Guide to Accessible Consumer Electronics Manufacturing Practices for Blind and Low-Vision Consumers

Accessible Digital Radio Broadcast Services

Prepared by National Public Radio

Mary Hinch

Ellyn G. Sheffield

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EXECUTIVE SUMMARY

The purpose of this report is to summarize and recommend to receiver manufacturers the technologies and features that would be most accessible to blind and low-vision consumers. Three sources were used to compile recommendations: (1) governmental standards, (2) data from a large-scale study conducted by NPR Labs with over 250 blind consumers, and (3) evaluations from American Foundation for the Blind (AFB) magazine *AccessWorld*, which focuses on consumer reviews of device features. Recommendations in this document center mainly on “first generation” prototype receivers, but in a few cases we include features that may be interesting for future-generation receivers. Consumer testing recommendations are also included, and are italicized for easy recognition.

Recommended Features

1. Use auditory displays to provide consumers with device state.
2. Place tactile symbols on keys that show their function, allowing consumers to identify and locate keys using touch alone.
3. Incorporate control features with which consumers have had the most experience to increase accessibility (e.g., telephone pad layout for panel design).
4. Place keypad controls on an accessible remote control.
5. Include an audio CD and a large-print hard copy manual.

Specific Recommendations

Device controls

1. Use a numbered keypad for the main device control. Controls should be chosen to keep device operation simple, regardless of how complex the device features are.
2. Use human spoken prompts to notify users of key identity.
3. For keypads on the receiver, *consumer test the lateral pitches* within standard range to determine the most accessible key spacing for those with low-vision or blindness. Additionally *consumer test key resistance* to ensure that keys are not accidentally activated.
4. Categorize key function by shape and alter key tops to improve key identification and localization.

5. *Consumer test embossed/tactile symbols* with low-vision and blind consumers prior to implementing them to ensure that the symbols hold proper meaning within the population.
6. Make the Power Key an alternate action key, allowing consumers to know its activation state by using touch alone.

Device Panel Layout and Location

1. Use a familiar layout, such as telephone keypad.
2. The keypad control panel could be placed on the device itself or on a remote control. Both have advantages and disadvantages. Placing the keypad on a remote control may be efficient and inexpensive; however the control may have insufficient surface space. Placing the keypad on the unit may have more utility, but may be expensive and require redesigning the base models.

Device Learning

Include a 'learning mode' on the device, allowing the user to press control keys and hear their name and function. The 'learning mode' should be activated by an alternate action key, so the user can use touch to determine the 'learning mode' activation state.

Device Displays

For radio receivers used with Personalized Audio Information Service (PAIS), include a pre-set dictionary of spoken prompts.

On-Device Markings and Warnings

1. Place tactile markings on the device to specify where external cords should be plugged in.
2. Include symbols that are perceived as warnings by low-vision and blind consumers, placing them on the back of the receiver as tactile markings, so they can be detected using touch alone.

Summary of recommended features:

CONTROLS	CONSUMER TESTING RECOMMENDED?
Keypad Design and Navigation	
Telephone numbered keypad placed on device or remote control • Use lateral pitch within standard range • Key-resistance pressure	 Yes Yes
Tactile feedback on keys • Bumps on key tops • Alter key top to improve identification • Tactile symbol markings on keys	 Yes
Function keys with identifiable shapes • Multiple functions per key presenting learning challenge	Yes Yes
Audible feedback on keys • Tone played or spoken prompt of key identity	
Power on/off key and information mode: Alternate action technology	
DISPLAYS	
Audible Feedback	
Spoken prompts	
• Pre-set dictionary of spoken prompts stored in device memory.	
Earcons	
• Easily identified auditory displays	Yes

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PART I: HISTORY AND CONTEXT

Introduction

Individuals with vision loss benefit from device interfaces that allow them to use touch and sound to navigate, resulting in substantially improved "ease of use". Designing accessible media products is not a new concept. VisuAide, the manufacturer of HumanWare products, Telex Communications, and the Plextor Corp. all design and manufacture devices for blind and low-vision consumers. These devices vary in the degree of sight required to operate them - some require minimal vision while others rely solely on the user's senses of touch and hearing.

Accessible design will help all consumers use radios efficiently. As WWII baby boomers age, the sensory-impaired population continues to grow and manufacturers are applying accessible interface designs to extend their market reach. Many consumer electronics manufacturers are incorporating customizable user-interface designs knowing that one solution will not apply to all users' needs.

There are two major types of visual loss – "low vision" and "blindness". According to the World Heath Organization (WHO), low vision is defined as "visual acuity of less than 6/18, but equal to or better than 3/60, or corresponding visual field loss to less than 20 degrees, in the better eye with best possible correction," and blindness as "visual acuity of less than 3/60, or corresponding visual field loss to less than 10 degrees, in the better eye with best possible correction." In 2002 there were a total of 161 million visually impaired individuals worldwide, with 124 million, or 77% having low vision and 37 million, or 23% with blindness.[1]

Because visual ability is so variable, it is often difficult to make a single recommendation that best serves both blind and low-vision users. For example, when designing an accessible device manual, individuals with low vision may prefer large print text, while blind consumers may prefer an audio manual. In consideration of this, our recommendations primarily focus on design features that would be accessible for all visually impaired individuals, but we also periodically present alternative design recommendations that provide substantial benefit to either blind or low-vision consumers.

[1] WHO statistics can be found at: http://www.who.int/en/

Specific Application – PAIS

One purpose of this report is to produce accessibility recommendations for manufacturers who are interested in producing radios that will receive broadcasts delivered by the Personalized Audio Information Service (PAIS)[2]. PAIS is a digital radio reading service that will automatically assemble a selection of locally relevant, customized audio content. For a user, it is the equivalent of a segment-level (i.e., topic-level) TiVO™-style radio. Operationally, users enter the types of stories they are interested in (i.e., 'music', 'health', and 'sports'). Each content segment broadcast by the local radio reading service will be tagged with a topic description as metadata in the overhead of the audio frames. Relevant, matching segments will be assembled by the radio in memory for later retrieval.

In contrast to the simple design of current Radio Reading receivers (see Figure 1 below), digital receivers will need to be more dynamic and offer a greater range of capabilities including conditional access for electronic control over copyright exemptions enjoyed currently by reading service broadcasters. The advanced designs of these new receivers will allow consumers to navigate sources and features via electronic menus, store and replay audio and access a significant number of new channels. This increase in service complexity will provide consumers with significant value, but presents challenges for a simple and effective accessible radio receiver design.

Figure 1: Photograph of Reading Service Radio Receiver

[2] PAIS is currently in development at NPR Labs through a grant from the National Institute for Disability and Rehabilitation Research (project number H133G070093).

In shifting to digital technology, a priority design consideration is how to transmit emergency messages to blind and low-vision consumers. Digital radios, for the first time, will incorporate a new "automatic on" feature to alert consumers even after they have turned their radios off. When tornados, wildfires, or other emergencies threaten listeners in the broadcast service area, digital radios will be able to connect with them, providing valuable emergency information. The alerting function and recommended strategies are given special treatment in this report.

Accessible Design and International Standards

There are several organizations that develop and enforce domestic and international standards relating to accessible design. This report focuses on the ACCESS Board and FAA standards used in the United States.

In conjunction with researchers for Electronic and Information Technology Accessibility (Section 508), the Architectural and Transportation Barriers Compliance (ACCESS) Board has developed standards for the design of products for those with low-vision or blindness and state specific rules that must be followed for a device to be called 'accessible.' The ACCESS Board's Electronic and Information Technology Accessibility Standards (Section 508) can be found at http://www.access-board.gov/sec508/standards.htm.

The Federal Aviation Administration (FAA) provides ergonomic standards for the design of accessible devices as applied by its Human Factor Design Standards (HFDS), http://hf.tc.faa.gov/hfds/. The FAA standards focus on accessible design as it relates to all consumers. However, a product that is accessible to blind and low-vision consumers must be designed using both universal accessibility design standards and national accessible design standards.

Subjective Design Preferences

In 2007 NPR Labs conducted a survey of blind and low-vision users' preferences for device features. The survey included responses from 217 participants, including 61% reporting blindness, 32% low vision, and 6% some other form of vision loss. It is important to note that the sample majority was blind, while on a global basis, most visually impaired are affected by low vision.

Results from this study suggest that participants shared near-consensus for several different interface elements. **Numbered keypads** for input were favored by a majority of participants (see Table 1 for percentages). Those surveyed overwhelmingly preferred numbered keypads over knobs, buttons, and dials. Numbered keypads readily fulfill several device requirements, including inputting frequencies and navigating the menu system decision trees.

For audible feedback systems, participants reported preferring **human-sounding spoken prompts** that can be sped up, slowed down, or turned off by the user. These spoken prompts were strongly preferred over beeps or generic sounds. For the blind user, audible feedback is the desired method for providing information to the user concerning device status. For a low-vision user, audible feedback displays would remain beneficial, in conjunction with large typeface display options.

A majority of the survey sample reported a preference for having **tactile feedback** included on the device, strongly indicating that tactile communication improves device accessibility and therefore should be incorporated into the device design.

Participants were also questioned concerning the TiVO™ style functions of the service options and radio device, including: (a) the number of hours they would like to record in a day, (b) preferred length of time to keep saved programs, (c) importance of saving programs onto a computer, (d) preference for being able to record in real time, and (e) importance of being able to pause live broadcasts. These TiVO™ style feature preferences are summarized in Table 1.

Table 1: Survey results

FEATURE	PERCENTAGE PREFERRED
Numbered keypads for input	71%
Spoken prompts	92%
Human sounding voices	56%
Tactile feedback	73%
TiVO™ Style functions	
Change speed of voice (Speed up/Slow down)	79%
Real-time recording	92%
Pause live broadcasts	65%
Keep programs indefinitely	41%
Record for 2+ hours per day	76%
Save programs on computer	71%

Device Controls

Type of controls. Classic control types include toggle switches, calculator or telephone style keypads, rotary switches, joysticks, or track balls (Kantowitz & Sorkin, 1983), while an example of a more modern control is a touch screen (FAA, HFDS). Based upon the PAIS survey data, **numbered keypads are recommended** for the main device control for the user. There are several considerations when designing keypads, including (a) physical features, (b) labeling, (c) panel design and position and (d) feedback.

Physical features

1. Key size and separation. Key separation is technically estimated by the distance from the center of one key to the center of the next - or lateral pitch. The standard lateral pitch ranges from 18-19 mm, as shown in Figure 2 (Kantowitz & Sorkin, 1983; ANSI, 1988 in FAA, HFDS).

Figure 2: Diagram of Key Size and Separation

Key Size and Separation

Key Top

Lateral Pitch

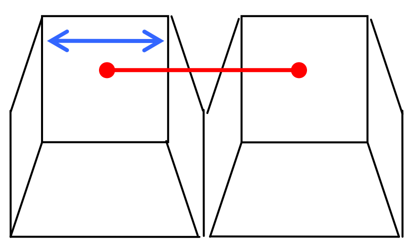

Diagram Key

Key Top Size
Standard Range
12-15 mm

Lateral Pitch
Standard Range
18-19 mm

To illustrate how important lateral pitch is to blind users, we present a study conducted by Mooney, Nussbaum, and Smith-Jackson (2002). These experimenters measured the impact of lateral pitch on phone number entry into a cellular phone unit. Participants in the study were either blind or had low vision or a physical impairment. In their experiment, lateral pitch was manipulated by using four different cellular phone models with lateral pitch ranging from 10 mm to 13 mm. Participants with low vision or blindness displayed the poorest dialing performance when using the phone models with 13, 11, and 10 mm lateral pitch and the best performance when using the phone model with 12 mm lateral pitch. Both the physically impaired and sighted participants did not exhibit as large a decrease in performance over lateral pitches but all groups rated the phone model with 12 mm lateral pitch as most preferable. These findings suggest that lateral pitch DOES make a difference to all consumers, but is particularly critical to blind users.

For a digital radio receiver with an inlaid keypad panel, a lateral pitch of 12 mm may be too small; however, if the keypad controls for the radio receiver were placed on a remote control, the 12 mm lateral pitch may present accessible key spacing for blind consumers. **For keypads on the receiver itself, lateral pitches within the standard range should be consumer tested to determine the most accessible key spacing.**

2. Key shape. Varying shape in pushbutton design is a common method used for button identification. Kantowitz and Sorkin (1983) mention several shapes that are described as being discernable using touch. AccessWorld, the official magazine of the American Foundation for the Blind, reviewed two scanners – the SARA, manufactured by Freedom Scientific, and ScannaR, manufactured by HumanWare (see Figure 3 for photos of these devices).

The keys on the SARA control panel vary in shape and are categorized in similar shape groups based upon key function. The following key groups can be found on the device: The scan and play/pause buttons are both large ovals found on the left side of the device; the sound keys are the two square orange keys on the front face of the device, with the volume on the left and sound speed on the right; the keys used to navigate are all in blue and shaped based on their navigation direction; and finally, the green power key found on the left and the yellow help key found on the right are both placed to represent independent function.

The ScannaR also uses shape to represent key function. Rather than grouping keys with similar shapes by function, as on the SARA, the ScannaR shapes keys based on their symbol. For example, the scan key is represented by a triangular key with a white triangle printed on it, which improves key identification because consumers associate a right facing triangle with ‘play’ and ‘play’ with starting a scanning operation. Further, the up and down navigation keys are shaped like upward and downward facing triangles, shapes associated with up and down. The square shaped key on right is the repeat key. Oddly, a square is normally associated with the stop function; therefore, this is a key shape the consumer may have to learn.

Figure 3: Pictures of the SARA Scanner and the ScannaR , Courtesy of AccessWorld magazine

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The ACCESS board (Rule 1194.25 (g)) states that accessible devices must use more design characteristics than color to provide the user with key type information. Both scanners qualify nicely under these rules, and the SARA additionally features color, which may help low-vision consumers.

Making key tops concave or flat can also improve accessibility. The Victor Reader Classic X Plus, manufactured by HumanWare, has a play/pause key with a concave top, making it easier to distinguish it from other keys on the panel (see Figure 4).

Figure 4: Victor Reader Classic X Plus, Manufactured by HumanWare

We recommend categorizing key function by shape and to alter key tops to improve key identification and localization.

3. Key resistance. Key resistance deals with the amount of pressure a user must apply to a key to activate its function. This consideration of pushbutton design involves both the amount of force required and resistance of the key. Invergard (1989) breaks key resistance standards down by user skill, suggesting a 0.25-0.5 N (Newton) required force for skilled users and a 1-2 N required force for unskilled users. Kantowitz and Sorkin (1983) recommend key resistance parameters to be a minimum of 140 grams (1.37 N) and a maximum of 560 grams (5.49 N). **We recommend making keys resistant to the point that they are not accidentally activated while the user feels the keypad. To achieve this, a greater amount of actuation force would be required. The parameters should be consumer tested for certainty.**

Coding/Labeling of Keys

Traditional standards require keys to be labeled, by means of a printed identification label, and to be coded by color or shape/size (Kantowitz & Sorkin, 1983). Many of the classic coding and labeling strategies are not accessible for blind and low-vision users. Alternatively, using touch and auditory input can be helpful in key identification.

Braille is a common tactual display. However, because less than 11% of those with blindness or low vision use Braille, the increase in accessibility its application would have is limited (National Federation of the Blind, 2008).[3] Other methods, such as placement of bumps on key tops may be more suitable to act as reference points for the user. This feature has been implemented in two ways – by placing the bump on the center key (i.e., number 5) or by placing three bumps on the middle three keys (i.e., 4, 5, and 6). Additionally, altering key shape between special function menu keys and numeric keys are used successfully to identify function, as is altering textures of key tops.

The most accessible key labels are those that already have meaning to the user and do not require learning a new symbol. For example, the universal symbol for power is a circle with a line through it, while that for help is a question mark, and a speaker icon is used for sound. The SARA scanner is a good example of providing tactile indicators on keys for identification and localization purposes. On the SARA, key labels are embossed or raised, allowing the user to feel the key label and identify the key. Interestingly, as featured on the SARA, a rabbit is used to symbolize speed of speech because it is classically associated with being a fast runner, contrary to the turtle. However, when determining the usability of symbols for tactile key markings, it is important to consider whether the symbols are easily identified by blind and low-vision consumers using touch.

[3] More information on the Braille initiative started by the National Federation of the Blind and more facts about Braille can be found at the following site: http://www.nfb.org/nfb/Braille_Initiative.asp?SnID=1794352496

We recommend placing tactile symbols on keys pertaining to their function, allowing the user to identify and locate keys using touch alone, but we also recommend consumer testing of embossed symbols to ensure that the symbols hold proper meaning with the blind population.

Audible feedback

Keypad key identity and key feedback can be expressed using audible feedback. One method for implementing this approach is to have a voice synthesizer name the key when it is pressed. For example, when the user presses the '1' key, the device would say "one". Another way to use audible feedback to notify the user that a key has been pressed is by playing a short tone every time a key is pressed.

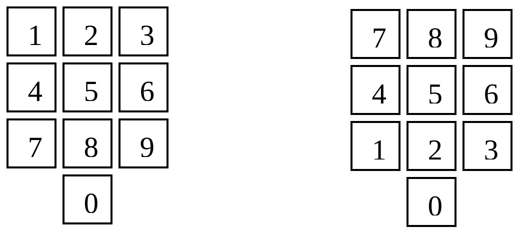
We recommend using spoken prompts to notify users of key identity in conjunction with tactile symbols.

Panel Design

There are two types of numeric keypad arrangements widely used; the telephone layout and the calculator layout (see Figure 5 for diagrams). Both have a 3 x 3 + 1 layout design (Invergard, 1989); with the standard zero position being in the bottom row (FAA, HFDS). However, most products with a calculator layout keypad place the zero below the one key. According to the FAA's HFDS, the telephone layout should be used for communication and the calculator layout used for entering and manipulating numbers (FAA, HFDS). For receivers, either format could be used in compliance with recommended practice, but since people generally have more experience with telephone layouts than they do with calculator layouts, **we recommend using a telephone layout to enhance device accessibility.**

Figure 5: Diagrams of two Numeric Keypad Arrangements: Telephone and Calculator

Telephone Layout *Calculator Layout*



Kantowitz and Sorkin (1983) discuss five of the most common rationales for choosing function key positions: (1) By *function*, (2) In operating *sequence*, (3) By *priority*, (4) By most *frequently* used, and (5) By *stereotypes* and *expectations*.

Function keys on a keypad can be made more accessible by applying different switch technologies. There are two types of switch keys - momentary contact and alternate action. Momentary contact keys only have to be pressed once to be activated and deactivated. This type of switch is used for common keys, such as cell phone number keys and computer keyboard keys. Alternate action keys turn on a function when the user presses the key once and requires the user to press it again for the function to be shut off. This key type may be most beneficial to a power key, allowing the user to know when the power is on and off just be feeling its compression depth.

We recommend making the Power Key an alternate action key, allowing the user to know its activation state by using touch alone. Where a key has an "alternate state function", such as turning on or off power, the alternate states should be identified by unique auditory feedback when the key has been depressed for a minimum of 3 seconds. Activation of the key for brief numeric or other types of momentary entries should be denoted with feedback identical to other numeric entry audible feedback sounds.

Often electronic devices have multiple functions, requiring the designer to place numerous functions under one key control. Under these circumstances, the user would press the 'zero' key to activate function one, press the 'zero' key again to activate function two, and so on. Keys with multiple functions were found on the Victor Reader X Plus. Such cases increase device complexity and reduce accessibility, but may be necessary for design purposes.

We recommend that when "multiple-functions per key" present distinct learning issues for the blind and low-vision consumer, consumer testing be conducted prior to bringing the product to market.

Learning about function keys is an essential component for consumer accessibility. Devices have learning operation modes; when activated, the device plays the key name and function when the user presses the key. This learning mode is found on the Victor Reader Classic X Plus and functions as a "demo mode". On the Victor Reader, the "demo mode" is activated by pressing the 'zero' key and deactivated by pressing the 'zero' key again. **We recommend having a 'learning mode' on the device, during which the user can press control keys and hear their name and function. Further, we recommend that the 'learning mode' be activated by an alternate action key, so the user can use touch to determine the 'learning mode' activation state.**

Placing the Keypad on the Device vs. the Remote

Placing the keypad on the device may ensure a larger, easy to locate keypad, but this may require complete radio redesigns which could increase cost substantially. Locating the keypad control on a remote may allow consumers to access radios that have already been designed, thereby potentially reducing costs. However, remotes may have small surface areas, which may not be preferred by low-vision consumers.

A common accessible product on the market for low-vision consumers is an oversized, large-print, large-button remote. If the accessibility guidelines for keypad design can be followed appropriately on this type of remote we **recommend placing the keypad controls on a remote.**

Additionally, several manufacturers have designed a docking station on the body of the receiver for the remote when it is not in use. We see this as a desirable feature. Finally, an increasingly common technology is a "find remote" signal, which allows the consumer to find a lost remote by following an audible sound. We believe this is particularly critical for blind and low-vision users.

Standardization and Stereotypes

These last two considerations in pushbutton design, standardization and stereotypes, concern the familiarity level the user has with the keypad design by sheer exposure to other keypads on the market. Standardizing keypad design increases the likelihood that the user will find familiarities among keypads they use. This reduces the necessity for new learning and assists product acceptance. **To increase accessibility we recommend incorporating control features the users have had the most experience with, (i.e., the telephone layout for panel design).**

Displays

Display content varies based upon the purpose of the device. Generally, radio receivers include visual displays to provide users with arrow navigation tools and visual labels of the menu section they are currently viewing. These display methods do not present an accessible environment for blind and low-vision users. Alternatively, auditory displays present information that allows the blind and low-vision user to navigate through the display. Section 508, Rule 1194.25 (f) states that "When products deliver voice output in a public area, incremental volume control shall be provided with output amplification up to a level of at least 65 dB. Where the ambient noise level of the environment is above 45 dB, a volume gain of at least 20 dB above the ambient level shall be user selectable. A function shall be provided to automatically reset the volume to the default level after every use." Further, Section 508, Rule 1994.25 (e) suggests that consumers need a way to listen to the audio in a private way (i.e., via headphones), and that user control of the audio including buffering, interrupt, and replay be provided.

The FAA (citation) provides principles to follow when designing auditory displays. Ones that may be pertinent to the radio industry include:

1. Limiting the number of alarms and alerts to 6 immediate action signals and 2 precursor, attention signals.
2. Creating signals that are 15 dB above ambient, background noise.
3. Creating signals that differ in frequency from the frequencies of background noise and that are between 500 and 5000 Hz.
4. Creating signals that differ sufficiently such that one signal does not mask another.
5. Modulating the signal, using intermittent "beeps" or rise and fall in pitch (1 to 3 cycles per second).
6. Using temporal patterns to increase signal detectability and discriminability.
7. Testing in the operational environment to ensure effectiveness.

Spoken Prompts – Human Voices and Speech Synthesizers

Just as spoken prompts can be used for key identification, they can be used as menu system guides that reinforce the user's position within the menu system as they navigate. In fact, the 2007 NPR survey showed users preferred human-sounding spoken prompts over beeps or sounds. In the PAIS system the spoken prompts would be beneficial to allow users to set up their listening profile through a dynamic menu system of subject trees and hear prompts of the segments of the menu system they are entering.

There are a variety of speech synthesizers on the market, differing in quality. A text to speech synthesizer should only be included if the radio requires generation of unique words in operation. Alternatively, a preset dictionary of spoken prompts (i.e., words) should be included if the number of prompts are limited.

The following considerations should be made when deciding on the speech output mechanism:

1. Language capabilities: How many language options will the speech component have?
2. What kind of volume control should the auditory displays have?
3. Should the auditory display volume control be independent of the radio content volume control?
4. Although adding a speech component vs. adding audible beeps will drive up the cost of the device, will the added functionality make the value proposition better?

We believe that testing marketability of products with consumers at various price points would be extremely beneficial prior to deployment.

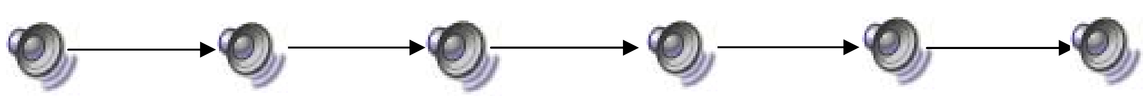
One advantage the PAIS service has over text-to-speech computerized/machine voices is that the article tiles and all article content are read by volunteers, eliminating the need for a text to speech synthesizer to generate robotic speech.

For radio receivers used with PAIS, including a pre-set dictionary of spoken prompts is recommended. Using a text to speech synthesizer is only recommended if volunteers will not be reading the article titles and content.

Earcons

Auditory icons or "earcons" are sounds that have meaning to the listener. When listeners hear a sound they already associate with a response or idea, they quickly respond or comprehend an environment when they hear the sound (Blattner, Sumikawa, & Greenberg, 1989). For example, earcons are used as auditory warnings in vehicles to enhance automobile safety. The "rumble strip" earcon activates when a driver doses off and drifts onto the shoulder, at which time the vehicle's external sensors detect the paint line on the road and send a message to the vehicle triggering the rumble strip earcon to be played to the driver. Because drivers have already learned the mechanically based road sound "rumble strip", they automatically respond by turning the wheel in the opposite direction than where the sound came from (Green, et al., 2008).

PAIS is a complex service that will require users to navigate an intricate and dynamic menu system. One possible way of 'simplifying' menu navigation is by using earcons as menu system guides. For example, the sound of an opening door could represent the movement from one room, or section, to the next. This may help the user visualize movement through the menu (see sound demonstration below). *This feature must be tested with blind and low-vision consumers to make sure that it is appropriate and meaningful.*



Sound Demonstration: Double click on the sequence of speaker icons (from left to right) above to simulate the 'opening door' sound the user would hear as they navigated through the menu system. (Sound clips provided by AT&T Labs and freesound.com)

We recommend development of several earcons for consumer testing. These could be implemented in either the first generation receiver or the future generation, depending on research findings.

The best solutions will employ a combination of both spoken prompts and earcons for ultimate navigation and device accessibility. However, more research is required to determine the best earcons for system navigation so it is likely that earcons will only be implemented in future generation receivers.

On-device Tactile Markings/Warning Displays

Warning labels and connector location indicators must be presented with tactile markings to indicate where the power cord or an external speaker can be connected. For example, the Victor Reader Classic X Plus places tactile nicks under these hook-up areas, using the number of nicks to represent the proper cord placement. We believe there are more meaningful tactile indicators that do not require re-learning. For example, an embossed image of a pair of headphones above the headphone jack is now common in other industries and should be extended to new receivers.

We recommend placing meaningful tactile markings on the device to specify where external cords should be connected.

Device warnings, such as those on avoiding water and moisture exposure to prevent electric shock, should also be displayed in a tactile way. Placing Braille warnings on the device is one appropriate solution; however this may reach a limited number of consumers who know Braille. A reasonable alternative would be to place meaningful embossed symbols on the device depicting warnings. *Several warning designs should be developed and consumer tested to determine those that lead to the greatest comprehension.*

We recommend designing and/or finding symbols that are perceived as warnings by blind and low-vision consumers, and placing them on the back of the receiver as tactile markings.

Device Orientation Manual Format

The ACCESS Board reports that both large-print and audio manuals are required forms of information presentation for those with blindness or low-vision (Section 508, Rule 1194.31 (b)). Results from the 2007 NPR survey show that blind consumers preferred an audio manual to all other instructional methods. Table 2 shows the breakdown of responses.

Table 2: Manual Type Preferences

MANUAL TYPE (LEARN METHOD)	PERCENTAGE PREFERRED
Audio Manual	47%
Trial and Error	16.5%
Having Someone Teach You	15%
Braille Manual	21.5%

Additional evidence from the PAIS survey suggests that a **device-independent** manual must be included for true accessibility. Audio manuals may be included on CDs or DVDs, so that participants can listen to the information using a familiar device. Our survey found that 70% of participants questioned reported having experience with a non-assistive music player and 67% with a home stereo system. Based on this we **recommend that the manual should be provided on a CD and large print hardcopy.**

PART II: On the market product reviews

The American Foundation for the Blind (AFB) produces a magazine called *AccessWorld.* Through AccessWorld, the AFB publishes reviews of consumer electronic devices from the standpoint of a consumer with blindness or low vision. We examined several product reviews and chose a small number to discuss in this paper.

A 5-star product evaluation tool was created.[4] Each product's star rating was evaluated based on information provided in the AFB reviews. The criterion for each star was as follows:

- Are the 'displays' accessible without vision?
  - ✓ Does the device provide auditory feedback?
- Are the 'controls' accessible without vision?
  - ✓ Are the buttons discernable by touch?
  - ✓ Are the buttons spaced appropriately and not crowded together?
  - ✓ Does the device provide auditory feedback on button identity and activation?
- Affordability
  - ✓ Can the product be considered as being a 'good value' for the money?
- Has the product been tested by users with blindness or low vision and been given a positive review — of accessible?
  - ✓ Was the product easy to learn?
  - ✓ Did the product come with an accessible manual?
- Portability
  - ✓ Is the device a good size for travel?
  - ✓ Does the device come with a battery backup?
  - ✓ Is the device's weight reasonable for carrying?

[4] The AFB *AccessWorld* has a product rating guide, which can be found through the following web address: http://www.afb.org/aw/evaluations.asp

PRODUCT 1: The Victor Reader Stream[5]
Reviewed: In the January (2008) Issue, Volume 9 (1)
Manufacturer: HumanWare
Purpose: Music/Book/Word Processing Files player and Voice Recorder with a Speech Synthesizer

Star Rating:

Accessible Displays: YES
"Everything in the Stream is voice guided."

Accessible Controls: YES
"Controls all tactile and easy to operate."
Bump on the 5 key; however, it was mentioned that the bump was not very easy to feel by touch.
Nothing mentioned concerning key spacing; however, nothing negative was mentioned.
Auditory feedback given on key identity.

Affordable: YES
Price: $329
"An unusually affordable price in the assistive technology market."
This product offers a lot of features, so it is a good value for the money.

Consumer Tested and accessible: YES
Information mode on device: used to learn how to use the device.

Portable: YES
Pocket sized.
12-15 hours of battery life.
Weighs 6 oz.

The Victor Reader Stream was given a great review by the AccessWorld Technology staff and received a 5-star rating on our scale. This product is a prime example of accessibility.

[5] Review can be found at: http://www.afb.org/afbpress/pub.asp?DocID=aw090105&select=1#1

PRODUCT 2: Milestone 311[6]
Reviewed: In the July (2008) Issue, Volume 9 (4)
Manufacturer: Bones/Swiss National Association for the Blind
Distributor: Independent Living Aids
Purpose: MP3 Player and Voice Recorder

Star Rating:

☆ Accessible Displays: YES
The device provides feedback when you touch the selector button, which decides where you will open the files from or make a voice recording. It does not announce other features, such as play, fast forward, etc.

☆ Accessible Controls: YES
The controls are easily discernable because they are different sizes. There are a minimum number of buttons, which reduces the amount of information a new user must learn.
No mention of any problems with key layout.
Auditory feedback good — "The audible prompts and feedback messages are all spoken in a clear female voice."

✘ Affordable: NO
Price: $369.
This product is NOT a good value for the money because it does not offer very many features.

☆ Consumer Tested and accessible: YES
Very positive review, product was easy to learn, comes with Braille "cheat sheet", printed manual, and manual in a word document format.

☆ Portable: YES
Very portable—about the size of a credit card, but thicker.
Built-in rechargeable battery.
Extremely light weight — can be worn around the neck with included lanyard.

The Milestone 311 was reviewed as accessible by the AccessWorld Technology staff and received a 4-star rating on our scale. This product includes some of the accessible features recommended in this paper; however, it is lacking on the affordability front. If no one can afford it, then it cannot be considered accessible.

[6] Review can be found at: http://www.afb.org/afbpress/pub.asp?DocID=aw090404&select=1#1

PRODUCT 3: iPod[7][8]
Reviewed: In the March (2005) Issue, Volume 6 (2)
Manufacturer: Apple Computer
Purpose: MP3/Music File Player

Star Rating:

✘ Accessible Displays: NO
The displays are screen based and imperceptible without vision.
The battery indicator icon is on the screen. Therefore, it cannot be detected without vision.
The device provides no substantial auditory feedback; however, it clicks when the wheel control is pressed.

✘ Accessible Controls: NO
The selection button is raised above the wheel control.
However, the wheel control has very low resistance or is “sensitive, so it is easy to accidentally raise the volume dramatically.”
It does not read menu names, so it is easy to get lost in menu system.
It plays the same click each time the wheel control is pressed. With this consistent sound, the user cannot discriminate one selection type from another using auditory input alone.

☆ Affordable: YES
Price: $299-$499, depending on memory space
This product can store a lot of information; therefore, the cost is somewhat reasonable.

✘ Consumer Tested and accessible: NO
The AccessWorld Technology staff reported that this device can be learned and used; however, they specified that the user would require “patience” for successful operation.
CD audio manual
PDF manual format, which could not be accessed using Adobe Reader 7.0.

☆ Portable: YES
Very portable.
Built-in rechargeable battery.
5.6 oz

[7] Review can be found at: http://www.afb.org/afbpress/pub.asp?DocID=aw060203&select=1#1
[8] In all fairness to Apple, the iPod was not designed to be an accessible product; however, the iPod was tested by the AccessWorld staff and found to be inaccessible.

The iPod is a prime example of when the accessibility recommendations are not followed. When using this product, a consumer with blindness or low vision must take extra steps. For example, AccessWorld stated that if testers got lost in the menu system they would continually press a key until they returned to the main menu. This type of response does not equal ‘ease of use’. AccessWorld rated the iPod as usable with practice and patience and we gave it two out of five stars.

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