Clemson University RAAV Final Report

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II. EXECUTIVE SUMMARY

The research conducted by the Prime III research team under the U.S. EAC Accessible Voting Technology Initiative has changed voting in the U.S.A. Voting machine manufacturers are creating universally designed voting machines, which were unheard of 10 years ago when Prime III was created. Prime III was the first universally designed voting machine intended for use by all voters. The results reported below include the Prime III interface design, implementation and evaluation. Also included in these results were multiple pilot and demonstration elections. You will also find the team was active in disseminating information about the research to elections officials and members of the general voting population. The Clemson University team moved to the University of Florida in 2014 where the voting research activities have continued under Dr. Gilbert's supervision.

A. Interface Design, Implementation & Evaluation

The Prime III interface is a multimodal user interface, meaning voters use it in multiple modalities, i.e. speech and touch. With the Prime III interface, voters that can't see, hear, and those without arms can all privately and independently vote on the same machine as anyone else. This design is a universal design that accommodates more voters on a single machine. Here's a summary of the major accomplishments conducted by the Prime III team.

Our early efforts on this grant began with incorporating the latest research and technological innovations to enhancing the interface design and system functionalities of the Prime III system. The team updated the Prime III interface to run within the web browser environment to improve portability and broaden access. This allowed Prime III to become a more commercial off-the-shelf (COTS) friendly system. In addition the Low Error Voting Interface (LEVI) designed by Dr. Ted Selker was integrated into Prime III, see figure 1. Prime III uses optical character recognition (OCR), to tally ballots. However, we have found that OCR software is about 90% accurate. As a result of these findings, we made a modification to the OCR software that will tally the results by reading each ballot and tallying the selection similar to how humans tally ballots. We call this process Informed OCR, or iOCR. We also conducted a sound detection study to evaluate the system's speech recognition at various levels of background noise. The goal of the study was to establish a threshold for when distortion occurs and speech recognition accuracy declines to establish a threshold for ambient noise to determine when speech recognition degrades. A setup using speakers inside a sound booth was used to imitate a voter marking their ballot using Prime III in a voting precinct.

In further exploring the imminent needs of the voting community, the Prime III team decided to expand its research efforts beyond the core Prime III system, by designing and developing solutions that address other gaps in the process that disenfranchises voters. For example, the Prime III Team created Televoting, designed to enable UOCAVA voters to return their ballots in a timelier manner versus mailing them back to the U.S.A. Per the request of the company Clear Ballot, the Prime III team produced a marked optical scan ballot as an option for the printout from Prime III. In response to the long lines of the 2012 Presidential Election, the Prime III Team developed VoterPass, a voter-line management tool designed to make voting more efficient. The Prime III team designed an Auto-Paper Handling concept for voting to make paper ballots accessible. Additionally, Balloting is a concept created by the Prime III team that involves the use of QR Codes for voting in an effort to make voting more efficient and accurate with respect to capturing the voter's intent. Voters mark a ballot online or using their phone. The resulting ballot is a QR Code that is scanned on Election Day at a Prime III voting machine. As a proof of concept, the Prime III team conducted a study using the 2012 Presidential optical scan ballot from Broward County, Florida. The results heavily favored the Balloting concept.

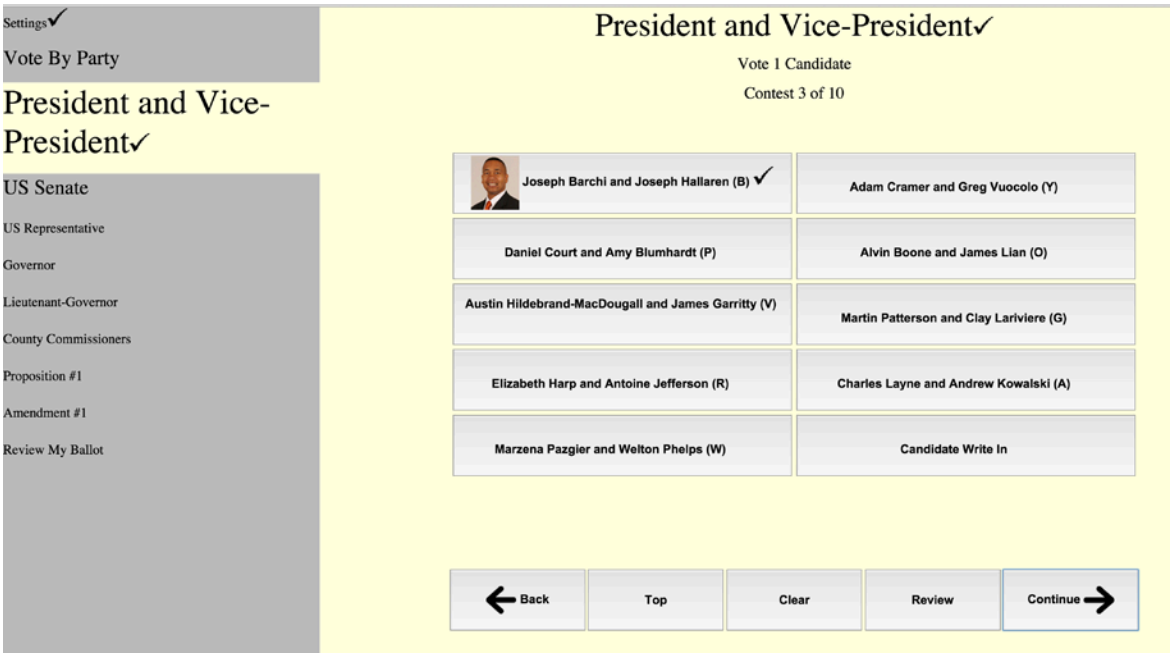

Figure 1: LEVI integrated into Prime III

B. Pilot and Demonstration Elections

To truly make a societal impact the Prime III team went beyond design and development in a laboratory space and took on partnerships and opportunities to put these efforts, theories and ideas to use in the public domain. There were more than 9 elections, or pilots, that used Prime III during the past 3 years. These elections range from student and national disability organizations to State elections. Prime III was used by National Society of Black Engineers (NSBE), National Council on Independent Living (NCIL) and Self Advocates Becoming Empowered (SABE) for their national elections over the life of the grant. In May of 2012, the State of Oregon used Prime III in the Presidential Primary in 5 counties. Dr. Gilbert also served as a participant on a roundtable discussion with the Presidential Commission on Election Administration (PCEA) in Cincinnati, OH where Prime III and Balloting were demonstrated to the commission. The Town of Newton and Town of Kossuth in Wisconsin used Prime III on April 1, 2014 in a statewide election. The election was a success, but there were many lessoned learned from this pilot. The State of New Hampshire used Prime III in a primary election in September 2014 in 2 precincts. The team also gave demonstrations to the League of Women Voters in South Carolina, election officials at Election Center meetings, and the team also consulted with the Los Angeles County Voting System Assessment Project (VSAP). Also, the Prime III team conducted the usability and accessibility evaluation of the ES&S ExpressVote machine. The resulting report was used in the certification of the ExpressVote machine.

C. Information Dissemination & Presentations

Much of the research and innovations the Prime III team implemented, were birthed from what was learned in the opportunities of information dissemination and presentations. In these opportunities the Prime III team interfaced with election officials and advocates that are on the ground. The team heard their needs and issues facing them in elections. In 2012, Dr. Gilbert gave presentations at the U.S. Access Board and he served as a panelist on the U.S. EAC Roundtable on Best Practices for Veterans Voting. He also gave a TEDx presentation and demo of Prime III in Greenville, South Carolina. The Clemson University Team gave presentations at the NIST Future of Voting Symposium on Prime III and

TeleVoting. Prime III team gave a demonstration of Televoting and Prime III on Capitol Hill in Washington, DC sponsored by Congressman James Clyburn of South Carolina. Prime III was demonstrated to several election officials in Savannah, GA at the Election Center Annual National Convention. As a result of this demonstration, the State of Wisconsin decided to pilot test Prime III in April 2014. In 2014, the team gave multiple presentations to the National Federation for the Blind, an accessible voting webinar sponsored by NIST, South Carolina: Laurens and Pickens County Election officials, Election Center Seminars (San Francisco, St Louis) and Richland County Columbia, SC election officials.

The future of voting has been positively impacted by the research we have conducted with Prime III. We have demonstrated concepts that were once thought impossible. For example, secure, accessible and usable voting. Prime III is the only voting technology, to our knowledge, that addresses all 3 of these requirements simultaneously for all voters on the same machine. We provided VoterPass and Balloting as methods to make voting more accurate, efficient and shorten lines. We provided a hands-free design to making paper universally accessible. We also created Televoting for overseas and military voters.

III. PERSONNEL

Juan E. Gilbert Ph.D. is the RAAV project primary investigator (PI). Dr. Gilbert has a B.S. degree in Systems Analysis from Miami University in Ohio and he received his M.S. and Ph.D. degrees in Computer Science from the University of Cincinnati. He is currently the Andrew Banks Family Preeminence Endowed Chair and Associate Chair of the Research Computer & Information Science & Engineering Department at the University of Florida. Dr. Gilbert has more than 20 years of research experience in usability, accessibility and advanced database systems. He has been designing and testing accessible voting systems for more than 10 years. Over the past 10 years, Dr. Gilbert has been a PI or Co-PI on more than 35 grants and contracts for more than $20 million dollars. Dr. Gilbert is a senior researcher who has worked with multiple organizations and researchers from coast-to-coast. He has also managed large-scale multi-year, multi-investigator, multi-institution research projects. Dr. Gilbert has published more than 100 articles, given more than 170 invited or keynote talks and he has received numerous awards for his research, leadership and innovative thinking. Dr. Gilbert has testified and served as an expert for the EAC, NIST, U.S. Senate and various other companies and organizations. He is a Fellow of the American Association for the Advancement Science (AAAS), an ACM Distinguished Scientist and one of the 50 most important African-Americans in Technology by eAccess Corp. He was also named a Speech Technology Luminary by Speech Technology Magazine and a national role model by Minority Access Inc. Dr. Gilbert is also a National Associate of the National Research Council of the National Academies, an ACM Distinguished Speaker and a Senior Member of the IEEE Computer Society. He was named a Master of Innovation by Black Enterprise Magazine, a Modern-Day Technology Leader by the Black Engineer of the Year Award Conference, the Pioneer of the Year by the National Society of Black Engineers, and he received the Black Data Processing Association (BDPA) Epsilon Award for Outstanding Technical Contribution. In 2002, Dr. Gilbert was named one of the nation's top African-American Scholars by Diverse Issues in Higher Education. Dr. Gilbert's research lab consists of 2 postdoctoral researchers and 16 graduate research assistants. He has directed more than 50 graduate degrees, including 13 Ph.Ds. In 2003, Dr. Gilbert's research team created Prime III, an accessible proof of concept voting system. His Prime III research team was awarded the Best Usability Metrics and Best Human Factors awards in the 2007 VoComp,

http://www.vocomp.org, competition in Portland, Oregon over other university teams that developed voting technologies.

James (Jim) Charles Dickson, who has more than 24 years of experience with non-partisan voter registration and education issues and served on the Board of Advisors to the U.S. Election Assistance Commission. Jim Dickson has 30 years experience with nonpartisan voter engagement issues. He is the former Vice President for Organizing and Civic Engagement for The American Association of People with Disabilities (AAPD). He led AAPD's nonpartisan Disability Vote Project, a broad coalition of 36 national disability-related organizations whose mission is to close the political participation gap for people with disabilities. The project focuses on voter registration and education, Get-Out-The-Vote drives, election reform and polling place access. Mr. Dickson played a central role with the Leadership Conference on Civil and Human Rights (LCCRH) effort to pass the Help America Vote Act (HAVA). He was part of the leadership team which passed The National Voter Registration Act. Mr. Dickson organized the campaign to place a statue of President Roosevelt in his wheelchair at the Franklin Delano Roosevelt Memorial on the National Mall in Washington, D.C. Mr. Dickson has organized grassroots, multi-issue organizations in Rhode Island, Connecticut and California. With the support of the Sierra Club, he organized the first grassroots congressional mobilization for the environmental movement, which resulted in the passage of the first Clean Air Act. In 1987, Mr. Dickson became the first blind person to sail a boat alone from Rhode Island to Bermuda. His objectives were to have a good time and to stimulate public discussion on the abilities of people with disabilities. Mr. Dickson is a graduate of Brown University.

Wanda Eugene is postdoctoral researcher in the Computer & Information Science & Engineering Department at the University of Florida, who specializes in the design of human centered computational artifacts, user interfaces. She is interested in how cultural, social, and personal surroundings affect the appropriation and can influence the design of new technologies. Dr. Eugene completed her doctoral studies in Computer Science and Software Engineering Department at Auburn University. She earned a bachelor's in Electrical Engineering a master's in Industrial Engineering from the Florida Agricultural and Mechanical University Florida State University College of Engineering, and a master's in Interdisciplinary Studies specializing in Instructional Technology and African American Studies from George Mason University. Prior to her current appointment she was a postdoctoral researcher at Clemson University in the Human Centered Computing Division where she served as the project coordinator on the Prime III team facilitating research studies.

IV. RESEARCH RESULTS

The Clemson University team was led by Dr. Juan Gilbert. The major results and accomplishments of this team will be described in the sections that follow. These results include Prime III interface design, implementation and evaluation. Also included in these results were multiple pilot and demonstration elections. You will also find the team was active in disseminating information about the research to elections officials and members of the general voting population. The Clemson University team moved to the University of Florida in 2014 where the voting research activities have continued under Dr. Gilbert's supervision.

When the U.S EAC awarded the Accessible Voting Technologies (AVT) grant to Clemson University under Dr. Gilbert's leadership, Dr. Gilbert had already been actively conducting research on how to make voting more accessible, usable and secure. This effort was manifested in voting system called Prime III. The Prime III system is a software tool that allows people to vote using touch and/or their voice. The system consists of a headset with a microphone, a touch screen, a 2-button switch and a printer. To make selections, voters can touch the screen, touch the switch and listen to the audio prompts, they can respond to the audio prompts with their voice and they can do all of these interchangeably. In other words, the voters do not have to specify how they will interact with the system; they simply use it. The Prime III interface is a multimodal user interface, meaning voters use it in multiple modalities, i.e. speech and touch. With the Prime III interface, voters that can't see, hear, and those without arms can all privately vote on the same machine as anyone else. This design is a **universal design**. Universal design refers to the fact that we design it once and multiple groups can use it.

A. Informed Optical Character Recognition (iOCR)

When the voters are done marking their ballot, the ballot is printed on an adjacent printer with only the contests and the selections the voter made. The printed ballot is the official ballot of record. This ballot is placed into a ballot box. Later, the ballot is scanned using an off the shelf scanner. The scanner takes a picture of the ballot and stores it on a computer attached to the scanner. The scanned images are then read by another piece of software called OCR (optical character recognition). OCR software is commonly used on most computers; however, it's not used in voting because it the accuracy rate isn't high enough for voting systems. We have found that OCR software is about 90% accurate. As a result of these findings, we made a modification to the OCR software. The modification is called Informed OCR, or iOCR. Given the fact that we have knowledge of the candidates and the contests that will appear on the ballot, we can use that information to correct mistakes made with the OCR. For example, a ballot may have the following selection for President.

1. President & Vice-President ==> Barack Obama & Joe Biden

When the OCR reads this line, it may produce something like

2. President Vice-President ==> Baran Odamu Joe Bibon

When we as humans see this, we know it's supposed to be the text from line 1. Therefore, using the information about the actual ballot options, we know that

President Vice-President ==> Baran Odamu Joe Bibon
are not options on the ballot, but

President & Vice-President ==> Barack Obama & Joe Biden

are options that are very similar to the OCR text that was produced. Therefore, the iOCR software will correct the OCR text to the correct ballot text. After iOCR has corrected the text, the software will tally the results by reading each ballot and tallying the selections. This approach was designed to model how humans tally ballots. We read them and score the results.

As such, we believe this will eliminate discrepancies between the machines' tally and any human tallies.

B. Prime III User Interface

In the beginning of the grant, the research team began making modifications to the Prime III interface. The original version of Prime III was developed in the Java programming language. Although Java runs on multiple devices, it's not very portable to modern mobile devices. Therefore, the team updated the Prime III interface to run within the web browser environment. This modification made the Prime III software immediately more accessible to more devices and ultimately more voters. We also implemented the Low Error Voting Interface (LEVI) designed by Dr. Ted Selker into Prime III. With these upgrades of the Prime III software, we were ready to do pilot elections, usability studies, and demonstrations.

C. Elections and Demonstrations

In 2012, the National Society of Black Engineers (NSBE) used Prime III in their national election. NSBE is the world's largest student run organization. They rented touchscreen computers and printers to conduct the election with Prime III. We had more than 200 voters use the software. We also tallied the results using the iOCR software. The election was a success and we have been doing the NSBE national election since 2012.

The National Council on Independent Living (NCIL) also used Prime III for their national election in 2012. NCIL is an organization of people with varying levels of ability or disability. In this election, the team didn't use the iOCR. Instead the team used barcodes on the ballots and a barcode scanner. This approach worked, but voters expressed concerns about what was actually in the barcode; therefore, we dropped the barcode implementation for tallies. The election had less than 100 voters, but the voters used the speech interface and other features of Prime III successfully.

In May of 2012, the State of Oregon used Prime III in the Presidential Primary in 5 counties. Prime III was setup on tablet devices with printers at rehabilitation and independent living centers. Voters used Prime III to print a ballot and the ballot was mailed in for tallying. The election was a success in that we had a significant number of voters use Prime III and there were no major issues with software.

Self Advocates Becoming Empowered (SABE) used Prime III for their national election in St Paul/Minneapolis, MN - Sept 1, 2012. SABE is an organization that represents people with cognitive disabilities. The SABE election was important for the development of our research because we put pictures on the ballots. We were aware that some of their voters would have reading literacy limitations. Therefore, we put pictures of the candidates on the ballots to see if the pictures would help the voters that may have low reading literacy. As a result, we never identified a single voter that could not use Prime III. Although we were fully aware that some of the voters had reading limitation, they could all vote using the pictures. This was a major development in our research because it suggested the pictures enabled people with reading limitations the ability to vote without assistance. Because we didn't setup the election as a formal study to definitively determine the effect the pictures were having on those with reading

limitations, we conducted a mock election at Clemson Elementary School. The mock President Election used pictures of the Presidential candidates and the voters were the students in grade PK5 through 5th grade; therefore, we knew there were voters that could not read. Just like the SABE election, all the students voted successfully using the touchscreens irrespective of their reading literacy levels. It was apparent that some of the students clearly voted using the pictures and they could tell you whom they voted for. Again, the major result here was the impact pictures could have for voters at various levels of reading literacy.

These elections provided input into the new interface for Prime III. We had people with and without disabilities use the same system in different elections. We learned that the barcodes would not work in a real election because of voter confidence issues. We also learned that iOCR was a much more effective way to process paper ballots.

In 2012, Dr. Gilbert gave a TEDx presentation and demo of Prime III in Greenville, South Carolina. TEDx presentations are viewed by thousands of people locally and worldwide. This presentation was a great way to disseminate what the team had done and the impact Prime III could have on voting nationally. The team also held a RAAV meeting at the Grand Hyatt in Atlanta where the new Prime III interface was demonstrated. The Clemson team worked with members of NIST to develop a survey for data collection purposes in future experiments and they also met with the Tennessee Disability Coalition to discuss poll worker training in Nashville, TN.

In 2012, the Prime III team decided to take on internet voting. Specifically, voting for military and overseas voters. We started a project called Televoting. Televoting was designed to enable UOCAVA voters to return their ballots in a timelier manner versus mailing them back to the U.S.A. Here's an overview of how Televoting works.

D. Televoting

Telemedicine is the use of telecommunication and information technologies in order to provide clinical health care at a distance (Wikipedia). Televoting is an approach that uses telecommunication and information technologies to provide our uniformed and overseas citizens the ability to vote from a distance, similarly to all voters. The conceptual model below, will describe the concept of Televoting.

Conceptual Model

Figure 2 illustrates the Televoting polling place. Notice the camera in the upper left-hand corner. This is a webcam that allows anyone and nearly everyone to be a poll watcher.

Figure 2: Polling place

Figure 3 is also an illustration of the polling place that captures the remote election officials. Notice that the remote election officials are seated with a monitor equipped with a webcam, a printer and a ballot box. We have made a recent recommendation to place the remote election officials against the walls if possible or maybe facing each other. Figure 3 does not include those recommendations. The remote election officials will service the overseas voters.

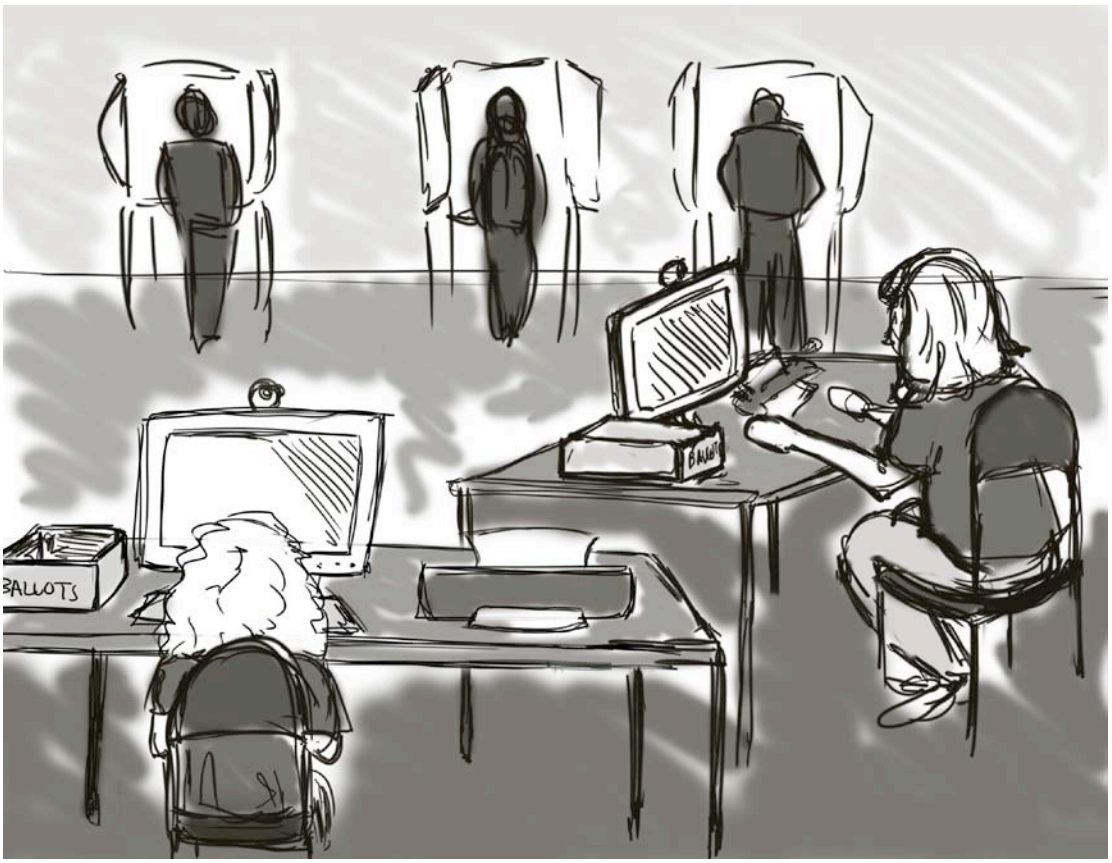

Figure 3: Polling place with remote election officials

Next, we have a soldier overseas that goes online and fills out his ballot. When the soldier is ready to cast his ballot, s/he will press a submit button and s/he will be placed into the queue for remote election officials. When the soldier's turn arrives, s/he will enter a live videoconference session with the remote election official, see Figure 4. The remote election official will verify the soldier's identity before printing the soldier's ballot. We are also adding a telephone line to the remote election official's desk so that s/he can actually use the phone line to also verify the soldier's identity and vice versa. Also, keep in mind that the remote election officials are located in the polling place; therefore, their identity is known by anyone that wants to poll watch.

Figure 4: Soldier interacting with a remote election official to cast his ballot

After the soldier's identity has been accepted, the remote election official will press a button on the screen and the soldier's ballot will print on a printer in the precinct. The soldier can actually hear and see his/her ballot being printed in real time using another camera that is positioned on the printer.

After the ballot prints, the remote election official will ask the soldier to confirm that his/her ballot printed correctly. If the soldier confirms that the ballot is correct, the ballot will go into the ballot box.

We have implemented a version of Televoting ready for pilot testing. We have Okaloosa County, Florida on board to pilot test Televoting as soon as we work out the details. Verizon Wireless has

come on board as a partner for the Televoting project as well. Verizon wireless has agreed to work with the Prime III team to provide the necessary network security for Televoting in a pilot.

In 2012, the Prime III team also met with Mr. Larry Moore, CEO of Clear Ballot. Mr. Moore's company has a technology that is used in optical scan voting. His technology uses images to better determine voters' marks on ballots. Mr. Moore asked the Prime III team to produce a marked optical scan ballot as the printout from Prime III. Therefore, our team took sample optical scan ballots, scanned them and developed a process to use Prime III to print a marked optical scan ballot on a blank piece of paper. Note that Prime III is not marking an existing optical scan ballot. Instead, we are printing a marked optical scan ballot on a blank piece of paper. This has significant benefits because there's no need to pre-print ballots, which saves money and paper. You only use blank paper with Prime III. This new extension to the Prime III system would be very useful in future elections. However, we personally prefer the iOCR ballots because humans more easily count them, but this approach works too.

In 2012, Dr. Gilbert also gave presentations at the U.S. Access Board and he served as a panelist on the U.S. EAC Roundtable on Best Practices for Veterans Voting.

Also in 2013, Clemson University Team gave presentations at the NIST Future of Voting Symposium on Prime III and TeleVoting. There were voting systems experts, election officials, researchers and others present.

On June 18, 2013, the Prime III team gave a demonstration of Televoting and Prime III on Capitol Hill in Washington, DC sponsored by Congressman James Clyburn of SC, see figure 5. The demonstrations included the acting Director of the National Science Foundation and other representatives from the NSF. The graduate students conducted demos of the technologies for all that attended.

Figure 5: Dr. Gilbert demonstrates Prime III to South Carolina Congressman James Clyburn

Furthermore, in 2013, Prime III was demonstrated to several election officials in Savannah, GA at the Election Center Annual National Convention. As a result of this demonstration, the State of Wisconsin decides to pilot test Prime III in April 2014.

In 2014, the Town of Newton and Town of Kossuth used Prime III on April 1, 2014 in a statewide election. The election was a success, but there were many lessoned learned from this pilot. First, this pilot election was critical in that it revealed some interesting findings about using commercially off the shelf (COTS) components in elections. Here's a breakdown of the findings:

1. If COTS components are used in elections, the local elections authority must have a strong technical staff. In the event, anything goes wrong, it is important that the staff have the necessary technical backgrounds to address any issues.

2. Extensive pre-election testing with the actual COTS components is required to validate all the components are working together.

The Wisconsin election resulted in a report that describes some of the issues experienced with the iOCR. The election found a flaw in the iOCR logic. This did not change the outcome of the election because the election staff did a manual recount, so no harm was done to the election. This bug was difficult to find, but it has been found and fixed.

Dr. Gilbert also served as a participant on a roundtable discussion with the Presidential Commission on Election Administration (PCEA) in Cincinnati, OH. The team also gave demonstrations to the League of Women Voters in South Carolina, election officials at Election Center meetings, and the team also consulted with the Los Angeles County VSAP. LA County has decided to build their own voting system and they consulted with the Prime III team on specific aspects of their designs.

The State of New Hampshire used Prime III in a primary election in September 2014 in 2 precincts. This election used Prime III to produce an optical scan ballot that was manually counted. The NH election officials have agreed to use Prime III in the November elections and they are making plans to go statewide in 2016 with Prime III.

In 2014, the team gave multiple presentations to the National Federation for the Blind, an accessible voting webinar sponsored by NIST, South Carolina: Laurens and Pickens County Election officials, Election Center Seminars (San Francisco, St Louis) and Richland County Columbia, SC election officials.

E. Elections and Demonstrations Summary

In summary of the year 2012, we had multiple demonstrations and presentations. One of the most frequent recommendations was for larger screen size. Given Prime III had moved to the web browser, this was not an issue because the system could operate on any device, so larger devices would work just as well as smaller devices. If the device had zoom capabilities, the device could enlarge the screen as well. It is important to remember that almost all of the participants were able to become independent users after a short demonstration and training of about 5 minutes. In addition a good number of individuals were able to use the standard features of the voting system to complete the sample ballot independently. This indicates that the current equipment does provide a solid array of access features and has some good universal design features built into the voting interface that enable voters with different needs to vote independently provided they have the opportunity to interact with a system before sitting down to cast their ballot at their polling place.

F. VoterPass

In 2013, the Prime III team also developed VoterPass in response to the long lines in the 2012 Presidential Election. VoterPass is a voter-line management tool designed to make voting more efficient. Voters will access VoterPass through multiple interfaces, including, but not limited to, Internet web browsers, mobile phone applications, interactive voice response over a phone line, etc.

Upon identifying the registered voter, the voter will select their assigned precinct and VoterPass will provide him or her with timeslots available for voting. VoterPass can provide the voter with a reminder email, phone call, or another form of communication to confirm the chosen time slot.

On Election Day, the voter will arrive at the voting precinct where he or she will bypass the regular voting line and enter the VoterPass line. When the voter reaches the front of the VoterPass line, his or her identity will be verified for voting as well as for the VoterPass time slot.

VoterPass was implemented, but we haven't had a chance to do a pilot study of the technology.

G. Balloting

Balloting is a concept created by the Prime III team in an effort to make voting more efficient and accurate. The concept involves the use of QR Codes for voting. Before an election, voters can go online or use their mobile phone to mark a ballot. When they are done, the system generates a QR Code representing their ballot. You can scan the QR Code and it will reveal the ballot to you. On Election Day, the voters can approach a Prime III voting machine, scan the QR Code and the machine will bring the voter's selection up on the screen in review mode. Therefore, the voters can change their selections if they chose to do so. After the voter accepts the ballot as is or the voter modifies the ballot, the system will print the ballot. The printed ballot is then ready to be cast. This changes the voting paradigm from read, mark and print my ballot to review and print. We conducted a study using the 2012 Presidential optical scan ballot from Broward County, Florida. We had voters mark the ballot using Prime III, mark an optical scan paper ballot and then some used Balloting. The results were clear. On average, it took voters 4.5 minutes to complete the paper ballot, 3.8 minutes to complete the ballot using the touchscreen on Prime III and 48 seconds to complete the ballot using the QR Code and Balloting. These findings reveal that the use of QR Codes to represent ballots before the election can significantly decrease voting times.

ES&S is the nation's largest voting machine manufacturer. In 2013, ES&S developed a new voting machine called the ExpressVote. This new machine implemented the Balloting concept created by our team. Also, this new machine was ready for certification and ES&S asked the Prime III team to conduct the usability and accessibility evaluation of the ExpressVote. The Prime III team successfully evaluated the ES&S ExpressVote and the machine successfully passed certification. Additionally, the ExpressVote is an universally designed voting machine like Prime III.

H. Refreshable Braille

In 2014, the Prime III team also explored avenues for integrating refreshable Braille with Prime III. At this time, the grant was coming to an end, so we didn't complete the implementation, but we have designs on how to make this work.

I. Auto-Paper Handling Concept

In 2014, the Prime III Team designed an Auto-Paper Handling concept for voting. It has been discussed at nearly all accessible voting technology meetings the fact that paper is inaccessible. The Prime III team developed a concept to make paper accessible and published a YouTube video sharing this discovery with the hopes that a manufacturer will implement the designs.

V. CONCLUSIONS

The research conducted by the Prime III research team under the U.S. EAC Accessible Voting Technology Initiative has changed voting in the U.S.A. Voting machine manufacturers are creating universally designed voting machines. Prime III was the first universally designed voting machine intended for use by all voters. The future of voting has been positively impacted by the research we have conducted with the funding from this grant. On November 4, 2014, the State of New Hampshire used Prime III in 2 precincts for voting. This is a great example of the impact of our work. In the September 9, 2014 primaries in New Hampshire where they used Prime III as well, our team was there to support and run the Prime III machines. We had 1 postdoc and 2 PhD students on site. On November 4th, no one from our team was present. The New Hampshire staff purchased off the shelf Dell Tablets that ran Windows and they setup Prime III per our instructions and ran the election without our help. Figure 6 contains an illustration of the Prime III setup in New Hampshire on November 4th. Notice they have the Dell Tablet running the Prime III software with a printer and attached headset. They also used a 2-button switch to run Prime III as well. Voters could touch the screen or use the switch to interact with Prime III as they listened to the audio in the headset or simply read the screen.

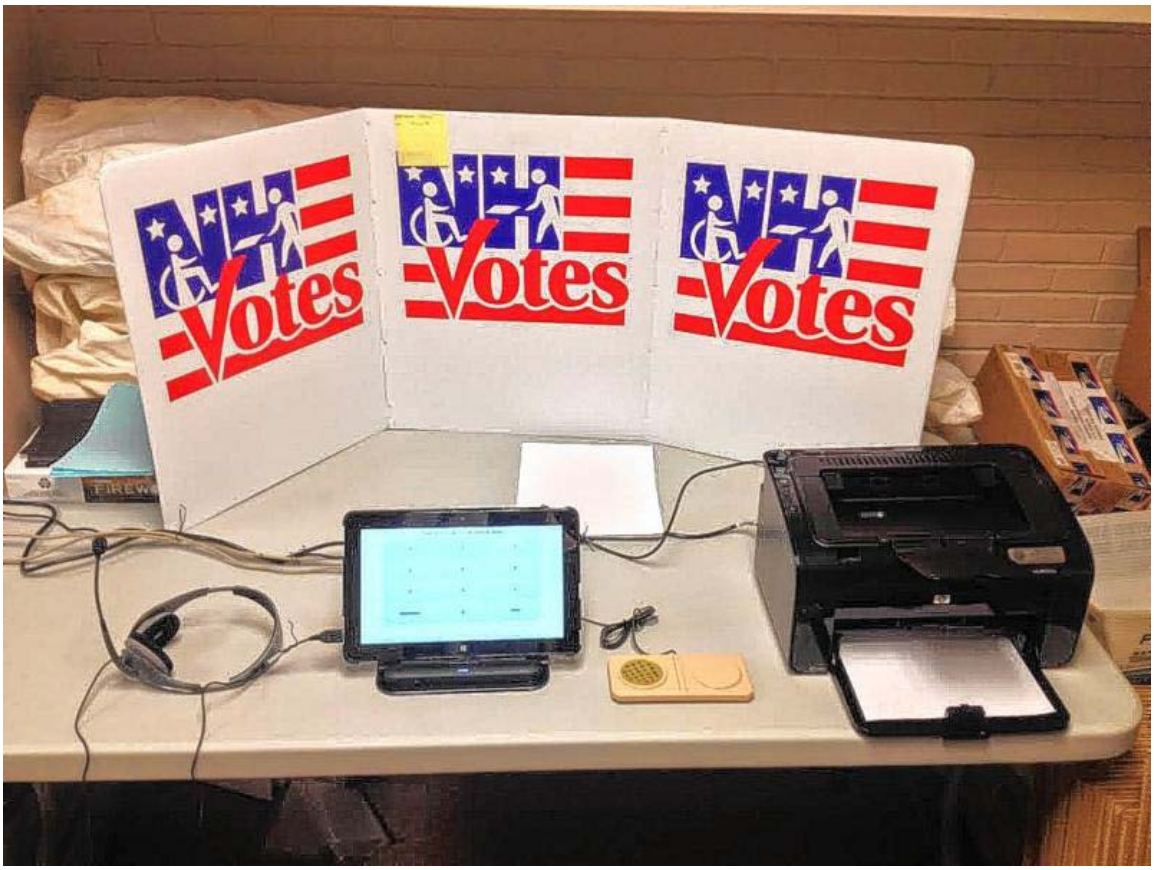

Figure 6: Prime III setup in the New Hampshire, November 4, 2014 election

According to Thomas F. Manning, the Assistant Secretary of State in New Hampshire

> *"We had a very successful trial of the Prime III voting system at Ward 4 in Concord yesterday. Extremely positive reports from the elections staff, voters and the head of our Disabilities Rights Center. Actually, the results were more positive than we had expected from the roll out of a new technology."*

In an interview with the New Hampshire Concord Monitor, Mr. Manning said,

> *"While Manning and others with the Secretary of State's office stressed that no firm plans are in place to expand the system statewide, Manning said it's his "personal goal" to implement this software-driven system by the next presidential primary in 2016."*

Now that we have New Hampshire on board, we are working towards pilots in Ohio and Florida. Mr. Manning's response is not unique from our experiences. When we have tested Prime III, we have consistently received reports about how it empowers and enables voters that couldn't vote privately and independently before.

We have also demonstrated concepts that were once thought impossible. For example, secure overseas voting via the Internet, which is Televoting. We provided VoterPass and Balloting as methods to make voting more accurate, efficient and shorten lines.

The funding from the Accessible Voting Technology Initiative also paved the way for the Research Alliance for Accessible Voting (RAAV). The RAAV consisted of 3 teams, Accessibility and Assistive Technology (AAT), Applied Research (AR) and the Election Administration (EA) Team. Our teams worked collaboratively to conduct research, pilots and more. The Applied Research team's research was informed by the research on accessibility from the Accessibility and Assistive Technology team. The Election Administration team made it possible for all teams to engage with election officials for pilots, presentations and demonstrations. Each team made contributions to the projects on the other teams. This was a collaborative effort that has resulted in findings that continue to positively impact elections in the U.S.A.

As the PI of this initiative, my outlook of the future of voting is positive. The EAC Accessible Voting Technology Initiative will be seen as the catalyst for making voting work in the U.S.A. after many years of challenges in security, accessibility and usability.

VI. YOUTUBE VIDEOS

Accessible Paper for Voting, http://youtu.be/YPorhOMzaKk

Prime III & Balloting Demo, http://youtu.be/bM5DKP4c4aw

Nancy Ward Post SABE Election Interview, http://youtu.be/G9NYbntJflw

Televoting Demo, http://youtu.be/plxh-O-fcVQ