InkaVote Plus Voting System Access Review

Noel Runyan and Jim Tobias

January 2, 2008

Table of Contents

Executive Summary

The accessibility and usability review of the InkaVote Plus 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 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).

In the second phase of the access review, the system was tested with 28 volunteer subjects having various disabilities. Each subject used the InkaVote 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.

For the purposes of the accessibility review, the InkaVote Plus ADA audio voting unit, the InkaVote manual ballot marking device, and their scanner/ballot box (PBC) were tested together as a voting system. As many types of voters with disabilities will not be able to vote on the InkaVote Plus ADA audio voting device, accessibility of the system must be analyzed in the context of the full voting system, which includes all three devices.

Although highly important, testing of the usability of the poll worker interface for the InkaVote Plus 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 InkaVote system by local election officials.

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 InkaVote 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 InkaVote Plus 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 used to guide future actions by the Secretary of State's office regarding certification. 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 InkaVote voting system.

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:

> "The 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.

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 InkaVote Plus ADA and manual marker unit were not identical, and were not based on a ballot design optimized for usability testing.

- The InkaVote Plus ADA audio ballot marking unit was tested as part of the typical polling place voting system, including the InkaVote manual ballot marker unit and

the Precinct Ballot Counter (PBC) ballot scanner and ballot box. This test of the combined voting system allowed us to better assess which voters with differing disabilities might be able to use either the audio or the visual/manual interface, as well as which could not manage to use either interface.

- The severe time limitations and the scheduling close to holidays meant that we had to limit the number of subjects to 28 formal and 3 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 audio InkaVote system was considered to be outside the scope of this access review because the California Secretary of State's (SOS) 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 voice. 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

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. 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 a subset of 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.

Methodology for User Testing

Physical Layout

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

Cameras were positioned to record the user’s actions at the voting system controls and the user’s face to capture any emotional expressions. Additionally, video cameras above the ballot scanners recorded the voters as they deposited their ballots in the PBC precinct count optical scan (PCOS) scanner units. A microphone recorded any speech by the user and “pollworker”, and an additional sound track recorded the speech output from the voting system. Unfortunately, one of the InkaVote Plus ADA units turned out to be configured improperly and could not be used for our testing. The inoperative InkaVote Plus unit was replaced with the InkaVote manual marker unit using the mechanical ballot marking dauber "pen". This setup allowed us to test voters on either or both the InkaVote manual marker unit and the InkaVote audio marking system. Voters with enough useful eyesight were given a choice of voting with the InkaVote audio and/or manual ballot marking units.

Testing Protocol

We developed a brief intake instrument 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 testing. To better simulate a real polling place experience, the test subjects were referred to as "voter" and the experimenters were referred to as "pollworker".

This access testing included two types of ES&S voting systems: the InkaVote; and the AutoMARK. Users were tested on both types of systems. The lab had four voting test booths, two for AutoMARKs, one for the InkaVote Plus ADA Audio unit and one for the InkaVote manual ballot marker. 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 users 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 out loud 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.

Major Findings

We found significant accessibility barriers for all categories of disabilities. The following issues will be addressed in this section:

- The system is not accessible to the needed broad spectrum of voters with disabilities.
- Printed ballots were incorrectly marked due to a write-in-overvote bug.
- Physical access has several limitations.
- There are serious personal safety hazards.
- The lack of a video display forces voters to use only audio.

- Voters with manual dexterity impairments may not be able to use the system.
- The keypad controls present challenges for a variety of voters.
- The speech is clear but difficult to use.
- It takes more time to vote with the audio interface.
- The audio ballot navigation is confusing.
- Write-in difficulties frustrated voters.
- The voting accuracy was limited by write-in failures.
- The markings on the paper ballot cannot be verified by many of the voters.
- The spoken instructions and prompts are inadequate.
- Several exposures threaten voter privacy.
- The system lacks support for good public hygiene.
- The systems did not operate reliably.
- The manual ballot markers are unreliable and not accessible for many voters.
- Pollworker training and materials need improvement.

Summary of Major Findings

Although the InkaVote system included several accessibility features, it did not meet the accessibility requirements of the 2005 VVSG. It did not perform satisfactorily in test voting by persons with a range of disabilities. In some cases the accessibility or usability deficits could be partially or wholly mitigated. Some of these mitigations would not require new federal and state certification testing. Many mitigations would depend on poll worker assistance and customization.

Write-in-Overvote Bug

Incorrectly marked ballots were identified for two of the 23 voters who attempted write-in votes on the InkaVote Plus ADA unit.

The printed ballot had write-in and the contest title printed but the candidate's name was not printed. This missing candidate name bug occurred whenever a voter completed a write-in in a fully voted contest without first deselecting another candidate the voter had previously selected. A voter is supposed to deselect their previous choice before selecting write-in. However, this bug in the InkaVote program allowed the voter to go through the whole write-in process without being warned about the overvote condition. This resulted in a ballot that was marked for the previous candidate. As far as the voters knew, the system had successfully accepted the write-in name and printed it on the ballot. This mismarking accounted for 40% of the write-in errors we observed.

After we discovered these incorrectly marked ballots we asked the SOS's office to attempt to reproduce this. They tested and confirmed the problem.

Physical Access to the InkaVote ADA Unit

Note that we did not use the InkaVote's vendor supplied bent-tubing supports for the InkaVote ADA stand during our human subject testing sessions, as the bent-tubing stand

was deemed too unsafe (see Personal Safety Concerns, below). Instead, the ADA unit was placed on a sturdy card table. The card table offered good clearance under it, with an opening 27 inches high and 30 inches wide. When back stopped up against a wall, this proved to be a reasonably stable and much safer support for the InkaVote ADA unit.

However, we performed our measurements in our expert analysis sessions using the InkaVote Plus ADA unit's vendor-supplied bent-tubing supports in order to assess its compliance with the VVSG and its general usability.

See the VVSG Conformance Section regarding required clearances.

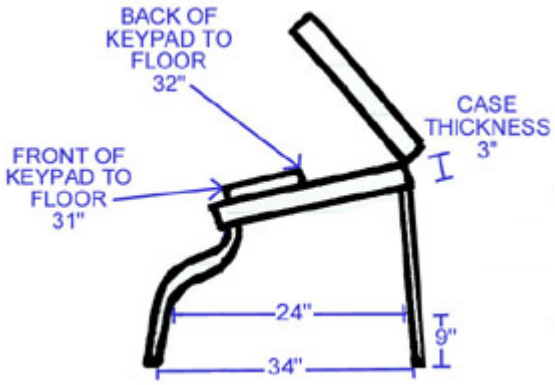


Figure 1; side view

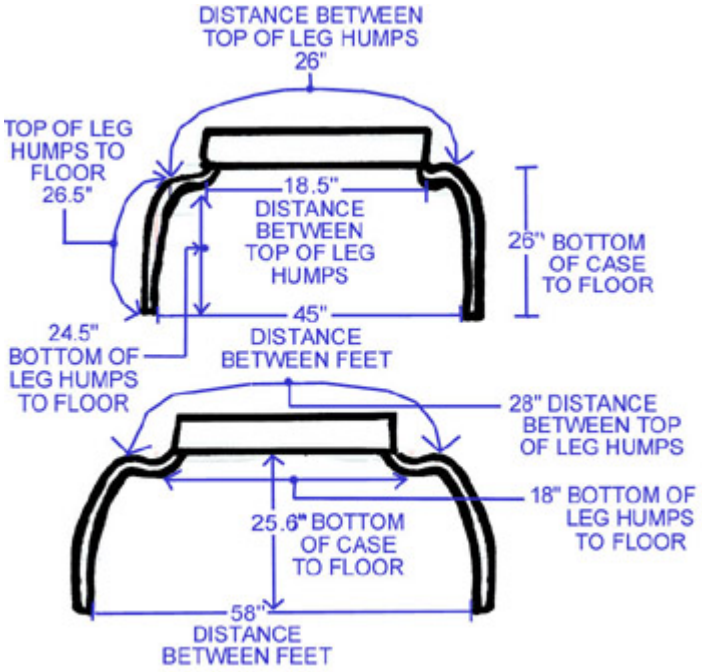


Figure 2; front view, legs adjusted to maximum splay

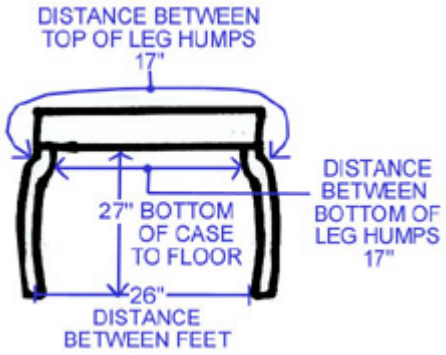


Figure 3; front view, legs adjusted to minimum splay

As visible in the Figures, the InkaVote ADA Unit has bent front legs that can be placed in different positions, resulting in different clearances, by rotating them in or out with respect to the front view of the unit. Basically, if the front legs are splayed out, the knee clearance is wide but somewhat lower; if the legs are not splayed, the knee clearance is narrower but somewhat higher. The differences are only about 1.5 inches in either dimension. The height difference of the front edge has a slight effect on the angle of the active surface of the unit, since the rear legs are unchanged.

Adjusting the legs for maximum splay provides better clearance for a lateral approach. That is, if the voter prefers or needs to be alongside the unit instead of facing it, having the legs approximately even with the front edge of the unit would bring the active surface as close to the voter as possible. They may need to be alongside the unit if they cannot get their wheelchairs under the unit.

This flexibility may be considered an accessibility advantage. However, the usefulness of this feature depends on the training, competence, and confidence of the poll workers to adjust the legs as needed for different users. The poll worker documentation we reviewed does not include any information on this feature or any such adjustments. In fact, the image of the ADA unit shows a completely different design for the legs. It is not clear to us that this feature is actually intentional, and not just an unintended side effect of the way the round leg tubing is connected to the base.

Testing of other voting machines has revealed that necessary accessories such as power wheelchair joysticks and reclining mechanisms often interact with the front edge of a voting machine. These 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. With only 27 inches of clearance in the highest condition, the original InkaVote mounting specifications are not sufficient for this purpose. However this is mitigated somewhat by the fact that the control keypad can be removed from the unit and placed anywhere convenient for the voter, within the limits of the overly short keypad cable.

Because there is no visual display to watch, the voter does not have to be sitting up close to the ADA unit.

Personal Safety Concerns

The weak legs of the vendor-supplied stand for the ADA unit can pivot if bumped by a wheelchair or voters' feet or knees, causing the stand to collapse and fall forward on the voter.

The heavy suitcase-style lid of the ADA unit cannot be locked in place when it is in the open position and can unexpectedly fall forward and strike the voter's face or hands. This can easily happen if the voter accidentally bumps into the system or pushes down on its front edge when starting to stand up from a seated position. The top edge of the lid has several sharp edges that could cut the voter.

The flimsy support legs and the falling lid of the InkaVote ADA terminal are the worst personal safety threat and liability risk we've ever observed in any voting system.

There are also other sharp edges or corners on the system, such as on the keypad keys and the front of the ballot printer. These may seem trivial to voters without disabilities. However, voters with visual impairments may gouge themselves on these sharp areas as they are exploring for the controls. Also many voters with dexterity impairments may have to strike the keypad keys forcefully in order to operate them. Others may lack the fine motor control to keep from hitting the keys on the sharp corners.

No Visual Display

There is no visual display on the audio voting unit, so voters with low vision cannot use the ADA unit to get magnified or high contrast text.

The design assumptions appear to be: voters who cannot see well enough to use the manual unit with its average size print will have to try to vote with the non-visual ADA unit's audio interface; and voters with impaired dexterity or alternative language needs must also try to use the electronic keypad and the audio interface.

There are several problems with these assumptions.

Most people with low vision want to and may need to use their residual vision. Many have hearing loss as well, making their residual vision an important source of functional effectiveness.

Many individuals have trouble with or cannot make any use of audio-only interfaces. They find the voices difficult to understand and the menu systems hard to operate. The cognitive demands of audio-only interfaces are substantial. In fact, even people without disabilities have significant problems with audio interfaces, as commonly seen in the many well known usability issues of voice mail systems.

Speech provides information one bit at a time, with limited ability to orient oneself. A long list of candidates or the text of a complex proposition pose real challenges when read with only audio output. At any given time a user may become confused as to where they are in the voting process and what actions they may take.

An audio-only interface forces all voters into receiving a linear presentation of information—e.g., if the voter hears the name of the third candidate and then wants to access the name of the first candidate, they cannot do so without having to encounter the second candidate. This imposes a cognitive load and usability impediment for users unfamiliar with speech-only interfaces.

People with learning or other cognitive disabilities, as well as people with beginning literacy skills, may be dependent on simultaneous access to visual and audio presentation for comprehension.

The lack of a visual display also significantly limits the ability of poll workers to lend any meaningful assistance when an audio voter gets confused and needs their help.

Manual Dexterity Accommodation Concerns

Users with impaired dexterity and reach had some difficulties using the InkaVote ADA system. All physical controls pose some degree of difficulty for people with impaired dexterity.

The lack of relief on the keypad control keys means that head- or mouth-sticks might pop out before activating the intended control.

Individuals who cannot use the provided keypad due to severe manual dexterity impairments and inability to use a head-controlled stick cannot use the system to vote. Voters with impaired dexterity must also use the audio interface, a type of interface which is likely to be unfamiliar to them and thus of questionable utility.

The system does not support standard dual-switch input controls for voters with severe manual dexterity impairments. The InkaVote lacks the standard 2.5 mm jack and the mechanical and sip-and-puff switches themselves.

Paper Ballot Handling

After the InkaVote prints a voter's ballot, the ballot can be removed from the ballot printer output slot with very little grip and extraction or pulling force required. However, some Voters with severe dexterity impairments may not be able to extract their ballot independently.

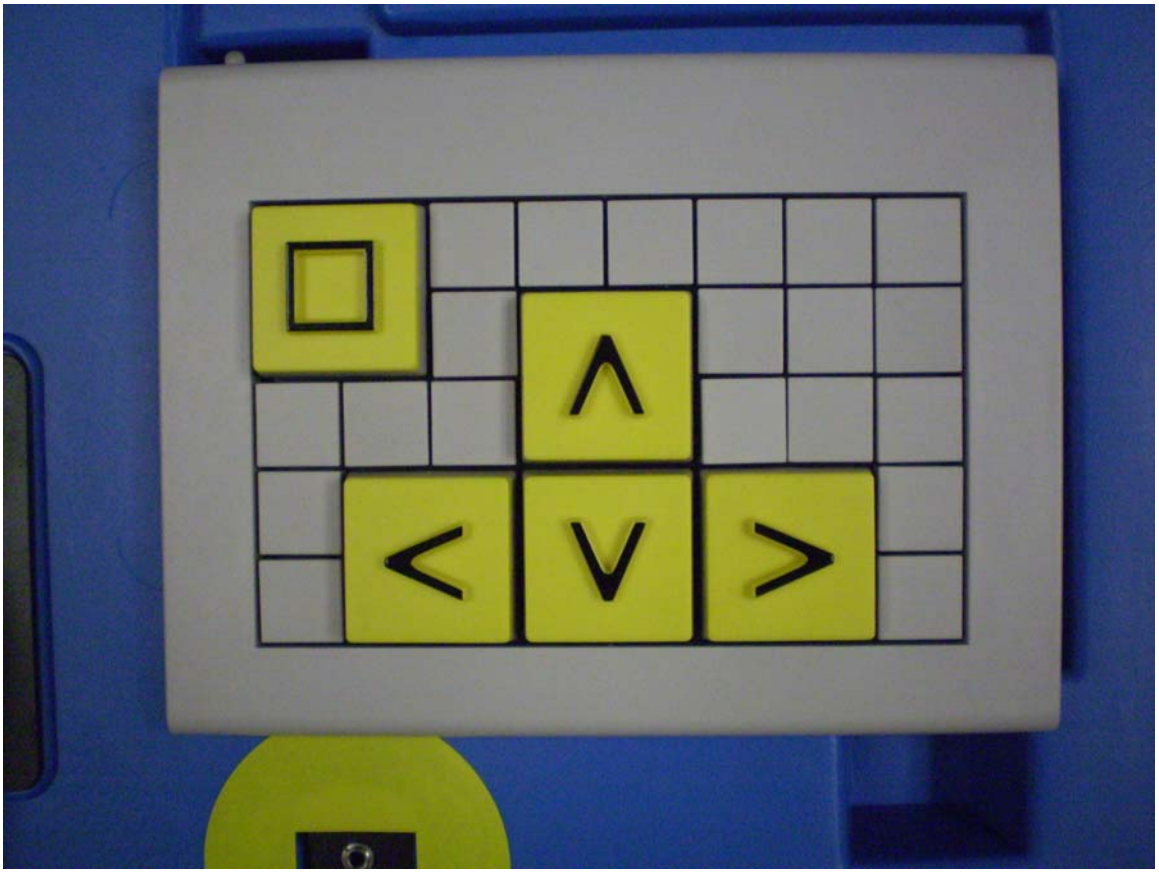
According to the InkaVote pollworker training manual, secrecy sleeves are supposed to be available for the voter's use in protecting the privacy of their paper ballot. The pollworker's manual says that the voter should place their ballot in the secrecy sleeve, but it appears that may be a difficult or impossible task for some voters.

The secrecy sleeves were not available at the beginning of our access review testing. Subsequently they were tested and found to be adequate for most voters' needs. However the design does not support automatic insertion in the sleeve when the ballot emerges from the printer. The voter or an assistant must place the ballot in the secrecy sleeve.

Since a pollworker may be standing behind the ballot scanner, just a few feet away from the ballot insertion slot, voters may feel that it is very important for them to be able to keep their ballot shielded from the pollworker and others.

Keypad Input Controls

The InkaVote control keypad normally rests in a parking well to the right of the ballot printer, but is tethered on a cable that allows it to be held by the voter, rested in the voter's lap, or positioned on a wheelchair lap tray. The keypad tether cable is 5.5 feet long; not long enough to comfortably reach some voters in wheelchairs, such as those in reclining wheelchairs.



The InkaVote Keypad

The keypad controls are laid out with arrow keys in an inverted cursor 'T' and with a fifth key added in the back left corner of the keypad for the Select control. There are no keys for Help, Summon Assistance, Pause, or Repeat Message.

The keypad is 7.75 inches wide and 6 inches deep. Some users complained that it was awkward and tiring to hold while voting.

Several voters in our testing found that the voting system required so many repeated button presses that they experienced hand fatigue, especially after the write-in test.

The force required to press the buttons was high, between 240 to 260 grams, as measured with a dynamometer.

The keys are 1.5 inch squares, raised .25 inch above the surface of the keypad. This is good for tactile registration. However, the key caps do not have the dished tops or raised edges that are important for keeping the mouth- or head sticks used by some voters with manual dexterity impairments from slipping off the key. Additionally, although the raised tactile symbols on the key caps are nice tactile labels for blind voters, the raised symbols also make it more difficult to press the keys with mouth sticks.

The sharp corners of the keys, as well as sharp corners and edges on the keys' raised tactile symbols represent abrasion and discomfort problems for many voters, especially because of the high activation force of the keys and the requirements for repeatedly pressing some of the keys so many times during a voting session.

The keys are all the same color, which makes them harder for low vision voters to

distinguish and locate. They are also all the same size and shape.

The keys have almost no separation between them, although there is room for separation on the keypad matrix. Keys that are too close together foster errors when used by people with dexterity impairments.

The tactile background pattern of the top surface of the keypad is distracting and actually caused some voters to think the patterns were other keys.

The labeling and shape of the keypad did not make its correct orientation obvious to some voters. At least one voter had problems trying to operate the keypad until they figured out they had it sideways. This user's confusion was partly due to the poorly scripted audio instructions which said that the Select key was on the left and the arrow keys on the right. Actually, the Select key is at the back left and the arrow keys are in the front center.

Speech Interface Concerns

Audio interface users mentioned several problems with the speech interface:

Speech Rate

It is important to remember that some probable users of an audio interface are highly skilled with them, while others typically do not use them regularly and may be uncomfortable with them. An adjustable speech rate is an essential customization feature for serving both types of users.

Many voters who use speech output on their own computers were extremely uncomfortable listening to the relatively slow fixed-rate speech of the InkaVote ADA unit. Some other voters actually found that the speech pace was too fast for them, especially because the system lacks a pause control.

More than 64% of the voters suggested that the system should have a speech rate control.

The InkaVote's lack of a speech rate control is clearly not in conformance with the VVSG 2005 requirement for adjustable speech rate.

Speech Volume

Volume normalization

The audio interface includes vendor-provided system messages and election-specific contest information. The audio volume of local contest titles and candidate names was 10 dB lower than the system instructions voice. This was made worse by the fact that the voter is only allowed to set the volume level initially, while listening to the system voice and before they've had a chance to hear the local contest voice. Several voters complained that they could barely hear the local contests voice because it was so much quieter than the system voice.

To measure volume sound levels, the speech volume measurements were made using help messages to generate audio output, with the headphones provided by the vendor. Other headphones may produce different results. The levels were measured with a sound level meter placed directly in contact with the headphones earpiece.

Sound Level Measurements

English System Voice Volume

Normal 82 dB

Minimum 58 dB

Maximum 97 dB

Number of Volume Steps: About 10 over the range of 20 dB

Average Volume Step Size: 2 dB

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

Chinese System Voice Volume

Normal 82 dB

English Candidates / Contest / County Voice Volume

Normal 72 dB (Note: 10 dB less than for normal system messages)

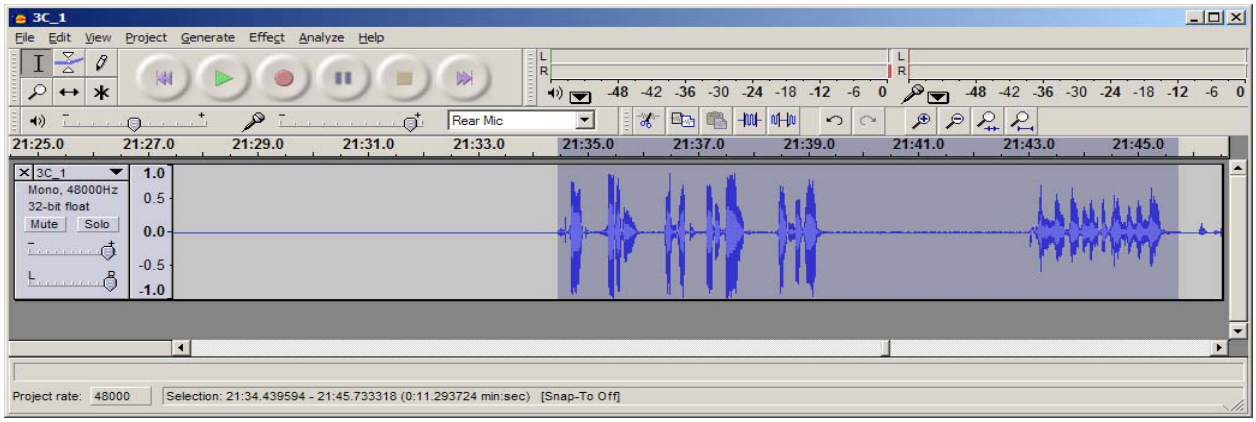
Chinese Candidates / Contest / County Voice Volume

Normal 72 dB (Note: 10 dB less than for normal system messages)

Pauses

One concern was the long pauses in speech where none should have occurred.

Undesirable pauses in the speech output were most noticeable in the write-in function. When trying to scroll rapidly through the alphabetical list, the speech was often delayed, running behind the current letter announcement by 8 seconds or more. There were also some extraneous sounds and partial pronunciations. Some speech delays as long as 14 seconds were observed in the write-in function.



Unfriendly Imperative Messages

The wording of system prompts and instructions was too imperative. Voters may feel forced to "obey" prompts immediately, as "ordered", even when a prompt is really a suggestion of several possibilities. Imperative prompts intimidate some voters and annoy

others. Imperative messages in an audio system make it seem unfriendly.

Examples of Imperative Messages

- Place your hands on the keyboard.
- Find the square select key on the left and the four arrow keys on the right.
- Press each key now to learn what it does.
- Right now, press up or down multiple times to adjust the volume.
- More volume.
- Less volume.
- Always use right to move onto the next contest in the ballot.
- When you are ready to begin voting, press right two times.
- Press right if you are ready to start voting now.
- Press down to hear each candidate. Press right to go on.
- President, vote for one.
- You did not select the maximum number of candidates for this contest. Press left to go back or press right to continue as is.
- Press down to find your previous selection.
- Press Select to deselect.

Total In-Booth Voting Times

In general, voters without disabilities can visually mark their regular ballots three or four times faster than voters using an audio voting system. The in-booth voting time for InkaVote ADA audio voters (excluding times for our special write-in and vote modification tests) was 12 and a half minutes for average subjects and as much as 21 minutes for the slowest. Since the elections on the test ballots available for this access review were very simple and short, it is clear that typical long California ballots with long lists of candidates would take many times longer to vote with the InkaVote ADA audio system.

Appendix D gives 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 in an election day, it also is a very long and exhausting challenge for many voters, especially if there are no chairs available.

Navigating the Audio Ballot

Audio interface users found the more complex tasks such as reviewing, making changes, write-in voting, and casting the ballot very 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 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 for it.

Similarly, it seemed unnecessarily awkward and strange that a previously selected choice in a race had to be deselected before a new choice could be selected.

Also, 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 generally more difficult for confused voters to figure out where they were in the ballot process and what their options were at that point.

An additional source of much frustration for voters was that operations such as canceling out of write-in or printing out the ballot had such significant consequences that the voter should have been protected with a request by the system for confirmation before taking the action.

Write-in Concerns

Using the InkaVote ADA audio voting unit to make ballot selections was so challenging for some voters that a large number (21.7%) of the voters who attempted to fill out a write-in vote for "John Smith" failed to complete their write-in successfully.

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 it is not a name.

The InkaVote write-in function required the voters to spell out a candidate's name by selecting one letter at a time from an alphabetical list of letters and other choices.

The process of scrolling up and down in the lists was very tedious. It took a minimum of 95 keystrokes and about 2.5 minutes to write-in "John Smith" as rapidly as possible. Another ballot marking system with a very similar write-in procedure took less than half the time (1 minute 20 seconds) to write in the same name.

There were substantial delays of several seconds when the up or down arrows were pressed repeatedly to move through the list of letters. This made the scrolling operation "feel" very sluggish.

Because the various points made in the initial write-in instructions message were all run together, most voters missed essential points like how to do a space or backspace.

Since the write-in process was tedious and complex, it was easy for the voters to lose track of what accumulated portion of the name they had already entered. There is no real time name review capability, either letter-by-letter or whole name.

A frustrating and frequent problem was that it was too easy for the voter to cancel their entire write-in name or to exit the write-in function without completing entry of the write-in candidate's name, because there is no confirmation warning.

After exiting prematurely, without finishing entering a name, the voter had to reselect the write-in option to attempt to finish their entry. Unfortunately, upon entry of the write-in function, there was no choice presented for accepting or rejecting any previous name entry. This meant that the voter would lose any previously entered name whenever they reselected the write-in.

Even after successfully entering a write-in name and exiting from the write-in properly, some of the voters lost their hard-won entry by pressing the Select key again. Hitting Select again at this point de-selects the write-in option.

Some voters patiently and painstakingly re-entered "John Smith" as their write-in over and over 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 lack of a confirmation dialog before canceling a write-in name or "normally" exiting the write-in function was the single greatest cause for the high (21.7%) rate of failures to complete write-ins successfully on the InkaVote audio system.

Voting Accuracy

For the methodology used to measure voting accuracy, see Appendix E.

There were no errors found for the free voting portion of the testing, the test phase in which the voters were allowed to mark the ballot however they wished.

Because our total number of subjects does not represent a very large sample set, readers should be 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 so 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. Voters typically do not do write-ins on their ballots. However, effective write-in capability is an important element of voting. Because write-in mechanisms on accessible voting systems are 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. One voter patiently re-entered his write-in five times, until he finally completed it successfully.

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, 25 of the subjects attempted to vote with the audio InkaVote. Of the 25, only 23 attempted the write-in.

Of those 23 who attempted to write-in on the InkaVote Plus, five did not successful complete the write-in of "John Smith" on their ballot.

Five voters or 21.7% failed to correctly complete the write-in. Two failures went unrecognized by the voters and three recognized the failures but accepted them. Only two of the five voters with write-in failures had a correct impression of what would actually end up marked on their ballot for that race.

In summary, we found free voting accuracy was 100% and write-in completion accuracy

was 78.3%.

Paper Ballot Verification

There are two ways to verify a ballot card printed by the ADA unit, and both require good vision. One is to insert the ballot card into a manual unit and check for accuracy, and the other is to compare the identification numbers of filled-in circles on the ballot card with a printed list of corresponding numbers that may be provided by a poll worker. Most voters with any degree of visual impairment or some forms of cognitive impairment will not be able to privately verify that the paper ballot is an accurate representation of their intended vote selections.

In light of the write-in-overvote ballot mismarking bug, which was discovered in this access review, it seems even more important that voters should have an effective way to privately verify that their ballot is printed properly.

Problems with System Messages

There were three major types of concerns regarding orientation, help, and instruction messages for audio users.

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.

Third, some users found the audio pace too fast and without sufficient pauses between messages to permit assimilation.

Privacy Concerns

Privacy of Distinctive Ballots

The ballots printed by the InkaVote ADA unit are different from the regular ballots from the manual ballot marker units. If only one voter uses the ADA unit to mark a ballot, someone could later identify the distinctive ADA ballot, violating the privacy of the vote.

Eavesdropping on the Printed Paper Ballot

Although the marking on the InkaVote paper ballots may seem quite difficult to decode at first glance, a pollworker or others who are familiar with the ballot marking can easily recognize with a quick glance, the marked choices in the top-most and generally most cared about races on the InkaVote ballot.

When the voter inserts their ballot in the PBC ballot scanner, there will often be pollworkers or other voters standing and watching from just a few feet away. The voter should be able to shield their print paper ballot from any would-be eavesdroppers near them as they move their ballot from the ballot marking station to and into the PBC scanner unit.

Also, 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 they may require.

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.

Public Health and Sanitation

There are public health concerns about the public sharing of headphones, controls, and other parts of a voting system that may not be kept in a sanitary condition. No headphone covers were provided, and the pollworker training materials did not provide information about maintaining sanitary conditions.

Reliability Concerns

Several times during the four days of access review testing the InkaVote Plus system failed to operate as expected. There were a number of failures in the audio and/or ballot printing systems. The following is a log of these events.

Sunday, November 18, 2007 subject testing:

InkaVote Plus #2 is dead.

Monday November 19, 2007 -- Subject testing

InkaVote #2 ("Booth C") did not come up active -- possibly a key problem. Turned out to be a configuration problem, and would be unusable for our tests.

9:58 InkaVote #1 audio stopped as voter began write-in. Not a headphone problem.

1:47 InkaVote #1 audio would not come up; error "Check Printer"; roll was not empty, but replacing the paper roll solved the problem.

Tuesday November 20, 2007, Subject testing

InkaVote write-in – voter reports that the word 'a' sounds weird. Other letters seem to hiccup occasionally also. All letters are delayed before being spoken, almost 1 second delay after user presses up or down key.

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

Voter 24 on InkaVote -- speech stopped, system re-booted.

Voter 24 InkaVote Video review: Voter entered US Representative contest on the Democratic Party Ballot. Voter pressed down arrow key to hear the first candidate in the contest and the system announced, "Michael P. Byron, Democrat, occupation prints here". The audio stopped and our video recording shows that the pollworker's display of the PCB scanner changes to the InkaVote Plus Logo Screen about one second after candidate was announced. About two seconds after the ballot reader screen changed to the logo the voter pressed the down arrow key and noticed no audio. Pollworkers tried to check what the problem was on the InkaVote and after waiting two minutes they restarted the InkaVote and restarted the voting.

Voters 18 and 26 had candidate's name left off the printed ballot on their write-in

for mayor. "Write-in" and contest title were printed, but the candidate name was not printed on the paper ballot.

Manual Ballot Marker Concerns

The InkaVote manual system has three components. First, there is a metal frame that holds one or more laminated ballot pages. The voter turns through these pages to proceed through the complete ballot. For each ballot page there is a column of small, round holes in the top plate of the frame; these holes correspond to candidate names printed on the laminated ballot pages. Below the top plate is a second plate with identical holes; this plate is spring loaded so that the holes in the two plates are not aligned at first.

Second, there is a ballot card. This card is inserted into the frame and latched into place by pins in the frame so that the holes in the two plates line up with each other and with the circles on the ballot card. Third, there is a marking device or "dauber". The voter identifies the candidate he/she wishes to vote for and places the dauber into the hole aligned with that candidate's name, pressing down through the hole so that a round mark is made on the ballot card.

The vendor provides a special marking device ("dauber") for the manual unit, fitted with a metal collar that facilitates lining up the dauber with the holes in the plates. The clearance is tight. The tip is spring loaded such that a click may be heard when the dauber actually goes through the holes and leaves a mark. We were told by an SOS staff member that LA County elections officials said that some poling places use the daubers and others use regular marking pens whose tips have been crushed somewhat. This allows voters to make a large, round mark on the ballot card with one press.

Several low vision voters said that they could only manage to read the text on the manual ballot marker unit’s laminated ballot pages if they had some form of magnifier. Low vision voters also found they could not see well enough to operate the ballot marker in normal room light.

Glare from the protective glossy coating on the printed cards of the manual marker unit makes it hard for some voters to read the text.

The manual unit uses text of only 6-9 points. This is too small for many people to read. There may be enough room for larger text for most elections. The space allowed for write-ins on the back of the ballot is too small, even for some voters with normal manual dexterity.

Red print used on the paper ballot is difficult or impossible for many voters with low vision to read, especially for the write-in field labels on the back of the ballot.

Reliably marking the paper ballot manually with a pencil or the mechanical dauber pen is difficult or impossible for many voters. This is even difficult for some voters with average eyesight and dexterity. The dauber inking is very unreliable, and it is difficult to determine when the dauber is worn out or out of ink.

The dauber can click like it marked but may be stopped by edges around the holes, so it leaves no mark. This is especially a problem if the dauber is held at an angle and not pressed straight into the hole.

It's difficult to verify marks made by the dauber.

The dauber may temporarily dry out if used for write-in voting, which voters may assume

if not provided with an additional pen specifically for write-ins.

The dauber is difficult to grip and operate for many people with dexterity impairments.

Poll Worker 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 InkaVote Plus pollworker training manual found the materials not to contain any usable information for this purpose.

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 other election officials, or by manufacturers, using materials and techniques we believe they may have at hand. The sources include 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 also other mitigations that would likely require redesign and recertification by the vendors and that could only be considered for the long term. When appropriate, the Long-term Mitigations will be listed secondarily.

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

Write-in-Overvote Bug

Near-term Mitigations

Pollworkers could warn voters to be extra careful about deselecting previous candidates before starting write-ins.

Long-term Mitigations

The vendor should be able to modify the code to fix this easily reproducible bug.

Physical Access to the InkaVote ADA Unit

Near-term Mitigations

Sturdy card tables or other large folding tables could meet the height, floor space, and other clearances necessary. 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.

Free-standing privacy curtains or panels could also be included so they would not block the voter's arm movements and approach to the voting units.

Election officials could provide pollworker training and reference materials with additional suggestions for physical accommodation alternatives, including how to remove the keypad from its parking well and place it properly where the voter can best reach and operate it. The materials should also cover proper setup of the polling place and placement of the ADA unit for good wheelchair clearance. Clearance for wheelchairs also includes space for wheelchair approach along side as well as across the front of the PBC 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 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. Also, some voters will need to sit down, with the keypad in their laps. 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

The concept of having adjustable and spreadable supports for the voting terminal could be improved so the whole support structure would be sturdy and reliable. This would at least require replacing the thin bent-tubing supports with much stronger supports that would not allow the rotation that currently results in instability of the ADA unit's stand.

The PBC scanner could be redesigned to allow ballots to be deposited into a slot on the front of the system, rather than on the top. The printed output of the overvote-warning printer on the PBC could be repositioned to make it easier for voters seated low in a chair to read.

Personal Safety Concerns

Near-term Mitigations

The InkaVote Plus ADA unit could be supported more safely on a sturdy table that has proper clearance to accommodate wheelchair access than on the supplied bent-tubing supports.

To prevent the lid from slamming on voters, a locking sleeve, a small C-clamp, or other locking mechanism could be added in the field to the support for the ADA unit's lid.

Pollworkers could be trained to make sure to warn voters about the sharp corners and

edges of the ADA unit.

Long-term Mitigations

The stand for the ADA unit could be completely redesigned to make it sturdy and safe.

The case could be redesigned so that the lid is firmly locked open for safety.

The top of the lid, printer and keypad keys could be redesigned to eliminate rough edges and sharp corners.

No Visual Display

Near-term Mitigation

There is no near-term mitigation.

Long-term Mitigations

The InkaVote system could be redesigned to support a touch screen visual display utilizing magnification, high contrast, and synchronous audio/video output.

Manual Dexterity Accommodation Concerns

Near-term Mitigations

There are no practical near-term mitigations.

Long-term Mitigations

A dual-switch input control jack could be added with support for external switches such as sip and puff, rocker, and jelly switches.

The keypad cable could be lengthened so it can better reach to the lap of voters in wheelchairs.

Automatic ballot shielding could be added to allow a privacy shield to be placed so it will automatically fold around or wrap the ballot as it emerges from the ballot printer.

Keypad Input Controls

Near Term Mitigation

Braille and large print materials could be made available with clear reference cards that identify the names of each of the keys.

The keypad could have tactile labeling added so that the correct orientation is more obvious.

The audio orientation message for the keypad could be changed to be less confusing. For example, it might describe the Select key position as "Back Left", and the arrow keys as "Front and Center". Also, the tether cable position might be described to aid in proper orientation of the keypad.

Long-term Mitigations

The length of the keypad tether cable could be increased by at least one foot so it can reach the lap of a voter in a wheelchair.

Key corners and the tactile labels on the key caps could have their rough edges and corners rounded to prevent hand gouging and abrasion.

The edges of the key caps could have a raised ridge added to help keep fingers and mouthstick tips from sliding off the keys. This may not be necessary along the front edge of the keys.

The tactile patterning on the keypad top surface could be removed to reduce tactile clutter and confusion.

Key caps could be color coded for differentiation as well as for intuitive function association.

A Help key could be added and it could be used to summon assistance if pressed multiple times (discounting jittery touches).

A Pause key could be added to pause and resume the speech output.

A repeat key could be added to repeat the last message.

As an alternative to adding too many new keys, pairs of keys might be pressed simultaneously for different commands, however the simultaneous pressing of two keys can be difficult or impossible for some voters with dexterity impairments.

A dual-switch input control jack could be added to the keypad to support external controls such as sip and puff, rocker, and jelly switches.

Speech Interface Concerns

Near-term Mitigations

All of the following solutions should be adopted to improve the speech of the InkaVote ADA system.

Use only human speakers with clear, unaccented voices to record any audio ballots.

Use proper professional audio recording studio equipment and procedures.

Normalize speech volume levels to assure that all messages have the same volume level.

Use a pitch queue tone or other technique to help voice talent keep the pitch of their voices normalized.

Test audio ballots with a thorough walkthrough on an actual voting system.

Rescript the text for clearer help, instructions, and prompts; and record new audio for the InkaVote ADA to improve its accessibility and usability. According to other voting system vendors, the "fixed" messages that are not part of the ballot definition can usually be changed without having to recertify the voting system.

Speech Rate Control

Near-term Mitigations

No practical near-term mitigation is available for adding variable speech rate.

Long-term Mitigations

For decades, Variable Speed Control (VSC) and other audio rate control systems for digitized human voice recordings has been readily available, inexpensive, and easy to implement in microprocessor-based systems.

This could be added to the InkaVote ADA to enable a user-adjustable speech rate control.

For decades, instant start-up/shut-up and quick response speech systems have been able to stop and start speech in hundredths of a second, without the sluggish performance found in the speech system of the InkaVote ADA unit. The response time of the InkaVote speech can and should be improved significantly.

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 to vote, chairs should be provided for the voters, and pollworkers should be trained to expect longer in-booth times, typically half an hour to an hour.

Pollworkers could also be trained to help the voter find a comfortable position for operating the voting system. Placement of the keypad on the lap may help some voters avoid a lot of fatigue from holding their hand and arm poised up in the air over the ADA unit's keypad.

Navigating the Audio Ballot

Near-term Mitigations

A context-dependent help function and controls for Pause/Resume and Repeat-Last-Message could make dealing with complex tasks a lot less challenging for the voter.

A confirmation dialog before printing the ballot and exiting would improve the voter's chances for navigating the ballot without prematurely printing their ballot and exiting unexpectedly.

Elections officials could check the audio ballot, by listening to it, for proper pronunciation of candidate names, freedom from confusing wording, and bad grammar.

Elections officials could perform complete walkthroughs of the audio ballots on an actual voting system.

To improve each voter's chances of successfully voting on the InkaVote system, effective and thorough accessible voting training of poll workers should be assured and the training materials improved. This thorough training in accessible voting is especially needed because of the lack of a visual display on the audio voting unit.

Write-in Concerns

Near-term Mitigations

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-ins; they should also warn against using the Select key again at the end of the write-in process to avoid cancelling their write-in selection.

Pollworkers could caution voters to be extra careful not to use the left or right key in 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 and Repeat-Last-Message could make dealing with write-ins a lot less challenging for the voter.

A confirmation response dialog before canceling or exiting out of the write-in function would greatly improve the voter's ability to successfully complete the entry of a candidate's name.

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.

The voter should be offered the option of clearing the write-in name if he/she returns to the write-in function; it should not be cleared automatically.

The speech response time could be significantly improved so that it will not be sluggish as voters scroll through the alphabet list.

Voting Accuracy

Near-term Mitigations

Instruct the voters to be careful to deselect any previously selected choice in a race before attempting a write-in. Also caution them to avoid using the left or right arrow keys while using the write-in feature, until they are really ready to cancel or exit the write-in.

Establish standards and train elections officials 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.

Paper Ballot Verification

Near-term Mitigations

No practical near-term mitigations are available for these accessible private paper ballot verification concerns.

Problems with System Messages

Near-term Mitigations

Rescript the text for help, instructions, and prompts; and record new audio for the systems.

Missing the Startup Orientation Help or Instructions

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.

Outreach to Inform Voters about Accessible Voting

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. 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.

Meet regularly with disability community members to discuss how to improve the accessibility of upcoming elections. Prepare sample ballots in alternative formats and distribute as needed.

Information Available in Braille and Large Print

Provide operating instructions and other usual information in braille and large print. Also post this information on the county's web site and elections info phone line.

Privacy Concerns

Near-term Mitigations

Because InkaVote ADA printed ballots look different from the manually marked ballots, polling place procedures could be modified to assure that at least five voters, including voters without disabilities if necessary, use the ADA unit during the Election Day, to assure privacy of the ADA voters.

Privacy Sleeves

While pollworkers are initially orienting voters to the InkaVote ADA audio voting terminal, the pollworker could present the voter with a privacy or secrecy sleeve and instruct them in its use.

Privacy Shields

Use soft curtains or other soft privacy screens where possible to prevent possible injury and interference.

Use 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 surround curtains easily and independently.

Vulnerability to Quick Glances or Camera Shots

Pollworkers should plan out the polling place layout so that it is not possible for voters standing in line or other possible eavesdroppers to view the InkaVote ballot after it

emerges from the ballot printer or when being inserted in the PBC scanner.

Do not allow cameras or cell phones with cameras to be used in the polling place.

Develop and use signage that informs voters and others at the polls of the ban on use of cameras and nonessential electronics in or around the polling place.

Eavesdropping on Audio Voting with Recorders and Wireless Bugs

Inform pollworkers about the possibility of bugs and recorders, and train them 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

The vendor could design an automatic insertion ballot system that shields and accepts the ballot as it emerges from the printer.

Public Health and Sanitation

Near-term Mitigations

Supply disposable covers for headphones. Note: Supplying cheap, disposable headphones is not an acceptable option as they would cause significant distortion in the audio speech reproduction.

Provide pollworkers with the proper materials and vendor-authorized sanitizing procedures for sanitizing the keypad, privacy sleeves, marking pens, manual marker daubers, and other hand-contact parts of the systems.

If mouth sticks are provided, they should be disposable rather than sanitized and reused.

Reliability Concerns

Near-term Mitigations

Daubers for the manual ballot marking units should be tested frequently to assure that they are working properly and are not drying up.

A high contrast pen should be tethered to the manual ballot marker units and the pollworkers should warn voters to use the pen, not the dauber, for any write-ins on the paper ballot.

The InkaVote ADA unit should be tested several times throughout the voting day and the resulting ballots inspected visually to verify proper operation and printing of the ballot.

During voter orientation on use of the InkaVote ADA audio system, the voter should be clearly warned to avoid overvoting and to deselect a selected choice before selecting another, especially before entering a write-in. This is to avoid the write-in-overvote bug that caused 40% of the write-in failures in the access review testing.

Long-term Mitigations

The write-in-overvote ballot mismarking bug in the code should be fixed to prevent ballots from being printed incorrectly.

The source of the premature paper-out sensing problem should be identified and fixed to prevent the system from halting with plenty of paper still on the ballot paper roll.

The source of the occasional random system hangs encountered during testing should be identified and fixed.

The InkaVote manual ballot marker dauber should be redesigned or replaced with a better dauber, in order to provide a reliable marker.

The problem with the dauber catching on the edge of the manual marker's mark holes template should be addressed so that the voter does not receive tactile feedback that indicates the dauber marked the paper ballot when in fact it did not.

Manual Ballot Marker Concerns

Near-term Mitigations

Magnifiers and good booth lighting would help low vision voters to better see the text and ballot marks.

The spacing between choices on the ballot should be increased to allow larger and easier to read text. Text should be as large and clearly formatted as possible given the current size and ballot page count limitations of the manual unit. This might be done by skipping every other mark position.

The printed cards on the manual ballot marking device could be fabricated with a less reflective matte surface.

Use high contrast text and background colors for all printed materials.

Sans Serif fonts should be used for the text on the marker pages and ballot. Italicized text should not be used at all.

The write-in area on the back of the ballot is too small, even for voters without disabilities, and it should be made as large as possible.

Voters should also be supplied with a good high contrast pen for doing write-ins, and they should be warned not to use the dauber to do write-ins, as it could damage the dauber.

The pen supplied for write-ins should be tethered to the manual ballot marker in the same manner as the dauber.

Because the dauber seems to unpredictably stop inking at times, pollworkers should test the daubers and other markers often throughout the Election Day.

Voters should be advised that the dauber can click like it marked but may be stopped by edges around the holes, so it leaves no mark. Voters should be careful to hold the dauber straight up and down when marking their ballot.

Long-term Mitigations

The dauber supplied for the access review testing should be redesigned or completely replaced with a different and much more reliable dauber.

A new dauber should be provided with a shape and grip surface that are easier for voters with manual dexterity impairments to hold, align, and press to activate.

Pollworker Training and Assistance Concerns

Near-term Mitigations

Elections officials should provide training and reference materials that compensate for omissions in the vendor-supplied pollworker training and reference materials.

Provide training videos and other materials that show pollworkers working with voters with disabilities.

Provide a list of frequently asked questions/answers about usability and accessibility to every pollworker.

Include pollworker training materials about the proper etiquette for interacting with folks with disabilities. For example: always direct your questions and answers directly to the voter, not to their attendants or friends.

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 more accessible products 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 InkaVote Plus voting system does not meet this criterion. It is substantially noncompliant when assessed against the requirements of the Help America Vote Act (HAVA) and specified in the 2005 VVSG guidelines.

We conclude that the InkaVote audio and manual ballot marking units used together without any additional accommodations cannot be considered an adequately accessible voting solution. This system cannot effectively serve the range of voters with disabilities that is supposed to be accommodated according to the HAVA requirements.

Below are some of the major categories of individuals with one or more disabilities who will find voting with either the audio or manual marking device especially difficult or impossible. These are people with:

- Low vision with some hearing loss
- Low vision with audio processing or cognitive difficulties
- Moderate manual dexterity impairment with hearing loss
- Moderate dexterity impairment with audio processing or cognitive difficulties
- Profound deafness and blindness
- Severe dexterity impairment, requiring dual switch input controls

These categories are listed here in approximate order of their frequency. Without doubt, the current InkaVote system would exclude or disadvantage a majority of California's voters with disabilities or alternative language.

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 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 project looked primarily at 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 clearly needs a lot of development. For example, we found several instances in which compliance with a VVSG guideline was difficult to test for one reason or another. We hope this report will be useful in driving that work.

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.

Much remains to be done to open up the channels of communication regarding usable and accessible voting. For example, voting equipment manufacturers and election officials could benefit from a greater understanding of how people with disabilities actually use voting equipment. To this end the Secretary of State might consider putting online some of the video of the walk-throughs and the user voting sessions.

Most of all, we want to express how important it is to remember that we are in the early days of electronic voting systems. As with all new technologies, innovation and reliable functionality do not yet have a stable relationship. As a technology driven by the needs of public policy, voting technologies are subject to political as well as technological and economic storms. The best way to weather those storms is to build trusting collaborations among manufacturers, public officials, experts, advocates, and testers in a manner that is open to the public and is communicated clearly. The explicit creation of a 'community of practice' would go a long way towards guaranteeing progress while reducing unnecessary confusion and concern.

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, more importantly, some of the

information within it can be shared with the larger community.

Acknowledgements

This study was undertaken with the assistance of many people, without whom it could not possibly have proceeded. We would like to take this opportunity to thank them.

The Office of the Secretary of State

Lowell Finley, Deputy Secretary of State, Voting Systems Technology and Policy

Deborah O'Donoghue

Ryan Macias

Jason Heyes

Miguel Castillo

Michael Lakey

Jane Howell

The Management and Staff of the Grassroots Organizations Who Helped Recruit Users

California Council of the Blind

Center for Accessible Technology

Emerald Gardens Nursing Center

NorCal Center on Deafness

Resources for Independent Living

Society for the Blind

The Center for Accessible Technology

The Users, Who Were Much More Than Subjects

Keith Alcombright

Christopher Bartlett

Regina Brink

JDD Doran-Jammer

Michael Dunne

Russell Fulton

Bob Foss

Ramona Garcia

Norma Guerrero

Frank Gaul

Amelia Guzman

Ann Jacobson

Bob Jones

Connie LeBlond

Kathy Ludwig

Thelma McDaniel

Margaret McGee

Joanie Patche

Paul Patche

Sheryl Starks

Mabel Stroughter

Garth Sturgill

Jeff Thom

Leslie Thom

Tammy Eudy

Stephanie Watts

Russ Zochowski

Also

Tammy Runyan (videography, data processing, graphic art)

Deborah Runyan (equipment acquisition, consulting, data processing, and report editing)

Jane Berliss-Vincent (Accessibility and usability expert, from the Center for Accessible Technology)

Sally Mirault (subject recruiting)

and finally, Scott Luebking (volunteer access and usability expert, whose dedicated assistance and insight were essential to the planning and implementation of this study)

References

Burton, D & Uslan 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*C0MM 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

A. Background of the Authors
B. Glossary
C. VVSG Conformance Notes
D. Timing Results for Phases of the Voting Process
E. Voting Accuracy
F. Comments on All Systems from Study Participants
G. Subject Recruiting and Screening
H. Intake Form
I. Post-Test Form
J. Ballot Design Summary
K. Testing Script

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.

AIMS: AutoMARK Information Management System.

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

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.

ES&S: Election Systems and Software, Inc.

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.

OSPC: Optical Scan Precinct Counter.

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.

VAT: Voter Assist Terminal.

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. VVSG Conformance Notes for InkaVote Plus Voting System

Vendor: ES&S/ILTS

Device Model: InkaVote Plus Precinct Ballot Counter Voting System version number 2.1

InkaVote Plus Precinct Ballot Counter with ADA Unit firmware version 1.10

PBC

PBC - ADA Key Board

Ballot Slip Printer - Model: Star TSP700

VVSG Evaluation of the InkaVote Plus ADA Unit

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 InkaVote 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)

VVSG Provision	***Y/N***	***Comment***
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	
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)	N	See comment on overvoting when using write-in
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	N	See comment on overvoting when using write-in

VVSG Provision	*Y/N*	*Comment*
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	P	See comment on overvoting when using write-in
e. The voting system shall allow the voter, at his or her choice, to submit an undervoted ballot without correction	Y	
f. DRE voting machines shall allow the voter to change a vote within a contest before advancing to the next contest.	Y	
g. DRE 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	
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	neither a summoning control or a help function is available
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.		

VVSG Provision	*Y/N*	*Comment*
i. The voting equipment should not visually present a single contest spread over two pages or two columns.	NA	
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.	N	see comment on audio failure during test session.
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	buttons are yellow, but this is not a barrier to use
3.1.5 Perceptual Issues		
a. No voting machine display screen shall flicker with a frequency between 2 Hz and 55 Hz.	NA	no display
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	
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.	N	can only adjust volume at beginning of session
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.	NA	no text

VVSG Provision	*Y/N*	*Comment*
e. All voting machines using paper ballots should make provisions for voters with poor reading vision.	N	see section on manual vs. ADA units
f. The default color coding shall maximize correct perception by voters with color blindness.	NA	
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.	NA	no text
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	this refers to the button labels
3.1.6 Interaction Issues		
a. Voting machines with electronic image displays shall not require page scrolling by the voter.	NA	no display
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	
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	
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.	NA	

VVSG Provision	*Y/N*	*Comment*
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.		
3.1.7.1 Privacy at the Polls		
When deployed according to the installation instructions provided by the vendor, the voting station shall prevent others from observing the contents of a voter's ballot.		
a. The ballot and any input controls shall be visible only to the voter during the voting session and ballot submission.	P	depends on setup and location
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.	N	See comment on overvoting when using write-in
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.	NT	this evaluation did not include the electronic cast vote record
b. No information shall be kept within an electronic cast vote record that identifies any accessibility feature(s) used by a voter.	NT	this evaluation did not include the electronic cast vote record
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	

VVSG Provision	*Y/N*	*Comment*
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 biometrics used
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.	NA	no text
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.	NA	no display
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.	NA	no display
e. Buttons and controls on accessible voting stations shall be distinguishable by both shape and color.	P	all buttons are identical in shape, but the tactile graphics on top of each are discernible; colors are identical
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.	NA	no display

VVSG Provision	*Y/N*	*Comment*
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	with minor limitations, when compared with the InkaVote manual system
ii. The ATI shall allow the voter to have any information provided by the voting system repeated.	Y	
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	
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.	NT	

VVSG Provision	*Y/N*	*Comment*
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.	NT	
v. The voting machine shall set the initial volume for each voter between 40 and 50 dB SPL.	N	Initial volume is 82 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	Minimum is 58 dB; maximum is 97 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.	Y	
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.	N	no rate control
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.	N	non-disabled voters using the manual device initialize the ballot; the ADA unit is initialized by the poll worker

VVSG Provision	*Y/N*	*Comment*
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	only by tactile graphic on top of each key
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	
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.	N	no jelly or puff/sip switches
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	inserting the ballot is difficult or impossible for some voters
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 setup

VVSG Provision	*Y/N*	*Comment*
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:		See comments on InkaVote case and setup; the evaluation was performed on a separate table.
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: • 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.	N	In order to approach, the legs have to be spread and the bottom drops below 27 inches.
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: • 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	If the front legs are spread far enough apart to meet the 30 inch toe clearance requirement, the stand becomes unstable.

VVSG Provision	*Y/N*	*Comment*
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: • 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	If the front legs are spread far enough apart to meet the knee clearance width requirement, the base of the unit drops down below the27 inch vertical requirement.
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.	NA	
vi. If the accessible voting station has a parallel approach with a side reach obstruction, the following sub-requirements apply: • 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	
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	Y	

VVSG Provision	*Y/N*	*Comment*
3.2.5 Hearing		
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.	-	See that section of this table.
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.	Y	design is audio-only
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.	NT	
3.2.8 Cognition		
The voting process should be accessible to voters with cognitive disabilities.	P	see comments on cognitive requirements

VVSG Mobility Evaluation of the InkaVote PBC Unit

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 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:		
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: • 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: • 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	
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: • 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	

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.	NA	
vi. If the accessible voting station has a parallel approach with a side reach obstruction, the following sub-requirements apply: • 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	
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	N	

D. 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 user 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 voting from the beginning to the end of the ballot)
- Review Phase (reviewing all ballot selections)
- Modification Test (return to a race and modify the choice)
- Write-in Test
- Ballot Casting Phase

InkaVote ADA Audio Voting Sessions

Orientation Phase

average = 02:36

minimum = 00:00

maximum = 08:00

Free Voting Phase

average = 06:55

minimum = 00:00

maximum = 12:00

Review Phase

average = 01:34

minimum = 00:00

maximum = 05:00

Modification Test

average = 01:27

minimum = 00:00

maximum = 05:00

Write-In Test

average = 05:37

minimum = 02:00

maximum = 11:00

Ballot Casting Phase

average = 01:20

minimum = 00:00

maximum = 03:00

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

average = 12:25

minimum = 02:00

maximum = 21:00

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

average = 19:29

minimum = 11:00

maximum = 29:00

InkaVote Manual Ballot Marker Voting Sessions

Orientation Phase

average = 03:45

minimum = 02:00

maximum = 06:00

Free Voting Phase

average = 07:00

minimum = 03:00

maximum = 12:00

Ballot Casting Phase

average = 02:40

minimum = 01:00

maximum = 05:00

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

average = 13:25

minimum = 09:00

maximum = 16:00

E. 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.

Unfortunately, we discovered that two of the 25, or 8%, of the paper ballots printed by the InkaVote Plus ADA unit had a mismarking error. This meant that we had to analyze and score the paper ballots themselves, instead of assuming that they would be reliably printed.

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 to be 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 marking was decoded and then transcribed for each of the paper ballots. Finally, the recorded audio ballot transcripts were compared to the resulting selections on the paper ballots.

F. Comments from Study Participants

Subject Testing Comments From Voters and Pollworkers

Voter ID: V1

Subject Comments:

Can't adjust speed, that's only suggestion.

Likes immediate direction during write-in, very simple for user.

V1 InkaVote Satisfaction: Yes, satisfied

Pollworker Comments:

Difficulty starting (no sound).

Once audio was working, voter used headphones but asked how to move to questions. Was advised to listen to entire message recording.

****

Voter ID: V2

Subject Comments:

Prefer AutoMARK.

Buttons hard to press.

Takes too much finger effort, worse than hard copy ballot.

Didn't hear name read.

V2 InkaVote Satisfaction: No. Prefers AutoMark. Buttons hard to press. Too hard and painful for someone with dexterity disabilities.

Pollworker Comments:

Declined use of hard copy ballot.

Stopped before casting any votes.

Terminated testing on InkaVote.

****

Voter ID: V3

Subject Comments:

Volume of contests doesn't match volume you hear for instructions.

Review takes forever.

Contradictory commands for reviewing.

No escape option to return to menu, really tedious.

Hard to remember location of space bar.

Much too slow - can't speed it up.

Likes simplicity of system, but it would totally frustrate a blind user.

Took forever to do write-in and check ballot.

Should increase voice monitoring and clarify directions.

Liked simplicity but not how long it took.

When voter adjusted volume, it wouldn't reset as she hoped it would.

Took too long to write-in, not very realistic.

Preferred first system (AutoMARK) that had more choices.

Pollworker Comments:

Selected two names in city contest, but only one was repeated. Both repeated during review phase.

Wrote in "Ellen De Gen" during free voting time.

****

Voter ID: V4

Subject Comments:

Keypad is good, person with some vision might want text labels of what keys do.

Want to be able to listen all the way through before entering answers like ability to adjust vote.

Subject Comments for English Version:

Is there a pause?

Is there a way it can read all names at once?

Need info on how to do review - especially how to get back to beginning - keep tapping without knowing where you are.

Subject Comments for Spanish Version:

Directions in Spanish other info in English ("Spanish: President, vote for one")

Spanish: Yes/No on ballot measure and does not read ballot.

Pollworker Comments:

Printed ballot before performing modification and write-in tasks.

Tester was not able to complete write-in.

****

Voter ID: V5

Subject Comments:

Doesn't like not being able to increase speed.

Seems to react a little slowly to choices, especially during write-in.

Instructions a little confusing and review went from bottom to top (counter-intuitive).

Thrown that so little instruction was given.

Pollworker Comments:

Voter chose to write-in during free voting time.

Had to start over during write-in.

****

Voter ID: V6

Subject Comments:

Voter's response to suggestions for changes on this system: "Orientation."

Pollworker Comments:

Unclear of keypad orientation - rotated keypad at 90 degrees - confusing - eventually turned to right orientation.

****

Voter ID: V7

Subject Comments:

Keyboard very easy to use with large buttons - a little easier to use than AutoMARK -

liked being able to...?

Pollworker Comments:

User declined manual InkaVote mark or "punch" voting.

Machine speech died during first attempt at "write-in" - timings are from second trial.

****

Voter ID: V8

Subject Comments:

"I found it very aggravating and I felt exhausted, especially the write-in process which was very tedious and tiring."

Prefer reading off screen to using headphones.

Voter's response to which way they would prefer to vote: Would do regular touch screen or vote absentee.

Pollworker Comments:

Finds "write-in" exhausting.

****

Voter ID: V9

Subject Comments:

Voter's response during write-in: I have to wait for it to catch up.

Would like to have quicker speech, but it was very clear speech.

Pollworker Comments:

After voter started free voting, asked if speed of speech can be adjusted (No).

****

Voter ID: V10

Subject Comments:

Voter's response to performing write-in: Takes a while.

Write-in could go faster - should be able to go down fast and had a hard time keeping up.

A lot easier to use than AutoMARK, instructions more to point.

Voter's response to which way they would prefer to vote: Don't know, but would probably prefer this to AutoMARK.

Pollworker Comments:

Requested to hide her face from cameras.

****

Voter ID: V11

InkaVote Manual Marker Unit

Subject Comments:

Ink was not spread very thoroughly, had to press too many times.

Trusts the manual system better, especially paper, with a good ink mark -- more reliable and checkable. Not into new technology. But of course you cannot go back and change your mind.

Was more confident that the paper marks were accurate, but not sure about the ballot reader machine (PBC) accuracy.

Voter agreed strongly that this voting method was private.

Pollworker Comments:

Testing of the manual marking unit was done while sitting in booth B.

****

Voter ID: V12

Subject Comments:

"Very explanatory system."

"Give this one a 10."

"Simple to use."

Voter's response to whether it took too long to vote: Just right speed.

Voter's response to whether the voting method was easy to use: Very easy.

Liked the InkaVote voice. Also liked better than AutoMark voice.

Pollworker Comments:

Voter did not want to review votes.

Likes volume control.

****

Voter ID: V13

Subject Comments:

Voter's response during write-in: I'm going too fast for it. I misspelled - what if I want to edit it?

Voter's response to suggestions or changes for system: This one was pretty good. And it seems portable and I like paper back up. I wish there was a backspace during write-in, need a prompt for editing if you make a mistake.

Voter's response to any problems or comments: I liked it.

Voter's response to whether they understood the speech output: Excellent!

Pollworker Comments:

None

****

Voter ID: V14

Subject Comments:

Faster speech. Speech is slow, so I jumped to conclusions while in ballot.

Voter's response to whether the system was confusing to use: Not technologically inclined.

Voter's response to whether it took too long to vote: Speech too slow.

Pollworker Comments:

Little confused about how to navigate through ballot.

Got better as she moved through ballot.

****

Voter ID: V15

Subject Comments:

Several keys were not labeled (Referring to textured squares on keypad not to keys).

Need to deselect - "silly and cumbersome."

Write-in, worse than the other one (AutoMARK).

Speech cleaner, but digitized samples are slow. No speed option, so takes longer.

Controls clumsy, because spread far apart, thinner? should be

Digitized speech much too low in volume.

Volume difference between system voice and candidates.

Voter's response to which way they would prefer to vote: Preferred AutoMARK.

Pollworker Comments:

None

****

Voter ID: V16

Subject Comments:

It's pretty good. It's slow enough to hear it and understand it. How to go back up to check your vote is not there -- not quite enough instructions. Likes the feel of the keypad, he has numb fingers, easy to detect the keys. The voice is disjointed -- different voices, should be the same. Using too much computer type language. Not clear to the average user. Too technical.

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

Pollworker Comments:

None

****

Voter ID: V17

Subject Comments:

Likes how it repeats your choice to you (when you select a candidate it confirms your selection right away).

Should tell you how many candidates are in that specific race.

Take too long to catch up during write-in portion when selecting your letters.

Would discourage him from doing write-in.

Wished write-in would read name when done not just spell it out.

Voter's response to any suggestions or changes on this system: Discouraging on write-in portion.

Voter's response to whether it took too long to vote: Agree somewhat because of Write-in.

Pollworker Comments:

None

****

Voter ID: V18

Subject Comments:

Would be neat if you could hold down key and move more quickly through letters.

Pollworker Comments:

None

****

Voter ID: V19

Subject Comments:

During write-in, unable to make correction, "I think I got an extra H..."

Voter's response to suggestions: It's just getting familiarized with the function of the buttons. I think it would be easier to vote on without any assistance.

I like the system; very good for people that are blind. Rather than fill out an absentee ballot; you can do it yourself.

Voter's response to whether they were able to vote independently: I really think I can with this system.

Pollworker Comments:

Experienced difficulty returning to previous races, returned to end of ballot repeatedly.

****

Voter ID: V20

Subject Comments:

The delay between speech was too long, instructions too slow, it was waiting and I didn't know it -- waiting for me to do something. It never gets me ready to move forward. The keypad has a good layout, but it didn't have to be so large. It hurt to reach out to operate the keypad, compared to the AutoMARK -- that one was neat and compact. This one was large and spread out. The voice was okay, but she preferred the synthetic speech on the AutoMARK to the slow digitized speech of the InkaVote. It was good that the ballot popped right up. No need to pull the ballot hard out of the machine. Also inserting the ballot into the reader was easier because the paper was narrow. The speech delays were really too long. If you're used to typing, it's hard to wait so long for a response to the arrow keys. Error messages were clear -- if she made an error, it said what it thought I was trying to do.

Too bad you lose everything if you deselect the write-in candidate -- shouldn't do that.

Voter's response to which way they would prefer to vote: Not as much as the AutoMARK, but still prefer it over absentee ballot.

Pollworker Comments:

None

****

Voter ID: V21

Audio InkaVote

Subject Comments:

Makes it harder because no screen - needs screen.

Better audio.

Voter's response to which way they would prefer to vote: Preferred AutoMARK.

Pollworker Comments:

InkaVote had a printer problem during orientation.

Voter ID: V21

Manual InkaVote

Subject Comments:

Voter's response to which way they would prefer to vote: System with voice.

Right? system, but if people bring their own sample they can understand better, but if read could be easier.

Pollworker Comments:

None

****

Voter ID: V22

Subject Comments:

Very self-explanatory, simplified, anyone should be able to operate it confidently - don't see how it could be simplified further, keys press easily, instructions clear - very different machine, especially with audio or ? card option, can be ? because repeats to me verbally. AutoMARK more accessible, but this one very simple also - personal preference.

Pollworker Comments:

None

****

Voter ID: V23

Subject Comments:

It says Chinese in instructions for no reason?

Too much talking.

Write-in portion too slow moving through letters.

Doesn't clarify to press select during write-in. Did not like keypad.

Voice too slow.

Voter's response to the whether the input controls were easy to reach and use: Easy to use but have faults, keys are too big.

Voter's response to whether the voting method was easy to use: Annoying cause it took too long.

Pollworker Comments:

None

****

Voter ID: V24

Subject Comments:

I really liked it - easy to learn and use. I liked being able to review and felt confident. it was fun!

I felt comfortable using this machine.

I like it!

Pollworker Comments:

At 9:52am audio stopped abruptly, restarted at 9:58am.

****

Voter ID: V25

Subject Comments:

Liked ease of deselecting vote - clear instruction.

Voter's response to any suggestions or changes: I found it very easy to follow

I liked the way the keypad's setup and no screen so others can't see what you're doing.

Pollworker Comments:

None

****

Voter ID: V26

Subject Comments:

Only "Headphones" labeled in braille - where's my braille?

I need a speed control and a help button.

I like that it asked for confirmation before going to next contest.

I need it to confirm current location and also how many options are in current contest.

Found out during use - perhaps that could be included in a help key.

Chose to under-vote (1 rather than 2 choices).

During review it should have reminded me I undervoted.

I need it to speak the word I've typed in, but it's not going it at this point.

Returned to contest after write-in and then it spoke write-in.

Help key could be located on right upper corner of keypad.

Wasn't keeping up with me on write-in.

In review, it didn't announce my undervoting.

It would be nice for braille to tell me this is the ballot printer or help key.

It didn't announce my undervoting, so I wouldn't have known.

Pollworker Comments:

None

****

Voter ID: V27

InkaVote Manual Marker Unit

Subject Comments:

Too hard to press, too hard to find the right spot.

Hard to see the mark - is it there? Is it big enough?

Voter's response to whether the voting method was easy to use: Prefers AutoMARK - electronic.

Pollworker Comments:

None

****

Voter ID: V28

InkaVote Manual Marker Unit

Subject Comments:

None

Pollworker Comments:

Voting was incomplete.

Did not press hard enough for vote to register.

Voter was quite confused - unable to answer questions.

G. 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
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, 5 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 between those who had voted absentee and those who had used an electronic system regarding ease of use.

H. 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 _____

I. 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

J. 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 have been 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 InkaVote system 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 solution was to use the California 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 place holders 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.

J. Testing Script

Escort voter to booth indicated on clipboard cover sheet. Tell videographer to roll.

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).

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 and language they want and select those options on the PBC system.

Note 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 free voting stop time.

Review Start

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

Note time of review start.

If possible, 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.

Review 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 PBC unit and help them orient on it to find the input slot.

Ask them to let you have the ballot for a moment so you can mark it with their voter ID number. Be sure to explain that this is necessary only for our testing purposes and would not be done in a regular election.

Mark their voter ID number on the upper left corner of their ballot and return the ballot to them.

Ask them to deposit the ballot in the slot on the PBC.

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.