

Election System & Software, Inc.

Unity 3.0.1.1

Access Review

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Executive Summary

The ES&S Unity 3.0.1.1 Voting System is generally accessible by a broad range of voters with disabilities; however, there are several concerns about its performance in certain areas and for voters with certain combinations of disabilities.

In some cases, these accessibility or usability concerns could be partially or wholly mitigated. Some of these mitigations would not require new federal and state certification testing. Much mitigation would depend on poll worker assistance and customization.

Introduction

Voting system accessibility surveys and reviews by Cook County (Illinois), Access World and others have shown that the voting systems previously used in California have significant limitations in accessibility for many voters with disabilities.

Recently, the designs of some of the voting systems have been changed to try to improve both their accessibility and their security. In some cases, the changes made to add security and privacy improvements have had a negative impact on the accessibility of the systems for voters with disabilities.

Because it is impossible to affirm overall accessibility and usability conformance merely by examining documentation for voting products, and because there have not been in-depth accessibility studies performed for the ES&S Unity 3.0.1.1 Voting System, rigorous testing was required to assess its accessibility and usability. However, there are currently no rigorous methodologies or standards defined, in the 2005 Voluntary Voting System Guidelines (VVSG) or elsewhere, for testing accessibility of voting systems. The Federal Election Assistance Commission (EAC) and the National Institute of Standards and Technology (NIST) are still in the early stages of development of standards for voting system accessibility testing.

Purpose of the Review

This review was undertaken primarily to identify whether the ES&S Unity 3.0.1.1 Voting System (also referred to as AutoMARK and M100 scanner system) was sufficiently accessible for voters with a range of different disabilities, and whether it was generally usable as well.

Additionally, this access review was tasked with identifying specific accessibility and usability concerns and reporting options for near-term mitigations appropriate for the 2008 elections, as well as longer-term mitigations including voting system design changes.

The results may be useful to assist the Secretary of State in making certification decisions. In addition, vendors and local election officials may find useful information in this report that will improve the usability and accessibility of voting technologies in both the near and long terms.

Finally, the authors hope that the larger community of stakeholders concerned with voting technologies will find both the methodology and results useful in developing advanced practices of design, testing, and implementation.

VVSG Provisions on Usability and Accessibility, Including a Brief History

The Help America Vote Act of 2002 (HAVA) established the United States Election Assistance Commission (EAC), the agency responsible for federal funding and technical assistance in voting technologies. HAVA section 301(a)(3) sets forth accessibility requirements. EAC inherited previous guidelines, the 1990 Performance and Test Standards for Punchcard, Marksense and Direct Recording Electronic Voting Systems, and the 2002 Voting Systems Standards (VSS). EAC empanelled the Technical Guidelines Development Committee (TGDC) to develop further standards, supported by the National Institute for Standards and Technology (NIST). The work of the TGDC, comments from the public and other experts at public hearings, and the EAC itself as well as other authoritative reviewers, resulted in the release of new Voluntary Voting System Guidelines (VVSG) in December 2005. The VVSG supersedes the 2002 VSS effective in December 2007.

The VVSG contain a completely new section on usability and accessibility requirements. These reflect the HAVA 301(a)(3) accessibility requirements.

As already indicated, there is not nor should there be an absolute line drawn between accessibility and usability. The Section 3 requirements in the VVSG contain references to both, and provide specific guidance regarding the goals of accuracy, efficiency, and satisfaction. Using a framework from the domain of accessible technology, they address the needs of users with functional limitations in vision, hearing, mobility, dexterity, speech, and cognition. For all of these dimensions of functional limitation, VVSG addresses both perception and interaction where relevant. Additional issues are also included: privacy and protection of voters who use alternate formats or methods for voting.

In this report, we will use the VVSG requirements in two ways. First, they form the framework in which we identify overarching issues we found in our testing. Second, they are the reporting method we use in the appended results of the review for the ES&S Unity 3.0.1.1 voting system (with AutoMARK and M100 scanner).

Usability and Accessibility

The scope of this accessibility review is primarily limited to human factors issues, meaning we are concerned with the entire process of the voter casting a ballot as they intended.

This process involves not only the voting system interface directly experienced by the voter, but also includes usability issues pertaining to ballot design, the influence of the polling place environment on accessibility and usability, as well as the setup, operation, and support of accessible voting systems by election administrators and pollworkers.

Definitions of Usability and Accessibility

The International Standards Organization defines usability as:

“[T]he extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use.”

It could be said that accessibility consists in defining those “specified users” as inclusively as possible. That is, the goals of effectiveness, efficiency, and satisfaction are unchanged, but equal attention is paid to making sure that those goals are met for people with disabilities. Accessibility can be further clarified by categorizing the accommodations used to include these “additional” users: some are extensions to usability features (such as magnification) with significant benefit to non-disabled users, and some provide compatibility with assistive technologies rarely useful to people without disabilities (such as sip and puff switches).

The Goal of Good Usability and Accessibility

The goal of good usability in voting equipment for voters and pollworkers is to easily, accurately, and intuitively use the equipment with minimal instruction and training and to successfully complete the voting process. Ease of use and intuitiveness are important, since voting is performed too infrequently by users to learn and remember the details of operation.

Accessibility can be seen as the additional accommodations, used primarily by people with disabilities, that help them to successfully use the voting equipment. For this reason, this report most often treats accessibility as a subset of usability.

Testing voting equipment for both usability and accessibility is potentially complex, but necessary for two key reasons:

- Any usability problems that a piece of voting equipment has are likely to impact voters with disabilities more seriously than voters without disabilities.

- A piece of voting equipment might have the legally required accessibility accommodations, but still may not be very usable by voters with disabilities, if the accommodations were poorly designed or improperly implemented.

Scope and Limits of the Review

This study was undertaken over an extremely brief period of time from its approval to its completion, due to the rescheduling of the California primary and the resulting compression of the election preparation schedule. This as well as other factors have unfortunately limited the scope of this access review, and we wish to be explicit about those limitations.

The ballot definitions used on the AutoMARK were not based on a ballot design optimized for usability testing.

- The AutoMARK ballot marking unit was tested as part of the typical polling place voting system, including the M100 Optical Scan Precinct Counter (ballot scanner and ballot box). This test of the combined voting system allowed us to better assess the accessibility of the complete user interface to the voting system, including the process of depositing the ballot in the precinct ballot scanner/ballot box (M100).
- The severe time limitations and the scheduling close to holidays meant that we had to limit the number of subjects to 28 formal and three informal subjects. Volunteers who served as test voters (“voters” or “users”) were selected to represent a broad range of disabilities. They cannot be assumed, however, to be perfectly representative of all possible voters with disabilities in degree and type of functional limitation, experience with voting, or pre-existing attitude toward voting technologies.
- Testing the usability and accessibility of the alternative languages interface on the AutoMARK voting system was considered outside the scope of this access review, because the California SoS's staff had already had the alternative language operation tested and felt that including it in this review would be redundant. However, we did allow some of our subjects who wanted to, to perform their vote testing with the Spanish language interface. Finally, because successful accessibility of the voting system by the voter depends, in many ways, on the ability of the pollworkers and elections administrators to set up, operate, and support the voting systems properly, it is important to also review and address the usability of the voting systems for pollworkers. This was outside the scope of the current access review.

General Methodology

The accessibility and usability testing of the ES&S Unity 3.0.1.1 Voting System had two phases. In the first phase, four accessibility and usability experts directly analyzed the voting system in a heuristic review. In addition to heuristic persona walk-throughs and other studies, the access expert team graded the system for conformance with the requirements listed in the 2005 Voluntary Voting System Guidelines (VVSG). See Appendix C, Heuristic Analysis, for more information.

In the second phase of the access review, the system was tested with 28 volunteer subjects having various disabilities. Each subject used the AutoMARK system to accessibly fill out and cast a full test ballot. These voting tests with live subjects were video and audio recorded for later analysis by the access team. See Appendix D, Methodology for User Testing, for more information

For the purposes of the accessibility review, the AutoMARK voting terminal and the M100 scanner/ballot box were tested together as a voting system.

Although highly important, testing of the usability of the poll worker interface for the ES&S Unity 3.0.1.1 Voting System was necessarily and unfortunately outside the scope of this review, as were both poll worker training materials and regular policies and procedures put in place for the use of the ES&S Unity AutoMARK and M100 Scanner system by local election officials.

Major Findings

We found accessibility concerns for certain categories of disabilities. The following issues will be addressed in this section:

- Physical access has some limitations.
- There are some personal safety hazards.
- Voters with severe manual dexterity impairments may not be able to independently remove the ballot from the AutoMARK and cast it.
- The keypad controls present challenges for some voters.
- It takes more time to vote with the audio interface.
- The audio ballot navigation can be confusing.
- Write-in difficulties frustrated some voters.
- The voting accuracy was limited by write-in failures.
- Many of the spoken instructions and prompts are inadequate.
- The system lacks support for good public hygiene.
- There were some reliability concerns.
- The vendor's pollworker training and materials need improvement.

Physical Access to the AutoMARK

The AutoMARK does not have its own support stand and positioning system. For testing we placed the unit on a typical folding table that provided the height and width clearances required by the VVSG (27 inches by 30 inches).

However, it should be noted that necessary accessories such as power wheelchair joysticks and reclining mechanisms often interact with the front edge of a voting machine or, in this case, a VVSG-compliant table. These accessories or wheelchair features may stand more than 6 inches higher than the voter's knees. In the case of a wheelchair joystick, the clearance problem is compounded by the fact that the voter must use the control itself to approach and depart from the machine. The AutoMARK control keypad, built into the unit itself, cannot be repositioned somewhere convenient for the voter. This makes clearance accommodation essential.



Figure 1. Voter in electric wheelchair can approach the machine because it is narrow enough not to interfere with the joystick. Note, however, that this voter's wheelchair, equipped with a reclining feature, positions the user's knees at 27 inches above the floor, exactly the required minimum clearance under the 2005 VVSG; closer approach is not possible because the voter's lap rises above the knee level. Note also that the highest active point on the touchscreen is slightly above her shoulder height, which is out of the convenient reach of this user.

Physical Access to the Touchscreen

The AutoMARK uses a touchscreen that has a usable area of approximately 23 cm. wide by 30 cm. high.

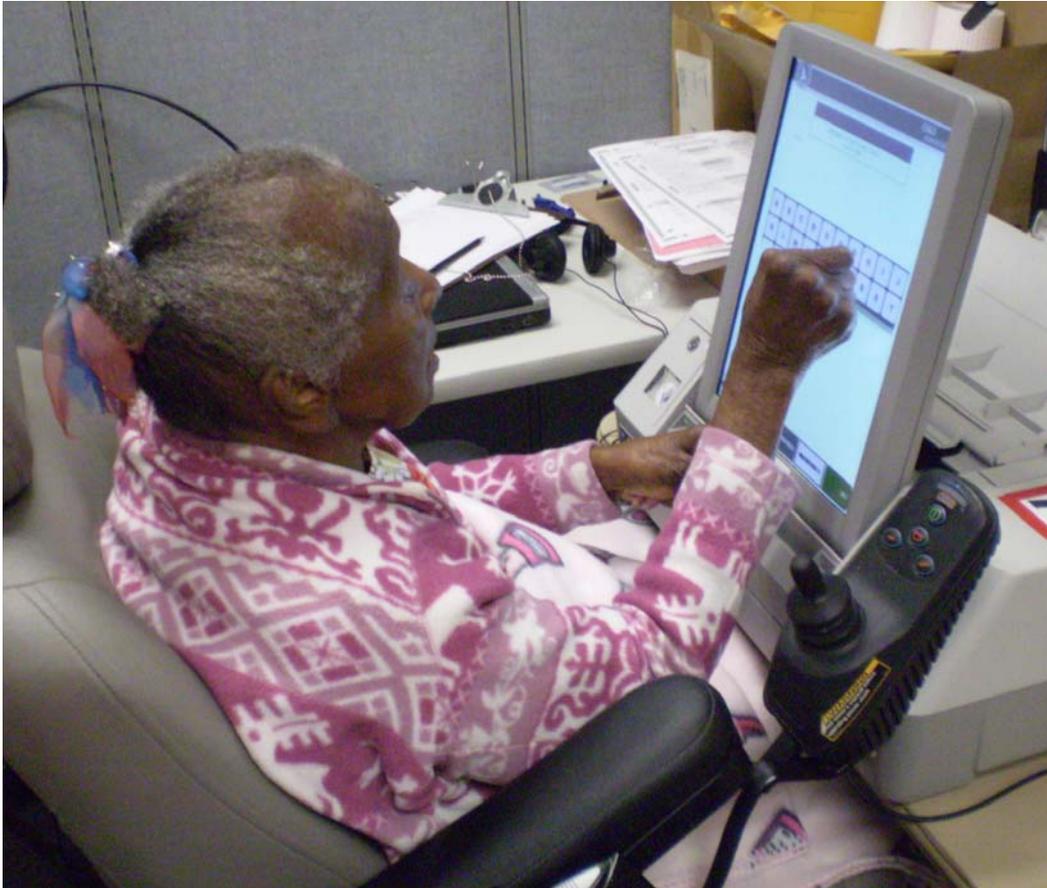


Figure 2. Voter with reduced range of motion and impaired dexterity using the touchscreen.

The touchscreen LCD unfolds up from the base unit and can be positioned at certain convenient angles, even slightly forward from the vertical. However, it cannot be adjusted in height, and some voters experienced problems reaching high enough to cover all the active points on the touchscreen. The lowest point on the active surface is approximately 15 cm. above the table surface; the highest point is approximately 45 cm. (18.5 inches) above the table surface.



Figure 3. This voter uses a standard manual wheelchair and can approach the machine as closely as she wishes, up to the leading edge of the armrests if necessary. However, her limited range of motion required her to use the keypad instead of the touchscreen. Note that the top of the active surface is well above shoulder height.

Physical Access to the Keypad

The AutoMARK has an additional input device, a keypad. Although this is intended for use with the audio interface, it must also be used by mobility or dexterity impaired voters who cannot use the touchscreen.



Figure 4. AutoMARK keypad. The directional array consists of four triangular buttons surrounding the square select button. The column of keys to the right is for use with the audio interface.

- The buttons are reasonably sized but usability would be improved if they were made somewhat larger and spaced further apart.
- They are tactilely distinguishable, but not color-coded in any way.
- Their rubbery surfaces provide good friction against slipping, and their edges are slightly raised, facilitating use with a mouth- or headstick.

Dual-Switch Alternative Input Control

For voters who cannot reach or operate either the touch screen or the tactile keypad, the Automark supports standard dual-switch input control devices such as sip and puff, jelly, and rocker switches. The dual-switch access jack on the front panel of the AutoMARK allows these external switches to be plugged in and positioned wherever is convenient for the voter.

Physical Access to the Ballot Feeder

The AutoMARK uses a feeding mechanism similar to that of a copier or scanner to collect the blank ballot page and return the printed, completed ballot.

- The user is expected to place the ballot page onto the intake surface of the feeder and slide it forward until the mechanism detects it and pulls it

into the machine. This task may require poll worker or attendant assistance for some voters with dexterity or reach impairments.

- The ballot feeder can be a forward approach obstruction, protruding 11.7cm (4.6 inches) from the front of the AutoMARK unit.
- The ballot feeder chute can obstruct left-handed use of the keypad, pressing buttons near the bottom of the display, or close-up viewing of the screen by voters with low vision. However, it can be folded up to limit its obstruction.



Figure 5. AutoMARK feeder tray and slot.

When voting is complete, the machine returns the completed ballot through the exit slot above the front input slot. However, significant force is required to actually pull the ballot free of the mechanism. This would certainly be above the physical ability of many voters, as it requires tightly gripping the paper ballot while pulling it out of the slot.

A voter who wants to insert their own paper ballot into the separate M100 optical ballot scanner and ballot box independently will need to insert the ballot into the ballot feeder on the top surface of the unit (approximately 42 inches above the floor). This ballot insertion task may also require poll worker or attendant assistance for some voters with dexterity or reach impairments.



Figure 6. M100 Ballot Scanner and Collection Device.

Manual Dexterity Accommodation Concerns

As described above, the AutoMARK has essentially three input systems: the touchscreen, the keypad, and the alternative dual-switch system (a pair of rocker switches and sip and puff switches). These three overlap somewhat regarding their physical demands and the abilities of voters to apply the needed amount of force, accurately, on the input controls. Most voters who cannot reach all the points on the active surface of the touchscreen may still be able to vote using the keypad; voters who cannot press the keypad buttons may still be able to vote using the larger touchscreen, by hand or by head- or mouthstick. Most voters with severe manual dexterity impairments who cannot use the touch screen or keypad may still be able to vote on the AutoMARK by using the alternative dual-switch input controls.

We are not aware of any public device that has more flexibility in accommodating the wide range of physical and dexterity abilities that voters may have. The key, as always, is whether pollworkers and voters will be able to identify and implement the optimal input system without better guidance or expert support. In fact, it may be that the more flexible a system is, the more difficult it is for novices to navigate through the necessary choices for configuring the access options in order to arrive at the best solution.

Of course, all physical controls pose some degree of difficulty for people with impaired dexterity. Some voters with dexterity and reach impairments may encounter minor difficulties using the AutoMARK voting system to mark and verify their ballots.

Paper Ballot Handling

After the AutoMARK prints a voter's paper ballot, the ballot must be removed from the ballot printer output slot, which requires approximately four pounds of pull to free the ballot. This high extraction force requirement also requires the ballot be grasped with a similarly high gripping force. Because of this high extraction force requirement, some voters with dexterity impairments may not be able to extract their ballot independently and may require ballot-handling assistance from an attendant or pollworker.

Although it is desirable, it is not possible for every polling place voter to be able to vote with absolute independence. However, it is possible and essential to assure complete privacy of the voter's vote selections throughout the voting process, especially during the phases that may require a voter to use assistance from pollworkers or others. The AutoMARK vendor supplies a special privacy sleeve to protect the privacy of the voter's ballot as it is extracted from the AutoMARK and then deposited in the M100 ballot scanner and ballot box.

Privacy Sleeve Concerns

- The instructions supplied by the vendor with their automatic insertion privacy sleeve are inadequate and confusing. The pictures did not match the actual unit.
- The set up and use of the sleeve is complicated; many pollworkers may be inclined to avoid using the vendor-supplied privacy sleeve altogether.
- The braille label was not applied to the privacy sleeve and had to be field applied, resulting in a wrinkle that made it hard to read. Additionally, the braille label material was so thin and brittle that the braille was extremely poor quality, with many burst and broken dots.
- When the privacy sleeve is mounted on the AutoMARK, the sides of the sleeve may open up and expose some of the voter's selections from either side.
- It is necessary for the voter to nudge the ballot from the privacy sleeve into the slot when inserting the ballot. The sleeve has a central cutout area to facilitate this nudging; after the ballot is ejected, this cutout can expose some vote information.
- It is necessary to pull the ballot out of the AutoMARK, after ejection, so it fits completely in the sleeve (if this is not done, some vote information will likely be exposed at the top of the ballot). This requires reaching in from the sides, through the side gaps of the sleeve, to grip the ballot on either side and pull it.
- No pictures or text indicated whether the lower flap should go into or below the ballot feeder input slot.

- When the bottom flap or tongue of the privacy sleeve was left in the input feeder tray area, resting on the surface, the sleeve was self-supporting. It was not self-supporting when the bottom flap was placed underneath the base of the input feeder tray. The ejected ballot did not enter the sleeve properly when the sleeve was set up in the self-supporting position. The ballot would eject underneath, missing the privacy sleeve, unless the sleeve's bottom was positioned under the foldable base of the input feeder tray. Reliable successful ballot deposit into the privacy sleeve required that the voter's end of the privacy sleeve be raised and supported by the hand of the voter or pollworker. The pictures with the instructions for use of the sleeve all showed the end of the sleeve being held up by someone's hand.

Visual Display Concerns

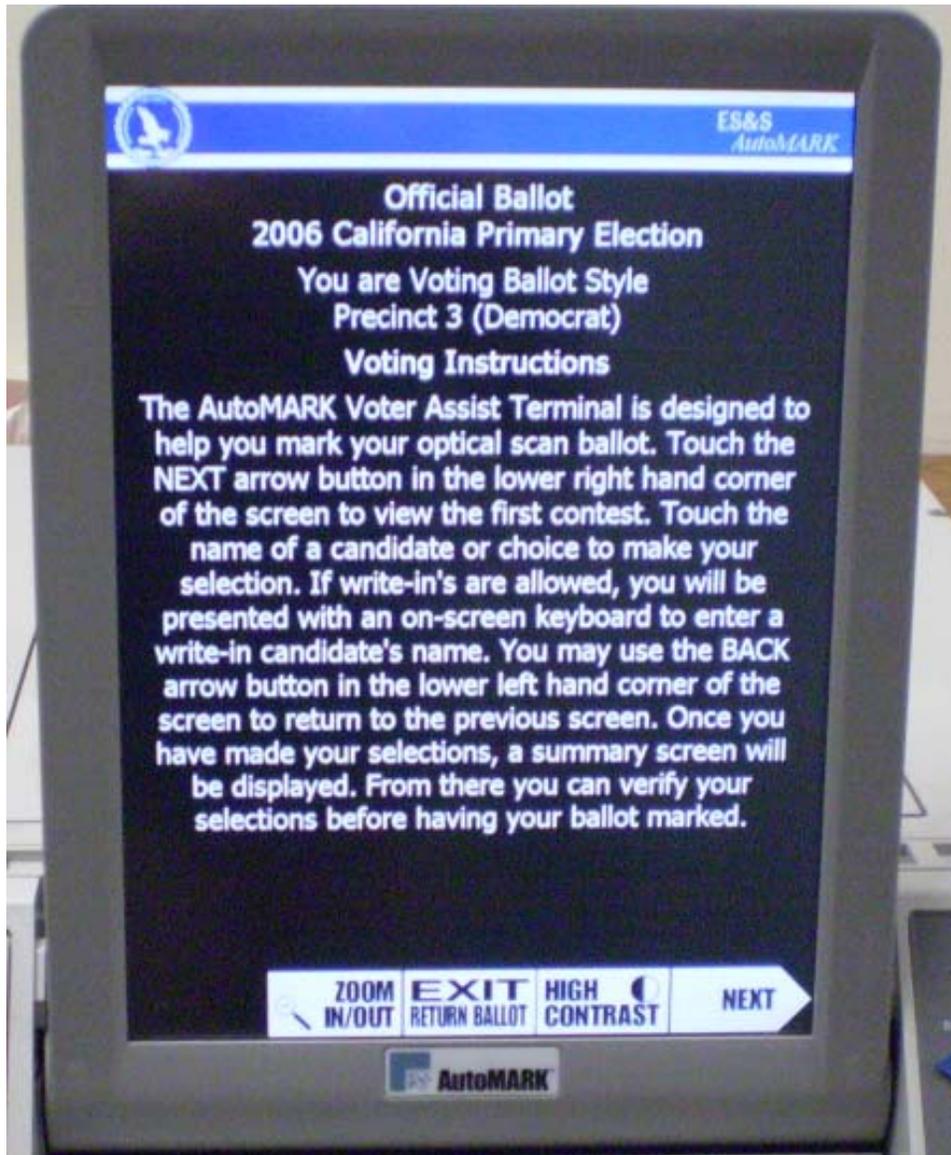


Figure 7. The AutoMARK visual display.

- The tilt adjustment of the visual display has nice range, but it should lock in place where the voter wants it to stay, so it does not wobble.
- Problems with room lights glaring off the screen bothered some voters quite a bit, unless they were able to adjust the visual display angle to minimize the glare.
- There was no apparent way to use the audio and keypad to configure the zoom and contrast settings for the visual display.
- Use of blinking to highlight or attract attention is overdone in some screens. For example, the Next button on the screen blinks too much and is distracting.

Color Usage

The VVSG requires red to be reserved for errors or emergencies; it is used for other purposes several times in this AutoMARK visual interface.

- For Under-vote indication: black on red on arrows is poor contrast and hard to read.
- For Ballot Review: "No Selection Made" (undervote) uses black on medium red, which is poor contrast and hard to read.
- For the no-selection-made options in the Verification Summary Screen, it shows black on medium red, which is also very hard to read.
- Red is used for the Exit/Return Ballot choice on the screen, which gets your attention, but it is not an error condition.

High Contrast

The AutoMARK visual interface offers both magnification and high contrast, which are set independently. These features, combined with the overall good quality of the LCD, result in effective display characteristics for most low vision users. However, there are some remediable problems.

- A bug in high contrast and magnification occurred in the Member of State Assembly Contest. The "Write-in" title showed magnified but did not show in high contrast.
- The high contrast screen control always shows "high contrast" no matter what the setting is; there is no indication of which state the AutoMARK is in.
- The high contrast setting is reverse video, white-on-black, with very clear text. However, instead of using appropriate color pairs, the high contrast setting eliminates colors from all the controls, even though the colors are very useful in normal contrast mode.
- Focus and selection status becomes much harder to tell in high contrast mode, although the text is easier to read. For example, in high contrast, the selected candidate only has an 'x' in the oval; the low contrast setting has a fully blackened oval.
- Monochrome highlighting for the speech output focus or cursor is confusing because it can cause the focused choice on screen to appear to be selected, especially as the selected status indication is no longer a filled in black oval, but a thin 'x' or check of the oval.

Magnification

Many of the test subjects asked for greater magnification and more steps of magnification, not just the two sizes (8.5 and 17 point sizes).

Some Comments from Voters

Most voters who would use the audio interface will have some residual vision, or have other reasons to use audio and video simultaneously (e.g., to accommodate a learning disability). These voters will use both audio and visual interfaces simultaneously.

"The voice and screen together helped to check accuracy of vote."

"Fairly easy, voice and touchscreen was nice and it voices your selection to you."

"The screen is flimsy."

"Screen was clear and readable."

"The screen looked good but touch was not."

"Initial messages (especially "please insert your ballot") are small print, but should be large."

"All screen controls should be in large print all the time."

"The wording of the Zoom In and Zoom Out display magnification control on the screen is confusing and enigmatic."

Touch Screen Control Concerns

The access testing demonstrated that there are many voters who need an alternative to touchscreen input controls. The AutoMARK provided several alternative input approaches for these voters.

In the testing, some voters used the keypad to navigate contest screens and then used the touch screen to make candidate selections. One voter used the touch screen for the write-in and used the keypad for all other input.

- The tilt adjustment of the visual display has nice range, but it does not lock in place where you want it, so it wobbles back and forth when pushed. During subject testing, it bounced back and forth from touches so much that some voters were getting multiple touches detected. At least one voter had to steady the screen with one hand, while using the other hand for touch screen presses.
- Rather than gently pressing on the buttons of a touch screen, some voters with dexterity impairments are only able to strike or "pop" touches, which unfortunately can cause the AutoMARK screen to bounce back and forth several times.
- Some voters felt it was necessary to press the screen very hard to get clean reliable touches.
- Touching the screen in certain areas caused focus highlighting without marking a checkbox. This caused several touch voters to inadvertently

skip selecting a choice or to think they had to press again or press harder to get reliable selections.

- The screen gave audible clicks whenever voters touched it, and this could mislead them into thinking they had made a selection, when they actually had not.
- Some voters with dexterity impairments found it tiring or difficult to hold their hands up high enough to reach the top of the active touch screen area.

Keypad Input Control Concerns

- Because voting with audio and the keypad interface may take the average voter with disabilities half an hour or more, voters can find it tiring to hold their hand up high enough to operate the AutoMARK keypad. It is built-in and does not have a tether cable that would allow more comfortable location in the voter's lap.
- The long in-booth times mean that many voters will need to sit down to vote. Because they are sitting, voters will have to hold their hand up higher to operate either the touch screen or the keypad.



Figure 8. The AutoMARK built-in control keypad is mounted on the right-hand sloping front panel of the system. The keypad controls are laid out with arrow keys (buttons) in a standard cursor cross arrangement, with left and right arrow keys to the left and right of a square Select key. There are also up and down keys above and below the Select key.

- There are no keys for Help, Summon Assistance, or Pause.
- The force required to press the keypad buttons was relatively high, between 320 and 350 grams, as measured with a dynamometer. For comparison, a typical computer keyboard or desktop phone key requires no more than 120-150 grams.
- Several voters found that the voting system required so many repeated button presses that they experienced hand fatigue, especially after the write-in test.
- The keys tilt rather than activate if pressure is applied near their edges, so finger pressure must be centered on each key cap.
- The keys are all the same color, which makes them harder for low vision voters to distinguish and locate.
- The contrast is poor, as the keys are blue, and the background is gray and medium blue.
- The keys have limited separation between them, although there is room for separation on the keypad matrix. The Select key is about 1 inch (between centers) from the surrounding arrow keys. Keys that are too close together foster errors when used by people with dexterity impairments.
- Although the physical dimensions on the keypad braille dot height and separation are good, the rubber surface of the keypad has a lot of viscous drag, so it is difficult to read under high humidity or high perspiration situations. Fortunately, the voter does not need to do much reading of this rubbery braille.
- The printed labels are too far from their keys, are too small, have too little contrast with the background, and their label font is too thin.
- After the repeat key is held down for several seconds, the system toggles between its regular speech and a degraded "duck talk" voice.
- There is also an audible tone when the screen on/off key is held down for several seconds, but it was not obvious what parameter or function it is supposed to be toggling or changing.

Voter and Pollworker Comments about Tiring from Use of Keypad

"I have tennis elbow, so it was hard to hold my arm up so long."

"Maybe something to place your arm on to rest and hold it up."

She would have liked a palm support for the keypad.

Her arm and shoulder got tired holding her hand up to the keypad.

Voter found tilt of keypad tiresome, needed to rest right hand briefly during voting.

She thought the keypad angle was bad, too steep, should be tilted "down a little more".

He has the feeling that the keys are hard to push reliably and must be pressed firmly and hard.

She spent a lot of time (14 minutes) reviewing tactile interface. Had difficulty re-finding keys after each race was voted.

She would like a palm rest in front of the keypad.

Keypad Braille Labels

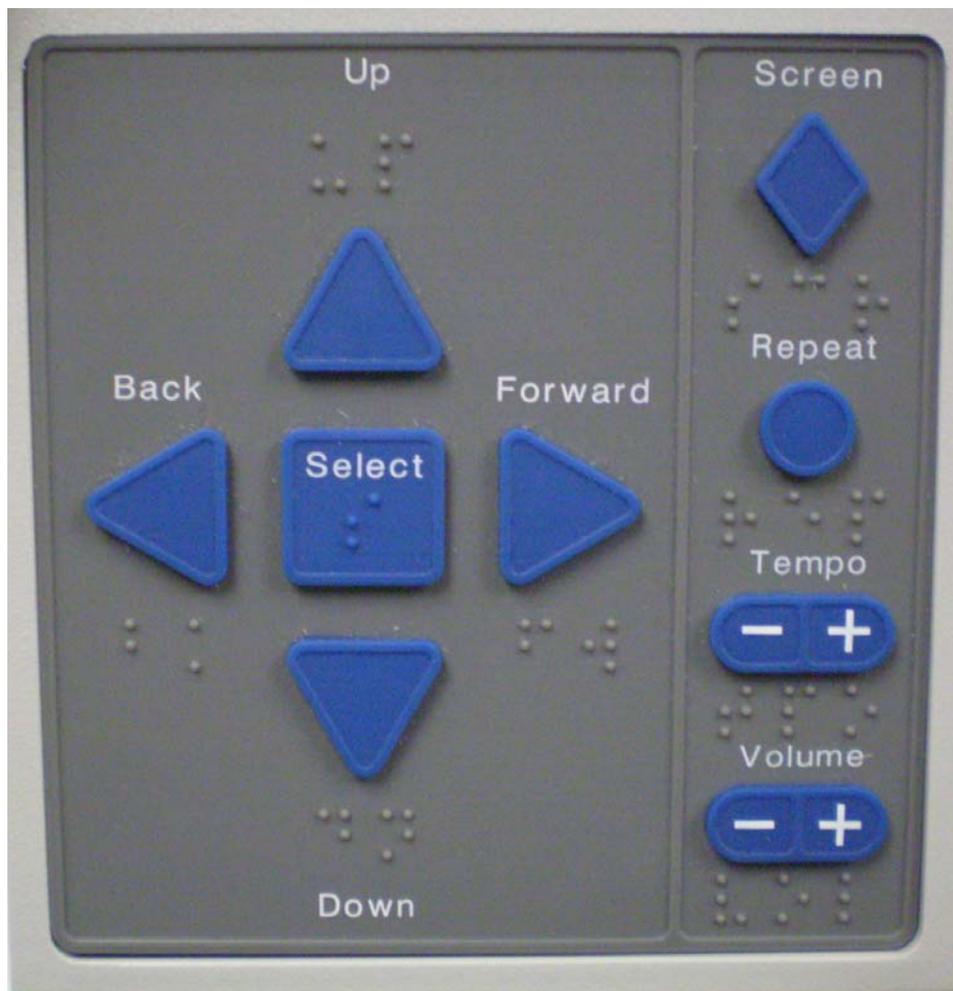


Figure 9. The braille labels are: s for Select; fw for Forward; bk for Back; up for Up; dn for Down; scr for Screen; rep for Repeat; tpo for Tempo; and vol for Volume. These are good abbreviations. The Select key is the only one with a braille label on the key cap. The other braille labels are on the keypad surface below each key, except for the Up key, where the label is above.

Some braille readers read with the tips of their fingers, with their fingers essentially perpendicular to the surface; others have to read with the fingerpad, with their fingers essentially parallel to the surface.

- The separation between the keys is only about 14.5 mm so the braille labels between the vertical buttons are hard to feel. It is difficult to get in between the rows of the vertical column of buttons for people that are fingerpad readers.
- The vertical line between keypad cursor keys and vertical keys actually adds to tactile clutter. A clear gap would be preferable.
- The Rubber background of the keypad feels too much like the key tops and has the same texture so it lacks good tactile contrast.

The AutoMARK orientation message says:

"...In addition to the arrow keys, there are four vertical keys to the right of the arrow keys. The bottom toggle will adjust the volume. The next toggle key will adjust the speed of the synthesized speech.

The round button will repeat the last spoken phrase, and the top diamond key will turn the display on or off for privacy."

However, there are not four vertical keys, as Tempo and Volume are double keys, not toggle keys, and should more accurately be called "rocker switches". They are also not really "vertical keys", and should be referred to as a "vertical column of keys".

- The "tpo" label is not intuitive for "Tempo" or speech rate. Voters with talking computer experience are not used to the term "tempo" in the context of speech rate.
- Several voters assumed that the "scr" label stood for "scroll".
- There is not enough separation between the arrow and Select keys, if a voter has to use a fist or blunt object for pressing.
- Some voters would like the Select key away from the center of the arrow keys to avoid accidental pressing.

Voters without manual dexterity problems would like the keys close enough to allow just finger movement to operate them, not requiring wrist or arm movement. However, voters with certain dexterity impairments would rather see more separation between all of the keypad keys. These contradictory requirements are not addressed well with the AutoMARK's single, built-in keypad.

Voter and Pollworker Comments about Keypad Braille Labels

Voter asked does "scr" in braille mean "Scroll"?

"scr" what is this? Don't know"

Some difficulty reading "tempo" ("tpo") braille label during orientation.

Wants something other than "tpo", probably "rte" for rate label.

"tpo" is not intuitive, suggest "spd".

"Braille "rep" means Representative, Replay, Report or what?"

Voter asked if "s" braille button was for "Stop".

Dual-Switch Input Control Concerns

The AutoMARK supports dual-switch input controls such as jelly switches and sip and puff switches. These controls allow the user to control the voting system by actuating one or the other of the two switches. Generally, one switch moves the system to the next choice in a list, and the other switch acts like an Enter or Select key.

A serious limitation of the dual-switch input controls for the AutoMARK is that the system does not have redefined help messages, instructions, or prompts that reflect use of the dual-switch controls. This leaves the dual-switch user with largely inappropriate instructions and help messages.

As an example of the lack of switch-aware menu options, there appeared to be no means for the voters with switch input to adjust the volume, rate, or other configuration parameters.

The AutoMARK Sip and Puff Switch Input Control

This alternative input control has a head-mounted mouthpiece tube that is connected to a switch control box. The voter operates the two switches in the control box by either sipping or puffing on the mouthpiece.

These switches work in the same manner as other dual-switch controls. Sip is like the Left on the rocker switch, and puff is like the Right on the rocker switch.

- The Velcro attachment for the mouthpiece of the AutoMARK sip and puff switch fails to keep it reliably attached to the head mount assembly. During the access testing, the mouthpiece repeatedly disconnected and fell off.
- Due to its design, it is very difficult to wear the AutoMARK sip and puff switch head-mount control while simultaneously wearing headphones and/or glasses.
- The sip and puff control has replaceable sanitary mouthpieces, and should have a new one supplied for each voter who uses the sip and puff input control as they cannot be sanitized and reused. The pollworker training materials do not address proper sanitary handling procedures for the sip and puff switch control.

The Rocker Dual-Switch Input Control

The rocker switch has a wide rectangular top plate that is activated by pressing on one side or the other.

- Both sides of the rocker dual-switch input control unit are beige; using different colors would facilitate understanding and use.
- Pressing the right-hand side operates like Select and the left-hand side is generally used for commands such as Next. This seems backwards to the voters and is not intuitive.
- The amount of force required differs across the single rocker top plate. It does not use the dual-switch design that employs two adjacent top plates for the switches.
- No Help or Request-Assistance control possibility is supported on the AutoMARK.

Dual-Switch Operation Concerns (Including Sip and Puff Control)

- Upon an undervote attempt warning, if the voter presses the left side, they are taken to a different contest, not the contest that was undervoted.
- At the beginning of write-in, pressing the left side issues the "Cancel write-in" command and exits the write-in mode, unless the voter first presses the right side to begin browsing the letters list.
- When first in write-in, pressing the right side takes the voter into the alphabet list, but then the voter has to change modes and start pressing the left side to move through the letters list. This is not intuitive. (A similar awkward mode-change situation arises with menus for language and other options).
- Since there are only two controls, there is no way to back up through the write-in alphabet -you can only move forward through it.
- When the voter is on a page, has not made any selection, and presses the left side, the AutoMARK system reacts as if the voter was already navigating the page and improperly gives an undervote message.

Ballot Scanning and Marking Concerns

- The ballot input feeder tray is an obstruction during voting that may need to be folded up to minimize interference.
- Lowering the ballot feeder tray when it is folded up requires knowing to lift straight up to unlock it first, before pulling it forward. The tray lock lift-to-unlock mechanism will result in some voters or pollworkers just pulling forward on the tray and possibly damaging it.

- The recessed arrow in the middle of the feeder tray is not tactilely obvious. It did not feel like a tactile indicator, just a latch hole or some other irrelevant part of the design.
- The braille "Insert Ballot" message is so close to the right edge of the feeder tray that it is difficult for right-hand braille readers to read.
- Upon exiting from the AutoMARK's printer, the ballot comes out from a hidden slot just above the input feeder slot. It is easy for the voter to assume that the ballot exit area is the input slot.
- The insert ballot prompt message could explain where to insert the ballot.
- Many of the voters worried unnecessarily about what was the correct orientation for inserting the ballot in the scanner, because the instructions did not explain that any orientation (front or back, top or bottom) will work.
- The insert instructions do not give the voter any warning about the loud ballot feeding sound, to prepare them to not startle or fear that they may have done something wrong to cause such an alarming sound. Some voters respond to the loud input feeder noise by jerking the ballot back out of the input slot.
- During ballot scanning or marking, the AutoMARK's audio messages can be drowned out by the loud noise of the scanner and printer mechanisms.
- The AutoMARK says, "The audio will be silent while the ballot is scanning", and this wording is confusing to some cognitively impaired voters.
- During the several long silent periods while the system is scanning or marking the ballot, some voters worried that the machine had died.
- The screen has a visual progress bar, but the audio has no analogous indicator.

M100 Optical Scan Precinct Counter Concerns

The M100 Optical Scan Precinct Counter is a floor-standing metal box unit, about 42 inches high that contains a ballot scanner and secure ballot box.

- Voters in wheelchairs cannot approach head-on, because there is no knee or foot clearance under the unit, so they would likely have to approach the unit sideways, across the front of the unit or approach along the left or right side of the unit.
- There are no useful indicator lights. The status indicators are a beep sound and possible ejection of the ballot.
- Voters can get some tactile vibration feedback status through the case, indicating that it's feeding the ballot in or out.

- The M100 display's contrast is poor and susceptible to glare. However, the visual display does not provide useful information to the typical voter, as its messages are cryptic. For example, the "Missed timing mark" message is technical and may be meaningless for the average voter.
- There are no braille instructions or labels to indicate where to insert the ballot.
- The M100 scanner seems to accommodate slow ballot insertion by the voter.
- The internal distance between the paper-inserted sensor and the paper feed rollers is close enough that jittery or slow timid ballot insertion is usually accepted.
- The top cover flap of the ballot feeder slot can be lifted if there is a paper jam, and the flap also serves to some degree as a privacy shield.
- Voters with impaired reach might have difficulties reaching under the flap, to retrieve their ballot, if it is rejected and returned.
- The M100 unit used in the access testing had some sharp and abrasive front edges that were probably smooth on a new unit, but may have been damaged by rough shipping and handling.

Speech Interface Concerns

The AutoMARK system audio interface employs synthetic speech for output and manual input controls. The synthetic speech is generated by a text-to-speech (TTS) program. It does not use prerecorded speech from a human speaker. The same voice is used for the system messages and the local races and choices.

- The speech quality is comparable to the speech many people who are visually impaired are used to using on their home computers but is not as good as the higher quality "natural sounding" TTS systems now commonly available. Visually impaired users not familiar with synthesized speech may find the voice hard to understand.
- The speech system includes controls for rate (tempo) and volume and includes a repeat function to replay the last spoken message.
- The audio output is through headphones connected by standard ¼ inch or 1/8 inch phone jacks on the front panel.

Speech Volume Range

The speech volume measurements were made using the system's Startup instructions, which were replayed with the Repeat key, and using the vendor-supplied headphones with soft cup-style muffs. Other headphones may produce different results.

The levels were measured with a sound level meter placed directly in contact with the earpiece of the headphones.

Sound Level Measurements

- Normal sound level = 80 dB
- Minimum sound level = 65 dB
- Maximum sound level = 95 dB
- 20 steps from minimum to maximum volume
- Approximate step size = 1.5 dB

Note: the lack of indications for the end limits makes an exact step count difficult. In addition, this volume level range is not in conformance with the VVSG audio volume range requirements of 20 to 100 dB, with an initial level of 40 to 50 dB.

Speech Rate Settings and Range

The speech rate measurements were made using the system's Startup instructions, which were replayed with the Repeat key. The rate is reflected by the time for the system to speak the full message.

- Normal rate = 1 minute 25 seconds
- Maximum rate = 9 seconds
- Minimum rate = 4 minutes 35 seconds

Note: the lack of indications for the end limits makes an exact step count difficult.

- This range of a factor of about 30 in speed with roughly 30 steps is excessive. The fastest and slowest speed settings in this range provide no additional value to the voter.
- The slow speech is stretched out and distorted. This is because the AutoMARK speech system slows the speech by stretching out and distorting the words themselves, rather than slowing speech by stretching out the time between words.
- The speech volume and rate controls do not give the voter a practical way to return settings to their normal values.
- Changing tempo triggers the repeat message as a sample, but changing volume does not.

Voice Pitch Control

There was no setting for speech pitch control.

Other Speech Concerns

- The “duck talk” voice (toggled on and off as described in the keypad section) is difficult to understand.

- Some elderly voters, especially those who were not used to using synthetic TTS (Text To Speech) systems, found it somewhat difficult to understand the normal AutoMARK TTS voice.

Some Voter Comments about Speech Quality

"That sounds like 'p', but it's a 't'."

"'T' didn't come through clear."

"Letter 't' did not sound right in write-in."

"Speech quality is great."

"Computer voice is terrible, worse than JAWS." (Her personal computer screen review program.)

"Took longer to understand because of scratchy voice."

"Change voice, too scratchy."

Many Audio Voters Asked for a Pause/Resume Control, as in these Comments

"It would help to be able to pause the instructions."

"It's not that it's too fast, it just doesn't pause between the messages."

"Might not need repeat-phrase if there was a pause/continue control."

She would like a control to just repeat a phrase, without all the rest of the message.

"I think it talks too much."

Some Voter and Pollworker Comments about Speech Rate Controls

"It's good to have rate control and repeat key." (He turned up the speech rate quite a bit.)

"Would help if speed could be adjusted at any point without repeating instructions from beginning." (Tempo switch started all over again, repeating the last phrase.)

"It's not obvious that pressing tempo changes tempo because instructions start to repeat, instead of saying 'faster' or 'slower'."

Liked speech rate and volume adjust.

Voter had speech set slow.

She has the speech rate pretty high.

Tempo or speech rate set fairly fast.

Liked ability to change speed.

Liked being able to speed up speech!

Navigating the Audio Ballot

Many audio interface users found the more complex tasks such as reviewing, making changes, write-in voting, and casting the ballot confusing. Some of the confusion may be due to the nature of those processes themselves.

- Although moving from race to race and making selections is somewhat intuitive, the acts of reviewing, modifying, verifying, and casting are not. It was difficult for some voters using the audio interface to understand and navigate through these abstract modes. For example, it was not obvious to many of the voters that they needed to press the Select key to start up the write-in function. Some thought there was no sense selecting the write-in choice until after they had managed to write in a name.
- Pressing the Select key to deselect a choice seemed counterintuitive to quite a few voters, especially those who were not very experienced with the operation of computerized interfaces.
- The lack of a Help command made it difficult for confused voters to figure out where they were in the ballot process and what their options were at that point.
- The review screen was confusing to many voters because it required the voter to switch from moving race by race through the ballot and start using the Up and Down keys to move through the races. Accidentally using the Forward and Back arrows in the review mode could have serious consequences, such as inadvertently marking the paper ballot prematurely.
- An additional source of much frustration for voters was that significant operations such as canceling out of write-in or printing out the ballot were not protected with a request for confirmation before taking the action.
- At the beginning of the voting process the system says, "...To exit without marking your ballot, press the diamond shaped screen button four times in a row. Press the right arrow key now to hear the first contest." Previously, the voter was told to press the left arrow twice to exit/return. At other times, pressing Select will exit, and in another, right arrow will exit.
- In the start of the Summary, when prompted to press Select to mark your ballot, pressing Right arrow caused it to mark and eject the ballot without getting a confirmation from the voter.
- With the ballot for Precinct 5, American Independent, when at the start of the ballot, pressing left arrow brings up an exit dialog that prompts you to press left arrow to continue marking your ballot. This prompt is not correct; you have to press right arrow to actually exit.

- In several places, the system said, "Press right for next screen" instead of "Press right for next contest."
- Several voters said that they would like a control that announces the name of the contest they are in, not just what is the current choice.
- If the voter scans in a ballot that they have already marked, the AutoMARK goes into a review mode that allows them to verify their selections. However, it does not allow them to add marks to undervoted races even though this should be possible on an incompletely marked ballot.
- When a race is fully voted and the voter makes a new selection, their previous selection is automatically deselected for them, to avoid an overvote. However, the voter is not informed about the deselection.
- At the start of the review procedure, the voter can press Select to print the ballot, but many of the voters seem to completely miss that option.

Write-in Concerns

The AutoMARK write-in function requires the voter to spell out a candidate's name by selecting one letter at a time from the list of letters and other choices. This can be accomplished via an alphabet laid out on the touchscreen or by navigating through the alphabet one letter at a time in the audio interface.

- A frustrating and frequent problem was that it was too easy for the voter to accidentally cancel their painstakingly entered write-in name or to exit the write-in function without completing entry of the desired write-in candidate's name. This was primarily due to the lack of an exit warning and confirmation dialog that would have helped them avoid inadvertent erasure of the write-in name or premature exit from write-in before completion of name entry.
- Using the AutoMARK voting system to write-in candidate names was challenging enough for some voters that 15% of the voters who attempted to fill out a write-in vote for "John Smith" failed to complete their write-in successfully. Clearly, the lack of a confirmation dialog before exiting the write-in function was the predominant cause of failures to complete write-ins successfully on the AutoMARK voting system.
- Many voters were quite confused about the process for starting a write-in. It was not obvious to them that they were supposed to press Select when prompted "write-in", because "write-in" does not seem like a selectable candidate name.
- For voters using the audio interface and keypad input, the process of scrolling through the alphabet was very tedious. It took 96 keystrokes and about 1.3 minutes to write-in "John Smith" as rapidly as possible. This was actually better than some of the write-in times of some of the other voting systems recently evaluated for the California SOS office. By way of

comparison, another ballot marking system with a very similar write-in procedure took 2.5 minutes (about twice the time) to write in the same name.

Some Voter Comments about Write-in Times

"The write-in may be pretty time consuming."

"Write-in is slow enough that it might discourage me from doing write-ins."

"Write-in is a lot of work."

"It would kind of discourage me from doing a write-in to push so many times."

"Write-in is very cumbersome; would take forever for people without a strong grasp of alphabetization."

"Found write-in tedious."

- Because the various points made in the initial write-in instructions message were all run together without pauses between them, most voters missed essential points like how to do a space or backspace.
- After exiting prematurely, without finishing entering a name, the voter had to reselect the write-in option to re-enter write-in and attempt to finish their candidate name entry.
- Even after successfully entering a write-in name and exiting from the write-in properly, some of the voters lost their entry if they then selected another candidate name from the list for the race. Selecting another candidate name in a fully voted race would cause the write-in to be deselected and the voter's write-in name to be erased.
- Some voters patiently and painstakingly re-entered "John Smith" as their write-in repeatedly as many as five times. Others gave up in frustration the first time they incorrectly exited the write-in without successfully completing the process.
- The Repeat command does not function properly. Voters are told during the orientation that the Repeat key will read back the last instructions; however, pressing repeat in the midst of a write-in just repeats the name of the selected candidate, rather than reading the candidate name and then the instructions.
- The write-in instructions say, "...When you are finished, press the right arrow key to return to the contest and select this write-in candidate..." This message caused some voters to press Select on the write-in option after they "return to the contest", exactly as they thought it had just instructed them to do. Unfortunately, pressing Select takes you back into the write-in, rather than just toggling on and off the selected status of any current write-in name.

- To clear a write-in name, the voter has to go back into the write-in process and left arrow to cancel out or select and deselect another candidate's name in the same race. This is only explained at the very end of the instructions, if you are patient enough to wait and hear it say, "To cancel and return to the contest without selecting this write-in candidate, press the left arrow key." It also is not obvious to voters that this means that left arrow would clear the name from the write-in option.
- When a voter has a candidate selected in a single seat race, and they select write-in, the AutoMARK does not tell the voter that it is automatically deselecting their previous choice.
- In some cases, voters with a candidate already selected in a race selected the write-in option and then gave up on the write-in and left the race without realizing that they had automatically deselected their previous candidate choice.
- When there were multiple write-in options available in a race, they were not distinguishable, with different names such as "write-in 1" and "write-in 2".
- When the AutoMARK pronounces the accumulated letters during a write-in, it does not also spell the name out. Voters were confused by hearing the accumulated letters "Jo", (sounding like "Joe") when they were in the middle of entering "John".

Here is a description of one frustrating write-in experience:

Voter attempted the write-in twice with the keypad; hit right arrow by accident and left the "write-in" screen; tried to return to the "write-in" screen by pressing the left arrow; was sent back to the previous screen (not the "write-in" screen). Tried to use large print/high contrast for the write-in process; had to have the Pollworker magnify the screen for him; used the touch screen on his third through fifth write-in attempt; and gave up after accidentally leaving his write-in on the fifth try.

System Instructions and Messages Issues

There are some concerns regarding orientation, help, and instruction messages for AutoMARK voters.

- First, the amount of information presented at one time was often overwhelming. Without a way to pause and resume the audio help function, users were not able to reflect on the meaning of the information and absorb it at their own pace.
- Second, the information sometimes covered several complex sequences. A typical voter comment was, "Can't remember the long instructions."

- There is not an initial orientation key identifier mode to help the voters learn the keypad functions more quickly.
- There are no introductory instructions informing the voter that ballot orientation is not important when inserting a ballot.
- There is no introductory instruction that tells you that you can press keys to interrupt messages rather than wait for them to finish before proceeding.
- When keys are inactive (like Up and Down in the exit dialog), they do not prompt to tell you that they are being ignored or why, they only produce a “beep” sound.
- With a ballot in the system and no input control for five minutes, the system goes into a warning state in which all the keypad keys are inactive, except the Select key.
- When the screen is displaying the timeout message, there is no way to get the audio to repeat or announce the message or even tell you that Select is the only thing you can do.
- In the contests, pressing the left arrow says, "Next contest", instead of "Previous contest".
- The system says, "Official ballot. You are voting ballot style." This message may leave the voter wondering what "voting ballot style" means.
- An on-screen prompt, “exit/return ballot” is confusing and poorly worded. The '/' is not spoken in the audio message, so audio voters hear, "Exit return ballot".
- The screen prompts tell you what the right arrow does, but do not similarly tell you that you can press the left arrow on the keypad to exit and return your ballot.
- After a ballot scanning error, the machine said, "Please insert your ballot." Pressing the Repeat key after that just produced, "Please insert your ballot." without repeating the error message.
- There were no timeouts offering helpful instructions but not requiring a voter response.
- At the bottom of a contest, it says, "You have reached the bottom of the list. Please press the right arrow key to proceed to the next screen." This actually caused one very compliant voter to follow the direction and press right arrow, even though they were not ready to leave the race.
- At the end of a contest with just a yes/no list, it said, "Press right arrow to..." so the voter did, and undervoted the contest.

- After a race has just been fully voted, the machine says, "You have now fully voted this contest. Press the right arrow key to continue to the next screen." It should say "...next contest", not "...next screen".
- Many audio users cope with audio clutter and overload by only paying attention to the first thing in a long audio message or the last thing in the audio message. This is why many voters will miss the "Selected" status at the end of a spoken contest choice.
- In the mark ballot dialog, the message says, "You ballot will be marked..." where "You" should have been "Your".
- As a voter complained, "It doesn't repeat instructions" while in "write-in" (after entering in a letter).

Paper Ballot Verification Concerns

- The AutoMARK system allows the voter to scan in a ballot, regardless of how it was marked, and use the AutoMARK to accessibly verify the marks made on that ballot.
- However, the AutoMARK is not capable of recognizing and displaying or speaking the contents of a write-in name field. It can only affirm whether or not there is something in each write-in field.
- If the ballot contains undervoted races, the AutoMARK will let the voter verify which choices have not been selected in each race. However, the system will not allow the voter to make any changes to an already marked ballot. The voter must start over with a new, blank paper ballot.

Total In-Booth Voting Times

Our previous testing of, and experience with, electronic voting systems demonstrates that, in general, voters without visual disabilities can mark their regular ballots three or four times faster than voters using an audio voting system.

The in-booth voting time for AutoMARK audio voters (excluding times for our special write-in and vote modification tests) was 17.8 minutes for average subjects and 35 minutes for the slowest. Because the elections on the test ballots available for this access review were very simple and short, it is clear that California ballots with more races and long lists of candidates would take many times longer to vote with the AutoMARK voting system.

- Average time = 17:50 minutes
- Minimum time = 10:00 minutes
- Maximum time = 35:00 minutes

Appendix F, Timing Results for Phases of the Voting Process. gives all the timing results of the testing.

On typically long California ballots, voters will usually take from half an hour to an hour to complete their audio ballot. Not only does this severely limit the number of voters who can vote on this system during an election day, it also is a potentially exhausting challenge for many voters, especially if there are no chairs available for them to sit in while they vote.

Voting Accuracy Concerns

For the methodology used to measure voting accuracy, see Appendix G, Voting Accuracy.

Two of the 28 voters (7%) had an error in the free voting portion of the testing, the test phase in which the voters were allowed to mark the ballot how they wished. However, the two errors were a small percentage of the total number of vote selections made by all voters and represent a 1.1% error rate.

Because our total number of subjects does not represent a very large sample set, and because this was not an actual voting situation, readers are cautioned against assigning any great statistical relevance to any quantitative accuracy score based on this testing.

Perhaps the most useful finding for the voting accuracy of this test is simply the qualitative conclusion that the accuracy for the free voting was good.

Write-in Completion Failures

Effectiveness of the voting system's write-in capability was treated separately from the free voting accuracy because of its different and more complex nature. Few voters typically use the write-in option. However, effective write-in capability is an important element of voting. Because write-in mechanisms on audio interface voting systems are, by their very nature, tedious and challenging, it is difficult to determine how much voter motivation, fatigue, and other factors influence the outcome of a test for successful write-in completion. Some of our voters were not even willing to attempt to do a write-in. Others dove into the write-in procedure without hesitation. Some endured great frustration, accidentally canceling out of their write-in repeatedly, each time losing the write-in name they had so painstakingly entered.

In a real election setting, with a real candidate name to write-in, the motivation to correctly complete a write-in might be very different from that of our testing environment.

In this review, 28 of the subjects attempted to vote with the AutoMARK terminal. Of the 28, 27 attempted the write-in.

Of those 27 who attempted a write-in on the AutoMARK, four (15%) did not successfully complete the write-in of "John Smith" on their ballot.

In summary, we found free voting accuracy was 99% for all free votes cast or perfect for 93% of the voters, and write-in completion accuracy was perfect for 85% of the voters.

Privacy Concerns

Eavesdropping on the Printed Paper Ballot

Voters with manual dexterity impairments or other disabilities may need to protect the privacy of their ballot from observation by attendants or pollworkers whose paper ballot handling assistance may be needed. The vendor-supplied privacy sleeve design does not offer as much independent operation as possible.

Eavesdropping on the Headphone Audio

Voters who use the AutoMARK terminal but do not use the headphones may leave the headphones plugged in and be unaware that the headphones are left lying around where someone else may be able to overhear the choices the voter makes on the visual display screen. There is no indication in the vendor's pollworker training materials that this may be an issue, nor how it should be dealt with.

Eavesdropping on Audio Voting with Recorders and Wireless Bugs

Modern miniature recorders or radio transmitters could actually be hidden on or inside a set of headphones or in its cable connectors, to permit eavesdropping on the headphone audio that would permit the eavesdropper to monitor the voter's selections.

Personal Safety Concerns

There are sharp edges and corners on several parts of the system normally contacted by voters, such as along the front edge of the ballot input feeder tray. These may seem trivial to voters without disabilities. However, voters with visual or motor control impairments may injure themselves on these sharp areas as they approach or tactilely explore the machine.

Public Health and Sanitation Concerns

There are public health concerns about the public sharing of headphones, touch screens and controls, sip and puff tubes, and other parts of this voting system.

- Voters stated concerns about sanitation of shared earphones and properly wiping down keypad and screen surfaces with disinfectant. One Voter asked, "Can you bring your own headphones?"
- The sip and puff input control unit's mouth tubes cannot be sanitized and reused, and the vendor's pollworker training materials do not address proper sanitary handling procedures for the sip and puff switch control.
- No sanitary headphone covers were provided, and the vendor's pollworker materials did not provide enough information about maintaining sanitary conditions of the relevant parts of the voting system.

Reliability Concerns

Several times during the access review testing the AutoMARK system failed to operate as expected. There were a number of failures in the AutoMARK terminals and the ballot-scanning unit. The older model of the AutoMARK machines (Model No. A100) had two program failures that resulted in error messages that would not go away until the system was switched off and then back on. See Appendix H, Notable Event Log for the ES&S AutoMARK and M100 OSPC Access Testing, for a log of some of the more notable events.

Pollworker Training and Assistance Concerns

Accommodating some of the voters required ad hoc changes and adjustments to the machines and their immediate surroundings, especially for voters who used wheelchairs and had impaired dexterity. In addition, the orientation to the audio interface for blind and low vision voters requires significant understanding of the needs and expectations of those users. This places a premium on the thoroughness and quality of training offered to typical pollworkers and the materials used for training.

A review of the vendor's AutoMARK pollworker training manual found the materials not to contain appropriate information for this purpose. This raises a key concern: given the fact that relatively few voters with disabilities will present themselves at regular polling places and the under availability of accommodation expertise and resources at those polling places, it is reasonable to assume that some voters with disabilities will not be able to vote successfully even though the machines they use are technically able to accommodate them.

Mitigations for Major Findings

The purpose of this section is to describe possible improvements to the problem areas identified in the Major Findings section above. Some of these options are actions that could readily be taken by poll workers or elections officials, or by manufacturers, using materials and techniques we believe they may have at hand. These mitigations come from both user suggestions during testing and the expertise of the project staff.

We do not assert any specific timeframe in which these actions could be taken, but believe them to be easy enough to be put in place soon, in the near term.

There are other mitigations that would likely require redesign and recertification by the vendors and that could only be considered for the long term. When appropriate, we have included some Long-Term Mitigations that will be listed separately.

In some cases, all of the options that address a major finding could be used; in others, only one option is necessary.

Physical Access to the AutoMARK Unit

Near-Term Mitigations

- Sturdy tables are needed to meet the height, floor space, and other clearances necessary to support the AutoMARK so voters in wheelchairs can physically access it. Tables with thin but strong tops are preferred, to allow more clearance underneath.
- Alternatively, mounting/positioning support frames could be procured that would meet the dimensional clearance and adjustability requirements. Specialty furniture suppliers have many such adjustable support frames used for therapy or other purposes, as well as adjustable height tables.

Obviously, any solution should be sturdy enough to provide a stable platform.

- In some cases, the AutoMARK could be positioned so its front portion protrudes over the front edge of the table, to make it easier for a voter in a chair or wheelchair to reach the touch screen, ballot feeder slot, and keypad. Care should be taken to protect both the unit and the voter from this protrusion.
- Pollworkers could be trained to be able to show voters how to fold up and let down the ballot feeder input tray.
- Freestanding privacy curtains or panels could also be included so they would not block the voter's arm movements and approach to the voting units.
- Elections officials could provide pollworker training and reference materials with additional suggestions for physical accommodation

alternatives, including when and how to use dual-switch input controls such as Sip and Puff or rocker switches.

- The materials could also cover proper setup of the polling place and placement of the AutoMARK terminal for good wheelchair clearance. Clearance for wheelchairs also includes space for wheelchair approach along either side as well as across the front of the M100 precinct ballot scanner unit.
- Double-stick tape, Velcro straps, and similar supplies can go a long way towards helping a voter over many physical access hurdles such as dexterity, stamina limitations, or gripping problems. These types of low-tech accommodations could be documented and added to the vendor's pollworker training and reference materials.
- Pollworker training materials could also instruct the pollworkers about the importance of supplying chairs and flat surfaces for the voters. Many voters with disabilities have difficulty standing for the long booth time some will experience. Some blind users with ballot marking notes in braille or other forms may also need to sit down to vote and may even need an adjacent table or flat surface on which they can place and read their voting notes. Other voters may need a flat surface to hold their purse, bag, or other materials while they are voting.

Long-Term Mitigations

- A tethered external alternative keypad option could be added to allow a keypad to be placed in the voter's lap, wheelchair tray, or wherever is more convenient. This keypad could also be designed with larger keycaps and bigger spacing between keys, to better accommodate voters with dexterity impairments.
- The display mount could be redesigned to be adjustable up and down so that its active surface is more convenient for users with different reach limitations.
- Lowering the ballot input tray, when it is folded up, requires lifting straight up to unlock. The lock could be replaced with a simple detent lock. Voters or pollworkers just pulling forward on the folded tray without properly unlatching it first can too easily break the current lift-to-unlock latch.
- The M100 precinct ballot scanner could be redesigned to allow ballots to be deposited into a more accessible slot on the front of the unit, rather than on the top.

Manual Dexterity Accommodation Concerns

Near-Term Mitigations

For near-term mitigations, see the Privacy Sleeve Concerns below.

Long-Term Mitigations

- The high gripping force with which the AutoMARK grips a returned ballot could be reduced to the minimum required to keep the ballot from falling out of the exit slot.
- To avoid the need for the voter to handle their marked ballot at all, the vendor could modify the AutoMARK design to permit the ballot to be optionally deposited automatically into a ballot box or drawer.

Privacy Sleeve Concerns

Near-Term Mitigations

- Pollworkers could be trained to help voters lift the front end of the privacy sleeve while their marked ballot is returning into the sleeve.
- The vendor-supplied privacy sleeves could be taped together on both sides, for about an inch near where the sleeve widens, and the bottom back edge of the sleeve slipped under the bottom of the input feeder tray for support. Then it would work more reliably and be self-supporting.
- Elections officials may find it simpler and more effective to supply voters with a large legal-sized manila envelope as an alternative to the vendor's privacy sleeve and to define procedures for helping to deposit the voter's ballot in the sleeve without violating the privacy of their ballot.
- The vendor's instructions for the privacy sleeve could be rewritten, including more helpful and appropriate pictures.
- The braille label could be applied to the privacy sleeve at the factory to avoid damage from misapplication in the field.
- The vendor's pollworker instructions for the current privacy sleeve setup and operation could be completely rewritten.

Long-Term Mitigations

- The braille label for the privacy sleeve could have better quality braille by using proper braille label material.
- The automatic insertion privacy sleeve could be completely redesigned to be self-supporting, more reliable, less complicated to set up, and to not require the front end to be elevated to assure proper ballot injection upon return.

Visual Display Concerns

Near-Term Mitigations

- Pollworkers could be trained to help the voter with visual display tilt adjustment to improve the viewing angle, minimize glare from room lights, and explain how to adjust one's "touchscreen aim" to account for the viewing angle – a common problem with touchscreens called "parallax"...
- Pollworkers could also be trained to help the voter with adjustments to display font contrast and magnification.
- The ballot design for the screen could limit ballot layouts to one race per screen. As we did not evaluate the ballot design tools for these systems, we are unable to say whether this option is near-term or not. We include it here for the sake of clarity.
- Even in magnified mode, all content and certainly all controls should be visible at all times. There may need to be an exception for races with many candidates. In that case, any screen bridging of races could be done with vertical scrolling, not horizontal scrolling. As we did not evaluate the ballot design tools for these systems, we are unable to say whether this option is near-term or not. We include it here for the sake of clarity.

Long-Term Mitigations

- The tilt and support mechanism for the visual display screen could be redesigned to be more stable and less wobbly while remaining adjustable.
- The configuration menus could be modified to allow the keypad and audio interface to be used to configure the visual display access parameters such as magnification and contrast.
- Distracting overuse of blinking to attract attention could be reduced, especially on screen controls such as the screen's "Next" button.
- In several places during the voting process, poorly contrasting red or blue letters and arrows appear on black background. These could be changed to a higher contrast pair of colors.
- Red color is used for the Exit/Return Ballot choice on the screen and could be changed, because it is not an error or warning message for which red is supposed to be reserved.
- In a Member of State Assembly Contest, the "Write-in" title shows magnified but does not show with high contrast, and this problem could be corrected.
- The high contrast screen control always shows "high contrast" no matter what the setting is, so it cannot serve as a toggle state indicator. The corresponding labels could read "High Contrast" and "Normal Contrast".

- In high contrast, the selected candidate could have a solid oval, not just an 'x'.

Magnification

- Initial messages (especially "please insert your ballot") are small print, but could be large.
- All screen controls could be in large print all the time.
- The enigmatic Zoom In and Zoom Out screen magnification control could be relabeled to be simpler to understand. For example, it might be changed to something like "Shrink Text" and "Magnify Text" or commonly used icons showing a small letter, a large letter, and an arrow between them. In any event, both states should not appear on the label at the same time.
- Larger magnification options could be made available in addition to the current 8.5 and 17-point font sizes, (normal and twice normal size). Some low vision voters want magnification to 24 points or even 34 points (four times normal).
- Magnification could be made available in several steps.

Touch Screen Control Concerns

Near-Term Mitigations

- To avoid touch screen bouncing due to wobbling of the support table, sturdy tables could be used.
- In some cases, the table might be backed up against a wall or other sturdy object to help prevent wobbling.
- The legs could be braced.
- In order to prevent wobbling, pollworkers could inform voters that heavy pressing of the touchscreen is not needed.

Long-Term Mitigations

- The tilt adjustment of the visual display could lock or be braced in place where the voter wants it to stay, so it does not wobble back and forth when the touchscreen buttons are pushed.
- The screen touch input software filter could be improved to reject multiple touches that occur when the screen bounces back and forth from a voter's presses.
- Touch acceptance upon initial screen contact, rather than upon contact release ought to be considered, as it gives the voter instant feedback to confirm their touch. This can improve the voter's confidence in their

touches and reduce the perception that they need to press hard and long for reliable touches.

- To help avoid confusion about screen navigation that moves focus without making selections, screen touches could trigger different sounds when selecting or deselecting a choice in a race, and these sounds could be different from the normal sound that is made for general screen touches. Care could be taken in designing these tones so that hard of hearing voters are accommodated.

Note: Having a unique Selected-choice sound triggered whenever focus moves to a current-selection choice in a list would also aid audio voters using only the keypad to navigate.

Keypad Control Concerns

Near-Term Mitigations

Braille and large print materials could be produced and made available with clear reference cards that identify the names of each of the control keys. This might be particularly helpful where the controls, for reasons of space, must have abbreviated braille labels or function identifiers.

Long-Term Mitigations

- The AutoMARK could have an alternative keypad that is connected on a flexible cable and has large keys spaced widely enough for use with a closed fist, elbow, or a blunt object. A tethered keypad would make voting more comfortable.
- The integrated or tethered keypad could have larger keys with greater spacing between the keys.
- The keypad orientation messages could be rescripted to make them clearer:

"...In addition to the arrow keys, there is a vertical column of four controls to the right of the arrow keys. The bottom rocker switch will adjust the volume. The next rocker switch up will adjust the speed of the synthesized speech...."

- The spacing between the keys of the vertical column of keys could be increased to make it easier to read the braille labels.
- It would be less confusing to use braille labels with "spd" for speed, instead of "tpo" for tempo.
- Print labels for the keypad could be made larger, with bolder fonts, higher contrast, and appropriately associated colors to help differentiate and identify the keys.

- The key caps of the dual-switch input controls, tethered external keypads, and built-in keypads could be color coded for differentiation as well as for intuitive function association/identification.
- The raised vertical line between the keypad directional keys and the vertical keys could be removed to decrease tactile clutter.
- A Help control could be added to keypads or dual-switch controls, and it might also be used to summon assistance if pressed multiple times (while filtering out unintended multiple touches).
- A Pause key could be added to pause and resume the speech output.
- As an alternative to adding too many new keys, pairs of keys might be pressed simultaneously for special, low usage commands. However, if not designed properly, the simultaneous pressing of two keys can be difficult or impossible for some voters with dexterity impairments.
- The "Duck Talk" toggle function after long hold-down of the Repeat key could be removed. The similar effect on the Screen key also could be removed.
- To reduce fatigue from having to hold one's hand over the keypad for long booth times, there could be a palm rest area in front of the keypad and/or its angle could be reduced.
- If the AutoMARK is not modified to support external keypads that are more accommodating, the built-in keypad could be modified to make it easier to press the keys with a closed fist or other blunt object. Alternatives could include moving the Select key out from the center of the arrow keys or increasing the overall spacing between the arrows and the Select key.

Dual-Switch Input Control Concerns

Near-Term Mitigations

- The help messages, instructions, and prompts could be redefined to reflect use of sip and puff or other dual-switch input controls.
- The sip and puff switch input control's Velcro attachment method could be improved.
- Velcro cloth might be added to the underside of the rocker dual-switch input control to accommodate Velcro attachment to a voter's leg, wheelchair armrest, etc.
- Jelly switches could be considered as an alternative to the rocker for dual-switch operation.

Long-Term Mitigations

- Menus and navigation controls could be changed to make them switch context aware, so they would operate differently and display/speak different, more suitable, messages when dual-switch input controls are being used by the voter.
- Help and Summon-Assistance options could be added for voters using the dual-switch input controls.
- Single switch control options (scanning) could be added to allow voting by voters who can only operate a single switch input control interface.
- The "Access" label on the right side of the front panel could be expanded to something clearer, such as "Access Switch Input".

Ballot Scanning and Marking Concerns

Near-Term Mitigations

For low vision voters who must get up very close to the screen to see it, pollworkers could instruct them how to fold up and let down the ballot input feeder tray.

Long-Term Mitigations

- The tray lock mechanism could release when it is simply pulled forward from its folded position, replacing the current lift-to-unlock mechanism.
- A slightly raised arrow with edges that do not snag the ballot could replace the hard-to-find recessed arrow label on the input feeder tray.
- The braille "Insert Ballot" label could be placed close to the center of the feeder tray width.
- The instructions could explain that the ballot comes out from a hidden slot above the input feeder slot.
- The insert ballot prompt message could explain where to insert the ballot.
- The "Insert your ballot" audio and screen messages could let the voter know that no particular ballot orientation is required.
- The insert instructions could give the voter warning about the loud ballot feeding sound, to prepare them for it.
- During ballot scanning or marking, the AutoMARK's audio messages could be timed to avoid being drowned out by the loud noise of the scanner and printer mechanisms.
- In the message, "The audio will be silent while the ballot is scanning."; "is scanning" could be changed to "is being scanned".

- In addition, during the several long silent periods while the system is scanning or marking the ballot, it could give a frequent sound or message to let the voter know that the system is still working. The screen has a visual progress bar; there could also be an audible status indication.

M100 Optical Scan Precinct Counter Concerns

Near-Term Mitigations

- To accommodate physical access by voters in wheelchairs, pollworkers could be trained to set up the M100 unit in the polling place with enough room for a wheelchair voter to approach the M100 across the front, as well as along both the left and right sides.
- Braille instructions or labels could be added to indicate how and where the ballot should be inserted.
- The ballot feeder tray has tactile ridges along its bottom surface, and pollworkers could point out to voters that the raised ridges indicate where voters can insert and slide their ballot.
- There could be a display message chart on the top of the M100, to translate its messages into large, easy to read versions in plain English and alternative languages.
- Sharp and abrasive edges on the M100 unit could be smoothed or covered with smooth, strong tape.

Long-Term Mitigations

- The M100 display messages, such as "Missed timing mark" could be made less cryptic.
- Generally, voters who have marked their ballot with the AutoMARK will already be certain that their ballot does not have any overvoted races. However, if the M100 detects and displays messages to be used by most voters, and not just by pollworkers, the displayed message could also be indicated audibly or tactilely. For example, it could produce an audible beep pattern or a vibration pattern from the ballot feeder mechanism.
- For voters with dexterity or reach impairments, the ballot feeder cover flap might need a deeper ballot-grasp opening up its center to accommodate grasping and removing a short ballot.
- It would help voters in wheelchairs if they could approach the ballot scanner from the front under a more accessible ballot input side chute that would then feed or slide the ballot to the side and into the scanner.

Speech Interface Concerns

Near-Term Mitigations

- The AutoMARK text could be rescripted for simpler and clearer help, instructions, and prompts, if they can be changed without having to recertify the voting system.
- All audio ballots could be tested, by a blind voter if possible, with a thorough walkthrough on an actual voting system.
- The vendor's pollworker training materials could suggest procedures such as unplugging headphones or turning down the volume for voters who don't want to use the audio and don't want the headphones making distracting sounds or exposing their vote selections to nearby listeners.

Long-Term Mitigations

- It would be better to announce each new volume or rate change and level, instead of repeating the fixed message as a sample.
- Volume could actually say "softer" or "louder", as both key samples and identifiers.
- Tempo changes could similarly say "slower" or "faster" as both samples and key identifiers.
- The synthesized voice of the AutoMARK terminal could be replaced with a higher quality, more intelligible and natural TTS voice.
- Maximum, middle, and minimum rate and volume settings could be announced or indicated with a special sound.
- The volume level range could be changed to fully conform to the VVSG requirements for volume, including the minimum initial volume setting.
- The range of the speech rate could be limited to realistically usable values.
- The vendor could modify the speech system to make slow speech by stretching out the time between words, rather than by stretching out and distorting the words themselves.
- When changing volume or rate from the keypad, it would be better to indicate each new level by changing the speech parameter and then announcing its value. Alternatively, it could announce "Louder", "Softer", "Faster", or "Slower". Either of these approaches gives better key identification feedback and acts as a better sound sample than just repeating the last instruction or phrase.
- The "Duck Talk" voice toggle mode for the Repeat key hold-down timeout ought to be removed, as should the "scr" key hold-down timeout toggle mode.

Navigating the Audio Ballot

Near-Term Mitigations

- Elections officials ought to check the audio ballot for proper pronunciation of candidate names, freedom from confusing wording, and bad grammar.
- Elections officials ought to perform complete walkthroughs of each of the audio ballots on an actual voting system with the display turned off.
- Accessible voting training materials could be improved and pollworkers could be given effective and thorough accessible voting training.

Long-Term Mitigations

- A confirmation dialog could be added before printing the ballot and exiting.
- Similarly, a confirmation dialog could be added before canceling or leaving the write-in feature.
- There could only be one consistent way to exit, not the four or more we encountered.
- Addition of a context-dependent help function and controls for Pause/Resume could make dealing with complex navigation and selection tasks less challenging for the voter.
- The instructions could say that the hyphen and other punctuation marks are listed after the alphabet, instead of after 'z'.
- In the start of the Summary, when prompted to press Select to mark the ballot, pressing Right arrow should not cause it to mark and eject the ballot.
- At the start of the review procedure, it could be made more obvious that the voter can just press Select to print their ballot right then if they do not intend to use the review feature.
- With the ballot for Precinct 5, American Independent, when at the start of the ballot, pressing left arrow brings up an exit dialog that prompts you to press left arrow to continue marking your ballot. This is not correct. You have to press right arrow to finish the exit. This problem ought to be corrected.
- In several places, the system could be changed to say, "Press right for next contest" instead of "Press right for next screen." and say, "Press left for previous contest" instead of "Press left for next contest".
- A voter could be notified about the deselection, when their previous selection in a fully voted contest is automatically deselected for them.

Write-in Concerns

Near-Term Mitigations

- Special braille and large print instruction materials could be produced and made available to voters, to help them better understand how to successfully complete write-ins on the AutoMARK.
- During orientation, pollworkers could caution voters to be extra careful not to use the left or right keys during write-in, until or unless they are sure they want to cancel or exit from write-in.

Long-Term Mitigations

- A context-dependent help function and controls for Pause/Resume could make dealing with write-ins a lot less challenging for the voter.
- System instructions and prompts could better explain proper use of the Select key to start the write-in, as well as for selecting letters while moving through the alphabet in write-in.
- Pauses between the separate points in the write-in help instructions could be added to help the voters to recognize and remember the points.
- The Repeat command operation in write-in could be modified to cause the current accumulated name to be both pronounced and spelled out, before the instructions are repeated.
- The instruction, "...When you are finished, press the right arrow key to return to the contest and select this write-in candidate..." could be modified so that it does not mislead the voter into pressing Select again after leaving the write-in and returning to the contest list.
- Multiple write-in options in a race could be titled distinguishably, with different titles such as "write-in 1" and "write-in 2".
- When the AutoMARK speaks the accumulated name during a write-in, it could also spell the name out.
- The AutoMARK could avoid the use of prompts that can be heard as one of several meanings, such as "Write in name" which a voter could interpret as a prompt or order to begin name entry, or as the title of a menu option.

System Instructions and Messages Issues

Near-Term Mitigations

Missing the Startup Orientation Help or Instructions

- Pollworkers could instruct the voter to put on the headphones and/or make any other necessary preparations before the voting session begins, so they will be ready to follow the initial messages of the voting machine.

- Pollworkers could be trained to then press the Repeat key to start the system reading the instructions from the start, rather than having the voter be confused by hearing the last part of the orientation instructions out of context.

Outreach to Inform Voters about Accessible Voting

We recognize that elections officials may already be conducting the following recommended practices.

- Elections officials could produce and distribute informative materials that explain that accessible voting systems are available in the local polling places, whom they assist, and how they work.
- Elections officials could circulate this information to organizations for people with disabilities, retirement homes, medical clinics, and other community organizations, via meetings, printed material and mailings, websites, phone lines, and to the media as press releases and public service announcements.
- Elections officials could meet regularly with disability community members to discuss how to improve the accessibility of upcoming elections.
- Elections officials could prepare sample ballots in alternative formats and distribute them as needed.

Information Available in Braille and Large Print

Elections officials could provide operating instructions and other usual information in braille and large print. In addition, they could post this information on the county's web site and elections info phone line.

Long-Term Mitigations

- A key identifier feature that speaks the name of each key without performing its function could be added to help voters more quickly become oriented to the keypad.
- Pauses could be inserted in the system instructions, after sentences, to allow the voters a brief opportunity to absorb the information better.
- Since the Language choice menu is presented before the audio orientation instructions for the keypad, alternative approaches could be considered for making a language selection. For example, the system might prompt the voter to "Press any key now to vote with the current language."
- When scanning a marked ballot into the AutoMARK, it says, "...Note that you will not be able to use the AutoMARK to change any of these selections...". Instead of "the AutoMARK", it could say "this voting machine", as many voters will not know what the name "AutoMARK" means. It also needs to explain that the voter will be able to change

selections or correct errors with the voting machine only by starting over with a fresh ballot.

- At the start of ballot verification scanning, the AutoMARK instructions could explain that it cannot read back the name in any write-in fields on the voter's paper ballot.
- There could be an early instruction informing the voter that ballot orientation is not important when inserting a ballot.
- There could be an early instruction that tells the voter that they can press keys to interrupt messages.
- When keys are inactive (like Up and Down in the exit dialog), the voter could be verbally told that the keys are being ignored and why.
- When the AutoMARK (with a ballot in it) goes into its five-minute inactivity timeout warning, it could replay the warning message when any of the keys except the Select key is pressed or, alternatively, pressing any key could cancel the timeout.
- In the contests, pressing left arrow could say "Previous Contest", instead of "Next Contest".
- "Official ballot. You are voting ballot style..." could be changed to "Official ballot. You are voting with the ballot style..."
- The message, "exit/return ballot" could be changed to "Finish and return the ballot".
- The message at the bottom of a contest could be changed to say, "You have reached the bottom of the list. You may press the right arrow key if you are ready to go to the next contest."
- A selected choice in a contest could indicate that it is selected at the beginning, by saying "Selected" and/or by having a unique selected sound indicator. The sound indicator could be in addition to actually saying "Selected". Note that it should not say, "Not selected" for all the unselected choices in a race.
- In the mark ballot dialog, "You ballot will be marked..." could be changed to use "Your", instead of "You".
- During a write-in, pressing the Repeat key could give the accumulated name spoken and spelled, then followed by the instructions (unless a Help key or help-after-timeout function has been added to give the help instructions).
- The message "You did not hear all the candidates or choices" could be omitted for a yes/no contest or when the voter hasn't moved down to hear "write-in" at the bottom of a list.
- In the overvote message, "More" would be better phrasing than "Greater number."

- Generally, the AutoMARK system text could be rescripted to simplify and improve most of the system message issues identified in the Major Findings section.
- The user could be able to repeat recent error messages.

Paper Ballot Verification Concerns

Near-Term Mitigations

The instructions or help for the ballot scan verification function could make it clear that the AutoMARK is only scanning and verifying the marks from the paper ballot and that it is not able to scan and recognize any write-in names.

Long-Term Mitigations

- The AutoMARK could be improved to support recognition of printed write-in names scanned in from the paper ballot, at least as a confirmation recognition of write-in names printed on the ballot by the AutoMARK itself.
- The AutoMARK could be improved to do text confirmation recognition, to confirm that the text image on the paper ballot is correct for the ballot definition. Note that this is not the same as the much more challenging task of full general optical character recognition scanning.

Total In-Booth Voting Times

Near-Term Mitigations

- Because voters using the audio interface to vote may take 3 to 4 times longer than other voters, chairs could be provided for them, and pollworkers could be trained to expect longer in-booth times.
- Pollworkers could also be trained to help the voter find the most comfortable position for operating the voting system.
- Public outreach programs, hands-on demonstrations, on-line demos and information about the voting systems, and other voter education programs could help educate voters before they arrive at the polling place and could decrease orientation and total in-booth voting times.

Voting Accuracy Concerns

Near-Term Mitigations

- Pollworkers could be trained to caution voters about avoiding the use of the left or right arrow keys while navigating the write-in process, until they are ready to cancel or exit the write-in.

- Election officials could establish standards and train those who process write-in ballots to be tolerant of misspelled or partially illegible write-in names, including names without separator blanks and names with repeating characters.

Long-Term Mitigations

- To help avoid premature marking of the ballot and improve success in entering write-in names, the AutoMARK could be modified with confirmation dialogs before the ballot marking process and before canceling or exit from the write-in procedure.
- To make it easier for the voters to make and confirm their selections reliably, there could be a clear and brief audible selected-choice indicator sound and/or "selected" spoken at the beginning of the choice announcement message of any selected choices in a contest. This would also make it much less tedious for voters to browse through and review all of their vote selections.

Privacy Concerns

Near-Term Mitigations

- If voters are not using the audio interface, pollworkers could disconnect the headphones.
- Because AutoMARK ballot marks look slightly different from typical marks of manually marked ballots, polling place procedures could be modified to assure that at least five voters, including voters without disabilities if necessary, use the AutoMARK unit during the Election Day, to assure the privacy of AutoMARK voters.
- Pollworker training could explain that the necessary long voting times for voters with disabilities mean that many of the voters will need to sit while voting. Seated voting may leave the display screen more exposed to eavesdroppers. Pollworkers could be trained to position the AutoMARK in the polling place accordingly, and control traffic and bystanders behind the voter's back.

Privacy Sleeves

- While pollworkers are initially orienting a voter to the AutoMARK voting terminal, the pollworker could show the voter a privacy sleeve and instruct them in its use.
- The AutoMARK vendor or the county elections officials could improve the instructions for the proper set up and use of the AutoMARK privacy sleeves.
- Tape could be added to hold the top and bottom side edges of the privacy sleeve together near the front edge of the ballot feeder chute. This would

make it possible for the lower edge of the privacy sleeve to be placed under the bottom of the ballot feeder chute, in order to assure that the ballot emerges into the privacy sleeve, instead of sliding out underneath and missing the privacy sleeve. Otherwise, the voter or an assistant will have to hold the front-most edge of the ballot sleeve up, as the ballot is fed out into it, to assure that the ballot feeds into the sleeve properly.

- If pollworkers cannot manage to set up the privacy sleeves so that they operate properly for voters, they could consider using large legal-size manila folders instead. If using alternate privacy sleeves, proper procedures could be developed and taught to pollworkers, so that they can help the voters to privately get their ballots in a privacy containment, help extract the ballot from the AutoMARK, and deposit the ballot in the M100 precinct ballot scanner.

Privacy Shields

- Freestanding privacy curtains or panels could be installed so they do not block the voter's arm movements and approach to or exit from the voting units. This may include curtains that do not come all the way down to the floor, but stop around table top level so that voters in wheelchairs can back out through them easily and independently.
- Unless set up with full surround curtains, the AutoMARK could be positioned so that there is no foot traffic behind the voter and no possible eavesdropping nearby. Care must also be taken to assure that the AutoMARK voter in a wheelchair has plenty of room to approach the AutoMARK in forward approaches, as well as approaches along side and sidewise approaches across the front of the unit.

Vulnerability to Quick Glances or Camera Shots

- Pollworkers could plan the polling place layout so that it is not possible for voters standing in line or other possible eavesdroppers to view the AutoMARK ballot after it emerges from the ballot printer slot or when being inserted in the M100 precinct ballot scanner.
- Pollworkers might not allow cameras or cell phones with cameras to be used in the polling place, and could develop and use signage to that effect.

Eavesdropping on Audio Voting with Recorders and Wireless Bugs

Pollworkers could be trained about the possibility of bugs and recorders, and to keep the area around the voting machine clear of odd gadgets, headphones other than those supplied with the equipment or brought by a voter solely for his or her own use, laptops or any other nonessential electronics, or items that might contain electronics.

Long-Term Mitigations

- Vendors could develop better ballot privacy sleeves that are much easier to set up and use with full privacy.
- The AutoMARK manufacturer could modify the AutoMARK ballot printer mechanism so that the ballot does not require so much force to pull out the ballot.
- The AutoMARK's instruction messages could mention the privacy sleeve option for the voted ballot privacy.

Personal Safety Concerns

Near-Term Mitigations

- The sharp edge along the front of the ballot input feeder tray could be covered with a strip of thick tape.
- Pollworkers could be trained to warn voters about the sharp corners and edges of the AutoMARK terminal.
- Pollworkers might also be trained to initially close up the ballot feeder chute when helping voters to approach and get oriented to the AutoMARK terminal. Then they could lower the feeder chute or explain to the voter how they can do it for themselves.

Long-Term Mitigations

The front edge of the ballot feeder chute and other areas with sharp edges could be smoothed or rounded to reduce the danger of cuts and abrasions.

Public Health and Sanitation Concerns

Near-Term Mitigations

- Disposable covers for headphones could be supplied. Note: Supplying cheap, disposable headphones is not an acceptable option, as they would cause significant distortion in the audio speech reproduction.
- Pollworkers could be supplied with the proper materials and vendor-authorized sanitizing procedures for sanitizing the touch screen, keypad, dual-switch input controls, privacy sleeves, and other personal-contact parts of the systems.
- If mouth sticks are provided, they could be disposable rather than sanitized and reused.
- Improved pollworker training materials could be developed by the vendor to help identify public health concerns and appropriate voting system sanitary procedures.

Reliability Concerns

Near-Term Mitigations

The AutoMARK could be tested by voting with audio several times throughout the voting day and the resulting ballots inspected visually to verify proper operation and printing of the ballot.

Long-Term Mitigations

The source of the occasional random system errors encountered during the access testing on the older model of the AutoMARK ought to be identified and fixed.

Pollworker Training and Assistance Concerns

Near-Term Mitigations

- Elections officials could develop and provide training and reference materials that compensate for omissions in the vendor-supplied pollworker training and reference materials.
- Elections officials could develop and provide training videos and other materials that show pollworkers working with voters with disabilities.
- Elections officials could develop and provide a list of frequently asked questions/answers about usability and accessibility to every pollworker.
- Elections officials could include pollworker training materials about the proper etiquette for interacting with people with disabilities.

Conclusions

Accessible technology is a mature field, with over thirty years of practical success in making information and communications technologies usable by people with disabilities. Inclusive design solutions are well tested, reliable, and inexpensive. Information about them is publicly available and non-proprietary. Every day products that are more accessible enter the market, driven by technological improvements, market demand, and policy insistence. In such an environment, all voting systems should be able to accommodate an overwhelming majority of voters with disabilities.

As a result of this access review, we have concluded that the ES&S Unity 3.0.1.1 Voting System (with AutoMARK and M100 Scanner) does meet this criterion. It is substantially compliant when assessed against the requirements of the Help America Vote Act (HAVA) and specified in the 2005 VVSG guidelines.

We conclude that the system represents an adequately accessible voting system.

This system should be able to effectively serve the large range of voters with disabilities that should be accommodated according to the HAVA requirements.

- This system appears to provide independent voting in all portions of the voting process that are essential for assuring the privacy of the voter's ballot.
- However, the system could be improved, especially in the following areas of accessibility concerns:
- Improved ballot privacy sleeves and handling procedures are needed
- The force required for ballot extraction force is excessive
- Unnecessary ballot marking errors and high voter frustration is caused by the lack of confirmation dialogs before canceling or exiting the write-in function and before marking and returning the ballot
- Improved speech synthesis and audio interface controls
- Switching modes for the controls in the summary and verification reviews place heavy cognitive loads on audio-only voters
- More voters could make better use of the visual display if its magnification range and use of color was enhanced.

This report has documented these accessibility concerns and offered options for short-term mitigations for upcoming elections. We have also suggested system design changes and other longer-term mitigations possible for voting systems.

It is essential to understand that the purely technological elements of a voting system do not solely determine its accessibility, or its inaccessibility. The usability and accessibility of voting encompasses far more than just the design of the voting machines. Election officials should analyze voting as an integrated system

of technologies and social practices. For example, many voters with longstanding disabilities have become accustomed to absentee voting, or not voting at all. Public service announcements that include a description of an accessible voting system would improve outreach to voters with disabilities and prepare them for a more positive experience at the polls. Providing pollworkers with more exposure to people with disabilities as well as more training in how to use the accessibility features of voting technologies could open up the voting process to people with disabilities. Working with grassroots organizations, as some counties do already, can aid local election officials in their efforts to improve their inclusiveness and maintain efficiency at the same time.

This review focused primarily on the voter interface. There should be formal, rigorous analyses of the other interfaces in voting systems, especially the ballot design interface and the interfaces used to set up, test, and administer the individual machines as well as any collection and tallying interfaces.

The EAC and NIST are in the process of developing accessibility and usability testing methodologies and certification practices. We can see from our experience that this area needs a lot of development.

Clearly, it will be important to use a balance of expert heuristics and user testing. As long as the design of voting technologies remains more art than science, objective testing methodologies will need to be supplemented with insight-based analytical techniques.

We are grateful to the California Secretary of State for giving us the opportunity to evaluate these systems, not only because this report may help the Secretary make near-term decisions about the systems themselves, but because we hope some of the information within this report can be shared with and helpful to the larger community.

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References

- Burton, D & Usulan M. (2002, November). *Cast a Vote by Yourself: A Review of Accessible Voting Machines*, *Access World*, 3(6), November, 2002.
- CalTech-MIT (2001). July, *Voting: What is, What Could Be*, <http://www.vote.caltech.edu/>.
- Center for Independence of the Disabled in New York; Fields, C. V., (2003), *Voting Technology for People with Disabilities*.
- Election Assistance Commission, *Voluntary Voting System Guidelines, Volume I* Version 1.0 at §3.1 (2005), available at http://www.eac.gov/VVSG%20Volume_I.pdf.
- CDC estimate that nearly 2 million adults over age 70 have both hearing and vision loss. http://www.newsmax.com/health/hearing_vision_loss_mind/2007/10/04/38048.html.
- Federal Election Commission (2003). *Developing a User-Centered Voting System*.
- Federal Election Commission (2003). *Usability Testing of Voting Machines*.
- ISO/TS 16071 (2003). *Ergonomics of Human-System Interaction Guidance on Accessibility for Human-Computer Interfaces*.
- ISO 13407 (1999). *Human Centered Design Processes for Interactive Systems*.
- Jones, D. (2002). *Voting Systems Standards: Work that Remains to be Done*, Testimony before the Federal Election Commission, Washington D.C., April 17, 2002.
- Jones, D.W. (2001). *Problems with Voting systems and the Applicable Standards*, Testimony before the U.S. House of Representatives.
- Mercuri R. (2002). *Humanizing Voting Interfaces*, Presentation to the UAPA Conference, Orlando, FL.
- Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63, p. 81-97
- Norden, L., The Brennan Center for Justice Voting Technology Assessment Project, (2006), *The Machinery of Democracy: Voting System Security, Accessibility, Usability, and Cost*, www.brennancenter.org.
- Pierce, K., Cook County State's Attorney's Office, (2005), *Accessibility Analysis of Four Proposed Voting Machines*.
- Quesenbery, W. (2001). *Voting for Usability: A Backgrounder on the Issues*, Talk presented at TECH*COMM 2001 in Washington DC.
- Roth, S.K. (undated). *Human Factors Research on Voting Machines and Ballot Designs: An Exploratory Study*.

Section 508 Electronic and Information Technology Accessibility Standards (2000). Architectural and Transportation Barriers Compliance Board, 36 CFR Part 1194.

Runyan, N.H. (2007). Improving Access to Voting Systems.

Tadayoshi, K.; Stubblefield, A; Rubin, A.D. & Wallach, D.S. (2003). Analysis of an Electronic Voting System.

Appendices

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- B. Glossary
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- E. VVSG Conformance Notes
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A. Background of the Authors

Noel Runyan

With his degree in Electrical Engineering and Computer Science, Noel Runyan has been working in human-factors engineering for over 35 years, primarily developing access technologies for helping persons with visual impairments use computers and other electronic devices.

During the 5 years he worked for IBM, he was involved in the design and testing of the security systems for both BART ticket machines and ATM credit card systems.

After starting his own company to supply access technologies, he designed and manufactured the Audapter speech synthesizer, to enable computers to talk to visually impaired users. He also authored the EasyScan, BuckScan, and PicTac programs that made it easier for visually impaired users to read print books, identify dollar bills, and convert print pictures into raised line tactile drawings.

To help their visually impaired customers access and make use of computer systems, the author and his wife, Deborah, have personally built over 500 custom-integrated personal computers with speech, braille and/or large print interfaces.

More recently, he has been involved in the development of talking Internet radios and talking pill bottles and other medical equipment for persons who have difficulties reading print labels and displays.

For several years, the author has been studying and testing accessibility features and the usability of all the major voting systems used in this country. He has worked with the Santa Clara County Voter Access Advisory Committee, voting rights advocates, and manufacturers to make voting systems more accessible for all folks with disabilities or special language needs. In February of 2007, he published *Improving Access to Voting, A Report on the Technology for Accessible Voting Systems*.

Jim Tobias

Jim Tobias has thirty years experience in technology and disability in both the public and private sectors. He began his career at Berkeley's Center for Independent Living, was a Member of Technical Staff at Bell Labs and Bellcore, and their principal liaison with the Baby Bells on accessibility, aging and education. He is now President of Inclusive Technologies, a technology and marketing consulting firm for large information and communication technology companies. Clients have included AOL, Cisco Systems, HP, IBM, Microsoft, Panasonic, Verizon and Xerox.

Jim was appointed to the Access Board's Telecommunications Accessibility Advisory Committee responsible for drafting Section 255 regulations, and the

FCC's Consumer/Disabilities Technical Advisory Committee. He was been re-appointed to the FCC's Consumer Advisory Committee for 2005-2007. He is co-Chair of the Access Board's Telecommunications, Electronic and Information Technologies Advisory Committee, currently revising the Section 255 and 508 Standards and Guidelines.

He is Chair of the Alliance for Telecom Industry Solutions' Interactive Voice Response (IVR) Accessibility Forum. He is a member of the International Standards Organization's JTC1 Special Working Group on Accessibility. He coordinates the accessibility component of the Usability Professionals Association's World Usability Day.

Mr. Tobias and Inclusive Technologies have developed several accessibility projects: an innovative deaf relay service that integrated speech detection and text-to-speech; a network-based talking PIM for blind users; and a database-driven customized interface for voice mail and IVR accessibility. In addition, Inclusive Technologies performs market analysis and accessibility management.

B. Glossary

Accessibility: Measurable characteristics that indicate the degree to which a system is available to, and usable by, individuals with disabilities. The most common disabilities include those associated with vision, hearing and mobility, as well as cognitive disabilities and alternative language needs.

Accessible Voting Station: Voting station equipped for individuals with disabilities or alternative language needs.

Alternative Format: The ballot or accompanying information is said to be in an alternative format if it is in a representation other than the standard ballot language and format. Examples include, languages other than English, braille, large print, and recorded audio.

ATI: Audio-Tactile Interface, Voter interface designed to not require visual reading of a ballot.

ATS: AutoMARK Technical Systems (manufacturer of the AutoMARK ballot marking system).

AutoMARK VAT: The AutoMARK Voter Assist Terminal.

Audio Ballot: a ballot in which a set of offices is presented to the voter in spoken, rather than written, form.

BMD: Ballot Marking Device (such as the AutoMARK or InkaVote systems).

CIF: Common Industry Format, Refers to the format described in ANSI/INCITS 3542001 "Common Industry Format (CIF).

Claim of Conformance: Statement by a vendor declaring that a specific product conforms to a particular standard or set of standard profiles; for voting systems.

Conformance: Fulfillment of specified requirements by a product, process, or service.

Corrective Action: Action taken to eliminate the causes of an existing deficiency or other undesirable situation in order to prevent recurrence.

COTS: Commercial off-the-shelf.

Disability: With respect to an individual, a physical or mental impairment that substantially limits one or more of the major life activities of such individual.

DRE: Direct Recording Electronic.

EAC: Election Assistance Commission, <http://www.eac.gov>.

Early Voting: Broadly, voting conducted before Election Day where the voter completes the ballot in person at a county office or other designated polling place or ballot drop site prior to Election Day.

Election Definition: Definition of the contests and questions that will appear on the ballot for a specific election.

Election Officials: The people associated with administering and conducting elections, including government personnel and pollworkers.

Electronic Voter Interface: Subsystem within a voting system which communicates ballot information to a voter in video, audio, or other alternative format which allows the voter to select candidates and issues by means of vocalization or physical actions.

Electronic Voting Machine: Any system that utilizes an electronic component. Term is generally used to refer to DREs. See also voting equipment, voting system.

Electronic Voting System: An electronic voting system is one or more integrated devices that utilize an electronic component for one or more of the following functions: ballot presentation, vote capture, vote recording, and tabulation device.

FEC: Federal Election Commission, <http://www.fec.gov>.

FFBS: Full-face ballot system.

HAVA: The Help America Vote Act of 2002, Public Law 107-252.

301(b)(3)

Accessibility for individuals with disabilities.--The voting system shall--

(A) be accessible for individuals with disabilities, including nonvisual accessibility for the blind and visually impaired, in a manner that provides the same opportunity for access and participation (including privacy and independence) as for other voters;

(B) satisfy the requirement of subparagraph (A) through the use of at least one direct recording electronic voting system or other voting system equipped for individuals with disabilities at each polling place; and

(C) if purchased with funds made available under title II on or after January 1, 2007, meet the voting system standards for disability access (as outlined in this paragraph).

Full text at <http://www.fec.gov/hava/hava.htm>.

Human Factors (Ergonomics): "The scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance." (Source: International Ergonomics Association).

Human-Computer Interaction: A discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. Also, a collection of behaviors and responses that occur between a computer and a human attempting to accomplish a task.

IEEE: Institute of Electrical and Electronics Engineers, <http://www.ieee.org>.

ILTS: International Lottery and Totalizator System, parent company of Unisyn, the manufacturer of the InkaVote voting system.

ISO: International Organization for Standardization, <http://www.iso.org>.

ITA: Independent Testing Authority (private test labs).

Marksense: System by which votes are recorded by means of marks made in voting response fields designated on one or both faces of a ballot card or series of cards.

Multi-Seat Contest: Contest in which multiple candidates can run, up to a specified number of seats. Voters may vote for no more than the specified number of candidates.

NASED: National Association of State Election Directors, <http://www.nased.org/>.

NASS: National Association of Secretaries of State.

NIST: National Institute of Standards and Technology.

OS: Optical Scan, System by which votes are recorded by means of marks made in voting response fields designated on one or both faces of a ballot card or series of cards.

Overvote: Voting for more than the maximum number of selections allowed in a contest.

PBC: Precinct Ballot Counter (InkaVote ballot scanner and ballot box)

PCOS: Precinct-count optical scan.

Personal Assistive Device: A device that is carried or worn by an individual with some physical impairment with a primary purpose of helping to compensate for that impairment.

Privacy: The ability to prevent others from determining how an individual voted.

Residual Vote: The total number of votes that cannot be counted for a specific contest (e.g., overvoting a contest, failure to cast ballot before leaving polling place).

Risk Assessment: The process of identifying the risks to system security and determining the probability of occurrence, the resulting impact, and safeguards that would mitigate this impact.

Rolloff: The difference between number of votes cast for contests in the higher offices on the ballot and the number cast for contests that are lower on the ballot. It is sometimes referred to as voter fatigue.

T-Coil: Inductive coil used in some hearing aids to allow reception of an audio band magnetic field signal, instead of an acoustic signal. The magnetic or inductive mode of reception is commonly used in conjunction with telephones, auditorium loop systems and other systems that provide the required magnetic field output.

TGDC: Technical Guidelines Development Committee.

Touch Screen Voting Machine: A voting machine that utilizes a computer screen to display the ballot and allows the voter to indicate his or her selections by touching designated locations on the screen.

Undervote: Occurs when the number of choices selected by a voter in a contest is less than the maximum number allowed for that contest or when no selection is made for a single choice contest.

Unisyn: manufacturer of the InkaVote voting system and a subsidiary of International Lottery and Totalizator System

Usability: Effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment. Usability in the context of voting refers to voters being able to cast valid votes as they intended quickly, without errors, and with confidence that their ballot choices were recorded correctly. It also refers to the usability of the setup and operation in the polling place of voting equipment.

Usability Testing: Encompasses a range of methods that examine how users in the target audience actually interact with a system, in contrast to analytic techniques such as usability inspection.

Voter Verifiable Audit Record: Human-readable printed record of all of a voter's selections presented to the voter to view and check for accuracy.

Voting Equipment: All devices, including the voting machine, used to display the ballot, accept voter selections, record voter selections, and tabulate the votes.

Voting Machine: The mechanical, electromechanical and electric components of a voting system that the voter uses to view the ballot, indicate their selections, verify their selections. In some instances, the voting machine also casts and tabulates the votes.

Voting Station: The location within a polling place where voters may record their votes. A voting station includes the area, location, booth, or enclosure where voting takes place as well as the voting machine.

Voting System: Combination of environment, equipment, ballot, voters, and other persons (e.g., poll workers and election officials) involved in the voting process.

VRA: Voting Rights Act of 1965.

VSS: Voting System Standards, the Federal guidelines for voting systems, last revised by the FEC in 2002, freely available from <http://www.fec.gov/pages/vssfinal/vss.html>. Conformance to the VSS is a prerequisite for certification by some states.

VVPAT: Voter-verified paper audit trail.

VVPR: Voter-verified paper record.

VVSG: Voluntary Voting System Guidelines.

Write-in Voting: To make a selection of an individual not listed on the ballot. In some jurisdictions, voters may do this by using a marking device to physically

write their choice on the ballot or they may use a keypad, touch screen, or other electronic means to enter the name.

C. Heuristic Analysis

The authors of this report, assisted by two others with expertise in accessible technology and voting systems, served as the expert reviewers of the system. The goal of their analysis was to identify as many potential accessibility and usability issues for voters as possible in advance of the user testing, and afterwards to confirm and clarify issues identified during the user testing.

We also took measurements of the following:

1. Physical dimensions of the entire unit and its interface elements
2. Operating force requirements
3. Font sizes
4. Audio output levels

These expert analyses took three forms:

Group Walkthroughs

The experts worked together in group sessions, engaging in a dialogue as one expert navigated through the scenario. These were recorded by note taking, video/audio recording, or both.

Individual Walkthroughs

A single expert exercised a specific interface, with his/her verbalized interactions and findings recorded on audio and video.

Review of User Videos

After the user testing was complete, we reviewed the sessions for several purposes. First, we wanted to confirm the accuracy of the session timing results. Second, we wanted to be sure that particular issues noted in the session data forms appeared similarly in the recording. Third, we wanted to identify any additional information that would help explain usability or accessibility issues, or deepen our analysis. Finally, the recorded sessions were examined to determine the accuracy of voter's intended ballot selections, as compared to the final marked results on their printed-paper ballots.

D. Methodology for User Testing

Physical Layout

The testing took place in one of the Secretary of State's conference rooms. Each of the two AutoMARK voting booths was approximately 8' by 8', and separated by sound abating partitions.

Cameras were positioned to record the AutoMARK's visual display screen, the user's actions at the voting system controls, and the user's face (to capture any emotional expressions). Additionally, video cameras above the M100 ballot scanner recorded the voters as the voters deposited their ballots. A microphone recorded any speech by the user and "pollworker", and an additional sound track recorded the speech output from the voting system.

Testing Protocol

We developed a brief intake form for the study, focused on basic demographic information, disabilities, and voting experience. Project staff assisted the users in completing this intake form, the Human Subject Research Bill of Rights form, and the consent forms as needed.

For privacy protection, the users were not referred to by their names during the recorded testing sessions. In addition, to better simulate a real polling place experience, the test subjects were referred to as "voter" and the experimenters were referred to as "pollworker".

The voting system access testing included two types of ES&S voting systems, the AutoMARK and the InkaVote Plus. During their November testing at the test lab, users were tested on both types of systems. The lab had four voting test booths, two for AutoMARK voting systems and two for the InkaVote Plus voting systems. Users were assigned to the four systems in a randomized order. For each system, users were assigned a pollworker who provided a standardized amount of orientation and assistance in getting started. For users using the audio interface this often meant adjusting the volume. For testers who used wheelchairs it was usually necessary to re-arrange the equipment.

Users were encouraged at all points to perform as many tasks as possible independently.

There were five timed segments to each trial. We collected the elapsed time for each of these voting segments.

- The first was the orientation provided by and with the pollworker.
- Next, the voter was allowed to complete the ballot however he/she wished, moving through the ballot "freestyle" as if in an actual election, and making choices according to his/her own preferences.
- Once the voter reached the end of the ballot, we asked him/her to go back to a specific race and modify one of his/her selections.

- Then we asked the user to enter a write-in name ("John Smith") for another specific race.
- Then we asked them to review their vote selections and print their ballot.
- Finally, we asked the voter to remove their paper ballot, move over to the PCOS unit, and deposit their ballot in the scanner/ballot box.

When they began their free voting selection phase, we asked the users to state aloud what selections they were making for each contest, as they made each of their selections. This was to assist us in determining their intended choice, so we could later determine their voting accuracy.

We also encouraged the users to verbalize their thoughts as they were working with the system. Several of the users were able to give us extremely useful verbal stream-of-consciousness observations.

After each user completed voting on each system, we interviewed the user to collect specific reactions on a data collection sheet. We asked the user to rate the system on several factors, and asked whether he/she would be willing to use that system in a real election. Additionally, we encouraged a full discussion of the user's reaction to the system, including specific features he/she thought were important as well as any suggestions. When possible we conducted these discussions while the user was still in front of the voting system, so they were able to look at and/or touch the system while commenting about it.

E. VVSG Conformance Notes for AutoMARK Voting System

Vendor: ES&S/ATS

Certification Application Name: Election Systems & Software, Inc. Unity 3.0.1.1 Voting System.

(Also referenced by SOS as: ES&S Unity 2.4.3 System)

AutoMARK Information Management System (AIMS software) Version 1.2.18 (Used to generate memory cards, but not loaded on the VATs)

AutoMARK Voter Assist Terminal (VAT) firmware version: 1.1.2258.

AutoMARK Test Voting Station A - Model No. A200 - Serial Number: AM0206470165

AutoMARK Test Voting Station B - Model No. A100 - Serial Number: AM0106456366

M100 Optical Scan Precinct Counter Version 5.2.1.0 - Serial Number: 230225

VVSG Evaluation of the AutoMARK

The table below includes all items from the 2005 VVSG that may relate to accessibility as it is defined for the purpose of this evaluation. For each provision drawn from the VVSG, there is an indication of whether the AutoMARK complies, and an optional note explaining that indication. The codes are as follows:

Y Yes, complies

N No, does not comply

NA Not applicable

NT Not tested

P Partial or provisional (compliance is not intrinsic to the design, but depends on setup or other implementation)

Section	Rating	Comments
3.1.2 Functional Capabilities		
a. The voting system shall provide feedback to the voter that identifies specific contests or ballot issues for which he or she has made no selection or fewer than the allowable number of selections (e.g., undervotes)	Y	The system informs you when you move to the next race.
b. The voting system shall notify the voter if he or she has made more than the allowable number of selections for any contest (e.g., overvotes)	Y	The system prevents overvoting by not allowing it in the first place.
c. The voting system shall notify the voter before the ballot is cast and counted of the effect of making more than the allowable number of selections for a contest	NA	Warning is not necessary because the system prevents overvoting.
d. The voting system shall provide the voter the opportunity to correct the ballot for either an undervote or overvote before the ballot is cast and counted	Y	
e. The voting system shall allow the voter, at his or her choice, to submit an undervoted ballot without correction	Y	
f. DRE [and BMD] voting machines shall allow the voter to change a vote within a contest before advancing to the next contest.	Y	This requirement should apply not just to DREs.
g. DRE [and BMD] voting machines should provide navigation controls that allow the voter to advance to the next contest or go back to the previous contest before completing a vote on the contest currently being presented (whether visually or aurally).	Y	This requirement should apply not just to DREs.

Section	Rating	Comments
3.1.3 Alternative Languages		
The voting equipment shall be capable of presenting the ballot, ballot selections, review screens and instructions in any language required by state or federal law.	Y	
3.1.4 Cognitive Issues		
a. Consistent with election law, the voting system should support a process that does not introduce any bias for or against any of the selections to be made by the voter. In both visual and aural formats, contest choices shall be presented in an equivalent manner.	Y	
b. The voting machine or related materials shall provide clear instructions and assistance to allow voters to successfully execute and cast their ballots independently.		
i. Voting machines or related materials shall provide a means for the voter to get help at any time during the voting session.	N	There is no voter control to get help instructions and no way to summon assistance.
ii. The voting machine shall provide instructions for all its valid operations.	Y	
c. The voting system shall provide the capability to design a ballot for maximum clarity and comprehension.	NT	
i. The voting equipment should not visually present a single contest spread over two pages or two columns.	Y	However, our test had no races with many candidates. Moreover, there is an issue with large print - scroll instead of multiple pages or columns.

Section	Rating	Comments
ii. The ballot shall clearly indicate the maximum number of candidates for which one can vote within a single contest.	Y	
iii. There shall be a consistent relationship between the name of a candidate and the mechanism used to vote for that candidate.	Y	
d. Warnings and alerts issued by the voting system should clearly state the nature of the problem and the set of responses available to the voter. The warning should clearly state whether the voter has performed or attempted an invalid operation or whether the voting equipment itself has malfunctioned in some way.	P	An “invalid argument” error message was encountered on the old model unit. It gave no audio indication.
e. The use of color by the voting system should agree with common conventions: (a) green, blue or white is used for general information or as a normal status indicator; (b) amber or yellow is used to indicate warnings or a marginal status; (c) red is used to indicate error conditions or a problem requiring immediate attention.	N	The “Exit/Return Ballot” message is in red, and the focus is indicated with yellow.
3.1.5 Perceptual Issues		
a. No voting machine display screen shall flicker with a frequency between 2 Hz and 55 Hz.	Y	
b. Any aspect of the voting machine that is adjustable by the voter or poll worker, including font size, color, contrast, and audio volume, shall automatically reset to a standard default value upon completion of that voter's session.	Y	

Section	Rating	Comments
c. If any aspect of a voting machine is adjustable by the voter or poll worker, there shall be a mechanism to reset all such aspects to their default values.	Y	
d. All electronic voting machines shall provide a minimum font size of 3.0 mm (measured as the height of a capital letter) for all text.	Y	
e. All voting machines using paper ballots should make provisions for voters with poor reading vision.	Y	
f. The default color coding shall maximize correct perception by voters with color blindness.	Y	
g. Color coding shall not be used as the sole means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.	Y	
h. All text intended for the voter should be presented in a sans serif font.	Y	
i. The minimum figure-to-ground ambient contrast ratio for all text and informational graphics (including icons) intended for the voter shall be 3:1.	Y	
3.1.6 Interaction Issues		
a. Voting machines with electronic image displays shall not require page scrolling by the voter.	Y	However, vertical scrolling is necessary in large font with many names per race. There is no horizontal scrolling.

Section	Rating	Comments
b. The voting machine shall provide unambiguous feedback regarding the voter's selection, such as displaying a checkmark beside the selected option or conspicuously changing its appearance.	Y	However, selection indication in high contrast mode could be improved.
c. If the voting machine requires a response by a voter within a specific period of time, it shall issue an alert at least 20 seconds before this time period has expired and provide a means by which the voter may receive additional time.	Y	There is a five-minute inactivity timeout warning displayed on the screen and spoken. There is an OK button displayed. However, the Select is the only active key on the keypad, and the keypad Repeat key does not repeat the warning.
d. Input mechanisms shall be designed to minimize accidental activation.		
i. On touch screens, the sensitive touch areas shall have a minimum height of 0.5 inches and minimum width of 0.7 inches. The vertical distance between the centers of adjacent areas shall be at least 0.6 inches, and the horizontal distance at least 0.8 inches.	Y	
ii. No key or control on a voting machine shall have a repetitive effect as a result of being held in its active position.	Y	
3.1.7 Privacy		
The voting process shall preclude anyone else from determining the content of a voter's ballot, without the voter's cooperation.	P	There is an optional ballot privacy sleeve. An audio voter can turn off the screen. The system has no built-in privacy shield. Assurance of privacy requires proper booth location and setup and/or the addition of privacy curtains.

Section	Rating	Comments
3.1.7.1 Privacy at the Polls		
a. The ballot and any input controls shall be visible only to the voter during the voting session and ballot submission.	P	Assurance of privacy requires proper booth location and setup and/or the addition of privacy curtains.
b. The audio interface shall be audible only to the voter.	Y	
c. As mandated by HAVA 301 (a)(1)(C), the voting system shall notify the voter of an attempted overvote in a way that preserves the privacy of the voter and the confidentiality of the ballot.	Y	
3.1.7.2 No Recording of Alternate Format Usage		
a. No information shall be kept within an electronic cast vote record that identifies any alternative language feature(s) used by a voter.	NA	
b. No information shall be kept within an electronic cast vote record that identifies any accessibility feature(s) used by a voter.	NA	
3.2 Accessibility Requirements		
3.2.1 General		
a. When the provision of accessibility involves an alternative format for ballot presentation, then all information presented to voters including instructions, warnings, error and other messages, and ballot choices shall be presented in that alternative format.	Y	

Section	Rating	Comments
b. The support provided to voters with disabilities shall be intrinsic to the accessible voting station. It shall not be necessary for the accessible voting station to be connected to any personal assistive device of the voter in order for the voter to operate it correctly.	Y	
c. When the primary means of voter identification or authentication uses biometric measures that require a voter to possess particular biological characteristics, the voting process shall provide a secondary means that does not depend on those characteristics.	NA	No biometric ID is involved.
3.2.2 Vision		
3.2.2.1 Partial Vision		
b. The accessible voting station with an electronic image display shall be capable of showing all information in at least two font sizes, (a) 3.0-4.0 mm and (b) 6.3-9.0 mm, under control of the voter.	Y	
c. An accessible voting station with a monochrome-only electronic image display shall be capable of showing all information in high contrast either by default or under the control of the voter or poll worker. High contrast is a figure-to-ground ambient contrast ratio for text and informational graphics of at least 6:1.	Y	
d. An accessible voting station with a color electronic image display shall allow the voter to adjust the color or the figure-to-ground ambient contrast ratio.	P	There is one high contrast setting, which is black and white.

Section	Rating	Comments
e. Buttons and controls on accessible voting stations shall be distinguishable by both shape and color.	P	There is no color differentiation on the keypad, but they are differentiated by shape and position. However, the volume and tempo keys have the same shapes.
f. An accessible voting station using an electronic image display shall provide synchronized audio output to convey the same information as that which is displayed on the screen.	Y	
3.2.2.2 Blindness		
b. The accessible voting station shall provide an audio-tactile interface (ATI) that supports the full functionality of the visual ballot interface, as specified in Subsection 2.3.3.		
i. The ATI of the accessible voting station shall provide the same capabilities to vote and cast a ballot as are provided by other voting machines or by the visual interface of the standard voting machine.	Y	
ii. The ATI shall allow the voter to have any information provided by the voting system repeated.	Y	With the exception of the five-minute timeout warning.
iii. The ATI shall allow the voter to pause and resume the audio presentation.	N	
iv. The ATI shall allow the voter to skip to the next contest or return to previous contests.	Y	
v. The ATI shall allow the voter to skip over the reading of a referendum so as to be able to vote on it immediately.	Y	

Section	Rating	Comments
c. All voting stations that provide audio presentation of the ballot shall conform to the following requirements:		
i. The ATI shall provide its audio signal through an industry standard connector for private listening using a 3.5mm stereo headphone jack to allow voters to use their own audio assistive devices.	Y	
ii. When a voting machine utilizes a telephone style handset or headphone to provide audio information, it shall provide a wireless T-Coil coupling for assistive hearing devices so as to provide access to that information for voters with partial hearing. That coupling shall achieve at least a category T4 rating as defined by American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids, ANSI C63.19.	NA	
iii. No voting equipment shall cause electromagnetic interference with assistive hearing devices that would substantially degrade the performance of those devices. The voting equipment, considered as a wireless device, shall achieve at least a category T4 rating as defined by American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids, ANSI C63.19.	NT	
iv. A sanitized headphone or handset shall be made available to each voter.	N	None were provided with the systems we tested.

Section	Rating	Comments
v. The voting machine shall set the initial volume for each voter between 40 and 50 dB SPL.	N	The initial volume is 80 dB.
vi. The voting machine shall provide a volume control with an adjustable volume from a minimum of 20dB SPL up to a maximum of 100 dB SPL, in increments no greater than 10 dB.	N	The range is 65 to 95 dB.
vii. The audio system shall be able to reproduce frequencies over the audible speech range of 315 Hz to 10 KHz.	NT	
viii. The audio presentation of verbal information should be readily comprehensible by voters who have normal hearing and are proficient in the language. This includes such characteristics as proper enunciation, normal intonation, appropriate rate of speech, and low background noise. Candidate names should be pronounced as the candidate intends.	P	Some voters found the synthetic speech difficult to understand and thought that the system should have higher quality speech.
ix. The audio system shall allow voters to control the rate of speech. The range of speeds supported should be at least 75% to 200% of the nominal rate.	Y	
d. If the normal procedure is to have voters initialize the activation of the ballot, the accessible voting station shall provide features that enable voters who are blind to perform this activation.	Y	

Section	Rating	Comments
e. If the normal procedure is for voters to submit their own ballots, then the accessible voting station shall provide features that enable voters who are blind to perform this submission.	Y	
f. All mechanically operated controls or keys on an accessible voting station shall be tactilely discernible without activating those controls or keys.	Y	
g. On an accessible voting station, the status of all locking or toggle controls or keys (such as the "shift" key) shall be visually discernible, and discernible either through touch or sound.	Y	The undocumented "duck talk" mode toggle is audibly obvious but does not appear to have a visible mode indicator.
3.2.3 Dexterity		
b. All keys and controls on the accessible voting station shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls and keys shall be no greater 5 lbs. (22.2 N).	Y	
c. The accessible voting station controls shall not require direct bodily contact or for the body to be part of any electrical circuit.	Y	
d. The accessible voting station shall provide a mechanism to enable non-manual input that is functionally equivalent to tactile input.	Y	

Section	Rating	Comments
e. If the normal procedure is for voters to submit their own ballots, then the accessible voting station shall provide features that enable voters who lack fine motor control or the use of their hands to perform this submission.	N	Removing the ballot from the voting station requires too much pinch and pull force. The privacy sleeve provided by the manufacturer or a manila folder used by elections officials can assure privacy when assistance is needed.
3.2.4 Mobility		
a. The accessible voting station shall provide a clear floor space of 30 inches (760 mm) minimum by 48 inches (1220 mm) minimum for a stationary mobility aid. The clear floor space shall be level with no slope exceeding 1:48 and positioned for a forward approach or a parallel approach.	P	This depends on the polling place setup.
b. All controls, keys, audio jacks and any other part of the accessible voting station necessary for the voter to operate the voting machine shall be within reach as specified under the following sub-requirements:		Note: we tested the AutoMark mounted on a table; the manufacturer does not provide mounting equipment.
i. If the accessible voting station has a forward approach with no forward reach obstruction then the high reach shall be 48 inches maximum and the low reach shall be 15 inches minimum.	P	This assumes that the supporting stand or tabletop is no higher than 29.5 inches from the floor. This also assumes that the ballot input feeder tray is folded up so it does not obstruct forward reach.

Section	Rating	Comments
<p>ii. If the accessible voting station has a forward approach with a forward reach obstruction, the following requirements apply:</p> <ul style="list-style-type: none"> • The forward obstruction shall be no greater than 25 inches in depth, its top no higher than 34 inches and its bottom surface no lower than 27 inches. • If the obstruction is no more than 20 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 44 inches. 	P	This assumes that the supporting stand or tabletop is no higher than 29.5 inches from the floor.
<p>iii. Space under the obstruction between the finish floor or ground and 9 inches (230 mm) above the finish floor or ground shall be considered toe clearance and shall comply with the following provisions:</p> <ul style="list-style-type: none"> • Toe clearance shall extend 25 inches (635 mm) maximum under the obstruction • The minimum toe clearance under the obstruction shall be either 17 inches (430 mm) or the depth required to reach over the obstruction to operate the accessible voting station, whichever is greater • Toe clearance shall be 30 inches (760 mm) wide minimum 	P	This depends on the use of a proper support stand or table.

Section	Rating	Comments
<p>iv. Space under the obstruction between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground shall be considered knee clearance and shall comply with the following provisions:</p> <ul style="list-style-type: none"> • Knee clearance shall extend 25 inches (635 mm) maximum under the obstruction at 9 inches (230 mm) above the finish floor or ground. • The minimum knee clearance at 9 inches (230 mm) above the finish floor or ground shall be either 11 inches (280 mm) or 6 inches less than the toe clearance, whichever is greater. • Between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground, the knee clearance shall be permitted to reduce at a rate of 1 inch (25 mm) in depth for each 6 inches (150 mm) in height. • Knee clearance shall be 30 inches (760 mm) wide minimum. 	P	This depends on the use of a proper support stand or table.
<p>v. If the accessible voting station has a parallel approach with no side reach obstruction then the maximum high reach shall be 48 inches and the minimum low reach shall be 15 inches.</p>	P	This assumes that the supporting stand or tabletop is no higher than 29.5 inches from the floor. This also assumes that the ballot input feeder tray is folded up so it does not obstruct side reach.

Section	Rating	Comments
<p>vi. If the accessible voting station has a parallel approach with a side reach obstruction, the following sub-requirements apply.</p> <ul style="list-style-type: none"> • The side obstruction shall be no greater than 24 inches in depth and its top no higher than 34 inches. • If the obstruction is no more than 10 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 46 inches. 	P	This assumes that the supporting stand or tabletop is no higher than 29.5 inches from the floor.
<p>c. All labels, displays, controls, keys, audio jacks, and any other part of the accessible voting station necessary for the voter to operate the voting machine shall be easily legible and visible to a voter in a wheelchair with normal eyesight (no worse than 20/40, corrected) who is in an appropriate position and orientation with respect to the accessible voting station</p>	Y	
<p>3.2.5 Hearing</p>		
<p>a. The accessible voting station shall incorporate the features listed under requirement 3.2.2.2 (c) for voting equipment that provides audio presentation of the ballot to provide accessibility to voters with hearing disabilities.</p>	Y	
<p>b. If voting equipment provides sound cues as a method to alert the voter, the tone shall be accompanied by a visual cue, unless the station is in audio-only mode.</p>	Y	

Section	Rating	Comments
3.2.6 Speech		
a. No voting equipment shall require voter speech for its operation.	Y	
3.2.7 English Proficiency		
For voters who lack proficiency in reading English, or whose primary language is unwritten, the voting equipment shall provide spoken instructions and ballots in the preferred language of the voter, consistent with state and federal law. The requirements of 3.2.2.2 (c) shall apply to this mode of interaction.	Y	The alternative language support appeared to be adequate, but was not tested extensively.
3.2.8 Cognition		
The voting process should be accessible to voters with cognitive disabilities.	P	The system supports simultaneous audio and visual output but has no help command and needs clearer instructions and prompts.

VVSG Evaluation of the M100 Optical Scan Precinct Counter

Section	Rating	Comments
3.2.4 Mobility		
a. The accessible voting station shall provide a clear floor space of 30 inches (760 mm) minimum by 48 inches (1220 mm) minimum for a stationary mobility aid. The clear floor space shall be level with no slope exceeding 1:48 and positioned for a forward approach or a parallel approach.	P	This depends on the polling place setup.

Section	Rating	Comments
b. All controls, keys, audio jacks and any other part of the accessible voting station necessary for the voter to operate the voting machine shall be within reach as specified under the following sub-requirements:		
i. If the accessible voting station has a forward approach with no forward reach obstruction then the high reach shall be 48 inches maximum and the low reach shall be 15 inches minimum.	NA	
ii. If the accessible voting station has a forward approach with a forward reach obstruction, the following requirements apply: <ul style="list-style-type: none"> • The forward obstruction shall be no greater than 25 inches in depth, its top no higher than 34 inches and its bottom surface no lower than 27 inches. • If the obstruction is no more than 20 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 44 inches. 	NA	
iii. Space under the obstruction between the finish floor or ground and 9 inches (230 mm) above the finish floor or ground shall be considered toe clearance and shall comply with the following provisions: <ul style="list-style-type: none"> • Toe clearance shall extend 25 inches (635 mm) maximum under the obstruction • The minimum toe clearance under the obstruction shall be either 17 inches (430 mm) or the depth required to reach over the obstruction to operate the accessible voting station, whichever is greater • Toe clearance shall be 30 inches (760 mm) wide minimum 	N	

Section	Rating	Comments
<p>iv. Space under the obstruction between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground shall be considered knee clearance and shall comply with the following provisions:</p> <ul style="list-style-type: none"> • Knee clearance shall extend 25 inches (635 mm) maximum under the obstruction at 9 inches (230 mm) above the finish floor or ground. • The minimum knee clearance at 9 inches (230 mm) above the finish floor or ground shall be either 11 inches (280 mm) or 6 inches less than the toe clearance, whichever is greater. • Between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground, the knee clearance shall be permitted to reduce at a rate of 1 inch (25 mm) in depth for each 6 inches (150 mm) in height. • Knee clearance shall be 30 inches (760 mm) wide minimum. 	N	
<p>v. If the accessible voting station has a parallel approach with no side reach obstruction then the maximum high reach shall be 48 inches and the minimum low reach shall be 15 inches.</p>	NA	
<p>vi. If the accessible voting station has a parallel approach with a side reach obstruction, the following sub-requirements apply.</p> <ul style="list-style-type: none"> • The side obstruction shall be no greater than 24 inches in depth and its top no higher than 34 inches. • If the obstruction is no more than 10 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 46 inches. 	Y	

Section	Rating	Comments
<p>c. All labels, displays, controls, keys, audio jacks, and any other part of the accessible voting station necessary for the voter to operate the voting machine shall be easily legible and visible to a voter in a wheelchair with normal eyesight (no worse than 20/40, corrected) who is in an appropriate position and orientation with respect to the accessible voting station</p>	<p>Y</p>	<p>The visual display messages that appear to be designed for use by pollworkers, not voters, are not easily visible to someone seated in a wheelchair.</p>

F. Timing Results for Phases of the Voting Process

Note: times for phases of voting sessions are in minutes.

We measured the time it took each AutoMARK voter to perform separate tasks within the total voting process.

The separate phases of the test sessions were:

- Orientation Phase (voter introduced to equipment)
- Free Voting Phase (user-paced and controlled their voting from the beginning to the end of the ballot)
- Review Phase (reviewing all ballot selections)
- Modification Test (Voter prompted to return to a race and modify the choice.)
- Write-in Test
- Ballot Casting Phase

AutoMARK Voting Sessions

Orientation Phase

Average = 04:24

Minimum = 01:00

Maximum = 11:00

Free Voting Phase

Average = 09:02

Minimum = 01:00

Maximum = 27:00

Review Phase

Average = 01:50

Minimum = <1

Maximum = 04:00

Modification Test

Average = 01:35

Minimum = <1

Maximum = 06:00

Write-In Test

Average = 04:02

Minimum = 01:00

Maximum = 10:00

Ballot Casting Phase

Average = 02:33

Minimum = <1

Maximum = 06:00

Total Voting Time (without the write-in or modify tests)

Average = 17:50

Minimum = 10:00

Maximum = 35:00

Total Test Session Time (includes write-in and modification tests)

Average = 23:28

Minimum = 12:00

Maximum = 39:00

G. Voting Accuracy

Accuracy for voting systems is the ability of the system to capture, record, store, consolidate, and report the specific selections and absence of selections, made by the voter for each ballot position without error.

For the purposes of this test, the accuracy is based on contests that the voter purposely decided to not undervote and in which the voter's announced selection intentions did not match the actual selections cast on their final ballot. This accuracy has both a user selection error component and a paper ballot printing error component. For the purposes of this review, it was originally assumed that the paper ballot printing error rate would be essentially zero.

When the voters chose to skip or undervote a race on purpose, that was not considered an error. Similarly, if the voter got too frustrated with the voting task and decided to skip voting on the later portion of the ballot, those undervoted races were not considered as errors for the accuracy score.

Write-in names were not considered to be in error if a reasonable elections official would be able to discern the name that the voter likely intended. Misspellings, lack of separator blanks between first and last names, repeated or missing letters, and even improperly imbedded digits or special characters were considered acceptable, as long as the intended name could be discerned. Elections officials normally have to be tolerant of misspelled and partially illegible write-in names.

In this test, errors also do not include the number of times a voter inadvertently attempted to overvote, unintentionally undervoted a ballot, changed their selection in a race or was unsure of the next step in a process, assuming that these conditions were corrected before their ballot was cast.

In this testing, the voters were asked to announce each of their vote selections, as they were made. The spoken announcements of intended vote selection were picked up with a microphone and recorded, along with any audio output from the voting machine, on the same DVD recorder that was being used to record the three camera views in each voting booth.

In this manner, the voter's intended ballot selections and the selections actually made on the voting machine were recorded for later analysis. Additionally, the paper ballots were marked with the voter's voter ID number, were collected from the ballot boxes at the end of the tests, and were archived as a backup method for checking the votes.

Ballot Data Processing

The video and audio records of the subject tests were carefully studied to develop ballot transcripts and to compare them to the choices each voter announced as they made voting selections. The printed-paper ballot was

transcribed for each of the paper ballots. Finally, the recorded audio ballot transcripts were compared to the resulting selections on the paper ballots.

H. Notable Event Log for the ES&S AutoMARK and M100 OSPC Access Testing

November 5, 2007 Expert testing:

Experts were using the Booth B AutoMARK Model No. A100.

The AutoMARK rejected the scan of a ballot, so the ballot had to be flipped over and scanned in again, before it was accepted.

The AutoMARK timed out after the repeat-last-phrase (rep) key was held down for several seconds and resulted in an audible toggle of the system in/out of a "duck talk" mode in which the voice quality was seriously degraded.

There is a similar event audibly indicated when the screen on/off (scr) key is held down for several seconds, but it was not obvious what it was changing.

This is not the same operation as the normal screen enable/disable toggle function that occurs when the "scr" key is briefly pressed to turn the screen display on or off.

At the start of the Summary Screen, the Down arrow was pressed on the keypad and a system error popped up as an "out of Range" error that would not go away until the system was turned off and restarted with the locking key.

The message was approximately: "AutoMARK error...please contact election officials. An error has occurred."

While testing the AutoMARK with dual-switch input controls, strong RF interference from nearby cell phones was repeatedly heard in the AutoMARK audio output.

Saturday, November 17, 2007 Setup for subject testing:

One AutoMARK had to be replaced on Sat. AM, after its operation became extremely noisy and it failed to properly feed ballots. The SOS staff techs assessed the problem as "bad paper rollers".

Sunday, November 18, 2007 subject testing:

The M100 ballot scanner rejected all ballot scan attempts. It pulled the ballots in and spit them back out immediately. Evidentially it needed a different configuration card.

Neither of the AutoMARKs had Spanish or Cantonese in their definitions, so they would not offer alternative language options.

The Automark in Booth B has no latch on the access door, so it could not be locked shut.

The AutoMARK rocker dual switch did not come with labeling instructions and the Sip and Puff unit was not available for testing.

Tuesday November 20, 2007, Subject testing

Voter v16 on AutoMARK -- voted with the Natural Law Party, but the first candidate's name on the ballot was just random letters and numbers, not a real name.

Voter V17's Initial ballot scan into the AutoMARK was rejected, so they had to flip the ballot over and rescan to get it to be accepted the.

Wed November 21, 2007, Subject testing (final day)

The AutoMARK sip and puff switch control unit was delivered to the test lab, but the Velcro connector on the head mount assembly was defective. It would not keep the mouth tube fastened to the head mount assembly, so the mouth tube kept falling off.

After a no-ballot-input timeout on the Booth B AutoMARK (Model No. A100), the system's manual lock key had to be switched to the test mode and switched back to On. This resulted in an error that read "ArgumentOutOfRangeException. Please contact an election official. An error has occurred." In this error state, the keypad users could continue to navigate the audio interface, even though the error message persisted on the visual display screen. The system had to be turned off and on again with the key lock to clear the error.

I. Comments from Study Participants

Subject and Pollworker Comments for Testing AutoMARK System

Voter ID: V1

Subject Comments:

More specific instructions for changing a vote.

Wondered if she had to wait for entire proposition text to be read, or if she could vote (didn't try that).

A little uncertain about how to undo a selection, but tried arrow and it worked.

Tempo switch started all over again, would like to be able to adjust speed without repeating or bouncing back (should just monitor rate).

V1 AutoMARK Satisfaction: No. Time is a factor; usually has a sighted person go to vote with her, as it's quicker.

Pollworker Comments:

Voter asked if "S" braille button was for "Stop".

Some difficulty reading "tempo" braille label during orientation.

Was able to self-correct extra letter entered during write-in vote.

Voter ID: V2

Subject Comments:

Liked ease of accessing ballot slot.

Didn't see need for privacy sleeve; no problem handing ballot to pollworker for casting.

Happy to see features for people with other types of disabilities than testers.

Had already seen machine devices - had tried prior.

Had to press twice because fingertips are cold - screen is hard to push.

Needs to be sufficient space between voting machine and casting box for wheelchair users to navigate.

Pollworker Comments:

Needed to arrange for wheelchair access. Needed to rearrange casting box to permit wheelchair access in space.

Prompt for "Next" confirmation before printing (when casting ballot).

Voter ID: V3

Subject Comments:

Keypad rocks too much, finger pressure must be centered on each point.

Likes option to turn screen off, but hard to follow along with audio.

Hard to find space (key) in write-in option.

Would like to enlarge text on screen more.

Enlarged text not large enough for user with partial vision.

Liked being able to speed up speech!

Found write-in tedious.

Took a minute to get used to input controls. Found system "different" to use.

Voter's response to question regarding reading the display easily: Not for reading, but Jaws was easy to understand.

Voter's response to question regarding the input controls were easy to reach and use: Took a minute to get used to it.

Voter's response to question regarding finding the system confusing to use: Just different.

Voter's response to question regarding general satisfaction: Yes, satisfied, if I couldn't use my eyes at all.

Pollworker Comments:

Enlarged text not large enough for user with partial vision.

Ballot ejected before voting completed at start of free voting.

Felt keys were arranged backward, unlike number pad, found write-in tedious.

Voter ID: V4

Subject Comments:

Voter's response to write-in: More trickier than InkaVote.

Liked review feature. Too many buttons - confusing - 5 only, especially for time consuming.

Voter's response to question regarding general satisfaction: Preferred InkaVote.

"It doesn't repeat instructions" while in "write-in" screen (after entering in a letter).

"Trickier than InkaVote."

Pollworker Comments:

Write-in bug: User is prompted to press Repeat to hear instructions; however, pressing repeat just repeats the name of previous selected candidate, rather than candidate name and instructions.

Voter ID: V5

Subject Comments:

Beginning of instructions should get you to pay attention to keypad to prepare.

Liked ability to change speed.

Might be good to say write-in instructions would be provided once you select "write-in" so you're not deterred initially.

Pollworker Comments:

Voter chose to write-in during free voting.

Tempo or speech rate set fairly fast.

Had to start over during write-in.

Voter ID: V6

Subject Comments:

Voter's initial reaction: "Couldn't use keypad because I can't see it."

How much orientation would people get?

Suggest learning program for users - practice opportunities.

Voter's response to which way they would prefer to vote: The way they've always been used to - absentee.

Wanted to know how much orientation voters would receive.

Voter asked how to perform write-in (no instructions on how to select option).

Pollworker Comments:

Voter asked how to start a write-in and he was instructed to select the "write-in" option to open the "write-in" window.

Voter attempted write-in twice with keypad and hit right arrow by accident and left "write-in" screen by accident (he tried to return to the "write-in" screen by pressing the left arrow and was sent back to the previous screen not the "write-in" screen). Tried to use large print/high contrast for write-in process. Pollworker magnified screen and voter used the touchscreen on the third through fifth attempt and after accidentally leaving the "write-in" on the fifth try he gave up.

Bug with high contrast when magnified in Member of State Assembly Contest: "Write-in" shows magnified but does not pick up high contrast.

Had difficulty getting touch screen to pick up his touch.

Used touch screen for write-in and keypad for all other input.

Voter bumped the ballot door by accident. It slammed shut and startled him. He tried to open it again and could not.

Voter asked where the "square select" key was when the audio instructions prompted him to push that key to mark the ballot.

Voter ID: V7

Subject Comments:

Voter's response to any suggestions for changes on this system: No, pretty good. Once I understood directions, e.g. for write-in, I was able to do it. Directions clear.

Pollworker Comments:

Accidentally ejected ballot prematurely.

Voter ID: V8

Subject Comments:

Screen too bright - hurts eyes - went to white on black (contrast) which helped. Hard to get chair under table, but system's fairly easy to use once set up right. With limited hand function, voter can't remove ballot on her own.

Voter's response to which way they would prefer to vote: Has used other voting machines that were preferable.

Pollworker Comments:

Unable to remove voted ballot without assistance.

Voter ID: V9

Subject Comments:

Would like to spell out candidates' names.

"It's not that it's too fast, it just doesn't pause between the messages."

Regarding removing the ballot, "I was like, should I pull it; is it gonna tear."

Voter asked does "SCR" in braille mean "Scroll"?

"How do you find a hyphen and stuff?" Couldn't tell from voice - it just keeps talking and talking.

Would like to know which race she's in, not just the choices repeated.

"I think it talks too much."

"How do you do a write-in?"

Pollworker Comments:

Had quite a bit of trouble trying to get into a race to modify the vote in review.

The instructions run together without any pauses between sentences.

She repeatedly prematurely left write-in because she pressed right arrow to move on after selecting a letter Her wrist is getting tired from holding it up in the air.

She and others are a little confused when they have "JO" and hear it say "Joe".

It should pronounce the accumulated name and spell it.

At start of review you can press Select to print the ballot, many seem to miss it.

There should be some audible feedback during the long pauses while it is preparing to eject the ballot. It could say something like, "One moment please".

Need pollworkers to offer a folder or other sleeve to keep the ballot private.

She would like a pause/continue control.

She would like a control to just repeat a phrase, without all the rest of the message.

Might not need repeat-phrase if there was a pause/continue control.

She thought the keypad angle was bad, too steep, should be tilted "down a little more".

She would like a palm rest in front of the keypad.

Didn't understand some of the names.

Found tilt of keypad tiresome, needed to rest right hand briefly during voting.

She has a guide dog.

She has the speech rate pretty high.

Asked for spelling of U.S. Congressional candidates name, couldn't tell from audio.

Some confusion about use of "up" or "back" to change voted choice.

Restarted write-in three times, third try was successful.

Voter ID: V10

Subject Comments:

"There's a lot of buttons."

Wants to be able to free text search instructions.

"What's 'S'?" (Select)

"Once I got going I got the hang of it."

"Would help if speed could be adjusted at any point without repeating instructions from beginning."

"Would help to be able to pause instructions."

Voter's response to which way they would prefer to vote: "Don't know, I could get used to it but may want other options."

Pollworker Comments:

Requested to hide her face from cameras.

Speech set slow.

Spent a lot of time (14 minutes) reviewing tactile interface.

Had difficulty re-finding keys after each race was voted.

Should have confirmation before ballot is actually printed.

Accidentally printed ballot before "write-in".

Voter ID: V11

Subject Comments:

"Why does it need to scan the ballot?"

"Sharp edge (of paper chute) would be a problem for people in electric chairs, who might not stop right."

He couldn't get his knees under the table: "It's too low."

"When you touch the screen, it doesn't do anything until I move off a button."

In modifying, screen does not give a hint on how to change a vote.

"Don't like front sharp edge."

"Dare I say it? I might find a little happiness with this machine."

The screen looked good but touch was not.

"Screen was clear and readable."

"Controls were somewhat difficult to use."

"I'd actually vote absentee."

"Out of all the machines I've , I prefer this one."

"I didn't like the way it did modify."

"Screen is flimsy."

"I am not a fan of electronic voting."

"Zoom is just a step." (Not multi-step scale)

There was no screen glare problem for him.

"I like the screen look, but not the touching."

Voter's response to which way they would prefer to vote: "Absentee instead."

Pollworker Comments:

His hearing was limited to the point that poll workers had to speak fairly loud for him to be able to understand instructions.

He was at the card table with the extra bar across the front, not the side. Floor clearance is 25 inches by 28 wide.

We pulled the AutoMARK unit forward, overlapping the table edge, so he could reach the screen.

He needed to press harder to get clean touches.

Wobbly table and machine caused doubled entries in write-in.

He had to stabilize the screen with one hand and touch with his other.

He didn't realize that he should touch "more" to scroll.

Voter ID: V12**Subject Comments:**

"Scratchy voice, can't understand very well."

"Change voice, to scratchy."

Likes high resolution screen but needs more zoom.

His computer at home has high contrast and larger font that he can use comfortably. He wished the AutoMark would have a larger font so he wouldn't have to rely on the audio.

"Took longer to understand because of scratchy voice."

"Good contrast but text needs to be able to be larger."

Voter's response to whether they found the system confusing to use: Once caught on it was easy.

Voter's response to which way they would prefer to vote: Previous system. (InkaVote) "Somewhat easy to use."

"Took longer to catch on than on InkaVote."

Pollworker Comments:

Turned off screen during orientation.

Voter left screen off while voting.

"Automatic review, no choice to skip it" (This is what Voter said).

Voter did write-in during free vote.

Voter adjusted tempo.

Voter ID: V13

Subject Comments:

Braille "REP" means Representative, Replay, Report or what?

You have to be able to mark two choices - it didn't seem to accept more than one in City Council Contest.

Should have better instructions for multiple votes.

But fairly easy to navigate and likes labeling with different shapes.

Voter's response to whether they would be satisfied using this system to vote in a real election: It won't take two choices - that would really mess me up because I pay attention to local races.

Pollworker Comments:

Accidentally de-selected one candidate in trying to go back to end second choice due to undervote.

Voter ID: V14

Subject Comments:

Bigger font.

Choice of more than one size of large font.

Fairly easy, voice and touchscreen was nice and it voices your selection to you.

The voice and screen together helped to check accuracy of vote.

Font needs to be bigger.

Voter's response to whether they were able to use this voting method independently: Pollworker had to assist.

"Seemed fairly easy."

Pollworker Comments:

Trouble selecting on touchscreen - or accidental deselect.

Voter ID: V15

Subject Comments:

Write-in is very cumbersome; would take forever for people without a strong grasp of alphabetization.

Nice to have way to indicate how ballot measure was voted instead of having to hear entire summary again.

Liked speech and volume rate adjust.

Braille is good.

(Braille label) "TPO" not intuitive, suggest "SPD".

Pollworker Comments:

Voter turned screen off.

Not obvious that pressing tempo changes tempo because instructions start to repeat, instead of saying "faster" or "slower".

Voter ID: V16

Subject Comments:

It needs better instructions.

"Instructions should say press arrow keys to go to next "contest" not "screen".

It doesn't say how to move up through the names, only down. So you can't easily go back.

Computer voice is terrible, worse than jaws.

Pollworker Comments:

None

Voter ID: V17

Subject Comments:

He thought "SCR" might be for scroll.

Wants something other than "tpo", probably "rte" for rate label.

Probably don't need the occupation and other information repeated after you've made a selection.

Confused by it saying, "You have 2 choices." when you only have one, as it is counting write-in as one choice.

In write-in instructions it says, "...Hyphen, space, and backspace appear after A - Z", and the sentence should be turned around in order.

"It would kind of discourage me from doing a write-in to push so many times."

"It was pretty easy to navigate."

"The write-in may be pretty time consuming."

"Write-in is slow enough that it might discourage me from doing write-ins."

"The keypad is very easy to use."

"It's very user friendly." (keypad)

The first time he loaded the ballot it did not accept it, so he flipped it over and re-fed it.

"Speech quality is great."

There should probably be instructions that tell you that ballot orientation is not important when inserting.

Pollworker Comments:

He turned up the speech rate quite a bit.

He thought he was selecting a candidate for Lemon Grove Mayor, but he evidently hit the right arrow, and then got undervote message, because nothing was selected.

He has the feeling that the keys are hard to push reliably and must be pressed firmly and hard.

Voter ID: V18

Subject Comments:

By trying to vote write-in after 2 candidates had been selected, it brought up message about the need to deselect one first.

Wants several languages on the ballot.

Could machine read info about candidates (from the ballot)?

Pollworker Comments:

None

Voter ID: V19

Subject Comments:

It said "Press right for next screen" instead of next "...race".

Letter 't' did not sound right in write-in.

""T' didn't come through clear."

She felt that key describer would have helped her to orient to keys.

Her arm and shoulder got tired holding her hand up to the keypad.

She would have liked a palm support for the keypad.

Pollworker Comments:

The election definition with Spanish and Chinese was loaded on this system just before this session.

She has some neuropathy that makes it hard to find keys.

It didn't clear the write-in when she went back into it.

Voter ID: V20

Subject Comments:

Voter's response for any suggestions for changes: No, I like it, easy to use, very impressed. I vote absentee, usually with a video magnifier about 30x. This

machine would make me get out to the voting booth. It's friendly, like an ATM machine.

Voter's response to any other problems or comments: No, it's good that it doesn't matter which way the paper ballot was inserted. Changing a vote is a bit different -- I didn't assume you had to unselect and then select another candidate. It would take practice.

Keypad is well laid out; instructions were clear. Distinct shapes are good; it's got braille. Insert slot is clearly marked with braille.

Can you bring your own headphones?

"Write-in is a lot of work."

Pollworker Comments:

Concerned about sanitation on earphone and wiping down keypad.

Voter ID: V21

Subject Comments:

No instructions relevant for sighted user who also wants audio.

Two plus candidates - required deselect.

Want louder volume, slower rate, and to know more about options.

Pollworker Comments:

Used touchscreen to select language, for write-in and for marking ballot.

Voter ID: V22

Subject Comments:

"This is really a neat machine."

"I think this is fine the way it is."

"It's simple, easy to follow."

"It's good to have rate control and repeat key."

"I would say that this machine is about as well developed as you can do."

"I would feel very comfortable going to the poll to use this."

"How do we do a write-in?"

Pollworker Comments:

He has low vision and may use audio and screen.

He reselected his write-in and accidentally cancelled it.

Voter ID: V23**Subject Comments:**

Did not want to vote for "Bush".

Keypad - not clear where to push, the whole keypad feels like one big key.

Pollworker Comments:

Accidentally processed ballot before we could modify (vote).

Voter ID: V24**Subject Comments:**

"SCR" what is this? Don't know "TPO" or "REP" braille labels.

The only thing it didn't say was how to deselect, but it worked when I did it.

It was fun - a good machine.

Pollworker Comments:

None

Voter ID: V25**Subject Comments:**

"Alert. You have not heard all choices on the current contest."

Write-in should both pronounce and spell the current entry.

"That sounds like 'p', but it's a 't'."

Maybe should have a cursor keys in inverted pattern 'T' with select in the middle.

Can't remember the long instructions.

"I have tennis elbow, so it was hard to hold my arm up so long."

"Maybe something to place your arm on to rest and hold it up."

Voter's response to their general satisfaction with using this system in a real election:

Yes, satisfied (assuming he could get to the polling place).

Pollworker Comments:

It said two candidates when there was only one name plus a write-in.

He uses ZoomText at home.

He may have skipped the first choice.

It is not obvious to some that write-in is started with the select key.

He pressed left or right key in the start of write-in and backed out of it.

He blew out of write-in again because he is used to pressing left arrow to backup on his home PC.

It maybe should remind you what hitting the left and right arrows do, after each entry and its review.

Should confirm before canceling write-in.

The front obstruction blocks his getting up close enough to the display to read it.

For privacy, he would probably have turned off the screen the whole time.

Voter ID: V26

Subject Comments:

He wanted "SPD" instead of "TPO".

"I would like [the audio] to spell out his (the candidate's) name."

Using right arrow, it says "Next", same for left arrow.

"Double tapping the next contest when undervoted does not move on, and that's good."

At the end of yes/no list it said "Press right arrow to..." so he did, and undervoted.

He hit right arrow and it finished and marked his ballot prematurely.

He skipped modify and write-in.

Need confirmation response before ballot marking.

Have to lift up on input chute to open it.

Does Screen toggle also turn off the touching?

He is worried about touching screen unintentionally.

"I really like the braille."

The keypad doesn't feel cluttered to him.

"I would like it to say that I've modified or changed my vote from the previous selection."

It should say that hyphen and others are after the alphabet, instead of after 'z'.

"I really like that it announces the accumulated name I've entered so far."

After hitting repeat key, it gives him the name, but gives no instructions for what to do next.

"I like that it spells out my entry after I've finished."

"It is not clear that right arrow will cause ballot marking, as well as select key."

Pollworker Comments:

He is a braille reader.

Uses very fast voice, maybe 350 WPM.

In the start of free voting, he turned off the machine, with the key, so we had to restart.

He would like to be able to move through the instructions with the right arrow.

Voter ID: V27

Subject Comments:

None

Pollworker Comments:

Actually moving quite quickly through free vote and did a write-in on her own.

Voter used keypad to move through contest screens and touchscreen to make candidate selections. Modified the write-in by voting for Marsha Feinland, so deselected write-in.

Voter ID: V28

Subject Comments:

None

Pollworker Comments:

Terminated her test prematurely because the procedure was too much of a cognitive challenge.

J. Subject Recruiting and Screening

Human Subject Research (HSR) Approval

All subjects for the accessibility testing were required to sign the Experimental Subject's Bill Of Rights form, as well as a subject's agreement/consent form. Some subjects read these forms for themselves in print or braille and others had one of our team members read the forms to them before signing.

Note: Throughout this report we refer to the subjects as "users", or "voters".

Recruitment

In order to perform effective and valuable user testing of the voting systems, we needed to recruit representative individuals with a range of different functional limitations that may affect their ability to vote: impairments in vision, hearing, mobility, dexterity, and cognition. One goal was to oversample among people who are blind or have low vision, as vision loss is a particularly frequent source of barriers in using all forms of voting technologies. However, we did not intend to ignore the other disability categories, and planned our recruitment correspondingly.

Many of the users participated in this past summer's Top-to-Bottom review of voting machines. They had been initially recruited through grassroots disability organizations and senior groups in the Sacramento area, using telephone, email, and personal visits. Most of the users were typical members rather than high-profile advocates.

We succeeded in recruiting 28 individuals with different disabilities.

Demographics

Below is a description of the disabilities of the users. Note that the numbers add up to more than 28 because several individuals had more than one impairment.

Blind	16
Low vision	8
Mobility	5
Dexterity	6
Cognition	3

21 of the 28 indicated that one or more of their disabilities has affected their ability to vote.

The gender distribution was 12 male, 16 female.

Below is the distribution by age:

Under 40	3
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40-60	16
Over 60	9

Voting Experience and Attitudes

All 28 users had voted before. They were asked what voting method they had last used; 13 had voted absentee, five had used an electronic voting system, and most of the rest had used a punch card method, some with assistance.

We asked the users to rate their recent voting method for confidence of accuracy, ease of use, and privacy. There was no significant result regarding confidence of accuracy. Absentee voters rated that method slightly lower for privacy; this may be because blind and low vision voters may have required the help of another individual. There was no significant difference regarding ease of use between those who had voted absentee and those who had used an electronic system.

K. Intake Form

California - Voting Systems Accessibility Testing

Intake Form v5

Name _____ Age _____

“Are you or any member of your immediate family employed by any manufacturer of voting systems, the Office of the California Secretary of State, or the office of any election official?” _____

Introduction

“As you know, we are testing the design of some voting systems that are used in California. This will be a test of the systems and how they work, **not a test of you**. If something is hard to understand or perform, it’s not your fault; it’s the fault of the system. The results of this test and your comments will help us improve how citizens are able to vote, so what you say is important.”

First, please describe the disabilities or difficulties you have. _____

Do any of those disabilities interfere with your voting? _____

What language would you prefer to use for voting? _____

Voting History

Have you ever voted before?

If NO: what keeps you from voting? _____ [skip to end]

What voting method or system did you use most recently? _____

Have you ever used a voting system with any accessibility accommodations? If so, what?

Have you ever voted with an electronic voting system? If so, what kind was it?

Now I'm going to ask you about your voting experience in the recent past. For each question, please indicate how strongly you agree or disagree with the statement. The choices are AGREE STRONGLY, AGREE SOMEWHAT, DISAGREE SOMEWHAT, DISAGREE STRONGLY [REPEAT scale as needed.]

	Agree strongly	Agree somewhat	Disagree somewhat	Disagree strongly
I was confident that my vote was recorded accurately.				
The voting method was easy to use.				
The voting method was private.				

END: Do you have any questions?

Subject ID _____ Testing appointment _____

L. Test Data and Post-Test Form

California Access Review for InkaVote Plus System

Voter ID

Pollworker ID

System

Session start Date/Time

Input controls used:

Touchscreen

Keypad/keyboard

Dual switches

Sip and puff

Other-

Output media used:

Audio

Video normal size

Video magnified

Video high contrast

Video magnified and high contrast

Color changes

OTHER: tilting display, attaching switches to wheelchair, etc.:

Orientation start time

Orientation stop time

Free voting start time

Free voting stop time

Review start

Review stop
Modify vote start
Modify vote stop
Write-in start
Write-in stop
Casting start
Casting stop

Wrap-up:

Do you have any suggestions for changes on this system:

No

Yes

Any other problems or comments?

No

Yes

Post-test questions:

I'm going to ask you about your experience with the voting system you've just used. For each question, please indicate how strongly you agree or disagree with the statement.

The choices are:

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

The voting instructions provided by the machine were clear and complete.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

I could read the display easily.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

I could understand the speech output.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

The input controls were easy to reach and use.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

I found the system confusing to use.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

I was confident that my vote was recorded accurately.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

It took too long to vote.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

The voting method was easy to use.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

I was able to use this voting method independently.

Agree strongly

Agree somewhat

Disagree somewhat

Disagree strongly

N/A

General satisfaction questions:

Would you be satisfied using this system to vote in a real election or would you rather try to vote in some other way? If other, what way?

Yes, satisfied

No, other

M. Ballot Design Summary

Ideal usability and accessibility testing of voting systems should be performed with ballots specially designed for testing a full set of different race types. William Killam has helped to develop a standardized test ballot for NIST. This is a neutral ballot without political bias loading. Its candidate names are not recognizable politicians, and the political parties are made up parties with only colors for names.

To support testing of voting on very long races, the NIST test ballot even has one extremely long contest race that should overflow on to multiple screens or pages.

We would have preferred to be able to use the NIST test ballots for our accessibility testing; however, several practical limitations prevented use of the NIST test ballot.

Designing new ballots is a nontrivial task, involving language translators, visual ballot layout, and audio studio work to record the sound files for the audio ballot.

We wanted to be able to test the ES&S Unity 3.0.1.1 Voting System (including AutoMARK and M100 Scanner) with ballots containing all types of races and at least three languages (English, Spanish, and Chinese). Chinese was requested in order to test the systems' ability to handle the non-Roman character graphics font video display capabilities of the systems. Supporting non-Roman fonts has been problematic for the video hardware and software of some voting systems.

Given the time constraints of this accessibility review, we found our best available solution was to use the California 2004 primary demonstration and test ballots already done up for previous testing.

The ballots were not complete in their support of alternative languages. The local contests only had English audio files as placeholders for contest titles and candidate names or options. As mentioned in the Scope section, this review did not include heuristic testing of the alternative language ballots.

However, as it turned out, for the types of testing we decided to employ in our review, these ballots served us well.

N. Testing Script for AutoMARK Voting Systems

Escort the voter to the booth indicated on their clipboard cover sheet. Ask the videographer to start recording.

Introduction to their First System

Say, "This is not a real election, but we would like to try to test these voting systems as if it is a real election. You can make any choices you want. You don't have to vote every race."

"You can stop to take a break if you get too tired or frustrated. You can even completely stop the test voting on this machine, if you get too uncomfortable, and you will still be allowed to continue with testing the other systems. Keep in mind that it's the machines we are testing, not you. If the system is wearing you out, we need to learn that."

Orientation and Configuration

Introduce voter to voting system and help them orient to system controls and output components (screen and headphones). Show them where they should insert their ballot and where it will emerge when finished.

If they wish to vote with audio, hand them the headphones and have them put them on.

Say, "Please announce each of your selections, when you make them, so we can check to make sure the machine gets your choice correctly. Of course, in a real election, you wouldn't need to speak your vote out loud." Gently encourage the voter to feel free to speak their thoughts out loud, as they go, but don't push this if they are too nervous about it.

Starting to Vote

Ask the voter which party primary they'd like to vote in, select the appropriate ballot, mark the upper left corner of the ballot with the voter's ID number, and give the ballot to the voter.

Note the free voting start time.

If the voter makes selections without verbalizing their choice, remind them to speak their choice out loud, or just ask them which choice they just made.

Free Voting Stop Time

Note the free voting stop time.

Review Start

If review does not start automatically, ask them to select and start review.

Note time of review start.

Review Stop

Note time of review stop.

Modify Vote

Next, ask them to review to the first race and modify their choice.

Note time of modify-choice start.

If they have not made a choice in that race, ask them to make a choice and then to change it.

Note time of modified-choice stop.

Write-in Start

Ask them to go back to another race and change to write-in "John Smith".

Note time of write-in start.

Write-in Stop

Note time of write-in stop.

Casting Start

Note time of casting start.

Have them print their ballot, and remove it from the printer.

Ask them to return the headphones.

Escort them to the M100 Ballot scanner and ballot box unit, and help them get oriented on it to find the input slot.

Ask them to deposit the ballot in the slot on the M100 Ballot scanner. It may help to point out that the parallel raised lines lead into the input slot where they should slide in their ballot.

Casting Stop

Note time of end of ballot casting.

Please make sure to thank the voter for helping us to test this voting system.

Post-test questions form:

If the voter wants help with the post-test questionnaire, read them the questions and help fill it out for them. Otherwise let them fill it out.