience" with an item is quite different when the item is for personal use than when it will not be used personally. The actual experience with an item for personal use primarily consists of the utility of the item. When items are purchased for others to use, actual experience may consist of direct knowledge of the outcomes experienced by those users (as would be the case with a purchase made for a family member or employee); but the purchaser

may have no knowledge of outcomes if the purchase is made on behalf of an agency or large company.

To illustrate, consider safety as a factor in making a purchase decision. Safety affects the decision only if a product's being "safe" or "safer" affects its inherent perceived value. It is a relevant factor for virtually all products. Even users of illegal drugs expect the drugs they buy to be "safe" with respect to the intended use (e.g., not cut with a poison that would cause immediate death). But the perception of whether an item is safe does not affect the perceived inherent value of an item if the purchasing agent does not, and will not, experience the outcome of the purchase with respect to safety. For example, an individual buying some product (e.g., an electrical extension cord) for personal use would not purchase the product if he or she perceived that it was unsafe—that using it might result in harm to self or damage to property. But if the purchase is to stock the shelves of a national discount retailer, the issue of safety is not a personal one. Safety is a relevant consideration only to the extent that job performance assessment or personal liability are affected by the eventual experiences of consumers who make retail purchase decisions.

If bulk purchasers are in a situation in which the accessibility of the products they select does affect their personal outcome—in the form of job performance ratings or other means of personal accountability—these purchasers will need access to information that will help them predict the accessibility outcomes that will be experienced by the eventual end-users of the products they purchase. Thus, two requirements must be met: personal outcome experienced by the bulk purchaser that is contingent on whether the product is accessible, and availability of reliable information on which to make the purchase decision.

The presence of discriminators that predict actual experience also affects decisions in the same way. If the item is for personal use, a discriminator that reliably signals the eventual experience will have virtually the same effect as the experience itself. Three types of discriminators are commonly found in the marketplace: brands (self-identifying words or symbols that are associated with a common source of products); unregulated claims (assertions and suggestions

made in advertising, packaging, and other methods about outcomes that will be experienced); and regulated labels (words and other data whose meanings are regulated so as to provide a more trustworthy basis for predicting the eventual experience with an item.)

Note that a purchaser's direct experience with the outcome of purchasing a product *cannot* affect the purchase of that product, because the actual experience of outcome occurs after the purchase is made. The experience of the outcome can only affect *future* purchase decisions, not past decisions. Further, the effect on future purchase decisions affects demand in the market only if the purchases are made often enough to have an impact on production decisions. To illustrate, if purchasers purchased a given product only once in their lifetimes, their actual experience with the outcome of that purchase would never affect the market, because they would never have the opportunity to use their experience to shape their next purchase. Similarly, if purchases of a given product are made quite infrequently—every few years, for example—their actual experience of the outcome with respect to accessibility would have relatively little impact on demand forces in the market.

If products are purchased infrequently, then, the actual accessibility of a product can affect the purchase decision only to the extent that information (such as labels, brands, or claims) is available to consumers that will allow them to predict (consciously or unconsciously) their experience of outcome. Otherwise, the lag times for effects of consumer demand in the market will be far too long to have a significant impact on production decisions.

On the other hand, if purchases are made frequently, the consumer's actual experience of outcome can more readily and directly affect demand forces in the market. To illustrate, if one brand of pay telephone is accessible (e.g., compatible with hearing aids) and another brand is not, consumers who have hearing aids and who regularly use pay phones will quickly learn which brand to select. If users in this category constitute a significant segment of the market, usage rates for the accessible product will increase and pull the market toward the accessible product. This is especially true when there are no other discriminators among competing products. Conversely, if

users in this category do not constitute a significant segment of the market, the pull factor will be slight and could well have no impact.

Thus, if the purchase decision is made frequently relative to the production decisions in the market, the consumer's actual experience can shape market demand if the segment of affected users is sufficiently large. The presence of good predictor information (labels, brands, claims) may further amplify this effect.

Reliable predictors in the form of labels, brands, or claims can also affect the market in an aggregate sense when they generally apply to multiple classes of products. For example, if brand A of one type of product is reliably accessible to users with a specific impairment, that same brand name on a different product could be used as a predictor of the experience of outcome and, therefore, affect demand for that product, even if the product is purchased infrequently.

If a consumer makes a decision to purchase, that decision usually involves selection of a specific choice from a field of available, competing products that meet some qualification criteria. The qualification criteria may simply be provision of the basic functionality of the device, but they may also include some other factors of personal significance to the purchaser. (Examples of other factors of personal significance are country of origin or trusted retailer.) A useful class of models of consumer choice from economic theory segments consumer choices among available products into the following three categories:

- Best price—the consumer selects the product with the lowest price from among all available, qualifying products.
- Best product—the consumer selects the best product from among all available, qualifying products, irrespective of price.
- Best value—the consumer selects a product on the basis of both price and performance, through some conscious or unconscious weighting of features and price. Of particular

interest in the present context is the notion that best value decisions may actually focus on one dimension of performance rather than impartially weighting all performance factors.

The accessibility of the product can affect "best price" or "best product" choices only if it forms part of the qualification criteria. This path could be used to influence the market for accessible products by advocating that consumers, businesses, and governments consider only products that meet some accessibility criteria (similar to purchasing paper with at least a certain amount of recycled content). Products then compete on price or on overall capabilities, but only if they meet minimum accessibility criteria.

The accessibility of the product can affect best value choices either through inclusion in the qualification criteria or by being one (and perhaps the only) dimension of performance that is considered in determining value. This can be promoted by providing information about product accessibility to consumers so they can consider it. Providing such information can lead to some best value decisions being based primarily on the level of accessibility in the product—that is, some consumers will select the most accessible product when they make a best value choice.

Demand forces in the market can therefore promote UD and accessibility of products through the following mechanisms:

- For products that are purchased often by individuals for their own use, consumer demand will help drive the market to supply accessible products.
- For products that are purchased relatively infrequently, consumers must be given information that helps them predict their experience of outcome in order for consumer demand to affect supply.
- For products that are purchased for use by others (e.g., bulk purchases made by large companies or government agencies), the outcome experienced by the purchaser is not the accessibility of the product itself. The outcome experienced by the purchaser, in terms of job performance ratings or personal accountability, must be made contingent on the accessibility outcomes experienced by the eventual users of the product in order for this

type of purchase to contribute to market demand. For this to happen, these purchasers need access to information that will help them predict the outcome that will be experienced by the eventual users.

Pull legislation can create and affect demand forces in three primary ways: imposing requirements to provide information (such as standard labeling) that can educate individuals and bulk purchasers; creating job-related outcomes for bulk purchasers (particularly in government); and creating opportunities for private tort lawsuits to pursue warranty issues related to accessibility.

Comparison of Strategies To Promote Universal Design and Strategies To Promote Safety

As policymakers consider the ultimate goal of promoting UD in consumer products, it becomes clear that no single strategy will be appropriate for all types of products. It is useful to consider the mixture of strategies that are necessary to promote *safety* in consumer products. The following points summarize (at the risk of oversimplification) the strategies that are used to promote safety of consumer products:

- For nonessential product features that are inherently dangerous, but the danger is not open and obvious, regulations either prohibit the feature altogether or prescribe safeguards that must be provided. Examples include levels of radiated energy generated by the product and presence of toxic chemicals in the product. Producers may not include these nonessential features in their product, irrespective of cost or inconvenience incurred.
- For design features that are inherently dangerous when used inappropriately, but that must be present to achieve the functionality of the product, a combination of government and industry rules dictates design safeguard features that must be added to prevent inappropriate use of the product and/or warnings and instructions that must accompany the product.

- For design features that pose an intermediate level of risk but that also contribute to functionality and/or reduce cost, a combination of industry practices, customer demand, and private tort lawsuits jointly shape the provision of design safeguard features, warnings and instructions, and other efforts related to promoting product safety. In this context, an intermediate level of risk means that the probability of an adverse event is not sufficiently high to warrant government or industry rules, but it is not trivially low either.
- For safety factors that are associated with interoperability of products (e.g., voltage compatibility, physical couplings and connectors with infrastructure), government and/or industry standards are used to define allowed configurations.

If these strategies were translated directly to the goal of promoting UD and accessibility, the following strategies would be suggested:

- Nonessential design features that inherently produce inaccessible products for a given recognized impairment should be prohibited altogether or should be allowed only if specified alternatives are also provided. For example, touchscreen interfaces for devices that do not inherently require a touchscreen could be prohibited unless accompanied by an equivalent voice display.
- Design features that reduce cost or contribute to functionality but that also cause accessibility problems should either be accompanied by alternative features that remediate the accessibility problem for the affected group of users or should have clear labeling that allows affected users to know about the accessibility problem.
- Design features that pose a risk of inaccessibility (i.e., the accessibility problem is not prohibitive, but there is a nontrivial probability that affected users will have trouble performing some tasks with the device or otherwise have restricted use of the device) should be accompanied by labeling (and other supporting information, as appropriate) that allows the affected users to know about the problem. Absence of such labeling could form the basis of private lawsuits through implied warranty. Alternately, labeling and warranty could be provided to assert the accessibility of the device and to specify the limitations

thereof, and failure to perform as specified could form the basis of an express warranty claim.

- When accessibility is dependent on interoperability of products or within an infrastructure (such as the telecommunications infrastructure), government and industry standards should be adopted to define allowable configurations, and all allowed configurations should result in accessibility.

The following table summarizes the comparison between promotion of consumer product safety and consumer product accessibility.

Table 2. Comparison Between Promotion of Consumer Product Safety and Accessibility

Issue	Strategy used for product safety	Equivalent strategy to promote accessibility
Nonessential feature poses significant problem	Government or industry standard prohibits the feature or requires safeguard.	Government or industry standard prohibits the feature or requires alternative interface.
Essential feature poses problem if used inappropriately	Safeguards must be provided to discourage inappropriate use; warnings and instructions must be provided.	Alternative interface must be provided, if possible; clear labeling is required to inform consumers of remaining accessibility issues.
Design feature creates risk with nontrivial probability, but not high enough to be prohibitive	Industry practices and consumer demand influence whether the feature is offered; warnings about the risk must be provided; private lawsuit is available to those who experience the problem.	Industry practices and consumer demand will determine whether the feature is offered; labeling must be provided to indicate level of accessibility (or to alert consumer to accessibility limitations); warranty claims are available to those affected by the problem.
Interoperability issues within some infrastructure can create problem	Government or industry standards adopted to define allowable configurations.	Government or industry standards adopted to ensure product accessibility when used in the infrastructure.

The recommendations derived from the above are as follows:

Recommendation #1. Use standards (government or industry) to prohibit nonessential features that pose accessibility problems unless an alternative interface that solves the problem is provided.

Recommendation #2. Use standards (government or industry) to eliminate interoperability problems that create accessibility problems.

Recommendation #3. Use market forces to regulate features that pose intermediate levels of accessibility problems. Require labeling and other information to be provided, and allow recourse through tort (warranty) lawsuits as well as through general demand as reflected in consumer purchases.

Analysis of the Market for Universally Designed Products and Services

Businesses, in general, are not aware of the market potential for universally designed products and services. Data gathered from the industry study indicated that the industry study partners generally took a rather narrow view of the market potential for UD products. By far the most important consumer of UD products and services is perceived by industry to be the Federal Government. Many of the industry partners recognized the need for developing accessible technologies for people with disabilities but failed to recognize the population as a significant market. Participating companies continue to struggle with the development of a supportable business case for UD products.

Recommendation #4. Develop training materials and educational articles documenting the market potential for UD products and services.

To address the needs of industry, the Federal Government should support the development of training materials and the publication of articles in major business journals that document the market potential for universally designed products. The publications should outline potential sources of untapped revenue and present a meaningful financial argument for developing

accessible technologies. The research should be conducted by reputable financial analysts with experience in the development of business cases and the evaluation of market trends. The project should include in-depth case studies of specific products that not only have had an impact on the lives of people with disabilities but are also mainstream commercial successes.

Analysis of the Impact of Section 508

Section 508 was developed to govern the purchase of electronic and information technology purchased by the Federal Government. Federal agencies must ensure that individuals with disabilities have access to and use of information that is comparable to the access and use by federal employees who do not have disabilities, unless an undue burden (significant expenses or difficulties) is imposed on the agency. The law also requires that individuals with disabilities in the general public seeking information or services from a federal agency have access to information and services comparable to those provided to individuals without disabilities, unless undue burden is imposed on the agency. When compliance does impose an undue burden, agencies must still provide disabled individuals with the information and data by allowing them to use it by an alternative means of access (e.g., captioning, audio description). While agencies must procure products that best meet the standards, section 508 does not require that manufacturers make their products more accessible.

> **Recommendation #5.** Institute procedures designed to ensure that due diligence is given to section 508 procurement requirements. Perform an internal analysis of the impact of section 508 on the procurement of actual products. Publish the results of the analysis as a way of convincing industry that the Federal Government is committed to section 508.

Despite having been in place for nearly three years, section 508 has failed to reach its potential. Section 508 has failed to have a real impact on the purchase of products. The industry study results demonstrate that the perception in industry is that companies are not losing sales by not having accessible products. If federal agencies need to make a purchase, they will purchase what

is available; they cannot wait for accessible products to become available. Some companies have put efforts into awareness and some development of the accessibility of their products, but their efforts are focused on the specific products that are most likely to be purchased by the Federal Government. Other products in the same company continue to be developed without consideration for accessibility. The products that are most likely to be purchased by the Federal Government are least likely to be purchased by small businesses or the individual consumer, greatly limiting the number of people that will benefit from even moderate accessible design.

> **Recommendation #6.** Consider requesting supporting evidence for claims made on VPATs from all vendors responding to bid proposals.

> **Recommendation #7.** Develop a quick accessibility checklist for specific product lines likely to be procured by the Federal Government. The quick accessibility checklist would assist procurement officials with market research by providing them with a list of items that they can inspect themselves when procuring products. The checklists would be tailored to specific product lines and would not require detailed expertise to evaluate.

When considering products for purchase, procurement officials consult VPATs for the purchasing decisions. However, there is wide interpretation of the section 508 requirements by those filling out VPATs; even within a company, two very different VPATs could be generated by different individuals for the same product. In some cases, those filling out the VPATs are not as familiar with the product as the designers and are likely not aware of the issues that people with disabilities may face when trying to use the products. In addition, there are rarely data from user testing (of people with disabilities) to support the statements made on the VPAT. Companies are also uncertain about which products are relevant under section 508 and which aspects of the covered products are governed by the regulations.

> **Recommendation #8.** Develop guidance for reporting conformance with functional performance criteria guidelines.

One of the greatest shortfalls of section 508 is the lack of understanding of and attention to the functional performance requirements. These requirements, in particular, are too ambiguous to support the needs of industry. Since the implementation of section 508, an increasing amount of information has been made available on how to interpret some of the language of the requirements (e.g., as seen at http://www.access-board.gov/sec508/guide/index.htm), but nothing has yet been made available on the functional performance requirements, which are the most difficult to interpret. Other UD standards and guidance are also ambiguous and insufficient to support the needs of industry in developing more accessible products. Lack of understanding of the issues is a disincentive to the company; in many cases, industry could benefit from product-line-specific guidance. Industries can also benefit from a methodology for measuring accessibility of their products.

> **Recommendation #9.** Support the coordination of state and local government adoption of section 508 technical requirements. Provide state and local governments with documents and training programs designed to ensure unification of technical requirements.

Despite these shortfalls of section 508, state and local governments will likely adopt accessibility legislation similar to section 508. There is concern at the state and local level for providing equal access for all citizens, and the adoption of similar legislation at these levels may spur more industries to be more attentive to the issues and increase their development of accessible products. In addition, state and local legislation may provide additional understanding of how to interpret the standards. It is hoped that this legislation will not contradict or conflict with federal legislation or laws enacted in other states or municipalities. Industry will suffer if the technical requirements for accessibility diverge.

> **Recommendation #10.** Study and document the nontechnical aspects of accessibility, including social, psychological, and organizational accessibility. Promote UD solutions that consider all aspects of accessibility.

Another way in which section 508 falls short is that it is limited to technological access. Accessibility solutions, when they exist, often address only technological access. They fail to address the social, psychological, and situational needs of users relating to accessibility. For example, as revealed in the user study, if an ATM machine were completely accessible, some individuals who are blind or have low vision would still not use it or would continue to use it only in the company of a friend or family member because of a concern for their safety. As another example, while technological access may be available for a product, it may still be inaccessible to a subset of individuals because they cannot afford to purchase the product. This situation is often interpreted by industry as low demand, when in fact the demand can simply not be demonstrated because of the low incomes of many people with disabilities. These situations that reduce overall accessibility should not diminish the efforts of industry to increase accessibility of their products for various individuals, however, as it does provide the option for individuals to use these products if the necessity arises or if their situations change.

Analysis of Industry Practices

Despite consumer demand and government oversight (and limited guidance) regarding accessible products, companies lack tools and information resources needed to create UD products. To begin with, corporate policy can affect the adoption of UD in a company. Without the support of upper management, UD often cannot become a reality unless there is a strong advocate within the company. If corporate policy emphasizes accessible design solutions and perhaps user testing with people with disabilities, those issues become more difficult for designers and managers to ignore, and they are likely to find ways to at least begin to address them despite a lack of tools or knowledge.

> **Recommendation #11.** Develop, test, and disseminate methodologies for integrating UD into existing design practices.

Companies are not aware of the design process modifications needed to incorporate UD principles. The Federal Government should support the refinement of specific design process

interventions that can easily be incorporated. Guidelines for incorporating UD principles into the design process should be developed and illustrated with real-world examples, if possible. Training materials should be distributed to companies interested in incorporating UD principles into their design process as a series of UD best practices.

> **Recommendation #12.** Support the development of university-level training materials that could be incorporated into the curricula of existing design-oriented degree programs. The training materials should include awareness-expanding videos and other teaching resources that illustrate the potential impact of key design process interventions on the lives of people with disabilities and other beneficiaries of UD.

> **Recommendation #13.** Develop, test, and disseminate design reference users to illustrate the range of functional capabilities and limitations typical among people with disabilities. Design reference users, popular in specifying target populations in Department of Defense acquisitions, is a set of descriptions of prototypical users that expresses the range of functional capabilities and limitations of the population that must be accommodated by the design project. The use of design reference users would greatly simplify the need for designers to research and integrate information pertaining to the functional limitations and capabilities of people with disabilities.

Designers and engineers lack information about the functional capabilities and limitations of people with disabilities. Few companies hire people with disabilities to provide design input for their products, and most university-level design courses do not adequately address UD. General information about functional capabilities is hard to come by and is not generally available in an easy-to-use format. Also, there is significant variability of functional capabilities, even within a disability group (particularly for individuals with upper-mobility impairments). All of these issues create a barrier for developing UD products. Despite the variability, some general

guidance can be developed (similar to section 508) to address the majority of issues that will arise.

> **Recommendation #14.** Develop a standard methodology for testing accessibility and comparing the accessibility of two similar products.

Even given an understanding of functional limitations, companies lack a methodology to truly measure accessibility, which would also provide a means to compare accessibility among similar products. They do not understand the importance of including people with a variety of disabilities in product evaluations. And, even if they do develop products that satisfy the standards of section 508 and other UD guidelines, that does not guarantee accessibility.

Despite the lack of tools, some products exist that are considered "accidentally accessible." Many of these designs were not created with a disability in mind (e.g., the Sidekick), but they happened to provide a great benefit for a particular disability population. In many cases, manufacturers may not even be aware that their designs have benefited special populations. The problem with these accidental solutions is that they may not carry through into future designs because their potential is not understood by the designers. If these features can be identified, however, and understood by the designers as benefiting more than the general public, designers may be able to overcome the fact that they lack formal tools or training to facilitate accessible design.

> **Recommendation #15.** Coordinate with industry to promote the integration of accessibility concepts, principles, and guidelines into the development tools used by designers to develop products.

If the concepts of UD are integrated into the tools that designers use to develop products, more accessible products will be designed with little extra effort or cost on the part of industry. Industry needs to recognize that a small amount of effort to modify existing practices will have great benefits in the long run.

Analysis of Consumers of Universally Designed Products and Services

Consumers with disabilities find many E&IT products to be inaccessible. They are quick to adopt accessible technologies when they become available and are loyal to companies that produce accessible technologies. Cost can be a significant barrier to adoption of these technologies, however. Many consumers with disabilities must pay for features they cannot use. For example, users who are blind typically cannot use many of the advanced features of cell phones, but companies today rarely provide a basic voice communication device. Also, many accessibility features tend to be bundled with higher-end products, increasing the cost for those who can benefit most but who are typically in a low-income situation. The focus group data indicated that people with disabilities are hesitant to pay for new technologies that are not proven to be effective for their needs. Perhaps one way to increase market share for these products is to distribute a small number of free devices for review by various disability groups, which can then spread the word of the value to be had for the cost. People with disabilities often do not have extra money to spend, but they are willing to spend a little bit extra for something they feel will benefit them in their daily lives. Increased demand and profitability will result as convenient, easy-to-use products become more prevalent at a lower cost.

> **Recommendation #16.** Develop an information clearinghouse where users can obtain information about accessibility issues and the features designed to address the issues for specific product lines. Educate consumers on how to shop for UD products and services. List vendor resources where consumers might obtain more information about universally designed products.

Consumers tend to be misinformed or underinformed regarding product features they can benefit from. Companies fail to adequately market to people with disabilities, and it is not uncommon for marketing materials to be inaccessible to some individuals. In addition, general-population marketing of accessibility features can increase sales as awareness of product features increases for those who have a temporary disability, are not involved with a disability-specific advocacy group, or live in remote areas with less access to health care and specialized services. If products

can benefit multiple populations, there should be an increase in sales. Someone might purchase a talking clock, for example, for an occasional specific need, but they first need to be aware that this product exists; therefore, companies should not limit marketing to the population they expect to benefit from the product.

> **Recommendation #17.** Develop marketing strategies and approaches that will facilitate a connection with people with disabilities.

An awareness from those in marketing departments of different populations believed to benefit from specific products and product features can help shape the marketing strategy, resulting in increased sales and more satisfied consumers. An example is the Sidekick. The Sidekick is a device about twice the size of the average cell phone that has extensive text messaging capabilities; it is also a cell phone. The Sidekick was not designed for the community of people who are deaf, nor has it been extensively marketed to users who are deaf, but its features greatly increase the communications capabilities of users who are deaf. Through word of mouth it has become a very popular device. General marketing of its text messaging capabilities has likely attracted the attention of users who are deaf, although they were not intended as the targeted population.

People with disabilities want to use the same products that everyone else uses. They do not want to be limited to specialized products that are more costly. Implementation of UD is the best way to satisfy this desire of people with disabilities, while also providing more cost-effective products for all users. While it is impossible to satisfy the needs of all users, products and services that come closer to accommodating a variety of physical and cognitive differences will benefit both users and companies.

> **Recommendation #18.** Train people with disabilities to become subject-matter experts for the purpose of participating in design focus groups and accessibility evaluations.

The Federal Government should consider the development of training programs to help consumers with disabilities communicate their needs to companies interested in UD. The training programs should educate users about the industrial design process and suggest strategies for effectively formulating and communicating user needs. The program should prepare users for participation in focus group research as well as research designed to measure the accessibility of a product.

> **Recommendation #19.** Create job-related outcomes for bulk purchasers related to the successful procurement of products and services with UD features.

Currently there are no incentives for successfully procuring accessible technologies and services. Indeed, the current system may actively dissuade some purchasers from considering accessibility, if the market research process is perceived as delaying the procurement of needed products. In addition, the outcome of purchasing inaccessible technologies is usually not known immediately and may never directly affect the purchaser. The Federal Government should institute programs designed to actively encourage section 508 compliance at the level of the individual purchaser through incentives or job-related performance criteria and provide direct feedback with regard to the accessibility of the products purchased.

For additional information, see the online version of this report at www.ncd.gov.

List of Acronyms and Abbreviations

AAATE	Association for the Advancement of Assistive Technology in Europe
ABA	Architectural Barriers Act
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
ANSI	American National Standards Institute
ASX	active streaming XML
AT	assistive technology
ATIS	Alliance for Telecommunications Industry Solutions
ATM	automated teller machine
B	blind
CAGR	compound annual growth rate
CC	closed captioning
CITA	Center for Information Technology Accommodations
CDMA	Code Division Multiple Access
D	deaf
DTV	digital television
DVD	digital video disc
DVS	descriptive video service
E&IT	electronic and information technology
EIA	Electronic Industries Alliance
ENCT	Electronic Newsroom Captioning Technique

EPG	electronic program guide
ESL	English as a Second Language
EU	European Union
FCC	Federal Communications Commission
GAO	Government Accountability Office
GPS	global positioning system
GSM	global system for mobile communications
GTRI	Georgia Tech Research Institute
HAC	Hearing Aid Compatibility Act
HDTV	high definition television
HH	hard of hearing
HREOC	Human Rights and Equal Opportunity Commission
HTML	hypertext markup language
Hz	Hertz
IDEA	Individuals with Disabilities Education Act
IDEN	Integrated Digital Enhanced Network
IEEE	Institute of Electrical and Electronics Engineers
IEP	individualized education program
IFA	International Federation of Ageing
IMAA	Instructional Material Accessibility Act
ISO	International Organization for Standardization
IT	information technology
IT&T	information technology and telecommunications

ITTATC	Information Technology Technical Assistance and Training Center
iTV	interactive television
IVR	interactive voice response
L	low
LED	light emitting diode
LM	lower mobility
LONGDESC	long description
LV	low vision
M	medium
mm	millimeter
NCAM	National Center for Accessible Media
NCD	National Council on Disability
NCI	National Captioning Institute
NCRA	National Court Reporters Association
NOIE	National Office for the Information Economy
PBS	Public Broadcasting System
PDA	personal digital assistant
PIN	personal identification number
PIP	picture-in-picture
POC	point of contact
PSAP	public service answering point
RAM	real audio movie
RF	radio frequency

RNIB	Royal National Institute of the Blind
ROI	return on investment
SAMI	Synchronized Accessible Media Interchange
SAP	secondary audio program
SMIL	synchronized multimedia integration language
SRT	speech recognition technology
STB	set-top box
TIDE	Telematics Applications for the Integration of Disabled People and the Elderly
TTY	teletype
UD	universal design
UM	upper mobility
USDLA	U.S. Distance Learning Association
VDRA	Video Description Restoration Act
VPAT	voluntary product accessibility template
VRT	voice recognition technology
W3C	World Wide Web Consortium
XML	extensible markup language

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Appendix

Mission of the National Council on Disability

Overview and Purpose

The National Council on Disability (NCD) is an independent federal agency with 15 members appointed by the President of the United States and confirmed by the U.S. Senate. The overall purpose of NCD is to promote policies, programs, practices, and procedures that guarantee equal opportunity for all individuals with disabilities, regardless of the nature or significance of the disability, and to empower individuals with disabilities to achieve economic self-sufficiency, independent living, and inclusion and integration into all aspects of society.

Specific Duties

The current statutory mandate of NCD includes the following:

- Reviewing and evaluating, on a continuing basis, policies, programs, practices, and procedures concerning individuals with disabilities conducted or assisted by federal departments and agencies, including programs established or assisted under the Rehabilitation Act of 1973, as amended, or under the Developmental Disabilities Assistance and Bill of Rights Act, as well as all statutes and regulations pertaining to federal programs that assist such individuals with disabilities, to assess the effectiveness of such policies, programs, practices, procedures, statutes, and regulations in meeting the needs of individuals with disabilities.
- Reviewing and evaluating, on a continuing basis, new and emerging disability policy issues affecting individuals with disabilities at the federal, state, and local levels and in the private sector, including the need for and coordination of adult services, access to personal assistance services, school reform efforts and the impact of such efforts on individuals with disabilities, access to health care, and policies that act as disincentives for individuals to seek and retain employment.
- Making recommendations to the President, Congress, the Secretary of Education, the director of the National Institute on Disability and Rehabilitation Research, and other officials of federal agencies about ways to better promote equal opportunity, economic self-sufficiency, independent living, and inclusion and integration into all aspects of society for Americans with disabilities.
- Providing Congress, on a continuing basis, with advice, recommendations, legislative proposals, and any additional information that NCD or Congress deems appropriate.
- Gathering information about the implementation, effectiveness, and impact of the Americans with Disabilities Act of 1990 (ADA) (42 U.S.C. § 12101 et seq.).

- Advising the President, Congress, the commissioner of the Rehabilitation Services Administration, the assistant secretary for Special Education and Rehabilitative Services within the Department of Education, and the director of the National Institute on Disability and Rehabilitation Research on the development of the programs to be carried out under the Rehabilitation Act of 1973, as amended.
- Providing advice to the commissioner of the Rehabilitation Services Administration with respect to the policies and conduct of the administration.
- Making recommendations to the director of the National Institute on Disability and Rehabilitation Research on ways to improve research, service, administration, and the collection, dissemination, and implementation of research findings affecting persons with disabilities.
- Providing advice regarding priorities for the activities of the Interagency Disability Coordinating Council and reviewing the recommendations of this council for legislative and administrative changes to ensure that such recommendations are consistent with NCD's purpose of promoting the full integration, independence, and productivity of individuals with disabilities.
- Preparing and submitting to the President and Congress an annual report titled *National Disability Policy: A Progress Report*.

International

In 1995, NCD was designated by the Department of State to be the U.S. Government's official contact point for disability issues. Specifically, NCD interacts with the special rapporteur of the United Nations Commission for Social Development on disability matters.

Consumers Served and Current Activities

Although many government agencies deal with issues and programs affecting people with disabilities, NCD is the only federal agency charged with addressing, analyzing, and making recommendations on issues of public policy that affect people with disabilities, regardless of age, disability type, perceived employment potential, economic need, specific functional ability, veteran status, or other individual circumstance. NCD recognizes its unique opportunity to facilitate independent living, community integration, and employment opportunities for people with disabilities by ensuring an informed and coordinated approach to addressing the concerns of people with disabilities and eliminating barriers to their active participation in community and family life.

NCD plays a major role in developing disability policy in America. In fact, NCD originally proposed what eventually became the ADA. NCD's present list of key issues includes improving personal assistance services, promoting health care reform, including students with disabilities in high-quality programs in typical neighborhood schools, promoting equal employment and

community housing opportunities, monitoring the implementation of the ADA, improving assistive technology, and ensuring that those persons with disabilities who are members of diverse cultures fully participate in society.

Statutory History

NCD was established in 1978 as an advisory board within the Department of Education (P.L. 95-602). The Rehabilitation Act Amendments of 1984 (P.L. 98-221) transformed NCD into an independent agency.

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