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Usability Testing Report:

Election Systems & Software ExpressVote Universal Voting System

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Submitted to:
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Usability Testing Report

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About This Report

This report documents the findings from testing the ExpressVote Universal Voting System from Election Systems & Software. The ExpressVote system includes two components: a ballot marking system for voters who are not able to independently mark a ballot by hand that also prints the ballot, and a ballot scanner and tabulator that processes both paper ballots that have been marked by hand and ballots that have been filled out using the ballot marking system. Voters using the ballot marking system must manually deliver their completed ballot to the ballot scanner.

The ExpressVote ballot marking system comes with four available interface options for an accessible voting session:

Touch Screen - Meant both for voters without disabilities and for those with disabilities that do not preclude use of a touch screen system.

Navigation Keypad - Meant for use by voters with very limited vision. The keypad has buttons to control speed, volume, screen visibility, audio pause, audio repeat, and navigation through the interface.

Paddle Button Controller - Meant for use by voters with limited dexterity. The paddle buttons offer a low button resistance (easy to push) and limited input options as there are only two buttons on the paddle button controller.

Sip and Puff Controller - This controller was not provided as part of the usability test. This report therefore does not include information about the suitability of the sip and puff controller for Maryland voters.

The findings of this study focus on both quantitative and qualitative results, and are presented in two sections. Quantitative analysis includes:

- How many input errors were made
- How many votes ended up being cast not as intended
- How many times voters needed to request extra assistance from poll workers
- How much time was required to vote
- Subjective user satisfaction scores

The qualitative results section describes the specific usability problems encountered by voters.

The primary purpose of this usability testing was to ensure that this system is usable for a broad spectrum of voters, particularly voters with accessibility needs, lower literacy skills, mild cognitive disabilities, and age-related impairments. Participants included voters with no vision, low vision, dexterity issues, low literacy, cognitive impairments, and hearing impairments. Elderly voters (age 65 and older) were included in these categories.

Research questions for the testing included:

- Are voters able to mark and print their ballots independently?
- Can voters verify that their marked ballot matches the voter's intent?
- Can voters submit the ballot successfully?
- Are privacy and confidentiality maintained?

This study was performed by the University of Baltimore and funded by the Maryland State Board of Elections.

Summary of Findings

This section summarizes key findings from this research, including key concerns and recommendations for addressing them.

The research found problems that prevented a few voters from voting successfully and independently. The most pressing concern was that the version we reviewed did not include audio instructions for either the Touch Screen or the Paddle Buttons.

Top-level conclusion: Assuming that appropriate audio instructions are included, the system could be deployed as is. Additional improvements suggested in this report will reduce obstacles to voting and increase voter satisfaction.

Summary of the Procedure

In order to simulate the use of the ExpressVote machine in a real election, participants were allowed to vote independently with little interruption from the moderator. After the ballot was cast, we asked questions in order to confirm that the votes marked on the ballot matched the voter's intentions.

An initial pilot test of the ExpressVote machine was conducted with four voters using the Precinct 1A ballot. After this initial pilot test, 25 voters completed the standard usability test using the Precinct 1B ballot.

Six voters used the paddle button controller (one used it as his first controller; five used it to vote a second time at our request); 12 voters used the Navigation Keypad controller (all used it as their first controller); and 16 used the touch screen (all as their first voting method).

Top-Level Findings

Research question: Are voters able to mark and print their ballots independently?

Finding: For the most part, the answer to this was positive. However, during 26 voting sessions, 25 participants made 55 calls for assistance, including 10 voters who needed assistance in taking their completed ballot to the scanner.

Research question: Can voters verify that their marked ballot matches the voter's intent?

Finding: Voters can do this by using the review screen before the ballot is printed. Voters can also verify that the printed ballot matches the voter's intent by reinserting the ballot. No voters requested this option during this test; if a voter does wish to verify the printed ballot, a poll worker would need to instruct the voter to reinsert the ballot. The interface does not provide this information.

Research question: Can voters submit the ballot successfully?

Finding: While most voters were able to do this, some voters (especially blind voters) needed assistance in moving from the ExpressVote machine to the scanner. No major issues were encountered that prevented voters from submitting their ballots successfully. A few voters had to struggle physically in order to reach the ballot scanner—pulling themselves upright out of their wheelchairs.

Research question: Are privacy and confidentiality maintained?

Finding: During 26 voting sessions, 25 participants made 55 calls for assistance, including 10 voters who needed assistance in taking their completed ballot to the scanner. The ExpressVote system includes a privacy sleeve that could be used to maintain voter privacy during this process; however, the sleeve was not provided to us for use during testing. Only 4 participants were able to vote without any additional assistance.

In general, while it is understood that voters needing special accommodations may also need to ask for assistance that reduces privacy and confidentiality, the need for voters to request assistance should be eliminated whenever possible in order to maintain voter privacy and confidentiality.

Votes Cast Not as Intended

Potentially the most serious problems for voting systems are ballots cast not as intended (that is, the voter accidentally marked and then cast a ballot that did not reflect the voter's intentions). There were two instances of this, both involving blind voters using the Navigation Keypad. The causes were as follows:

- Misunderstanding of an error message led to a premature ending of the voting session. Since the voter was blind, she was not able to tell that the ballot was blank.
- An accidental key press ended the voting session early, leaving the voter unable to make an intended change to her ballot.

Calls for Assistance

As noted above, another issue that affects voter experience is the degree to which voters can vote independently, without requesting special assistance from poll workers. During 26 voting sessions, 25 participants made 55 calls for assistance. Only 4 participants were able to vote without any additional assistance.

Calls for assistance were most commonly to help voters figure out how to write in a candidate, locate the scanner, insert the ballot into the scanner, and receive reassurance that their vote had been cast correctly. In particular, since votes are marked using the ExpressVote and must then be taken over to the scanner, most blind voters required assistance in moving between machines.

Time to Mark and Cast Ballots

Voter experience is also affected by the amount of time it takes to mark and cast a ballot, especially when others are waiting. If the process takes very long, disabled voters are likely to feel rushed and uncomfortable. Average times to mark and cast ballots ranged from 8:34 minutes for the touch screen to 15:12 minutes for the paddle buttons and 17:34 minutes for the navigation keypad.

Sources of Error

Physical Interfaces

Of the three input types that were tested on the ExpressVote machine, we observed the lowest average number of button confusion errors by voters using the touch screen interface. In contrast, those using the touch screen had the highest average number of button insensitivity errors—a category of errors that did not

have as great an impact on voter performence. While only sighted voters used this type of input, it allowed for greater ease of use across a wide range of voters, including low dexterity and some low vision voters. For example, out of 11 participants in the current test who had needed to use a controller during the Dominion usability testing, 4 were able to use the touch screen in the ExpressVote testing. (The Dominion system did not provide a touch screen option.) Overall, the touch screen provided sighted voters with an intuitive voting experience with minimal observed errors (though voters with limited dexterity did have some difficulty pressing hard enough to register a touch on the screen, leading to minor frustration and delays).

Of the blind and low vision voters who required use of the navigation keypad, many needed additional assistance with the keypad at the start of voting. 5 of the 12 voters who used the keypad requested help from a poll worker in order to adjust the volume using the keypad or to have keypad explained to them. Based on our analysis of the specific errors made by voters, difficulties with this controller appeared to be the result of:

- The interface not walking voters through their customization options before beginning a voting session
- Ineffective braille mapping
- Unclear label abbreviations

There is no initial walkthrough built into the audio instructions for the navigation keypad. While instructions about the keypad can be heard by pressing the home button, not all voters took advantage of this. As a result, some voters completed their voting experience without knowing the function of the other keys (e.g., pause or privacy/screen button). This issue can be mitigated by integrating instructions into the initial use of the machine, or by increasing initial poll worker involvement. Poll workers should make sure that voters using the navigation keypad have a firm understanding of its functions, either from an explanation by the poll worker or by directing the voter to the home button for the audio instructions.

Voters who were able to read braille also had difficulty identifying and locating the correct buttons, leading to button confusion errors. The way the braille labels were mapped led to many of the button confusion errors noted in the quantitative results. Many of these errors occurred in the initial use of the keypad when voters needed to turn up the volume in order to hear the audio instructions. Some did not feel the braille label for volume (“VOL”) as it was located in the bottom right hand corner. Some voters hit the tempo button thinking it was the volume button, while others pressed the wrong side of the toggle, decreasing the volume instead of increasing it.

The abbreviations used were also not always clear to the voter. One voter thought that “REP” stood for Republican and not for repeat. Another voter stated that he did not think “TMP” would stand for tempo.

Non-Matching Audio Instructions

For voters using the paddle buttons, the biggest issue (leading to voter confusion and input errors) was audio instructions that did not match the input options on their paddle button controller. Currently the ExpressVote Machine only has one set of audio instructions, which are tailored to the navigation keypad. As a result, participants using the paddle buttons were confused when the audio narration directed them to use buttons (such as the arrow keys) that were not available to them.

Casting the Vote

Once participants had finished printing their ballot, many of them had difficulty casting their vote. Issues experienced while trying to cast a vote included the following:

- Reduced volume for audio instructions after ballot is removed from the ballot marking machine
- Difficulty finding the scanner
- Difficulty inserting the ballot into the scanner
- Lack of confirmation as to whether the vote had been successfully cast

A serious issue with the ExpressVote’s audio system is that once the voter removes the ballot from the machine, the audio volume resets to the lowest level and the audio instructions move to the instructions for a new session. As a result, audio instructions for taking the ballot to the scanner are cut off. This caused some voters to miss vital instructions if they removed the ballot before the audio instructions finished.

While many blind and low vision voters were able to mark their votes independently, they required a poll worker to help escort them to the scanner. Once there, some blind participants struggled to figure out where and how they should insert the ballot. Without any audio instructions to guide them, this process could take several minutes and often resulted in incorrectly fed ballots or requests for poll worker assistance. Additionally, with no sleeve or folder in which to place their marked ballot, blind voters had no expectation of privacy while being walked to the scanner machine. (Note that privacy sleeves are expected to be available with this system, but were not provided for the testing.)

Having a poll worker help insert a ballot (as was needed by P08) also presented a possible compromise of the voter's privacy, not solved by a privacy sleeve. To improve this voting experience for all voters, consider creating an option for the ExpressVote machine to both mark and cast ballots, while still allowing voters to review the physical paper ballot before casting if so desired.

Once the vote was inserted into the scanner, participants required additional confirmation that their vote had been cast. Both sighted and non-sighted voters experienced concern as to whether their vote had gone through, or if any additional steps were required. For sighted voters, the screen on the scanner did not provide sufficient confirmation, while blind and low vision voters expected some kind of verbal confirmation.

Initial Poll Worker Involvement

The initial set-up of the voting session was difficult for some participants and resulted in extra calls for assistance that could potentially be mitigated by poll worker assistance. The issue most commonly observed before the start of the voting session was difficulty inserting the blank ballot into the ballot-marking machine. This proved difficult for both sighted and non-sighted voters. Blind and low vision voters had difficulty locating the slot into which the ballot was to be fed. While sighted voters could locate this slot, many struggled to feed the ballot into the machine at the correct angle. The instruction graphic printed on the machine was misleading for voters, causing them to insert the ballot at an incorrect angle. Ideally, the visual design and the instruction graphic should be improved so that voters can submit their ballots more successfully. Until improvements are made, this issue can be easily mitigated if the poll worker inserts the blank ballot for the voter before the start of a voting session.

Voters also had difficulty with the initial option screen, which asked whether they wanted to scan a QR code or begin voting now. Though this screen may not occur in an actual election (depending on the settings selected by the state), voters might benefit from additional poll worker assistance at this point.

User Satisfaction

Voters had mostly positive feelings about this system. Most voters felt they could vote successfully—although their actual experience demonstrated that they often experienced errors in the voting process and typically needed some assistance voting. Subjective satisfaction scores based on the SUS are reported in the Appendix.

Usability Recommendations

Recommendations to address the usability issues identified as a result of the analysis described above are provided in the Qualitative Usability Issues and Recommendations section of this document. High-priority changes include the following:

- Make the audio compatible for all controllers, or make sure the audio matches the controller being used. Perform user testing for usability and accessibility of the additional instruction sets.
- Make sure the instructions for casting the ballot finish playing—at the same volume level—even after the ballot has been removed.
- Provide a voting machine stand with legs further apart so voters with wheelchairs and scooters can fit their legs under the stand. Make the stand adjustable in height. Ideally, it would also be more sturdy, to reduce the danger that it could be knocked over.
- Lower the height of the ballot scanner.

Recommendations for Poll Worker Training

Some of the usability problems observed during the testing can be somewhat mitigated by extra help from poll workers. These recommendations include:

- Until the insertion process and/or instruction graphic is improved, poll workers may need to offer to insert the blank ballot for all voters before the start of a voting session.
- Provide blind voters with a brief introduction to the keys on the navigation keypad.
- For voters using the audio with headphones, ensure that the initial volume is set to the proper level for that voter and adjust the volume for the voter if necessary.
- Explain to all voters that the ExpressVote system has magnification and contrast options which can be found at the bottom of the screen.
- Provide all voters with instructions on what to do once they have successfully marked their ballot.
- Inform voters that once they have placed their ballot in the scanner, they are done voting. They will not get their ballot back unless there is an error, and they will not get a receipt.

Methods

Testing of the ExpressVote machine took place in the User Research Lab at the University of Baltimore from April 23, 2014 to April 30, 2014. The study consisted of 4 participants as part of an initial pilot, and 25 participants for the main testing. Participants were recruited to represent a wide range of voters with varying abilities, as shown below:

Table 1 - Summary of Participant Demographic Data*

PARTICIPANT CHARACTERISTICS	# OF PARTICIPANTS
Blind	10
Low Vision	9
Impaired Mobility	8
Impaired Dexterity	5
Over Age 65	3
Hearing Impaired	2
Mild Cognitive Impairment and Low Literacy	2
Quadriplegic	1

** Note that some participants fit into multiple categories; complete demographic data is available in the appendix of this report. Mild cognitive impairment and low literacy were related.*

Testing Procedure

Testing was filmed with two cameras: one for the participant's face and hands and one for the screen of the voting equipment. The ExpressVote machine was set up using the stand provided. The stand was set to the lower of two height settings to accommodate voters in a wheelchair or scooter. In sessions where audio instructions were either required or requested, sound from the voting equipment was routed through speakers instead of headphones for the purposes of recording. Participants were reassured that in actual voting, they would be using headphones rather than speakers for privacy. The researchers were trained as poll workers by the staff at Election Systems & Software so they could properly operate the voting machine as a poll worker would during an actual election.

During testing, voters were asked to fill out a ballot from a Maryland certification ballot.

Voters filled out most of the ballot without direction from the moderator. At the end of the ballot, voters were prompted to complete any of the following tasks that had not yet occurred naturally: filling in a write-in candidate, attempting to overvote, identifying and revising an undervote, and changing a vote in one or more contests. If voters had paused, looked uncertain, showed evidence of confusion or surprise, made a comment, or did anything unexpected, the moderator asked follow-up questions after the voting.

Participants checked in to vote as if with a poll worker, then marked and cast their ballots. Participants chose whether to vote using the touch screen, the navigation keypad, or the paddle buttons. Participants also chose whether or not to have sound. Some low-vision participants opted to use magnified text and no sound. Five of the 25 voters in the main test were asked to vote a second time using the paddle buttons, in order to provide additional data on this interface—resulting in 34 voting sessions total, including both the initial pilot test and the standard usability test.

Poll workers provided voters with a ballot and explained that it would need to be inserted in the ExpressVote machine. Poll workers also explained that after the ballot was marked, it would need to be removed and taken to the scanner for casting. If voters needed help getting to the ExpressVote, poll workers guided them to the machine. The poll worker asked if the voter needed audio, and asked which interface the voter would like to use. After observing 6 voters use the navigation keypad, it became clear that voters needed an introduction to the navigation keypad before marking their ballots. Unless this introduction is added to the interface, poll workers will need to provide this introduction to the navigation keypad. Starting with participant 17, this introduction was added to the initial poll worker instruction.

If a voter needed further help from a poll worker during the voting session, the voter could raise his or her hand.

After completing the ballot, the participants were asked a set of follow-up questions based on the System Usability Scale to assess subjective satisfaction with the voting process and voting equipment.

Observation and Analysis Procedures
Both qualitative and quantitative results were gathered during the course of this study. Qualitative results were in the form of observed usability issues that occurred during testing. Each issue was noted by a minimum of two independent observers. During analysis, these issues were assigned severity levels based on the definitions listed in the Qualitative Usability Issues and Recommendations section. For each usability issue listed, a corresponding recommendation was created, along with recommendations for further testing if relevant.

The quantitative measures used in this study included: votes cast not as intended, calls for assistance, time to mark and cast ballot, input errors, and subjective satisfaction scores. Specifics as to how these measures were calculated are listed below.

Votes Cast Not as Intended - Votes cast not as intended are defined as votes that did not accurately reflect the voters' intentions when they were cast: i.e., the voter accidentally marked and cast the ballot in ways that did not reflect the voter's intentions. This count may also include votes that were not cast successfully. In order to obtain this measure, researchers marked possible instances of votes being cast not as intended, then the voters' actual intentions were verbally confirmed with participants after the voting session.

Calls for Assistance - During a voting session, voters received aid only when they clearly indicated they needed help from the "poll worker" (i.e., the moderator). In order to simulate possible procedures in a real election, voters were asked to raise their hand in order to call over a poll worker for help. Once the poll worker had resolved the voter's questions, the poll worker would leave. If the voter required additional assistance, the voter raise his or her hand again in order to recall the poll worker.

Time to Mark and Cast Ballot - The time to mark and cast the ballot was measured in two ways:

- From when the participants first inserted their ballot into the ExpressVote machine to when they printed and removed the marked ballot
- From when the participants first inserted their ballot into the ExpressVote machine to when the ballot scanner/tabulator counted the ballot

Input Errors - Input errors (as defined in the Input Errors subsection under Quantitative Results) were observed by two independent observers during testing. After testing, two additional observers re-watched all of the sessions to confirm the error counts. If the error counts differed between the observers, then the error counts of the final observers were averaged.

Subjective Satisfaction Scores – Subjective satisfaction scores were collected verbally after the voting session, using a modified version of the System Usability Scale. If voters had two voting sessions, using different controllers, they were asked for their subjective satisfaction ratings after each session. Average and median were calculated for each question, as well as an overall score; these scores are available in the appendix.

Quantitative Results

The tables in this section present the quantitative data collected from testing Election Systems & Software's ExpressVote system, including votes cast not as intended, calls for assistance, average time required to mark and cast ballot, and input errors.

Votes Cast Not as Intended

The most serious error in voting is when a voter accidentally casts a vote that does not reflect the voter's intention. Two of the 34 voting sessions using the ExpressVote system (including one from the initial pilot test and one from the standard usability test) resulted in votes cast that did not accurately reflect the voters' intentions. Discrepancies between the cast ballot and the voter's intentions were verified verbally after the ballot was cast. Both of the ballots cast not as intended occurred during sessions with blind voters using the Navigation Keypad.

Table 2 - Summary of Votes Cast Not as Intended

PARTICIPANT #	CONTROLLER USED	FACTOR(S) AFFECTING INDEPENDENT VOTING	DESCRIPTION OF OCCURRENCE
P04 (Pilot)	Navigation Keypad	Blind, Over 65	The voter received an error message which instructed her to press the left arrow to continue voting or the right arrow to exit and receive her ballot card. The participant interpreted this message as the end of the ballot and had the ballot ejected. When she had received her ballot she thought that her selections had been printed on it when it had actually returned a blank ballot.
P27	Navigation Keypad	Blind	The voter had reached the end of the ballot review and wanted to go back to change one of her votes. She accidentally hit the wrong button, which printed her ballot instead of returning to the review screen.

Calls for Assistance

As noted above, another issue that affects voter experience is the degree to which voters can vote independently, without requesting special assistance from poll workers. During 26 voting sessions (out of 34 voting sessions total, including the initial pilot tests), 25 participants made 55 calls for assistance by raising their hands to signal a poll worker. The highest number of calls for assistance by a single voter was four. Four participants were able to vote without any additional assistance. Additionally, four of the five participants who were asked to use the Paddle Button controller after using one of the other controllers did not call for assistance during their session with the Paddle Button controller.

Noteworthy categories of calls for assistance included the following:

- Need for assistance in adjusting the initial volume control (3 voters). This may or may not be a requirement in actual election sessions, during which voters would be using headphones rather than listening to the audio through speakers. If polling places are noisy, voters are likely to need help adjusting the volume.
- Need for assistance in initially inserting the ballot into the ExpressVote machine (2 voters)
- Need for guidance in writing in a candidate (6 voters)
- Need for guidance in how to proceed/where to submit the ballot after it was printed (3 voters)
- Need for assistance in locating the scanner (10 voters)
- Need for assistance and/or guidance in inserting the printed ballot in the scanner (6 voters)
- Desire for reassurance that the vote was cast successfully (6 voters)

Table 3 - Calls for Assistance by Voter Characteristic

PARTICIPANT CHARACTERISTIC	NAVIGATION KEY PAD	PADDLE BUTTONS	TOUCH SCREEN	TOTAL
Blind (10 out of 10 voters)	26	1	0	27
Low Vision (8 out of 9 voters)	6	0	12	18
Impaired Mobility (5 out of 8 voters)	2	1	4	7
Impaired Dexterity (2 out of 5 voters)	0	1	1	2
Over 65 (3 out of 3 voters)	9	0	0	9
Impaired Hearing (2 out of 2 voters)	0	0	3	3
Mild Cognitive Impairment and Low Literacy (2 out of 2 voters)	0	0	3	3
Quadriplegic (1 out of 1 voters)	0	0	2	2

** Individual voting sessions are counted more than once in cases where the voter had more than one of the listed participant characteristics. An explanation of input error types is provided under Input Errors in the Quantitative Results section of this report.*

Table 4 - Summary of Assistance Needed and Help Rendered

PARTICIPANT #	INTERFACE USED	SUMMARY OF ASSISTANCE
P01 Blind	Navigation Keypad	1. The voter did not know how to write in a candidate and needed to be instructed by the poll worker. 2. Later, the voter wanted to perform an additional write-in but had forgotten how and needed to be reminded by the poll worker. 3. The voter required a poll worker to escort her to the scanner.
P02 Blind	Navigation Keypad	1. The voter could not hear the initial audio instructions and was unfamiliar with the navigation keypad so she required assistance from a poll worker in order to increase the volume. 2. During the write-in session, the voter asked the poll worker where she could find the space key. 3. The voter asked the poll worker how she could go back and change one of her votes. 4. The voter required a poll worker to escort her to the scanner.
P03 Low Vision	Touch Screen	1. The voter asked the poll worker if there was a button that would allow her to review her ballot at any time during the voting process.
P04 Blind, Over 65	Navigation Keypad	1. The voter encountered a system error and could not continue. The poll worker reset the machine and began the voting session again. 2. The voter did not know how to write in a candidate and needed to be instructed by the poll worker. 3. During the write-in session, the voter had difficulty understanding the audio and was unable to tell if she had spelled the name of her candidate correctly. She asked the poll worker to read aloud the letters that had been entered. 4. The voter required a poll worker to escort her to the scanner.

Table 4 (Continued) - Summary of Assistance Needed and Help Rendered

PARTICIPANT #	INTERFACE USED	SUMMARY OF ASSISTANCE
P05 Mild Cognitive Impairment and Low Literacy	Touch Screen	1. The voter was unsure how to proceed after the ballot was printed. The poll worker instructed him to insert the printed ballot into the scanner. 2. After successfully inserting his marked ballot into the scanner/tabulator, the voter called a poll worker and asked what he had to do next.
P06 Low Vision	Touch Screen	1. The voter needed confirmation from the poll worker as to whether he had successfully voted.
P07 Blind and Impaired Mobility	Navigation Keypad	1. The voter required assistance from a poll worker in order to increase the volume of the audio instructions. He could not hear the initial audio and wasn't sure if it was too quiet or if he needed to press a button to start it. 2. The voter required a poll worker to escort him to the scanner.
P08 Quadriplegic	Touch Screen	1. The voter (who had requested audio despite using a touch screen) was confused by the audio since it was giving him instructions that were only appropriate for the navigation keypad and not applicable to the touch screen interface. The participant requested clarification of how he should proceed. 2. Since the participant was unable to hold the ballot himself, he required a poll worker to take the ballot out of the ExpressVote machine and insert it into the scanner.
P09 Low Vision, Over 65	Navigation Keypad	1. The initial volume level was too low for the participant, so he couldn't hear how to begin the voting session. The poll worker helped him to adjust the audio level and got him started. 2. The voter asked the poll worker again how he could make the volume louder. 3. The voter asked the poll worker to restart his voting session so he could start again at the beginning. 4. The voter asked how he should insert the ballot into the scanner.

Table 4 (Continued) - Summary of Assistance Needed and Help Rendered

PARTICIPANT #	INTERFACE USED	SUMMARY OF ASSISTANCE
P11 Mild Cognitive Impairment and Low Literacy	Touch Screen	1. The voter did not realize that the ballot scanner/tabulator also casts the ballot. She called a poll worker to ask if she was going to receive the ballot back after it was inserted.
P12 Low Vision	Touch Screen	1. The voter asked for instructions about where to submit his ballot once he had finished voting.
P13 Impaired Mobility and Dexterity	Paddle Buttons	1. The voter did not understand how to navigate the ballot with the paddle buttons. Specifically, he did not understand that the paddle buttons only cycle through the options which are currently visible on the screen, instead of cycling through all available options. He wanted to know how he could scroll back up through the options. The poll worker told him to select the “more” option on screen in order to navigate through all available candidates.
P14 Blind	Navigation Keypad	1. The voter needed an explanation of the keys on the Navigation Keypad. 2. The voter required a poll worker to escort him to the scanner.
P15 Low Vision and Hearing Impairment	Touch Screen	1. The voter struggled with initially inserting the ballot into the ExpressVote machine and had to call a poll worker to help him insert the ballot at the correct angle. 2. After the voter inserted the ballot into the scanner/tabulator, he was unsure if he was finished voting or if he should wait for the ballot to come back out. He required confirmation from a poll worker to ensure that he had finished voting.
P16 Low Vision	Touch Screen	1. The voter was unsure how to go back and change her vote in a contest. 2. Once at the scanner, the voter had to ask a poll worker how to insert the ballot into the machine. 3. The voter fed the ballot into the incorrect slot and required assistance from a poll worker in order to submit it into the correct tray.

Table 4 (Continued) - Summary of Assistance Needed and Help Rendered

PARTICIPANT #	INTERFACE USED	SUMMARY OF ASSISTANCE
P17 Blind	Navigation Keypad	1. The voter did not know how to insert a space during her write-in vote. 2. Once the participant had finished marking her ballot, she was unsure how to scan it for the vote to be cast. She called a poll worker, who escorted her to the scanner. 3. Once the ballot was placed into the scanner, the voter was unsure whether she had successfully cast her vote or not.
P17 Blind	Paddle Buttons	1. The participant accidentally hit the exit button, and was alerted that she could exit the voting session and eject her ballot. She called a poll worker to assist her in returning to the voting session.
P18 Blind	Navigation Keypad	1. The voter required a poll worker to escort him to the scanner and explain how to insert the ballot.
P19 Low Vision	Touch Screen	1. The voter could not read the text at the minimum zoom level and called a poll worker for help. The poll worker showed her how to increase the default zoom setting. 2. The voter did not know how to write in a candidate and required additional instruction for a poll worker. The participant had yet to see the write-in option during her voting session because she was at the maximum zoom level and did not click the "more" button in order to scroll through additional candidates and possible write-In selections. 3. Once the voter inserted the ballot into the scanner/tabulator, she had to call a poll worker in order to confirm that she was finished voting. 4. The voter needed confirmation from a poll worker that she had successfully cast his ballot.
P20 Impaired Mobility	Touch Screen	1. The voter needed confirmation from a poll worker that he had successfully cast his ballot.

Table 4 (Continued) - Summary of Assistance Needed and Help Rendered

PARTICIPANT #	INTERFACE USED	SUMMARY OF ASSISTANCE
P23 Impaired mobility	Touch Screen	1. The voter struggled with initially inserting the ballot into the ExpressVote machine and eventually had to call a poll worker for assistance. 2. Once the voter inserted the ballot into the scanner/tabulator, she had to call a poll worker in order to confirm that she was finished voting.
P24 Impaired Mobility, Impaired Dexterity, and Hearing Impairment	Touch Screen	1. The voter did not know how to write in a candidate and required additional instruction from a poll worker.
P26 Blind and Over 65	Navigation Keypad	1. The voter required a poll worker to escort him to the scanner, explain how to insert the ballot, and ensure the process had been completed.
P27 Blind	Navigation Keypad	1. The voter did not know what a write-in was and needed it to be explained by the poll worker. 2. The voter did not know how to insert a space into the name of her write-in candidate. 3. The voter required a poll worker to escort her to the scanner.
P28 Low Vision	Navigation Keypad	1. The voter required a poll worker to escort her to the scanner. 2. The voter needed confirmation that her vote had been successfully cast.
P29 Blind	Navigation Keypad	1. The voter required a poll worker to escort him to the scanner. 2. The scanner rejected the voter's ballot and he required assistance from a poll worker. He was told to insert the ballot into the upper slot of the scanner. 3. After having correctly inserted the ballot into the scanner, the voter asked for confirmation that his vote had been successfully cast.

Average Time to Mark and Cast Ballot

Voter experience is also affected by the amount of time it takes to mark and cast a ballot, especially when others are waiting. This was measured in two ways:

- From when the participants first inserted their ballot into the ExpressVote machine to when they printed and removed the marked ballot (time to mark ballot)
- From when the participants first inserted their ballot into the ExpressVote machine to when the ballot was inserted into the scanner/tabulator (time to mark and cast ballot). If the ballot had to be inserted more than once before the vote was counted, the time to the final (successful) insertion was counted.

For purposes of evaluating the total voter experience, the latter information (time for voters to mark and cast their ballot) is both more relevant and more directly comparable to voting systems that include ballot tabulation as an automatic part of the voting process.

Time to Mark Ballots

Times for voters to mark ballots using the Navigation Keypad ranged from 8:44 minutes to 19:20 minutes, with an average of 15:00. Times with the paddle buttons ranged from 12:27 minutes to 17:03 minutes, with an average of 14:13. Times for touch screen users ranged from 4:15 to 12:38, with an average of 7:50.

Table 5 - Average Times to Mark Ballot

PARTICIPANT CHARACTERISTICS	# OF SESSIONS	NAV. KEYPAD	PADDLE BUTTONS	TOUCH SCREEN
Blind	6	14:07 *(5 voters)*	17:03 *(1 voter)*	-
Blind and Impaired Mobility	1	18:50 *(1 voter)*	-	-
Blind and Over 65	1	17:19 *(1 voter)*	-	-
Low Vision	6	15:49 *(1 voter)*	-	09:00 *(5 voters)*
Low Vision and Over 65	1	12:32 *(1 voter)*	-	-
Low Vision and Hearing Impaired	1	-	-	09:04 *(1 voter)*
Impaired Mobility	3	-	14:46 *(1 voter)*	05:19 *(2 voters)*
Impaired Mobility and Impaired Dexterity	6	-	13:05 *(3 voters)*	06:20 *(3 voters)*
Impaired Mobility, Impaired Dexterity, and Hearing Impairment	1	-	-	06:06 *(1 voter)*
Quadriplegic	1	-	-	10:00 *(1 voter)*
Mild Cognitive Impairment and Low Literacy	2	-	-	8:50 *(2 voters)*
CONTROLLER AVERAGE		**15:00 (9 voters)**	**14:13 (5 voters)**	**7:50 (15 voters)**

Time to Mark and Cast Ballots

Times for voters to mark and cast ballots using the Navigation Keypad ranged from 13:25 minutes to 21:03 minutes, with an average of 17:34. Times with the paddle buttons ranged from 13:29 minutes to 17:42 minutes, with an average of 15:12. Times for touch screen users ranged from 5:30 to 13:23, with an average of 8:34.

Table 6 - Average Times to Mark and Cast Ballot*

PARTICIPANT CHARACTERISTICS	# OF SESSIONS	NAV. KEYPAD	PADDLE BUTTONS	TOUCH SCREEN
Blind	5	17:54 *(4 voters)*	17:42 *(1 voter)*	-
Blind and Impaired Mobility	1	20:09 *(1 voter)*	-	-
Blind and Over 65	1	18:37 *(1 voter)*	-	-
Low Vision	6	16:45 *(1 voter)*	-	9:40 *(5 voter)*
Low Vision and Over 65	1	13:25 *(1 voter)*	-	-
Low Vision and Hearing Impaired	1	-	-	9:50 *(1 voter)*
Impaired Mobility	2	-	-	6:30 *(2 voters)*
Impaired Mobility and Impaired Dexterity	5	-	13:57 *(2 voters)*	7:11 *(3 voters)*
Impaired Mobility, Impaired Dexterity, and Hearing Impairment	1	-	-	6:41 *(1 voter)*
Quadriplegic	1	-	-	10:13 *(1 voter)*
Mild Cognitive Impairment and Low Literacy	2	-	-	9:29 *(2 voters)*
CONTROLLER AVERAGE		**17:34 (8 voters)**	**15:12 (3 voters)**	**8:34 (15 voters)**

**Some participants voting for a second time did not cast their ballot for a second time.*

Input Errors
The most frequently observed error was **button confusion**. Button confusion occurred when voters pressed an incorrect button, resulting in an action that was different than the one they intended.

Cursor selection errors occurred primarily during the write-in sessions, when the voter entered an incorrect or unintentional selection. This error differs from button confusion, in that they were using the correct buttons to select an option, but they made selections they did not intend due to difficulty controlling the cursor or difficulty identifying the current location of the cursor.

Deactivated button presses were not an issue with this system.

Each physical interface had a different level of button/touch sensitivity, leading to both **button sensitivity** and **button insensitivity** errors. Button insensitivity was most often experienced by voters with limited dexterity who chose to use the touch screen interface. These voters sometimes had to press the touch screen multiple times to get touches to register.

Button sensitivity errors were most commonly experienced by voters using the paddle buttons. These occurred when the voter pressed once but the interface registered it as two touches. While the low resistance of the paddle buttons makes the controller easier to use for voters with limited dexterity, it also increases the number of sensitivity errors. Most of the sensitivity errors that occurred with the paddle buttons resulted from the voter accidently pressing an unintended button while balancing the controller in his/her lap. A stand or table where voters could place the paddle button controller during voting might help to reduce this error.

Table 7 - Average Number of Errors by Controller

	Button Confusion	Cursor Selection Error	Deactivated Button Presses	Button Insensitivity	Button Sensitivity	TOTAL (AVERAGE)
Navigation Keypad (9 voters)	5.61	0	0	0	0	5.61
Touch Screen (15 voters)	1.33	0.23	0	4.23	0.2	6
Paddle Buttons (6 voters)	2.33	0.75	0	1.25	0.83	5.17

Table 8 - Percentage of Participants That Experienced Controller Error

	Button Confusion	Cursor Selection Error	Deactivated Button Presses	Button Insensitivity	Button Sensitivity
Navigation Keypad (9 voters)	7 voters (78%)	0 voters (0%)	0 voters (0%)	0 voters (0%)	0 voters (0%)
Touch Screen (15 voters)	8 voters (53%)	3 voters (20%)	0 voters (0%)	12 voters (80%)	2 voters (13%)
Paddle Buttons (6 voters)	5 voters (83%)	3 voters (50%)	0 voters (0%)	2 voters (33%)	2 voters (33%)

Qualitative Usability Issues and Recommendations

The tables in this section present the qualitative data collected from testing the ExpressVote system, including usability issues and recommendations, and recommendations for poll worker training.

Qualitative Usability Issues and Recommendations

We observed 4 issues that prevented task completion, caused a significant error, or led to a vote not being cast as intended. There were 18 errors that caused a significant delay and/or frustration. There were also 9 errors that caused minor frustration but did not affect task success or cause a significant delay, including one that was fixed by the vendor during the testing. As some of these issues can be mitigated by poll worker involvement, recommendations for poll worker training are included.

Usability issues are listed separately by ExpressVote equipment or interface element:

- Audio
- Navigation keypad
- Touch interface
- Paddle buttons
- Voting machine stand
- Initial interaction and screen
- Voting screen
- Zoom
- Write-in
- Review screen
- Scanner
- General

Description of Severity Levels

Below is the full list of usability issues that were noted during testing. Each issue was assigned a severity level based on the following definitions:

High: *Problem could lead to a vote not being cast as intended; may prevent task completion or lead to error*

Moderate: *Problem creates significant delay and frustration; extra effort is required to overcome*

Low: *Problem will reduce satisfaction and may cause some frustration, but is not likely to affect task success or cause significant delay*

Table 9A - Usability Issues: Audio

#	OBSERVATION	SEVERITY	RECOMMENDATION
1.	The recorded audio only provides instructions for using the navigation keypad. No audio instructions for using the paddle buttons or the touch interface were provided. We assume that audio instructions for using the paddle buttons and the touch interface will be provided, but we are concerned that when the audio is provided for the paddle buttons or for those who need audio but want to use the touch interface, it will not have been tested.	HIGH	Make sure the audio matches the controller being used. Perform user testing for usability and accessibility of the additional audio.
2.	The instructions for casting the paper ballot stop playing as soon as the paper ballot is removed from the marking system. Yet at one point in the instructions, voters are told to remove the ballot. Some voters who removed the ballot immediately then missed the instructions about how to cast the ballot, and were forced to request help from a poll worker. Voters could think that they are finished and that the printed ballot is their receipt, leading to lost votes.	HIGH	Instructions for casting the ballot should finish playing—at the same volume level—even after the ballot has been removed.
3.	When using headphones, some voters had trouble hearing the audio playback, and they were not always able to adjust the volume without help from a poll worker (see Usability Issue 4 below). This problem would probably occur more often in a potentially loud polling place. Additionally, when the voter first inserts the ballot, the instructions do not repeat as the voter adjusts the volume. When voters increase the volume or press any other button, the system provides a tone at a constant volume, so the confirmation that the volume is increasing is inadequate.	MODERATE	Initial volume should be set at a somewhat louder level. When the volume level is changed, the current instructions should be repeated.

Table 9A (Continued) - Usability Issues: Audio

#	OBSERVATION	SEVERITY	RECOMMENDATION
4.	The volume of the audio instructions can only be adjusted using the navigation keypad. Voters using the audio along with the touchscreen interface or with the paddle buttons could not increase the volume. The only way for these voters to increase the volume was to ask for help from a poll worker, who could use the navigation keypad. Some users who did not ask a poll worker for help ended up voting without being able to hear the instructions as clearly as they wished.	MODERATE	Volume controls need to be added to the touchscreen interface.
5.	The recording of individual letters is unclear on several occasions: The Letters “T” and “D” sound the same. The letter “I” was also unclear, causing one participant to call for a poll worker in order to confirm which letters she had selected.	MODERATE	The audio recording should be improved so that individual letters are better enunciated.

Table 9B - Usability Issues: Navigation Keypad

#	OBSERVATION	SEVERITY	RECOMMENDATION
6.	Voters were sometimes confused by the button options on the navigation keypad, and they often needed additional instruction from a poll worker in order to begin. Even voters who received an explanation of the keypad from a poll worker did not remember the function of all the buttons during their voting session. Few users found the HOME button, which would have provided a review of the button functions.	MODERATE	Poll workers need to provide an introduction to the keypad. They also need to emphasize the availability of the HOME/HELP button for review. The HOME button should probably be renamed the HELP button. Similarly, TEMPO should probably be renamed SPEED Consider reducing the number of options on the keypad. (For example, PAUSE may be unnecessary.)
7.	The mapping of braille labels on the keypad caused confusion for some voters.	LOW	Remap (and test) a new layout for the braille labels so that labels are located closer to their buttons.

Table 9B (Continued) - Usability Issues: Navigation Keypad

#	OBSERVATION	SEVERITY	RECOMMENDATION
8.	One voter accidentally pressed the PAUSE button during her session, leading her to believe that the audio had stopped working. She was not able to proceed without assistance from a poll worker.	LOW	The pause button should only pause the current audio instruction. If the user navigates to a new audio segment the audio should restart. Consider separating the main navigation and selection buttons from the buttons that provide additional options (i.e. the pause, repeat, home, tempo, and volume buttons) in order to prevent accidental button presses. (This has been partly done, but not completely.)
9.	The braille abbreviations were confusing for some voters.	LOW	Change the "home" button to a "help" button (in both the braille/ text on the keypad and in the audio as well). Consider spelling out full words in braille (e.g. “VOLUME” instead of “VOL”) . Consider finding simpler words (e.g., “SPEED” instead of “TEMPO”).

Table 9C - Usability Issues: Touch Interface

#	OBSERVATION	SEVERITY	RECOMMENDATION
10.	Some impaired dexterity voters experienced button insensitivity errors with the touch screen. For these participants, some actions required multiple "touches."	LOW	We do not recommend a change.

Table 9D - Usability Issues: Paddle Buttons

#	OBSERVATION	SEVERITY	RECOMMENDATION
11.	One voter experienced button confusion due to the “YES” and “NO” labels on the paddle buttons. These labels did not correspond to any actions/responses on the ballot.	MODERATE	Relabel the paddle buttons to better correspond with the actions they perform during voting (e.g. “MOVE” and “SELECT” instead of “YES” and “NO”).

Table 9E - Usability Issues: Voting Machine Stand

#	OBSERVATION	SEVERITY	RECOMMENDATION
12.	The position of the stand has only two settings - high and low. The higher of the two settings was too tall for users in wheelchairs and the lower setting required users in certain scooters or motorized chairs to lean forward or hunch over to read the ballot screen. Additionally, the stand provided with the ExpressVote system did not allow all voters in wheelchairs and scooters to get close enough to it to be comfortable. Two users had to position their chairs facing to the side instead of directly looking at the screen in order to get close enough to vote. Other voters had to lean out of their wheelchair or scooter to vote. With varying levels of trunk control for voters, leaning out of the chair would not be an option for everyone. Some voters in wheelchairs bumped into the stand with some force while trying to get close enough to vote.	HIGH	Provide a stand with legs further apart so voters with wheelchairs and scooters can fit their legs under the stand. Make the stand adjustable in height. Ideally, it would also be more sturdy, to reduce the danger that it could be knocked over.

Table 9E (Continued) - Usability Issues: Voting Machine Stand

#	OBSERVATION	SEVERITY	RECOMMENDATION
13.	For users with decreased dexterity, holding either the navigation keypad or paddle buttons in their hand or balancing it on their lap was difficult. In one instance, an elderly blind voter placed the navigation keypad on the touch screen in order to press the buttons on the keypad. This led to accidental button pushes on the touch screen when her hand accidentally rested on it.	MODERATE	Consider adding a place for the keypad to the stand. If this cannot be done, then polling places should consider placing the Express Voting machine on a table where participants can get comfortably close and also place controllers or belongings on the table. Audio instructions for voters using the navigation keypad need to include a warning not to touch the touchscreen during the voting session. We do not recommend disabling the touchscreen, because some voters found it easiest to mark their ballot using a combination of the touchscreen and one of the other controllers.
14.	Users had trouble figuring out where to place the controllers after they were done voting. Most users tried to place it to the left side or on top of the screen.	LOW	Consider including a side table or slot in the front of the voting machine to place controllers on.

Table 9F - Usability Issues: Initial Interaction and Screen

#	OBSERVATION	SEVERITY	RECOMMENDATION
15.	Inserting the ballot into the ExpressVote machine was difficult for both blind and sighted voters. Some blind and low vision voters had difficulty locating the slot where the ballot needed to be inserted. Some then had difficulty figuring out the correct angle for inserting the ballot once they had found the slot. Some sighted voters also had difficulty inserting the ballot at the correct angle. This error occurred because the angle pictured on the machine does not match the angle needed to correctly insert the ballot.	MODERATE	Improve audio instructions to help blind users find the correct slot to insert the ballot or have poll workers assist them in inserting the blank ballot. Revise the instructional drawing on the front of the Express Voting machine to clearly demonstrate the proper angle needed to correctly insert the ballot. Revise the slot itself to provide better visual guidance, including some visual contrast (rather than uniform black).

Table 9G - Usability Issues: Voting Screen

#	OBSERVATION	SEVERITY	RECOMMENDATION
16.	When voters have already made a selection in a single-vote contest, and then make a second choice, the system automatically deselects their first choice and selects the second choice instead of confirming with voters that they want the first choice deselected. While this did not cause any observed problems during the testing, it represents a violation of best practice.	MODERATE	In a single-vote contest, require voters to deselect their first choice before selecting a new choice.
17.	Some voters did not find the "MORE" bar/button which allows voters to scroll through candidates on the touch screen (located at the bottom of each screen in contests with several candidates). Users tend to only notice the “MORE” bar if they get to the alert screen which says they have not heard all of the candidates. The majority of users just kept clicking "next." Voters using the audio expected the audio to read them all the available options for a given contest. They could not see the screen, so did not expect to need to select a “MORE” button in order to hear the rest of the names.	MODERATE	Eliminate the “MORE” button from the audio; make sure the audio reads all the selections in a contest. For sighted voters, consider redesigning the “MORE” bar to look more like a button by making it equal in width to the candidate selections (currently it is the full width of the screen).
18.	"MORE" bar at times was confused to be "Next."	LOW	Relabel the “MORE” buttons as “SEE MORE NAMES” (and make it less wide).
19.	In contests where voters can vote for multiple candidates, some users "lost count" of how many choices they could still make.	LOW	Consider providing a visual cue to let the user know how many votes they have left or how many they voted for out of the total votes available.

Table 9H - Usability Issues: Zoom

#	OBSERVATION	SEVERITY	RECOMMENDATION
20.	Some low vision voters could not read the screen even with the maximum zoom.	MODERATE	Increase the default text size, so that zoomed text will also be larger.
21.	Some low vision voters needed larger text, but did not find the zoom button and did not know that zoom was available.	MODERATE	Create a stronger visual cue for the zoom and contrast buttons. Consider making these buttons larger and easier to read in their default size. Consider providing a screen of customization options at the beginning of the voting session (audio, speed, text size, contrast, language).

Table 9I - Usability Issues: Write-in

#	OBSERVATION	SEVERITY	RECOMMENDATION
22.	Many voters relying on the audio instructions had trouble finding the space bar when attempting to write in a candidate. The audio mentions that there are clear and backspace options but does not mention a space bar key. Some users typed in only the first name of their candidate. Additionally ,the audio instructions tell users to use the arrow keys to move to the clear and backspace options, but do not explain that these options are located after the letters of the alphabet.	MODERATE	Improve initial audio for the write-in session so that the user knows to cycle through the alphabet in order to locate the clear, space and backspace buttons.
23.	Some voters who used both audio and visual feedback experienced initial difficulty and confusion during write-in sessions, as the layout of the keyboard did not match the audio. Visually the letters were arranged as a QWERTY keyboard but the audio scrolled through the letters alphabetically. Experienced keyboard users are comfortable with QWERTY keyboards, but voters with less experience will be more successful with a keyboard in alphabetical order. An alphabetical keyboard will increase task success for some voters, at the cost of mild inconvenience for other voters.	MODERATE	Set the machine to display the alphabetical keyboard during a write-in session if audio is enabled. Consider replacing the QWERTY keyboard with an alphabetical keyboard.
24.	Some users did not realize that they could write in who they wanted to vote for. Many users asked "what is a write-in?"	MODERATE	Consider changing the wording (both visually and in the audio) to "write in your own candidate."
25.	Initially, each letter was announced as a capital letter (e.g. "Capital A") though there was no way to choose between upper or lowercase letters in the write-in session.	LOW*	*This was changed during testing so now only the letters are said. Keep this change.

Table 9J - Usability Issues: Review Screen

#	OBSERVATION	SEVERITY	RECOMMENDATION
26.	Some voters used the back button to enter a previous contest instead of directly entering the desired contest through the review screen.	LOW	Consider providing a call to action on the contests in the review screen, e.g., “Touch here to change".

Table 9K - Usability Issues: Scanner

#	OBSERVATION	SEVERITY	RECOMMENDATION
27.	The ballot scanner was too high for some participants in wheelchairs or scooters to reach. One user had to pull himself up from his wheelchair to insert his ballot.	HIGH	Lower the height of the ballot scanner.
28.	Participants had a tendency to put ExpressVote ballots in the bottom tray rather than the top tray of the scanner, which sometimes resulted in rejected ballots and the need for poll worker assistance in order to recover. The instructional image showing the voter how to insert the ballot only shows full-size ballots being inserted in the bottom tray.	MODERATE	Revise the insertion process so that only one tray is required, or revise the instructional image to address both full-size and ExpressVote ballots.
29.	Several voters were unsure what to do when they approached the scanner with their paper ballot.	MODERATE	Provide a stronger visual cue and audio instructions on how to insert the ballot.
30.	Many voters expected to receive stronger confirmation that their vote had been cast, and sometimes requested help from a poll worker to confirm that their vote had been cast successfully. Blind voters were particularly anxious, as there was no audio confirmation.	MODERATE	Audio feedback is needed and the confirmation screen should be changed to indicate that the voter has successfully cast his/her vote.

Table 9L - Usability Issues: General

#	OBSERVATION	SEVERITY	RECOMMENDATION
31.	Several voters were unsure what to do once their ballot had printed from the ExpressVote machine.	MODERATE	Provide additional guidance about what to do with the paper ballot after the ballot is marked. Make sure that audio instructions for casting the ballot finish playing even after the ballot is removed from the slot. Make sure poll workers explain the process of printing the ballot and inserting it into the scanner before the voter begins the voting process.

Recommendations for Poll Worker Training

While changes to the voting system are the only way to guarantee improved voter experience, some of the usability issues we observed can be mitigated by proactive poll worker instruction. We have therefore listed a set of recommendations that should be considered for implementation in the Maryland poll worker training program if Election Systems & Software's ExpressVote system is adopted.

Table 10 - Recommendations for Poll Worker Training

#	OBSERVATION	RECOMMENDATION
1.	Many blind participants needed additional assistance at the start of voting while they became accustomed to the navigation keypad. Also, some participants never pressed the home button, so they never heard an explanation of the other buttons/features on the navigation keypad.	To ensure that voters understand how to use the navigation keypad, poll workers should provide a brief overview of all the controller buttons to users requesting to use the navigation keypad, with special attention to the home button as a way to hear a review of the overview.
2.	Many blind participants had difficulty at the start of voting because the volume was too low and they were unable to hear the audio instructions.	Since hearing the audio instructions is critical to a blind voter's ability to use the navigation keypad, it is important to ensure that the volume is set properly for each of these voters. Though an introduction to the keypad from a poll worker will help voters understand how to adjust the volume themselves, ensuring that the volume is set correctly at the beginning of the session will mitigate the need for later calls for assistance.

Table 10 (Continued) - Recommendations for Poll Worker Training

#	OBSERVATION	RECOMMENDATION
3.	The buttons to change the magnification and contrast settings had low visual discoverability, causing some participants to struggle with the ballot at the lesser magnification. Sometimes the magnification and contrast options were only discovered halfway through a session, and sometimes not at all. One participant who had not discovered the magnification option requested that a poll worker read the ballot to her because the text was too small for her to see.	As the magnification and contrast options may benefit a large number of voters (not just those who self-identify as having a disability), it may be useful for poll workers to explain to all voters that these options are available and can be found on the bottom of the screen during a voting session. As we discovered, those with low vision who need these options the most are more likely to miss them on screen, so a brief mention of the options will greatly benefit these users. (Note that the interface should also provide a screen to allow voters to choose their settings before beginning a voting session.)
4.	Many participants were unsure what to do once they had finished marking their ballot. In the case of blind voters, they were forced to call a poll worker in order to be led to the ballot scanner/tabulator.	The current ExpressVote does not have a strong indicator of what voters should do after printing their ballot. A brief explanation from the poll worker of how and where to insert their ballot once it has printed will greatly benefit voters. For blind voters, they must also be informed as to how they should contact a poll worker (once they have printed the ballot) so that they may be led to the ballot scanner/ tabulator.

Table 10 (Continued) - Recommendations for Poll Worker Training

#	OBSERVATION	RECOMMENDATION
5.	Some voters were unsure of what to expect once they inserted their ballot into the scanner/tabulator.	Poll workers should inform voters that the scanner/tabulator will scan their ballot and cast it within the machine. Voters should be told that the ballot will not come back out (unless there is an error) and they will not receive a receipt. Voters need to be informed that once the ballot is cast within the machine, they are finished voting.
6.	Voters often experienced difficulty inserting the blank ballot into the ballot-marking machine. This proved difficult for both sighted and non-sighted voters. Blind and low vision voters had difficulty locating the slot into which the ballot was to be fed. While sighted voters could locate this slot, many struggled to feed the ballot into the machine at the correct angle. The instruction graphic printed on the machine was misleading for voters, causing them to insert the ballot at an incorrect angle.	The visual design should be improved to increase contrast between the exact ballot insertion point and the surrounding black plastic material. The instruction graphic should be changed to reflect the correct angle for ballot insertion. and the instruction graphic should be improved so that voters can submit their ballots more successfully. Until improvements are made, this issue can be easily mitigated if the poll worker inserts the blank ballot for the voter before the start of a voting session.

Appendix

Table 11 - Participant Demographics

P#	Age	Gender	Race/Ethnicity	Factors Affecting Independent Voting	Controller Used	Time to Vote and Cast Ballot
P1	52	Female	Caucasian	Blind	Nav. Key Pad	*
P2	54	Female	Caucasian	Blind	Nav. Key Pad	*
P3	23	Female	Caucasian	Low Vision	Touch Screen	*
P4	65	Female	Caucasian	Blind and Over 65	Nav. Key Pad	*
P5	43	Male	African American	Mild Cognitive Impairment and Low Literacy	Touch Screen	10:25.1
P6	19	Male	Caucasian	Low Vision	Touch Screen	08:41.0
P7	34	Male	African American	Blind and Impaired Mobility	Nav. Key Pad	20:09.0
P8	49	Male	Caucasian	Quadriplegic	Touch Screen	10:13.2
P9	75	Male	Caucasian	Low Vision and Over 65	Nav. Key Pad	13:25.0
P10	51	Female	Caucasian	Impaired Mobility and Impaired Dexterity	Touch Screen	04:53.4
P11	50	Female	African American	Mild Cognitive Impairment and Low Literacy	Touch Screen	09:27.0
P12	57	Male	Caucasian	Low Vision	Touch Screen	09:49.8
P13	24	Male	African American	Impaired Mobility and Impaired Dexterity	Paddles	14:24.6
P14	44	Male	African American	Blind	Nav. Key Pad	20:42.7
P15	53	Male	Caucasian	Low Vision and Hearing Impaired	Touch Screen	13:22.9
P16	27	Female	Caucasian	Low Vision	Touch Screen	10:31.7

** These participants voted on a precinct 1A ballot (a ballot with fewer contests than the 1B ballot used), so their times were not included with the other scores.*

Table 11 (Continued) - Participant Demographics

P#	Age	Gender	Race/Ethnicity	Factors Affecting Independent Voting	Controller Used	Time to Vote and Cast Ballot
P17	58	Female	Caucasian	Blind	Nav. Key Pad	21:02.6
					Paddles	17:42.4
P18	41	Male	Caucasian	Blind	Nav. Key Pad	15:12.7
P19	56	Female	African American	Low Vision	Touch Screen	10:15.2
P20	48	Male	African American	Impaired Mobility	Touch Screen	07:16.7
P21	43	Female	Other	Impaired Mobility and Impaired Dexterity	Touch Screen	11:09.0
					Paddles	Did not cast ballot
P22	27	Female	African American	Impaired Mobility and Impaired Dexterity	Touch Screen	05:29.6
					Paddles	13:28.9
P23	54	Female	African American	Impaired Mobility	Touch Screen	5:44.0
					Paddles	Did not cast ballot
P24	60	Male	African American	Impaired Mobility, Impaired Dexterity, and Hearing Impairment	Touch Screen	06:40.7
					Paddles	*
P25	19	Male	African American	Low Vision	Touch Screen	05:31.4
P26	67	Male	Caucasian	Blind and Over 65	Nav. Key Pad	18:36.6
P27	49	Female	Caucasian	Blind	Nav. Key Pad	Did not cast ballot
P28	35	Female	Caucasian	Low Vision	Nav. Key Pad	16:45.2
P29	35	Male	Caucasian	Blind	Nav. Key Pad	14:39.5

** These participants voted on a precinct 1A ballot (a ballot with fewer contests than the 1B ballot used), so their times were not included with the other scores.*

Table 12 - Average Number of Errors by Participant Characteristic*

	Button Confusion	Cursor Selection Error	Deactivated Button Presses	Button Insensitivity	Button Sensitivity	TOTAL (AVERAGE)
Blind (8 sessions)	3.56	0.25	0	0	0.06	**3.88**
Low Vision (8 sessions)	5.38	0.13	0	2.56	0.25	**8.31**
Impaired Mobility (12 sessions)	1.08	0.33	0	4.00	0.38	**5.79**
Impaired Dexterity (8 sessions)	1.13	0.06	0	4.88	0.56	**6.63**
Over 65 (2 sessions)	16	0	0	0	0	**16**
Impaired Hearing (3 sessions)	0.67	0.17	0	0.67	1.5	**3**
Mild Cognitive Impairment and Low Literacy (2 sessions)	0	0	0	1	0	**1**
Quadriplegic (1 session)	0	1	0	0.5	1	**2.5**

** Individual voting sessions are counted more than once in cases where the voter had more than one of the listed participant characteristics. An explanation of input error types is provided under Input Errors in the Quantitative Results section of this report.*

Table 13 - Number of Errors by Participant

P#	Controller Used	Button Confusion	Cursor Selection Error	Deactivated Button Presses	Button Insensitivity	Button Sensitivity	TOTAL
P1	Nav. Key Pad	*	*	*	*	*	*
P2	Nav. Key Pad	*	*	*	*	*	*
P3	Touch Screen	*	*	*	*	*	*
P4	Nav. Key Pad	*	*	*	*	*	*
P5	Touch Screen	0	0	0	2	0	2
P6	Touch Screen	0	0	0	0	0	0
P7	Nav. Key Pad	0	0	0	0	0	0
P8	Touch Screen	0	1	0	0.5	1	2.5
P9	Nav. Key Pad	26	0	0	0	0	26
P10	Touch Screen	0.5	0	0	1	0	1.5
P11	Touch Screen	0	0	0	0	0	0
P12	Touch Screen	3.5	1	0	5.5	2	12
P13	Paddles	2	0	0	0	0	2
P14	Nav. Key Pad	1.5	0	0	0	0	1.5
P15	Touch Screen	0	0	0	0	0	0
P16	Touch Screen	5	0	0	1.5	0	6.5

**These participants voted on a precinct 1A ballot (a ballot with fewer contests than the 1B ballot used), so their error counts were not included with the other scores.*

Table 13 (Continued) - Number of Errors by Participant

P#	Controller Used	Button Confusion	Cursor Selection Error	Deactivated Button Presses	Button Insensitivity	Button Sensitivity	TOTAL
P17	Nav. Key Pad	8.5	0	0	0	0	8.5
P17	Paddles	5.5	2	0	0	0.5	8
P18	Nav. Key Pad	0.5	0	0	0	0	0.5
P19	Touch Screen	6	0	0	12.5	0	18.5
P20	Touch Screen	0.5	0	0	1	0	1.5
P21	Touch Screen	0	0	0	23	0	23
P21	Paddles	0	0	0	6	0	6
P22	Touch Screen	1	0	0	5.5	0	6.5
P22	Paddles	3.5	0	0	1.5	0	5
P23	Touch Screen	2.5	1.5	0	8	0	12
P23	Paddles	1	2	0	0	0	3
P24	Touch Screen	0	0	0	2	0	2
P24	Paddles	2	0.5	0	0	4.5	7
P25	Touch Screen	1	0	0	1	0	2
P26	Nav. Key Pad	6	0	0	0	0	6
P27	Nav. Key Pad	6.5	0	0	0	0	6.5
P28	Nav. Key Pad	1.5	0	0	0	0	1.5
P29	Nav. Key Pad	0	0	0	0	0	0

Table 14 - Subjective Satisfaction Scores for Navigation Keypad

Question	Average	Median
I would like to use this voting system in an election.	3.75	4
There were too many steps in using this voting system.*	2.08 (3.92)	2 (4)
I thought this voting system was easy to use.	3.67	4
The instructions for this voting system were difficult to understand.*	2.17 (3.83)	2 (4)
The buttons or touch screen were easy to use.	4	4
It was hard to move around the ballot with this system.*	1.67 (4.33)	1 (5)
I think that most people could learn to use this voting system very quickly.	3.92	4
I found this voting system awkward or difficult to use.*	2.25 (3.75)	2 (4)
I felt very confident that my vote was cast correctly with this voting system.	4.5	4.5
I would need help each time I used this voting system.*	2.42 (3.58)	2 (4)
The ballot text was easy to read or hear.	4.67	4
Casting my vote was easy.	4.08	4
Writing-in a candidate was easy.	3.17	3.5
Overall SUS score (out of 100): 72.6		

**These questions were inverted for calculating the final SUS score. Inverted values appear in parentheses.*

KEY: 1 = strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = strongly agree

Table 15 - Subjective Satisfaction Scores for Paddle Buttons Controller

Question	Average	Median
I would like to use this voting system in an election.	5	5
There were too many steps in using this voting system.*	2 (4)	2 (4)
I thought this voting system was easy to use.	4	4
The instructions for this voting system were difficult to understand.*	1 (5)	1 (5)
The buttons or touch screen were easy to use.	4	4
It was hard to move around the ballot with this system.*	1 (5)	1 (5)
I think that most people could learn to use this voting system very quickly.	5	5
I found this voting system awkward or difficult to use.*	2 (4)	2 (4)
I felt very confident that my vote was cast correctly with this voting system.	5	5
I would need help each time I used this voting system.*	4 (2)	4 (2)
The ballot text was easy to read or hear.	4	4
Casting my vote was easy.	4	4
Writing-in a candidate was easy.	2	2
Overall SUS score (out of 100): 76.9		

**These questions were inverted for calculating the final SUS score. Inverted values appear in parentheses.*

KEY: 1 = strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = strongly agree

Table 16 - Subjective Satisfaction Scores for Touch Screen

Question	Average	Median
I would like to use this voting system in an election.	4.375	5
There were too many steps in using this voting system.*	2 (4)	2 (4)
I thought this voting system was easy to use.	4.38	5
The instructions for this voting system were difficult to understand.*	2 (4)	2 (4)
The buttons or touch screen were easy to use.	4.44	5
It was hard to move around the ballot with this system.*	1.81 (4.19)	2 (4)
I think that most people could learn to use this voting system very quickly.	4.69	5
I found this voting system awkward or difficult to use.*	1.5 (4.5)	1.5 (4.5)
I felt very confident that my vote was cast correctly with this voting system.	4.31	4
I would need help each time I used this voting system.*	1.75 (4.25)	2 (4)
The ballot text was easy to read or hear.	4.13	4
Casting my vote was easy.	4.375	4.5
Writing-in a candidate was easy.	4.13	4.5
Overall SUS score (out of 100): 82.2		

**These questions were inverted for calculating the final SUS score. Inverted values appear in parentheses.*

KEY: 1 = strongly disagree 2 = disagree 3 = neither agree nor disagree 4 = agree 5 = strongly agree