Recommendations to Improve Accessibility for Absentee Voting Among Recently Injured Service Members

Task 7 Final Technical Report

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Preface

This technical report documents work performed during the first and second contract year for the research project entitled "A Consideration of Voting Accessibility for Combat-Injured Service Members," under contract E4064914. This report specifically addresses the Task 7 portion of the Military Heroes Initiative project, although work preceding this task is included for background and relevance to this task. The work was performed by the Georgia Tech Research Institute (GTRI) and was sponsored by the Election Assistance Commission (EAC) via a grant to the Information Technology & Innovation Foundation (ITIF). Dr. Brad Fain of GTRI was the Principal Investigator for this effort. Mr. Jerry Ray and Ms. Carrie Bell of GTRI served as Co-Investigators. Mr. Andrew Baranak and Ms. Laura Schaeffer of GTRI made significant technical contributions to this work. Operation Bravo Foundation provided additional contributions on policy and other election administration processes.

Abstract

Several aspects of the voting process present accessibility challenges for wounded service members, including the accessibility of the physical space in which voting occurs, the design of the ballot (legibility, consistency, and the organization and presentation of information), and the technologies by which ballots are displayed to and marked by voters.

GTRI has developed practical recommendations for the development and adoption of voting technology to meet the accessibility requirements of recently injured service members. The goal of this work was to consider the needs of service members and supporting staff, the maturity level of accessible voting technologies, and the usability of voting systems employing those technologies. This report discusses the assessment of existing voting technologies and other technologies that could be incorporated into the voting process to improve accessibility, and the development of technical recommendations to improve voting accessibility to meet the specific needs of wounded service members. In addition, GTRI recommends several modifications in election administration practices and expansion of voter assistance resources to be more responsive to the circumstances of the target population.

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1 Introduction

This report describes a number of recommendations to enhance voting accessibility for recently-wounded service members, in such areas as improving voting technology, streamlining electoral processes, and eliminating technological and environmental barriers. Previous work on this project included identifying the needs of recently injured service members and the obstacles they face with regard to voting. Once identified, those needs were further analyzed to determine what types of assistive technologies could help enhance the voting experience for the target population. Additionally, advanced technologies were studied to determine if they could break through the voting barriers and provide an improved voting system that would allow voters with disabilities the ability to vote privately and independently.

The focus of the current effort was to take the information collected across those tasks and provide a set of recommendations to improve the accessibility of voting systems (particularly for absentee voting). Barriers to accessibility include problems with absentee voter registration, requesting an absentee ballot, marking the ballot, and submitting the ballot. Current paper and pencil absentee ballots do not support assistive technologies (AT), so although many individuals with disabilities use AT, it provides little or no help for filling out an absentee ballot. Providing the ballot electronically, along with improving the ballot design, would allow those individuals using AT and others attempting to vote absentee to more easily obtain ballots and vote independently.

A list of identified issues has been extracted the document entitled *Georgia Tech Research Institute Accessibility Monograph Series- #8 Accessibility of the Voting System*, which discusses issues and potential solutions in greater detail. The monograph has been developed, in part, from the literature review and findings of Tasks 1 and 4 of the current effort, which will be discussed in section 2 of this report.

1.1 Overview of the Problem

Individuals with disabilities have somewhat different experiences at the polls as compared with the general population. In the 2008 election, individuals with disabilities were

- More likely to report having had a voter registration problem;
- More likely to report having had a problem with the voting equipment; and
- More likely to report having needed help voting. (Current Population Survey, 2008)

Individuals with disabilities also report voting by mail at much higher rates than do individuals not reporting a disability. This is especially true for people with disabilities that constrain them getting out of the house (2008 Survey of the Performance of American Elections). In 2008, only 27% of polling places were fully accessible. Due to widespread inaccessibility at the polling place, transportation to the polling place, and other logistical issues, many individuals with disabilities default to absentee or mail in voting. Given the large number of veterans with disabilities who will require an absentee ballot in order to vote in elections, it is important to identify and solve potential barriers in the absentee voting process.

In order to understand how the barriers were selected for inclusion or exclusion from this document, some context about the problem under consideration is useful. The voting situation in which these issues apply is for recently wounded military veterans residing in a VA hospital or similar facility. Because these veterans are likely to be away from their home voting districts, but are no longer eligible for the voting assistance they had access to when they were on active duty, they must follow the same absentee voting process as other civilians. The current work is part of a larger effort to develop voting resources for recently wounded military veterans, and based on the direction of that larger effort, the following assumptions were used when identifying the issues herein:

- The voters will use an iPad-based (or similar hardware) portable absentee voting system to vote. This includes obtaining a ballot, marking it electronically in an accessible way, and submitting the ballot (printing it out and mailing it, or whatever other process policy requires them to follow).
- A "voting facilitator" familiar with the use of the absentee voting system will bring the device to the voter's hospital room, either as a handheld device or installed on an adjustable stand compatible with beds and/or wheelchairs.
- The voter should be able to mark the ballot mostly independently, but the voting facilitator may set the system up for the voter, assist with problems during voting, and help with submitting the ballot (printing, physical handling of the ballot, etc.).
- There may also be a "voting room" available at the facility, with one or more of the portable absentee voting systems installed as voting kiosks, so that voters who are able to and/or prefer to vote in that environment could go to the voting room and use the device there. Voting facilitators will still be available to assist, but one voting facilitator may be responsible for several systems instead of the one-on-one assistance provided when bringing the system to a room.

In this context, most issues associated with the external environment (parking, accessing the building) and with typical polling places (stairs, inaccessible doors) will not be discussed in this report. The primary focus falls upon barriers associated with ballot design and presentation on a small electronic device and new technologies that may facilitate voting among the target population.

Descriptions of the issues related to absentee voting are provided in this document, along with a number of potential solutions, some of which include advanced technologies in the voting arena. The results of these analyses are presented in this report as recommendations and potential solutions to make the electoral process more accessible. In addition to the potential technological solutions described herein, some of the solutions discussed are simply interface design changes, the addition of peripheral access points and integrating software to the current technology for improved accessibility.

1.2 Organization of the Report

1. Section 1 of this document describes the purpose of this research effort and provides a brief overview of the problem.
2. Section 2 describes the accessibility needs of the target population and how their needs differ from those of the general population with disabilities. This discussion provides the explanation for why the focus of this report is on absentee voting, as opposed to voting at the polling place.
3. Section 3 documents the voter task analysis that identifies all tasks, both physical and cognitive, that the voter must perform in order to cast a ballot.
4. Section 4 describes technological barriers and facilitators as they relate to the voting process for the target population. A detailed discussion of the barriers that were found to be the best candidates for action is provided. A list and brief description of current assistive technologies is included in this section.
5. Section 5 documents in more detail the technological interventions and solutions that can provide accessible solutions for absentee voting. This "technology roadmap" incorporates findings from the research performed in Task 6 ("Identify and evaluate solutions to improve accessibility of voting technology").
6. Section 6 provides a brief summary of the major conclusions from GTRI's overall effort.
7. Section 7 lists the references cited in this report.

2 Needs Assessment

GTRI conducted a needs assessment to identify, clarify, and evaluate the voting needs of injured service members. This assessment consisted of six major activities: (1) general review of the epidemiology of casualties incurred in the current conflicts abroad, (2) review of published studies on common injuries found in service members of interest as applies to information on accessible voting, (3) “top down” analysis of military voting related injuries and associated barriers to voting , (4) development of a data collection protocol and selection of sites for visiting, (5) collection of data from selected sites, and (6) documentation of the facilitators and barriers to accessible voting.

The needs assessment addresses the problems and issues that injured service members face with respect to mobility, communication, sensory and cognitive limitations, and limitations imposed by assistive technology. In order to understand the functional limitations the injured service members might experience when engaged in voting activities, a sample of the target population was interviewed using a structured interview battery.

2.1 Description of Target Population

Due to the nature of the military environment, particularly in hostile, deployed settings, service members experience a range of injuries that differ from those typically found in the general population. Thus, the range of accommodations needed for military voting also differs from those needed for the general population. The Help America Vote Act (HAVA) disability requirements and the Military and Overseas Voting Empowerment (MOVE) Act have created a need to more closely examine voting accessibility for military voters who are injured and have physical and cognitive limitations. This need has become most apparent as a result of reported injury statistics from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF). According to statistics compiled by the U.S. Department of Defense (2012), as of July 10, 2012, 49,008 U.S. troops have been wounded during the current conflicts in Iraq and Afghanistan, many returning home with a range of disabilities including loss of limbs, impaired vision, and traumatic brain injury (TBI).

2.2 Characteristic Injuries of the Population

The target population served by this research include wounded service members and veterans currently undergoing medical treatment or rehabilitation including, but not limited to, service members who have experienced the spectrum of traumatic brain injuries, loss of vision, loss of limbs, and loss of upper or lower mobility due to trauma. Three major categories of injuries were identified among the population of interest: polytrauma (multiple region traumatic injury), traumatic brain injury, and, Post-Traumatic Stress Disorder (PTSD).

“Polytrauma” or multiple region traumatic injury, is the most common form of injury in the current military conflicts. The average service member wounded in OIF/OEF has 4.2 different body region injuries (Owens, Kragh, Wenke, et al., 2008). TBI is often referred to as the “signature injury” of OIF and OEF. These types of injuries can cause a wide range of functional limitations. Lew and colleagues (2007) studied symptoms among a sample of 62 patients in a Polytrauma Network Site (PNS) clinic. They found that 97% of patients had three or more post-concussion syndrome symptoms (headaches, dizziness, fatigue, irritability, concentration or memory problems, substance abuse, and heightened reactivity to stress and emotions). They also found that over 70% of patients reported sleep disturbances, hyper-arousal symptoms, mood symptoms, headaches, and cognitive complaints. Pain was a prevalent issue in this group of patients, with 97% complaining of pain. PTSD had a prevalence of 71% and cognitive disorder had a prevalence of 55%. In addition, co-occurrence was common, with 42% of patients having diagnoses of both PTSD and cognitive disorder. Fifty-two percent of patients had significant depressive symptoms and all of those patients also had a diagnosis of PTSD. Fifty-eight percent of patients complained of tinnitus (i.e., ringing of the ears), 44% complained of difficulty hearing, and 35% failed the hearing screening test. Seventy-five percent of patients reported vision problems, including photosensitivity (59%). Oculo-motor problems were found in 70% of patients. Lastly, 59% of patients reported reading problems that began after their concussive injury.

2.3 Impact of Impairments on Voting

Although the difficulties imposed by physical disabilities can be fairly straightforward, TBI, PTSD, and other types of injuries can also affect functioning in cognition, sensation and perception, and emotion, which can cause difficulties in the voting process in more subtle ways. These limitations include problems with memory, decision making, light and noise sensitivity, hearing loss, crowd anxiety, mobility, and dexterity. As a result of these limitations, injured military voters may be unable to perceive, understand, complete, and submit a ballot.

The following themes emerged from the needs assessment:

- Reliance on technology (e.g., PDAs, prosthetics, wheelchairs)
- Avoidance of social situations and crowds
- Sensitivity to overstimulation (light, ambient noise)
- Loss of motivation
- Difficulty with memory and concentration
- Limitations in endurance (fatigue, pain)
- Hearing impairments (hearing loss and tinnitus)

The goal of the needs assessment was to ensure that investments in voting technology and services are directed at reducing the barriers that are most consequential to the target population (consequently increasing the potential for positive impact through intervention). The assessment clarified the needs of the target population and considered voting accessibility more broadly to establish the degree of commonality existing between recently injured service members and the disability community as a whole. The needs assessment was the starting point for establishing the program's overarching goal: to establish an understanding of what currently exists, and what gaps or barriers must be addressed to reach the goal of ensuring that all may vote privately and independently. Objectives for the needs assessment included

1. Determining the prevalence and types of injuries sustained, and identifying the classes of individuals who are most in need of technological or procedural support in an attempt to understand the full spectrum of experiences from initial injury through recovery that might impact voting in the target population.
2. Identifying and documenting technological barriers and potential facilitators that inhibit injured service members from voting privately and without assistance. Data collection protocols were designed and site visits were performed at major military medical centers. Absentee voting at rehabilitation and definitive care facilities was the primary focus, although other levels of care, such as care provided at a combat support hospital, were considered by inference.

A summary of impairments and their impact on voting by recently injured service members can be found in Appendix A, Table 5. The most prevalent injuries included loss of visual acuity (including blindness), sensitivity to light, hearing loss or tinnitus, difficulty concentrating, memory problems, difficulty learning new tasks, loss of dexterity and fine motor control, loss of sensation, amputation requiring the use of a prosthetic hand or arm, limitations in endurance, loss of mobility requiring the use of a wheelchair, and pain.

Several aspects of the voting process present accessibility challenges for wounded service members, including the accessibility of the physical space in which voting occurs, the design of the ballot (legibility, consistency, and the organization and presentation of information), and the technologies by which ballots are displayed to and marked by voters.

3 Task Analysis

A task analysis was conducted in an effort to ensure each segment of the voting process was covered in this accessibility study. The intended scope was to identify all tasks, physical and cognitive, involving the voter, where the major objective of a voting system is to provide eligible voters with a private and accessible means to complete and cast valid ballots accordant with their intended choices. In this context, "accessible" should be interpreted broadly, considering the needs of all users, not just those with disabilities. For example, voting systems that require people to travel long distances, wait in very long lines, or that require burdensome proof of eligibility might all be considered "inaccessible."

Table 1. Task analysis for the voting process

Task	Relevant Disability
1. Establish eligibility	
1.1. Produce/obtain ID	Memory – difficulty obtaining ID
1.2. Register to vote	Memory – forget to register
2. Obtain ballot	
Plan: Do 1 or 2	
2.1. Obtain federal write-in absentee ballot (cannot be used in local & state elections)	Executive control, cognitive
2.1.1.1. Find federal voting assistance program website	Vision – cannot see screen Motor – cannot operate controls Working memory – difficulty finding website
2.1.1.2. Find application	Vision, cognitive
2.1.1.3. Complete form-Enter info (e.g., name, address, DOB)	Attention & executive control – difficulty competing form
2.1.1.4. Submit form	Motor, vision
2.1.1.5. Download ballot	Cognitive, motor, vision
2.1.1.6. Print ballot	Motor
2.2. Obtain absentee ballot (specific to each county)	Memory – what county do I live in?
Plan: Do 1 or 2 or 3	
2.2.1.1. Request online via Federal Post Card Application	Cognitive – difficulty understanding directions
2.2.1.1.1. Find website	Vision – cannot see screen Motor – cannot operate controls Working memory-difficulty finding website
2.2.1.1.2. Find application	Cognitive, vision
2.2.1.1.3. Download application	Cognitive, motor, vision
2.2.1.1.4. Read instructions	Cognitive, executive control-difficulty comprehending
2.2.1.1.5. Complete application	Attention & executive control –

Task	Relevant Disability
	difficulty competing form
2.2.1.1.6. Mail application	Motor, vision
2.2.1.2. Request online via county	Vision – cannot see screen Motor – cannot operate controls
2.2.1.2.1. Find website of county clerk	Working memory – difficulty finding website
2.2.1.2.2. Enter info (e.g., name, address, DOB)	Executive control – difficulty completing form
2.2.1.2.3. Submit form	Motor, vision
2.2.1.2.4. Download ballot	Cognitive, motor, vision
2.2.1.2.5. Print ballot	Motor
2.2.1.3. Request by phone	Cognitive, motor
2.2.1.3.1. Find phone number	Cognitive Working memory – difficulty finding phone number
2.2.1.3.2. Place call	Vision – cannot dial number Hearing – cannot use phone
3. Cast absentee ballot	
3.1. Open envelope(s)	Motor
3.2. Complete the voter's declaration/affirmation	Motor, vision
3.2.1. Sign and date voter's declaration/affirmation	Motor, vision
3.2.2. Obtain signature of witness/notary (if applicable)	Memory
3.2.3. Put declaration/affirmation inside envelope	Motor
3.3. Mark ballot	Motor, vision
Plan: Do 1 or 2	
3.3.1. Vote straight ticket	
3.3.2. Vote for each race	
Plan: Repeat 1 or 2 until all races are voted	
3.3.2.1. Vote for a listed candidate	
3.3.2.1.1. View all candidates within a given race	Vision
3.3.2.1.2. Mark choice (bubble or arrow)	Motor, vision
3.3.2.2. Write-in vote	Motor, cognitive
3.3.2.2.1. Mark appropriate bubble/arrow	Vision, motor
3.3.2.2.2. Write name	Motor
3.4. Retain ballot identifier (this can be used later to	Memory

Task	Relevant Disability
verify the vote was counted)	
3.4.1. Tear off ballot receipt or write down ballot number	Motor, vision
3.4.2. Store receipt or number in a safe place	Memory
3.5. Return absentee ballot	Memory
Plan: Do 1, 2, 3, or 4	
3.5.1. Return ballot postal mail	Executive control, motor, some vision
3.5.1.1. Obtain postage stamps	Cognitive
3.5.1.1.1. Determine required postage	Executive control
3.5.1.1.2. Purchase postage stamps	Cognitive
3.5.1.2. Place ballot in envelope	Motor
3.5.1.3. Seal envelope	Motor
3.5.1.4. Place sealed envelope in 2nd envelope; seal	Motor
3.5.1.5. Sign 2nd envelope	Motor, vision
3.5.1.6. Place 2nd envelope in 3rd envelope; seal	Motor
3.5.1.7. Affix postage to 3rd envelope	Motor
3.5.1.8. Write return address on 3rd envelope	Motor, vision
3.5.1.9. Place envelope in mail box	Motor
3.5.2. Return ballot by facsimile	Executive control, motor, vision
3.5.2.1. Verify identity (e.g., sign voter identification form)	Vision
3.5.2.2. Enter fax number	Memory, vision
3.5.2.3. Orient ballot for machine	Executive control, motor, vision
3.5.2.4. Scan ballot	Executive control, motor, vision
3.5.2.5. Send fax	Executive control, motor, vision
3.5.2.6. Receive confirmation	Memory, vision
3.5.3. Return ballot by e-mail	Executive control, motor, vision
3.5.3.1. Verify identity (e.g., sign voter identification form)	Motor, vision
3.5.3.2. Scan ballot and identification form	Executive control, motor, vision
3.5.3.3. Enter e-mail address	Executive control, motor, vision
3.5.3.4. Attach scanned file to e-mail	Executive control, motor, vision
3.5.3.5. Send e-mail	Executive control, motor, vision
3.5.3.6. Receive confirmation?	Memory, vision
3.5.4. Return ballot to a pre-specified location (e.g.,	Executive control, motor, lower

Task	Relevant Disability
drop box)	mobility, vision
3.5.4.1. Place ballot in envelope	Motor
3.5.4.2. Seal envelope	Motor
3.5.4.3. Place sealed envelope in 2nd envelope; seal	Motor
3.5.4.4. Sign 2nd envelope	Motor, vision
3.5.4.5. Place 2nd envelope in 3rd envelope; seal	Motor
3.5.4.6. Place in drop box	Motor, lower mobility, vision
4. Verify vote was cast as intended	Executive control
4.1. Retrieve encrypted number from ballot receipt	Vision, working memory
4.2. Visit web bulletin board	Vision, motor
4.3. Enter encrypted number into bulletin board	Vision, motor, working memory
4.4. View feedback	Vision

Once the tasks were identified, they were categorized according to the events within the voting process, including registration and submitting the ballot. Consequently, absentee voting has potential accessibility issues in the following areas:

- Absentee voting process
  - Obtaining the ballot
  - Reading the ballot
  - Marking the ballot
  - Returning the ballot
- Voting technology
  - Physical ability factors
  - Audio and speech output
- Ballot design and presentation
  - Instructions and help
  - User interface design
  - Information presentation
  - Write-in voting
  - Ballot review
- Policy barriers

4 Technological Barriers and Facilitators

In addition to gaining an understanding of the current functional limitations of recently injured service members and newly transitioned veterans, GTRI assessed a number of voting systems, both current and older technologies, some of which are still being used in the election process today. Individuals with disabilities may have difficulty placing their votes, whether they vote at a polling place or place their vote by absentee ballot. Table 4 provides a brief description of the issues found among people with visual and/or hearing impairments, upper and/or lower body impairments, and other injuries and limitations discussed earlier in the report. Although some of the issues described only affect those with low vision or blindness, others may affect all of the absentee voting population.

4.1 Barriers

An extensive list of voting issues was compiled based on the literature review, interviews and discussions with service members, experts familiar with current voting systems, and election officials. As a result, over fifty potential issues are listed below. Some of them are common problems that affect the general population of individuals with disabilities, while others pertain to a smaller portion of the target population. The issues are described in more detail once they are rank ordered. A number of these issues contain more than one possible solution and those solutions are discussed in greater detail in Section 5 of this report.

4.1.1 Prioritization of Issues

In an effort to determine the issues that were the best candidates for intervention, an extensive list of issues was identified, and potential solutions for those issues were developed. (See section 5.2 for a brief discussion of solutions for the top issues, or the *Accessibility of the Voting System* monograph for full details.) The issues were then scored based on the *feasibility*, *impact*, and *cost* of implementing the associated solutions. A score was assigned to each issue in each of three categories, as described below.

> *Feasibility* refers to how resource intensive implementing the solutions would be. The more resource intensive, the more difficult it will be to resolve the issue. Feasibility scores are as follows: 1 - not resource intensive; 2 - somewhat resource intensive; 3 - very resource intensive.
>
> *Impact* refers to the estimated number of disabled voters who are affected by the issue and who would benefit if the issue were eliminated. Impact scores are as follows: 1 - high; 2 - moderate; 3 - low.
>
> *Cost* refers to how expensive it would be to implement the solution(s) to an issue. If an issue would require considerable cost to resolve, it would rank poorer as a potential candidate for implementation. Cost scores are as follows: is broken into the following categories: 1 - inexpensive (< $100,000); 2 - moderately expensive ($100,000 - $500,000); 3 - expensive (> $500,000).

The three individual scores for each issue were averaged to obtain an overall score. Lower overall scores indicate issues that are the best candidates for intervention. The technologies and their scores are listed in Table 2, with the best candidates highlighted green, lesser candidates highlighted yellow, and the least likely candidates highlighted red. (Issues with the same score are not further ranked – they are presented in no particular order.) The top 15 issues, all of which received an overall score of 1.0, are discussed in greater detail below.

Table 2. Assessment of candidate issues for intervention

Issue	Feasibility	Impact	Cost	Score
	1=Not resource intensive 2=Somewhat resource intensive 3=Very resource intensive	1=High 2=Moderate 3=Low	1=Inexpensive 2=Moderately expensive 3=Expensive	
1. Speech output is inaccurate.	1	1	1	**1.0**
2. Voters who need assistance marking the ballot cannot vote privately.	1	1	1	**1.0**
3. Error feedback is not provided.	1	1	1	**1.0**
4. No headphone jack is provided on the device.	1	1	1	**1.0**
5. Speech output via speakers may be inappropriate due to privacy concerns.	1	1	1	**1.0**
6. The system does not provide sufficient instructions.	1	1	1	**1.0**
7. Instructions may be difficult for users with cognitive impairments to understand.	1	1	1	**1.0**
8. The system does not provide clear and consistent navigation controls.	1	1	1	**1.0**
9. Onscreen controls that are small and close together may be difficult to activate without activating adjacent controls.	1	1	1	**1.0**
10. Complex or inconsistent user interface screens may be difficult for users to understand.	1	1	1	**1.0**
11. The voting machine does not provide sufficient feedback to the user.	1	1	1	**1.0**
12. Small text and icons are difficult for users with low vision to perceive.	1	1	1	**1.0**
13. Control names are not descriptive.	1	1	1	**1.0**

Issue	Feasibility	Impact	Cost	Score
14. Users do not notice when the review screen differs from their intended selections.	1	1	1	**1.0**
15. The system does not provide adequate notification of or protection against overvoting and undervoting.	1	1	1	**1.0**
16. Registering to vote is different from state to state.	1	2	1	**1.3**
17. Most recently disabled voters cannot read Braille ballots.	1	1	2	**1.3**
18. Paper-based vote verification must be visually inspected.	1	1	2	**1.3**
19. Physical submission of the ballot is difficult for some users.	1	1	2	**1.3**
20. Some components of voting devices may be difficult for users with mobility impairments to reach.	1	1	2	**1.3**
21. LCD viewing angle limitations and other components of voting machines may be difficult to see from a seated position.	1	2	1	**1.3**
22. Glare makes it difficult for some users to see the display.	1	2	1	**1.3**
23. The volume level is insufficient.	1	2	1	**1.3**
24. Speech output is not repeated.	1	2	1	**1.3**
25. Speech output requires users to listen to large blocks of text without the ability to pause, start over, or skip ahead.	2	1	1	**1.3**
26. The content of speech output is repetitive.	2	1	1	**1.3**
27. Time of instructions is inappropriate.	1	2	1	**1.3**
28. Display elements do not receive focus in the correct reading order.	2	1	1	**1.3**
29. The system does not provide clear and consistent status information.	1	2	1	**1.3**
30. Icons used in place of text labels may be ambiguous.	1	2	1	**1.3**
31. Candidates are listed on multiple columns or pages.	1	2	1	**1.3**
32. Multiple races are displayed on one page of an electronic ballot.	1	2	1	**1.3**

Issue	Feasibility	Impact	Cost	Score
33. Revising a ballot is excessively complex or difficult.	1	2	1	**1.3**
34. The voting device does not provide or support necessary accessibility options.	2	1	2	**1.7**
35. Ballots are not available online.	1	2	2	**1.7**
36. Text-only paper ballots cannot be read by voters with visual impairments.	2	1	2	**1.7**
37. Correct postage is not indicated.	1	3	1	**1.7**
38. The voting device is not portable.	2	1	2	**1.7**
39. Voters may not be able to physically hold a portable voting device.	2	2	1	**1.7**
40. The placement of the headphone jack allows the headphone cord to interfere with use of the machine.	1	3	1	**1.7**
41. The rate at which speech output is provided is not adjustable.	2	1	2	**1.7**
42. Non-verbal output is not meaningful.	2	2	1	**1.7**
43. The system does not provide clear and consistent page titles.	1	3	1	**1.7**
44. When scrolling is required (and it should be used sparingly and consistently), the user is not notified that scrolling is needed.	2	2	1	**1.7**
45. The voting device changes the ballot automatically based on assumptions about user intent.	2	2 (impact dependent on # of voting machines with this feature.)	1	**1.7**
46. Non-text elements are not accessible to some users with visual impairments.	2	2	1	**1.7**
47. System response time to user input is slow.	1	3	2	**2.0**
48. The voting machine does not support t-coil coupling.	1	3	2	**2.0**
49. Speech output is difficult to understand due to poor sound quality or interference.	2	2	2	**2.0**
50. The mapping of hardware controls to user interface functions is inconsistent.	2	2	2	**2.0**
51. Use of the write-in option is confusing.	2	3	1	**2.0**

Issue	Feasibility	Impact	Cost	Score
52. Obtaining accurate information on voter registration is difficult as service members transition out of active duty status.	2	1	3	**2.0**
53. Voters cannot sign the application form.	2	2	3	**2.3**
54. System time-outs may cause problems for some users.	2	3	2	**2.3**
55. Typing the name of a write-in candidate is difficult.	2	3	2	**2.3**

**Note: Issue #34 is highlighted as it has considerable impact and should be considered along with the top priority issues.*

The top 15 issues fall into three categories: assistive features for vision impairments, general ballot design and software considerations, and privacy considerations.

Assistive Features for Vision Impairments

- Speech output is inaccurate.
- No headphone jack is provided on the device.
- Small text and icons are difficult for users with low vision to perceive.
- Control names are not descriptive.

General Ballot Design and Software Considerations

- Error feedback is not provided.
- The system does not provide sufficient instructions.
- Instructions may be difficult for users with cognitive impairments to understand.
- Complex or inconsistent user interface screens may be difficult for users to understand.
- Users do not notice when the review screen differs from their intended selections.
- The system does not provide adequate notification of or protection against overvoting and undervoting.
- The voting machine does not provide sufficient feedback to the user.
- The system does not provide clear and consistent navigation controls.
- Onscreen controls that are small and close together may be difficult to activate without activating adjacent controls.

Privacy Considerations

- Voters who need assistance marking the ballot cannot vote privately.
- Speech output via speakers may be inappropriate due to privacy concerns.

A description of each of the top issues is presented below.

Speech output is inaccurate. Computer generated speech output can be difficult to understand if the computer generated voice does not mimic human speech well enough. Computer generated speech may mispronounce names, contain unnecessary pauses, and/or speak with an odd cadence, making the output difficult to parse and understand. Transitions between recorded human speech and computer-generated speech can be jarring due to differences in voice, volume and cadence.

No headphone jack is provided on the device. Users with visual impairments often rely on audio output to interact with voting machines. Interference from ambient noise may make it difficult for users to perceive information provided via audio, especially for users who are hard of hearing. Use of headphones allows users to hear audio output more clearly and also enhances privacy. However, some voting machines do not provide a headphone jack or headphone jack is not standard size.

Small text and icons are difficult for users with low vision to perceive. Text and icons on GUI displays may be difficult for some users to read if they are too small.

Control names are not descriptive. The user interface may be designed primarily for sighted users, with visual context working in conjunction with control labels to provide the appropriate meaning. However, visual context is not available for users with visual impairments, and users who have recently become visually impaired may lack experience interpreting interfaces without visual cues. Control labels should be descriptive enough that their purpose is evident even without visual cues.

Error feedback is not provided. Overvotes and undervotes are common errors that can be detected by electronic voting systems used at polling places. Such error detection is not supported by paper based mail-in ballots. Voters are less likely to correct mistakes if they do not receive error feedback.

The system does not provide sufficient instructions. Before users begin voting with a device, the device should provide instructions that give users with the basic information they need to operate the voting device and to interact with the ballot. More detailed information (help) should be available on request throughout the voting process as needed.

Instructions may be difficult for users with cognitive impairments to understand. Instructions that are poorly written, overly complex, or that are written at too high a reading level may lead to comprehension problems for users with cognitive impairments. Instructions describing a series of sequential actions may also be confusing, if the instructions are poorly structured.

Complex or inconsistent user interface screens may be difficult for users to understand. User interfaces that are complex (for example, displays that contain many controls associated with multiple tasks) can be difficult for users with cognitive impairments to navigate. Inconsistencies in displays, such as changes in control placement from screen to screen or inconsistent use of terminology, can be confusing to users with cognitive impairments. Similarly, inconsistent or excessive use of abbreviations can decrease reading comprehension for users with cognitive impairments. Maintaining consistency and keeping the interface as simple as possible are important usability considerations, and will improve the accessibility of the machine to all users.

Users do not notice when the review screen differs from their intended selections. Many electronic ballots provide voters with no review screen at the end of the ballot. The primary purpose of the review screen is to assist voters in detecting errors, which include unintentional selections, overvotes, and undervotes. Users might make unintentional selections of candidates. Then they may fail to notice their error when viewing their selections on the review screen. The potential solutions to this problem rely on the voter remembering who he or she intended to vote for, or at least the party affiliation.

The system does not provide adequate notification of or protection against overvoting and undervoting. Some electronic ballots simply allow users to mark the ballot but do not provide any error detection capabilities. Electronic ballots should, at a minimum, notify users when undervotes or overvotes have occurred, and allow them to correct these situations if desired. Research shows that a substantial portion of voters do not notice undervotes and overvotes on review screens (Campbell & Byrne, 2009). Occasionally these are not errors, but instead are intentional choices to abstain from voting in a particular race. Therefore, voters should not be forced to "correct the mistake."

The voting machine does not provide sufficient feedback to the user. Users with different disabilities have different needs for the amount and type of feedback provided by a voting machine. The feedback that is provided may be insufficient because it does not cover the full range of events for which feedback is required, or it may be insufficient because it is provided in a format that is not useful to a user with a particular disability (for example, visual feedback indicating that input has been accepted is not useful to a user who is blind). Providing feedback for a wide range of events and user actions in a variety of sensory modalities is beneficial for all users.

The system does not provide clear and consistent navigation controls. Navigation controls (for example, "Previous Contest," "Next Contest," "Help," etc.) should be provided in a consistent location on every page and should be easy to locate, identify, and operate.

Onscreen controls that are small and close together may be difficult to activate without activating adjacent controls. If onscreen controls are small or are placed too close together, they may be difficult for users without fine motor control to activate without accidentally activating adjacent controls. Because no tactile feedback is provided by touchscreen controls, if redundant visual and auditory feedback is not provided when controls are activated, these accidental activations may go unnoticed.

Voters who need assistance marking the ballot cannot vote privately. If voters are physically unable to mark the ballot, they may require assistance from another person. Markings are made directly adjacent to candidate names on typical ballots. Therefore, voter privacy is compromised when assistance is required.

Speech output via speakers may be inappropriate due to privacy concerns. Audio output may be required for some users to interact with voting machines. The audio output may need to be at a relatively high volume to overcome ambient noise or to accommodate users who are hard of hearing. However, much of the information provided by voting machines should remain private, rather than being broadcast over speakers.

**The voting device does not provide or support necessary accessibility options. (See note below Table 2)* Voters may not have the ability to physically interact with a traditional voting device. Voters without the use of their arms may not be able to physically touch the voting machine. These individuals may utilize other devices, such as the "sip-and-puff," eye tracking, head tracking, and speech recognition user interfaces (described in the following sections).

4.2 Facilitators

In order to ascertain the assistive technologies that are relevant to voting, a technology assessment was conducted. This research focused on the identification of methods of presenting data in a different format than is needed for the general population. For example, a screen reader provides the information on the screen to the voter via voice output (typically through a set of headphones). These technologies assist the voter in placing their vote using a variety of input/output devices, such as a screen magnifier or a sip-and-puff controller. Other devices may be used to assist the voter in providing input, such as a mouth stick for those who have upper mobility impairments. The following is a list of widely available Assistive Technologies that are currently used by voters. These assistive technologies are described in more detail in the *Accessibility of the Voting System* monograph.

Table 3. Assistive technologies applicable to voting

Assistive Technology	Description
Alternative Input Devices	A variety of input devices are available for individuals unable to use a standard keyboard and/or mouse. These alternative input devices may be used by individuals with upper mobility impairments, visual impairments, or cognitive impairments and replace traditional equipment
Earphones	Earphones are a common listening device, but can help users to hear direct audio information from a machine with reduced background noise
Input Switches	Switches come in many forms, and are fundamental and well-proven accessible technology that enables individuals with cognitive disabilities or other limitations to interact with and access computers or other related technology. Switches replace a keyboard and mouse by allowing users to tab or scan through an interface.
Magnifying Glass	A magnifying glass (or magnifier) is a handheld lens used to increase the size of an image or text.
Manipulation Stick	A manipulation stick is a rod, typically a wooden dowel, used as an aid to

Assistive Technology	Description
	increase a user's reach or strength. Common end attachments are rubber tips and hooks used for completing various tasks.
Mouth Stick	A mouth stick is similar to a manipulation stick, but it is held in the mouth. The mouth stick is held by the teeth and lips, and is controlled by neck and lip movement. Many mouth sticks are made of aluminum, and can be equipped with end attachments such as clips or rubber points.
Neckloop	A neckloop is an assistive listening device that transmits magnetic signals to hearing aids set in "t-coil" mode. The hearing aids do not pick up anything but the magnetic signals in this mode, thereby blocking out all background noise and enabling users to hear the device output clearly.
Reaching Aid	A reaching aid is a 1 to 2 foot long device with a trigger handle used to open and close the end for the purpose of grasping objects that are difficult to reach.
Screen Magnifiers	A screen magnifier is a software application that works as a virtual magnifying glass to enlarge portions of a computer screen
Screen Readers	Screen readers are software often used by visually impaired individuals. They use a text to speech (TTS) synthesizer to identify and interpret what is displayed on the computer and convert it to speech or a refreshable braille display.
Sip-and-Puff	Sip-and-Puff technology is a type of input switch that can be used to control devices by turning air pressure into electrical signals. These systems are often used by people with severe motor disabilities or double amputees to replace traditional devices such as a computer mouse.
Speech Recognition	Speech recognition software, along with a microphone, enables a computer to receive and understand voice commands and dictation from a user.
Touchscreens	Touchscreens are computer screens that enable users to have direct interaction with the content on the screen. These are especially helpful for individuals who may have trouble using traditional input devices or those with cognitive disabilities.

5 Technology Roadmap

The following sections describe specific technology interventions that could be implemented to improve the accessibility of the voting process.

5.1 Advances in Technology

A number of technologies are available or currently in development that have significant potential for making voting more accessible for disabled veterans. Some of these technologies, such as screen readers, accessibility switches, and speech recognition software, have been in use for years, while others, like tablet computers and digital pens, are gaining popularity due to continuing advancements in the technology.

A number of assistive technology products were assessed to determine the *feasibility* of incorporating the products into the voting process, the accessibility *impact* of doing so, and the *cost* of doing so. A score was assigned to each product in each of three categories, as described below.

> *Feasibility* refers to how difficult the technology is to implement, and to how difficult it will be for users to learn to use the technology. The more difficult the technology is to implement or learn, the less feasible will be to implement the technology. Feasibility scores are as follows: 1 - easy to implement and learn; 2 - moderately difficult to implement and learn; 3 - difficult to implement and learn.
>
> *Impact* refers to the potential benefits to accessibility that can be gained by implementing the technology. Impact scores are as follows: 1 - high; 2 - moderate; 3 - low.
>
> *Cost* refers to how expensive it would be to implement the technology. More expensive technologies receive poorer scores than less expensive technologies. Cost scores are as follows: 1 - inexpensive (< $250); 2 - moderately expensive ($250 - $1,000); 3 - expensive (> $1,000).

The three individual scores for each technology were averaged to obtain an overall score. Lower overall scores indicate technologies that are the best choices for implementation in future voting systems. The technologies and their scores are listed in Table 4, with the best candidates highlighted green and lesser candidates highlighted yellow.

Table 4. Assessment of candidate assistive technologies

Technology	Feasibility	Impact	Cost	Score
	1=Easy to implement and learn 2=Moderately difficult to implement and learn 3=Difficult to implement and learn	1=High 2=Moderate 3=Low	1=Inexpensive 2=Moderately expensive 3=Expensive	
1. Switches	1	1	1	**1.0**
2. Speech Recognition Software	1	1	1	**1.0**
3. Tablet Computers	1	1	2	**1.3**
4. Sip-and-Puff	1	1	2	**1.3**
5. Head Pointers	1	2	1	**1.3**
6. Screen Readers	2	1	2	**1.7**
7. Digital Pens	1	3	1	**1.7**
8. Head Tracking Software	1	2	2	**1.7**
9. Eye Tracking Software	1	2	3	**2.0**
10. Accessible Voting Machines	2	1	3	**2.0**

Each of these 10 technologies are discussed below.

Switches. Switches are basic, well-proven assistive technologies that enable individuals with sensory, cognitive, and physical disabilities to interact with and access computers, tablets, and similar devices. Switches replace a keyboard and mouse or touchscreen and allow users to tab or scan through an interface. Switches are often pushbuttons and come in myriad sizes, shapes and forms. Switches can be operated by a push/pull, squeeze, blink, or by breathing in or out (sip-and-puff devices are a form of switch), among other methods of interaction. They can be activated with hands, feet, or any other body part that can consistently produce voluntary movement. While some people use multiple switches, others prefer to use a single switch. Some switches also deliver different functions based upon the length of time they are held, which can be especially helpful in providing input options for individuals using only one switch.

Switches do not connect directly to a computer, so they require a switch interface that connects to a USB or serial port to map the switch or switches to the specified commands. Bluetooth switch interfaces are also becoming more common, removing the need for a wired connection to the device with which the user is interacting.

Many companies produce switches, with prices in the $30-$200 range (including the switch interface), though some specialty switches can retail for nearly $1000.

Speech Recognition Software. Speech recognition software (also known as speech-to-text software) is technology that converts the spoken word into text or into inputs that can be used to interact with software applications. Speech recognition software is used for tasks like interacting with automated phone systems, creating detailed dictations, or issuing computer commands. There are two types of speech recognition programs: *speaker independent* and *speaker dependent* systems. This refers to whether or not the software utilizes a training routine to increase recognition accuracy. Speaker dependent software requires the user to "train" the software so that it can learn the speaker's voice and speech patterns. Speaker independent software does not utilize training, so it can be used immediately by any user, but it may be less accurate or may recognize a smaller vocabulary than speaker dependent software. High-end dictation software is usually speaker dependent, due to the large vocabulary utilized. Automated phone systems are more likely to be speaker independent, allowing for a large number of users to communicate a small subset of commands to the software.

Speech recognition software is already a useful accessibility tool in many situations. It can be used to generate closed captioning for hearing impaired individuals, and it enable users with hand or arm mobility impairments or missing limbs to interact with various computer software programs that typically require the use of a keyboard and mouse. In terms of voting, many new systems are beginning to incorporate speaker independent speech recognition software that allows disabled users to navigate and mark a ballot. Users can give predetermined verbal commands that allow them to interact with a ballot quickly and efficiently. There are privacy concerns associated with speech recognition voting, as voters will be speaking their choices out loud, but the voting interface can be designed to mitigate these issues, for example by presenting candidates in a random order and allowing users to speak a letter or number associated with the candidate, rather than the candidate's actual name.

Speech recognition software is widely available on the market. The leader in speech recognition software is Nuance, the vendor of Dragon NaturallySpeaking (Windows) and Dragon Dictate (Mac). These two products retail for about $200 for the professional versions (although multi-user license fees may be more expensive) and have reported accuracy rates of about 96%. Windows and Mac computers come with Windows Speech Recognition and Speakable Items, respectively, which are preinstalled speech recognition packages. Speech recognition programs such as Tazti, MacSpeech Dictate, TextSpeech, SpeechMagic, and Sonic Extractor range in price from as low as $29 (Tazti) to as high as $35,000 (Sonic Extractor), depending on their capabilities and industry focus. There are also a number of open source speech recognition programs in development that are entirely free to download and use for development or research. Most of these programs are very general in application, but there are even specific programs available for the medical and legal fields. Mobile speech recognition is also becoming more prominent, especially with applications like Apple's iOS-based Siri, which is an "intelligent personal assistant," and utilizes speech recognition technology to interact with and perform actions dictated by the user. Even gaming consoles, like the Xbox Kinect, now have speech recognition capabilities, allowing for the general public to enjoy and benefit from this technology.

Tablet Computers. A tablet computer, or a tablet, is a mobile computer larger than a cell phone but generally smaller than a laptop and typically operated by a touch screen rather than a physical keyboard. An onscreen virtual keyboard is available for text entry, and some tablets also use a digital pen. The slate is the most common form of tablet; these do not have an integrated keyboard, but can be attached to one through an interface port, or can be used with a wireless keyboard. Another type of tablet is called the hybrid. Hybrids use a keyboard that is detachable from the touch screen. The third form of tablet computer is called a booklet. These have two touch screens and can be used like a notebook computer, with one screen dedicated for the virtual keyboard.

Standard computers often call for a user to operate a mouse. This requires that the user be able to perform physical and visual functions. Physically, the user must be able to grip the mouse, move it on a level surface, press buttons, and accurately select targets on the screen. Some commands require that the user perform multiple actions, such as pressing and holding a button while moving the mouse. Visually, the user must be able to see where the cursor is and track it as it moves around the screen. The user must be able to see their target to select it with the cursor.

A touch environment makes navigation easier for many users, compared to the conventional use of keyboard and mouse. Often, tablets also feature a text-to-speech option and adjustable font features which increase accessibility for low vision users. Sliding and tapping on a tablet is often easier than typing or writing for users with coordination or cognitive difficulties. Tablets are easier to use while lying down as compared to a laptop computer; this can be helpful for people who spend much of their time in bed for medical reasons, or who find that sitting or lying in bed is more comfortable than using a chair or standing. Tablets also offer word and sentence completion, which is helpful for those who may struggle to type.

Popular tablets include the Amazon Kindle Fire, Barnes & Noble Nook Color, Sony tablet S, Asus Eee Pad Transformer Prime, Samsung Galaxy Tab, and the Apple iPad, which range in their available capabilities and price (typically $200-$700+). There are also companies, such as DynaVox, who have created tablets made specifically for disabled users to aid them with communication and activities such as web browsing.

Sip-and-Puff. Sip-and-Puff, Sip/Puff, or Sip 'n' Puff (SNP) technology is a system used to control a device by turning air pressure into electrical signals. For people with motor disabilities or double amputees, operating a traditional computer mouse or switch can be frustrating or impossible. This technology allows users to control devices such as computer mice or motorized wheelchairs by inhaling/sipping and exhaling/puffing on a “wand” or tube.

Devices that use SNP technology require specific amounts of air pressure to be “sipped” or "puffed" by the user. These amounts of pressure are typically denoted as a hard sip/hard puff or soft sip/soft puff. The words “hard” and “soft” depend on the user’s breathing abilities and therefore are relative to the user. A calibration process, with the aid of an assistant or technician, is usually required before the user begins using the SNP device. Sips and puffs can effectively be used to navigate a computer screen and accomplish mouse button clicks. A sip-and-puff input device combined with scanning software means many keyboard-accessible programs can be used. In 2010, a sip-and-puff prototype for the iPhone was being developed by a student at Georgia Tech. Ranging in price from $300-$3,000, SNP technology allows users with very limited control of their bodies to be able to interact with electronics.

Head Pointers/Wands. Head pointers, also known as head wands, are aids for people with limited hand use. The device is comprised of an aluminum pointer that is attached to the center of the forehead or jaw via a headband made of thermoplastic or similar material. The pointer can provide keyboard access, as well as activities such as turning pages or drawing. Size and shape of the frame, as well as the length and angle of the pointing rod are adjustable to fit a variety of users. These devices help people with limited verbal communication skills to use communication boards and to point. It is also used for pushing in buttons.

Head pointers are relatively simple and range in price from $30-$300. They often require more energy to use than other assistive technologies, are slow to type with, and can even cause strain of the head and neck. They could still be useful in assisting voters who need to use a pen or pencil to write on a ballot, or to press buttons on an electronic ballot.

Screen Readers. Screen readers are the direct counterpart to speech recognition software, utilizing text-to-speech versus the speech-to-text found in speech recognition. Whereas speech recognition aims to interpret a user’s input and convert it to a command or a written document, screen readers use a text to speech (TTS) synthesizer to identify and interpret what is displayed on the computer and convert it to speech or a refreshable braille display. Because the majority of screen reader users are visually impaired, they typically interact with their computers without the use of a mouse, which is a visual tool. Instead, these users utilize a wide variety of keyboard commands – some unique to the screen reader and some standard operating system shortcuts – to accomplish tasks such as reading documents, navigating the internet, and managing files. This experience is, understandably, much different for a screen reader user than a sighted user. The audio interface has to present all of the information linearly, though users can skim through content at a higher level (i.e. section headers) before delving into the main content. While screen readers are advanced software programs, much of their functionality is dependent on the underlying design of the content they are dealing with. For instance, if a website author did not organize a page with any differentiation for the headers and body, the screen reader will have no way of distinguishing this difference and the skimming method will not be possible. While this does pose some drawbacks for screen readers, there are many benefits as well. One primary benefit of screen readers is that users are actually able to listen to content at speeds upwards of 300 words per minute, allowing for incredibly fast information processing.

Screen readers are one of the most proven assistive technologies, having been in development since the early 1980s. These early programs were mainly focused on providing computer access to visually impaired individuals, but as screen readers have evolved, their applications as aids for illiterate and learning disabled individuals have become more apparent. For voting, screen readers have the potential to give visually impaired individuals the ability to cast their ballot independently. The issue with this is that screen readers require digital data and, as stated, this data needs to be designed in such a way that a user can interact with it efficiently. However, with more options for electronic voting machines and ballots, the implementation of text-to-speech is much easier to realize. One example of a successful implementation of screen reader technology in the voting process was the Alternative Format Ballot (AFB) used in Oregon for the 2008 General Election. This digital ballot could be accessed at one's home as an absentee ballot using whatever assistive technology they preferred, but was also available for use on computers at polling locations using a screen reader called ZoomText. While this is a slightly outdated example, it does show the successful implementation of this technology in a voting situation.

Some of the most common screen readers available are programs such as JAWS, Window-Eyes, System Access, VoiceOver, NVDA, Orca, WebAnywhere, Supernova, and the aforementioned ZoomText. While WebAnywhere, NVDA, Orca, and VoiceOver (ships on all Mac systems) are free, the leading screen reading software, JAWS and Window-Eyes, range from $895-$1095, depending on the version desired. These software programs all have some variations in their hotkeys and the features that they offer (such as the ability to define macros, optical character recognition, and eBook compatibility), but they all provide a highly improved accessible experience for their users. Because much of the complexity in these programs is their ability to "read" and speak a high volume of information, a simpler version of text-to-speech technology could be utilized for a voting application where there is a predefined set of words and phrases that need to be uttered.

Digital Pens. A digital pen is a device that captures analog handwriting information and converts it to digital data. This data can then be read into a computer and interpreted by optical character recognition (OCR) software or simply displayed as graphics. Digital pens use one of three technologies to record and convert analog data: accelerometers, positional sensors, or a small Infra-red camera. The camera based digital pens are becoming more and more popular in the consumer market. These use a special "digital paper" covered with a non-repeating micro dot pattern to detect the location of the stylus on the paper. Some models also include a digital audio recorder that, when used with this special digital paper, will record not only what is written, but will also synchronize the notes with the recorded audio. Users are then able to replay specific excerpts of audio by tapping on the notes taken at the time the recording was created.

Anoto, the creator of the camera-based digital pen/digital paper technology, makes two different digital pens that utilize Bluetooth to transfer data. Along with their own products, Anoto also licenses this technology to many other leading companies, including Logitech and Livescribe. Furthermore, most current optical scan voting systems are based on Anoto technology. Livescribe is a popular smartpen manufacturer that makes two pens called the Echo and Pulse; both are about the size and weight of a large ballpoint pen. Livescribe pens support audio recordings that are indexed to the handwritten text, can function as a calculator, and even translate words. Digital pens can range in price from about $50 to $300, with most lying in the $100-$200 range.

Head Tracking Software. Head tracking allows users with good head control to guide their computer mouse. Head tracking software is most often calibrated to a tiny reflective dot that can be stuck to the forehead, eyeglass frame, tip of nose, etc. The monitor-mounted transmitter/receiver sends infrared beams out, and senses reflections from the dot. Other systems use a specific feature on the face, such as the inside of an eyebrow or eye, or area between the nose and mouth and a standard webcam (these tend to be less precise and lighting can affect accuracy). Movement of the head corresponds to movement of the mouse.

Selecting items is usually accomplished by “dwell clicking”. Users can left click, right click, double click, and drag by simply holding the cursor still, or “dwelling” on an icon or button. The Dwell Click time interval can often be adjusted (example: from 0.2 to 2 seconds) for maximum control and comfort. For those users that have limited control over their bodies, some systems allow switches to be incorporated to perform clicks while others support voice control options. Head tracking could potentially allow users to navigate and “dwell click” to interact with a digital ballot and it is commonly accepted that head trackers are easier to use than eye trackers.

Head tracking devices are commercially available under names such as Camera Mouse, SmartNav, ViVo Mouse, and Tracker Pro. CameraMouse is available for free download and uses a standard webcam, but more accurate head trackers range from $300-$1000.

Eye Tracking Software. Eye tracking software is a technology that works in conjunction with some type of sensor, such as electrodes placed around the eyes, special contact lenses, or video to measure the point of someone’s gaze (where they are looking) or the motion of the eye relative to the head. This task of gaze tracking with video is accomplished by utilizing a camera and an infrared (IR) or near-IR light source to create corneal reflections. These corneal reflections are then related to the center of the pupil to generate a vector that corresponds to the gaze location. Some calibration is necessary prior to usage. In video eye tracking, two main techniques are used: bright pupil and dark pupil reflection. The difference between these two methods is the location of the illumination source with respect to the optical axis of the imaging sensor. Bright pupil tracking involves placing the illumination source coaxially with the optical path, thereby lighting up the pupil similar to the “red-eye” effect. This method reduces the noise created by features such as eyelashes, but tends to work better with individuals with light colored irises and in a darker environment. Dark pupil tracking, on the other hand, places the illuminators away from the optical path, making the pupil appear black. This method is much more robust in bright and natural lighting and with darker irises, though eyelashes and other features have been known to cause false positives in the detection process.

Eye trackers have been used for about a decade as assistive technology for people with conditions that limit or prevent hand control, such as Amyotrophic lateral sclerosis (ALS), quadriplegia, Cerebral palsy (CP), Multiple Sclerosis (MS), or miscellaneous brain injuries. While eye trackers require users to fixate on objects for a short duration to record gaze information, many of the commercially available eye trackers do very well at handling spastic head movements, like those associated with CP, as well as physical interferences such as eyeglasses. Many eye trackers also work with monocular tracking, if binocular tracking is not allowed by a particular situation. Once the system is calibrated (though some allow for calibration-free interaction) and users are comfortable using an eye tracker, they can use movements of their eyes to type, move a mouse, browse the internet, check and respond to email, play games, read books, and even synthesize speech.

Eye trackers, while very useful, are still expensive systems and require a combination of specialized hardware and software. Popular eye trackers used for Assistive Technology include EyeGuide™ Assist, Intelligaze, EyeMax System, ERICA, EyeTech TM3, SeeTech, Eyegaze Communication System, and VISIOBOARD. These range from just over $700 (EyeGuide) to $25,000 (VISIOBOARD) and up. While at least one of these systems, EagleEyes, is free for qualified users, the median price for an eye tracking system is about $6000.

Current Accessible Voting Devices. Clearly, increased attention is being brought to the importance of making voting more accessible. With new guidelines are continually being put in place to make polling locations ADA compliant, many counties and states have begun using some of the different accessible voting machines that are currently available.

One example is the eSlate, made by Hart Intercivic. The eSlate has a tactile (not touch screen) interface and a headphone jack for added accessibility. Sighted, as well as visually impaired users can interact with the push button interface located at the bottom of the slate. Five control buttons and a round “select” wheel allow the voter to scroll through the ballot. The eSlate uses a straight linear ballot and allows the user to scroll through each contest, select a candidate, and has a final screen summarizing their selections with an option to go back and change selections. The eSlate also has a verifiable ballot option (VBO) which automatically creates a paper audit trail. Depending on the selected options, the eSlate retails for $3300 - $5300.

Another accessible voting machine is the Vote-Trakker, made by Avante. The Vote-Trakker has both a touch screen interface as well as a QWERTY keyboard for low vision users. Synthetic speech output is used to read the title of the contest as well as each candidate’s name. To choose a candidate, the user must press *Enter* after the name is said. The voter can scroll back with the arrow keys, but if the voter waits too long, the machine enters "Abstain" for that particular race. The review page at the end of the voting allows the user to select a contest and change their vote.

Other notable accessible voting machines are the ES&S iVotronic ($4000) and AutoMark ($5700), the Premier (formerly Diebold) AccuVote, and the Sequoia AVC Advantage. While these machines are much more accessible than their predecessors, studies have found that all of these machines do pose some difficulties with changing votes and submitting ballots. Furthermore, a fear of system glitches or hacking when using electronic voting technologies still worries many voters. Pricing is difficult to obtain for these machines, as they are not sold to general consumers, but with accessories and maintenance fees, most are priced from about $2500-$6000.

5.2 Solutions to Improve Accessibility of Voting Technology

A number of potential solutions have been identified to address the barriers described in Section 4.1. Issues with solutions that scored in the top 15 (as shown in Table 2) are listed below, and the proposed solutions are described.

Speech output is inaccurate. *(Impacts low vision or blind users)* Ensure that computer generated speech output passes a certain standard. While newer computer generated speech programs have remarkably human-like speech output, older systems may present a problem. If an older program is being used, the quality of the speech output should be evaluated. There are multiple tests for evaluating different aspects of speech quality, but the most common problems involve prosody (rhythm, stress, and intonation of the speech). This aspect of synthetic speech can be evaluated with a test such as SAM Prosodic Form Test (van Heuven & van Bezooijen, 1995). Screen readers are improving steadily and a robust program should not be difficult to locate and implement.

No headphone jack is provided on the device. *(Impacts low vision or blind users and hearing impaired users)* Provide a headphone jack so that users can connect personal headsets to the device. The headphone jack should use a standard headphone connector (a 3.5 mm pin is most common). External audio playback through speakers should be disabled when headphones are connected. Ensure headphone jack is 1/8 inch stereo headphone jack to allow individual voters to supply personal headsets. The use of a standard sized headphone jack would allow voters who want to use their own headphones the ability to do so easily.

Small text and icons are difficult for users with low vision to perceive. *(Impacts low vision users)* 1) Ensure that the font size used for text is sufficiently large. Characters should be at least 3 millimeters tall. Where possible, allow font size to be magnified or adjusted to a larger size.

2) Provide alternatives to the visual display to facilitate interaction by users with low vision. A voice display should be integrated into the machine, so that visual content is presented in an

auditory fashion as well. For example, using a set of hardware controls, the user could navigate through configuration menus that are voiced, without having to read the menus on the display. This issue is a prime candidate for a screen reader.

Control names are not descriptive. *(Impacts low vision or blind users, and potentially impacts cognitively impaired users)* Control labels should be descriptive enough that their purpose is evident even without visual cues. For example, a control should be visually and auditorily labeled "Next Contest" rather than simply "Next."

Error feedback is not provided. *(Impacts all users with disabilities)* Provide an electronic absentee ballot. A web application that supports overvote and undervote detection could be provided. The ballot need not be cast electronically, even though it could be obtained electronically (it could be printed and mailed or faxed, if allowable). If provided electronically, a screen reader could be implemented to allow the voter to obtain error feedback if they over/undervoted. The screen reader would also allow the absentee voter to vote in privacy, without the assistance of an aid or voter representative.

The system does not provide sufficient instructions. *(Impacts all users with disabilities)* Instructions and help should be provided at appropriate times. Before users begin voting with a device, the device should provide general instructions that give users the basic information they need to operate the voting device and to interact with the ballot. More detailed information (help) should be available on request throughout the voting process as needed.

Instructions may be difficult for users with cognitive impairments to understand. *(Impacts all users with disabilities, particularly those with cognitive impairments)* 1) Use simple language in instructions. Use the simplest language that conveys the required information. Use familiar words, and use short sentences and paragraphs. Use the imperative form of verbs (e.g., "Press the down arrow" instead of "The down arrow should be pressed"). Use appropriate illustrations to reinforce the contents of the text.

2) Ensure that instructions are grammatically correct and free from typographical errors. Instructions should be reviewed by a technical writer or a proficient editor who is familiar with the ballot for which the instructions were written.

3) Provide structure to the steps by grouping them into sub-goals. A long sequence of actions may appear to lack structure, making it difficult for users to understand. Provide structure by using headings to group sets of related steps. Use of indentation can help delineate sets of sub-steps. However, do not rely solely on indentation, because it is inaccessible to blind voters.

4) Ensure that the sequence of actions is presented unambiguously and in the proper order, especially if the instructions are presented via speech output. Instructions for actions should be presented in the order in which they are to be executed (e.g., "Insert coins, then insert bills" instead of "Before inserting bills, insert coins").

5) *Place* CONDITION *before* ACTION. Goals or conditions for action should be presented before the action, especially if the instructions are presented via speech output. For example, use the form "To select the 3 PM showing, press 1" rather than "Press 1 to select the 3 PM showing."

6) Test instructions with members of the user population to ensure that they are easy to understand and to follow. User testing will help identify potential sources of errors or confusion in instructions. Care should be taken to sample a representative portion of the targeted user population, including users with disabilities.

7) Use unambiguous words and phrases. Ambiguous words and phrases will confuse voters. For example, the instructions, "Continue voting next page" might be interpreted to mean (a) continue to the next page for the next race or (b) continue to the next page to see more candidates for this race. This is an example of an issue that would benefit from a simple solution, based on sound design principles regarding instructions and assistance.

Complex or inconsistent user interface screens may be difficult for users to understand. *(Impacts all users with disabilities, particularly those with cognitive impairments)* 1) Reduce the complexity of user interface screens where possible. Design screens around individual user tasks (for example, a voting machine might have one screen dedicated to each contest). Avoid complex displays that contain a large number of options and controls.

2) Use consistent terminology throughout the user interface. Ensure that names and abbreviations are applied consistently throughout the user interface. 3) Limit the use of abbreviations. Abbreviations (especially those that may be unfamiliar to users) should be used sparingly in the user interface.

Users do not notice when the review screen differs from their intended selections. *(Impacts all users with disabilities, particularly those with vision impairments or cognitive impairments)* 1) Use color and icon codes for party affiliations. Each political party could be coded by a color and icon. The color and icon would appear with each selection on the review screen. Clear instructions and a color/icon legend should appear at the top of the review screen.

2) Use instructions to stress the importance of review. With a brief statement at the top of the screen, urge voters to carefully review their selections. For example, "Voting errors are common. Carefully review your selections below."

3) Place hyperlinks on the review screen. Hyperlinks to review data would make it easier for voters to see a summary of their voting actions. Voters should be able to click on each race shown on the review screen. The system should make it easy for users to navigate directly to a specific contest from the review screen, make desired changes, and then return to the review screen after changes have been made.

The system does not provide adequate notification of or protection against overvoting and undervoting. *(Impacts all users with disabilities)* Highlight undervotes and overvotes. Use a salient visual and auditory cue such as highlighting to draw attention to undervotes and overvotes on the review screen or through headphones. This will give the voter an opportunity to go back and adjust, if they so choose. Undervotes/overvotes may be the result of an inadvertent action and thus should be corrected in order for the vote to count as expected. A screen reader may be helpful for those with low vision.

The voting machine does not provide sufficient feedback to the user. *(Impacts all users with disabilities)* 1) Ensure that feedback is provided for all relevant events. Provide feedback for all user inputs, system status changes, user or system errors, and other events that are relevant to the user's interaction with the machine. Feedback for different events should be distinct from one another and appropriate to the events represented. For example, a simple click may be sufficient to acknowledge a keypress, but a more prominent tone may be necessary to indicate that an error has occurred.

2) Provide feedback in a visual format. Visual feedback is necessary for users with hearing impairments, but it can also be helpful for users with low vision (if the feedback is sufficiently large or if it also makes use of color or other visual cues), and for users with upper mobility impairments (to help the user determine when unintentional inputs have been made).

3) Provide feedback in an auditory format. Auditory feedback is necessary for users who are blind, and it can also be helpful for users with low vision and for users with upper mobility impairments. Beeps and other sounds help users know that input was accepted (e.g., an item was successfully scanned), and also serve to alert users if an unintentional input was made (e.g., a quantity of "22" was entered instead of "2"). Voice output of more complex data (such as the price of an item that was scanned, or indications of required user actions) helps users with visual impairments verify transactions and allows them to operate voting machines more effectively. A screen reader would provide appropriate assistance for solution #3.

The system does not provide clear and consistent navigation controls. *(Impacts all users with disabilities, particularly those with cognitive or mobility impairments)* Place common controls consistently throughout the user interface. If there are controls that appear on multiple screens, such as navigation controls, ensure that the placement of those controls is the same on every screen. The availability of a switch could provide the necessary navigational controls if implemented appropriately. An eye tracker or head tracker could be a viable solution with an electronic voting system.

Onscreen controls that are small and close together may be difficult to activate without activating adjacent controls. *(Impacts all users with upper mobility and dexterity impairments, and users with low vision)* 1) Redundant visual and auditory feedback should be provided. If the user makes a mistake, the redundant feedback will alert the user to the mistake.

2) On touch screens, controls should have an appropriate size and minimum distance from other controls. Controls should have a minimum height of 0.5 inches and minimum width of 0.7 inches. The vertical distance between the centers of adjacent areas should be at least 0.6 inches, and the horizontal distance at least 0.8 inches. Providing a separate switch or a button control pad for those with upper mobility impairments or dexterity limitations may alleviate activation errors.

Voters who need assistance marking the ballot cannot vote privately. *(Impacts users with vision impairments and users with upper mobility impairments)* Separate the list of candidates from the response fields. Candidates could be listed on a sheet to be read by the voter. A separate response sheet – to be marked by the voter's assistant – could contain a list of arbitrary letters. The letters would be paired with the candidates on the document viewed by the voter. The voter would be required to dictate only the letter associated with their chosen candidate, thus ensuring privacy. A screen reader, head tracker, or eye tracker may provide the necessary assistance, provided the ballot is electronic.

Speech output via speakers may be inappropriate due to privacy concerns*. (Impacts users with vision impairments and users with hearing impairments)* Provide a headphone jack so that users can connect personal headsets to the device. The headphone jack should use a standard headphone connector (a 3.5 mm pin is most common). External audio playback through speakers should be disabled when headphones are connected. Ensure headphone jack is 1/8 inch stereo headphone jack to allow individual voters to supply personal headsets. The use of a standard sized headphone jack would allow voters who want to use their own headphones the ability to do so easily. Avoid outputting potentially sensitive information through speakers*.* Due to privacy concerns, information regarding a user's votes should not be broadcast through speakers. Rather, it should be delivered via a screen reader through the headphone jack.

The voting device does not provide or support necessary accessibility options.* *(Impacts all users with disabilities)* Provide multiple input methods for voting, including write-in votes. Given the various types and severity of injuries, no single solution will be accessible for all individuals with disabilities. Therefore, it is necessary to provide multiple methods of input. Voting systems utilizing touchscreen displays must provide at least one other input method that can be used by individuals with visual impairments and upper mobility impairments. These methods may include speech recognition software or other software applications, or external peripherals, such as a mouth stick, sip-and-puff, or a reaching aid. A number of AT would be relevant to this issue, such as accessible voting machines (see additional details in Section 5.3), switches, voice recognition, sip-and-puff device, or a digital pen.

*This was an issue that was not rated in the top 15 barriers of voting, but should be recognized due to its impact on the target population.

5.3 Additional Design Recommendations for Accessible Military Voting Systems

The needs assessment resulted in the identification of general areas of the voting process that present accessibility challenges (issues with the physical space, ballot design, and voting technologies), and of specific types of accessibility challenges that arise from the injuries most common to service members. Because members of the target population may reside in a hospital or treatment center for extended periods of time, military voting accommodations must not only consider the needs of patients in a wide range of physical states, but must also consider accommodations that could be feasibly implemented in a rehabilitative setting. An additional consideration is that, because many of the users in this context will be newly-disabled, they will have little or no experience with assistive technologies and will still be learning how to function in their new circumstances.

A variety of alternative forms of presenting, completing, and submitting the ballot are discussed below. Many of these recommendations do not require new and emerging technologies in order to improve accessibility. Improvements in ballot design through application of basic human systems integration principles that address efficiency and ease of use can result in significant increases in accessibility.

5.3.1 Software Considerations

Software considerations for an accessible voting system for the target population include addressing issues with ballot design and presentation, and also providing an assortment of assistive features to support users with a variety of disabilities.

5.3.1.1 Ballot Design

Many of the software considerations for an accessible voting interface for service members with disabilities are in the area of ballot design – the visual appearance and spatial layout of the information in the ballot. The major ballot design features are described below.

Sparse layout. Only essential information will be displayed on ballot pages, to reduce clutter and focus attention on the most important elements on the page.

Large controls. Active area of controls will be large, to facilitate touchscreen use and reduce selection errors, particularly for users with dexterity and fine motor control issues.

Large fonts. The smallest font used in the interface will be around 14 point (for blocks of text), with larger fonts used for critical information such as contest titles and candidate and party names. The sparse design of the interface allows the use of larger fonts without the display becoming cluttered. The font size will be also be adjustable by the user if desired.

Mixed case. All of the text in the interface will be presented in mixed case for improved readability. Varying font sizes and weights and other techniques will be used to distinguish headers and other information.

High contrast. The basic presentation of the ballot will have high contrast between the background and the foreground. The ballot will predominantly use black and white with some shades of gray.

Color will be used sparingly for high priority elements like user selections and error notifications. Users will be able to select from an assortment of color schemes providing a range of contrast levels.

Consistent layout. Each page of the ballot will have a consistent layout; key elements will appear in the same location across all pages. The page title or contest name will appear in a title bar at the top of each page. A navigation and control bar will appear directly below the title bar, followed by any pertinent instructions (such as the allowable number of selections for the current contest). Contest-specific information (candidate and party names, proposition text, etc.) will appear in a scrollable area that occupies the bulk of the page. A progress bar will appear at the bottom of each page.

Simple, linear presentation. Initial screens will present basic instructions to users and allow them to configure accessibility options (or have them configured by someone else) before entering the ballot. The ballot will be organized to present one contest per page, with all the information and options for a contest presented on a single page. Navigation of the ballot will be linear, using Back and Next buttons to move between screens. A context-sensitive help and accessibility options page can be accessed from any page; when the user dismisses that page, he is returned to the previous ballot page. Write-in entry is handled in a similar way.

Error handling. The two predominant "error" conditions that will be encountered are overvoting (selecting too many options, which is not allowable) and undervoting (selecting fewer than the number of allowed options, which is allowable, but is something the user should be notified about). The system will prohibit overvoting by preventing users from making more than the allowable number of selections. (The precise mechanism by which this will be accomplished is a topic for further investigation.) The system will allow undervoting, but will notify users of undervoted contests both when navigating away from the contest page and on the summary page. Error notifications will be clear and unambiguous, and the system will be designed to facilitate easy recovery from error conditions.

Summary/review page. Before a ballot is submitted, a summary/review page is displayed. All of the user's selections for the entire ballot are displayed for review. Notifications of potential errors (such as undervoted contests) are displayed. From this page, the user can return directly to previous ballot pages to make changes or corrections, and then return directly to the summary page.

Flexible controls. The ballot is designed to be compatible with a variety of control inputs. It supports direct selections via touchscreen or mouse, but is also compatible with keyboard controls and 2- or multi-button switch controls without changing anything about the user interface.

5.3.1.2 Adjustability and Accessibility Features

Beyond ballot design issues, an accessible voting interface for service members with disabilities must also provide an assortment of assistive features to support users with a variety of disabilities. This includes adjustability of key elements of the display, as well as features designed to provide accessibility for specific types of disabilities.

Adjustable font size. Users can adjust the display to increase (or decrease, if desired) the size of all fonts used in the system. The screen layout will automatically reflow to accommodate changes to font size while preserving the overall layout of elements.

Adjustable contrast. Users can select from a range of display schemes that provide a variety of contrast options, including light text on a dark background, dark text on a light background, and an overall dim presentation for users who are sensitive to light.

Context-sensitive help. A context-sensitive help system will be available to users via a Help button on the control bar at the top of each page. Help content relevant to the current page type will be displayed, and users will also be able to access controls for adjustments and accessibility features through the help system. When the user exits the help system, the interface will return to the state it was in when the help system was accessed.

Voice output. The system will provide a simple, integrated voice output system. Only basic adjustments will be available (voice output on or off, volume adjustment, and possibly speed adjustment), and the ability to pause, resume, and repeat audio output will be provided where necessary. Due to the fact that users of this system may be unfamiliar with screen readers (due to the recentness of their injuries), it is important to ensure that the voice output system is simple and easy to operate for a novice user.

Save and resume. Concentration issues and fatigue are major considerations for the target population. Because ballots can be long and involved and take an extended period of time to complete (especially when using assistive technologies), the system could provide the ability for users to save an in-progress ballot and return to it later, after a period of rest. This functionality is under consideration for inclusion in the military voting prototype.

Speech input. Although not currently in development in the military voting prototype, the system could be extended to incorporate support for speech input. A major consideration when implementing speech input is to design the interface to ensure that speech input users could make their selections privately.

Tracking input. Although not currently in development in the military voting prototype, the system could be extended to incorporate support for tracking-based control. With minimal changes to the user interface, the system could track a marker or features of the user's head or eyes to control a pointer and make selections.

5.3.2 Hardware Requirements

Understanding the hardware requirements will assist in meeting the necessary goals to achieve accessibility in voting systems. Currently, many machines do not provide the appropriate input/output peripherals to promote full accessibility. For example, not providing neckloops and t-coil inputs may limit voters who primarily use those devices. Some of the hardware examples listed below have been mentioned in the issues section, but additional declarations are warranted.

Portability. A voting system for use in a rehabilitative setting should be portable, so that it can be brought to users where they are, rather than requiring them to go to the system. This would be particular beneficial for users with mobility issues or anxieties related to social situations, because it would allow them to vote from a location where they are physically or psychologically comfortable.

Flexible mounting. The voting system hardware should support a variety of physical use cases. It should be small and light enough to be hand-held (perhaps in a tablet form factor), but should also be able to be mounted on a portable stand for use from a bed or a chair, or installed as a fixed kiosk in a more centralized voting situation.

Accessible touchscreen. Touchscreen interfaces are beneficial because they provide direct mapping between display and control elements by allowing users to touch display elements to activate them. Touchscreens also reduce parallax issues (i.e., the misalignment of physical controls with display items at certain viewing angles – a particular concern for users in wheelchairs), and eliminate ambiguous display-control mappings. The touchscreen hardware should be compatible with materials other than skin, such as prosthetic devices, to allow use by a wider range of users.

Headphone jack. The voting system should provide a standard headphone jack so that the system can be used privately with speech output.

Interface with external controls. The voting system should be capable of interfacing with a variety of external controls, such as keyboard, mouse, or various types of button panels and switches. Wireless interface with those devices is preferred where possible.

5.4 Recommendations for Policy, Processes, and Support Services

There are policy issues that must be overcome to fully implement an end-to-end voting solution. Although policy issues were taken into consideration during this research effort, the primary focus was on applying technology to assist service members with disabilities with the voting effort. However, the following recommendations should be considered for improving the voting process at the policy level.

Obtaining accurate information on voter registration is difficult as service members transition out of active duty status. Voting assistance could be provided more extensively to Veterans Administration facilities. Mandate that state offices participate in Warrior Transition Unit meetings to ensure that injured service personnel preparing to transition from military service to civilian life have current information about voting. The state offices could work directly with Department of Veterans Affairs (VA) facilities, or this could be initiated at the local level.

Obtaining absentee ballots. The process of obtaining absentee ballots needs to be streamlined. During the needs assessment, it became evident that many of the service members interviewed were not aware of the various ways in which they could access voter registration and absentee ballot forms. Having that information readily available to all service members, whether active, transitional, or veterans in medical institutions would be a simple way to increase familiarity with the absentee ballot process. Regular reminders in the months leading up to an election would be helpful for those service members who have difficulty remembering to do things.

Availability of ballot data. In order for this proposed design to have maximum impact, all ballot data needs to be made available in an electronic format that is independent of any specific presentation style, so that the data can be displayed in a variety of ways based on the needs of each individual voter. Given the vast number of different ballot styles in use across the country, this is a big hurdle to overcome, but a number of proposals for storing ballot data as XML exist.

Prescribed ballot design. Attempts to improve ballot design may hindered by state or local laws that prescribe ballot design in undesirable ways (cluttered layout, all-caps text, etc.). These ballot design requirements must be relaxed in order for this proposed design to be implemented.

Internet voting. Internet voting is not currently allowed anywhere in the United States, but it is becoming an important topic of conversation in the voting community. A primary issue with internet voting is security; it is important to determine the acceptable level of risk for an internet voting system. Security concerns will play a role in acceptance of the technology (Hoke, 2009).

5.4.1 State Accessibility Practices Survey

A State Accessibility Practices Survey was conducted by Operation BRAVO Foundation, and a summary of data collected indicates that some of the issues described in this report are already being addressed by a number of states. The questionnaire was sent to the state election offices of the 55 states and territories. Forty-seven jurisdictions responded. States reported a variety of best practices and special projects for military voters, as well as for disabled civilian voters. A general summary of the report follows.

Indiana was the only state to report a best practice specifically for disabled veterans. Indiana’s work with Warrior Transition Units directly serves the target population of this study. The state office participates in Warrior Transition Unit meetings to ensure that the injured service members preparing to transition from military service to civilian life have current information about voting. California and North Dakota have implemented special online ballots for all military voters.

Many other states employ a variety of best practices for disabled civilian voters that may apply to disabled veterans as well. Forty-one of the states that responded to the survey offer online voter registration forms. Nine states allow these forms to be submitted electronically (via fax or e-mail). Several other states indicated that this capability will be provided in the near future. Thirty-nine states provide absentee ballot request forms online, and fifteen allow electronic submission as well. Several states indicated that electronic submission will be allowed soon, but most states require the forms to be submitted by mail or in person. Thirty states provide supervised voting for voters who are hospitalized or reside in group living facilities. Missouri has a unique outreach program to inform disabled voters.

The Secretary of State's office works with the Department of Revenue to identify persons who have applied for a handicapped license. They send a mailer to this list that outlines the options available for a handicapped person to register and vote.

Several states have implemented training programs or materials for poll workers and disabled voters. Several counties in California utilize instructional videos or graphical and text instructions for using accessible voting devices. Connecticut's Office of Protection and Advocacy provides videos of the accessibility devices available in polling places and conducts sensitivity training classes for poll workers. Maine works with advocacy groups to demonstrate their accessible voting system to voters and to provide information about the voting and registration process. In Wyoming, the Protection and Advocacy organization provides hands on training to the disabled community with actual voting equipment.

Based on the survey, the list of state best practices for voter accessibility includes

- Providing supervised voting in long-term care facilities, such as nursing homes, hospitals, etc.
- Allowing individuals to register to vote online. Forty-one states currently provide voter registration forms online, but only 9 allow them to be submitted online.
- Providing sample ballots online, with graphics and text instructions for filling out ballots and registration forms. States should consider allowing these to be used for absentee ballots.
- Providing voter information for people with disabilities online. At least 23 states do not currently have a webpage dedicated to information for voters with disabilities, according to the survey report by Operation Bravo Foundation.
- Providing pamphlets or brochures for voters with disabilities. At least 15 states do not currently have these. These materials could be created by other state government offices that are responsible for assisting disabled citizens, or by advocacy groups.
- Creating a check box on the voter registration form to indicate if assistance is required for voting (12 states do this, but nothing is statutorily required for the clerk to reach out to the voter). A marked check box could initiate different actions, such as emailing or calling the voter with due dates for absentee ballots.

6.0 Conclusions

This report has presented a comprehensive list of voting accessibility barriers for the target population and technologies that, if implemented appropriately, could help overcome those barriers. Many of the proposed solutions are based on applying basic design principles for users with disabilities, but some of these solutions may be ambitious, based on the current state of the art in voting technology and the current policy environment. Consideration must be given to not only to technology, but also to the overall voting process. Advancements in voting technology alone will not fully address existing accessibility barriers unless accompanied by changes to the policies, processes, and support services associated with voting.

Accessible voting technology may increase the likelihood that individuals with disabilities will vote. Inaccessible equipment denies the opportunity for a private and independent ballot for people with disabilities. However, there is assistive technology available that can level the playing field for all citizens regardless of disability. Accessible equipment allows people with disabilities to more readily involve themselves in the democratic process. As voting increases among people with disabilities, issues important to the disability community will gain more attention from the community at large, including politicians who shape the policies that affect people with disabilities. Weighing in on the debate over voting machines and voting technologies has an effect on the ability of the disability community to advocate for the laws and services needed to further integrate into their community.

Enabling the target population to secure full access to the electoral process was the primary goal for this project. With or without a disability, an individual should be assured they are able to vote privately, securely, and independently. More details about assistive technology, voting accessibility issues, design guidelines, and potential solutions can be found in the *Accessibility of the Voting System* monograph published in coordination with this report.

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Appendix A

This table contains a summary of the injuries and impairments common to recently injured service members in OIF/OEF as well as how those impairments affect the voting process. This information was obtained as a result of the Task 1 effort.

Table 5. Impairments and their impact on voting by recently injured service members

Injury	Impairment	Impact on Voting
TBI, Other	Loss of visual acuity (including blindness)	Voters may experience difficulty with completing or be unable to complete the following tasks: • Viewing a display • Reading a ballot • Reading instructions for completing the ballot • Selecting the desired option • Reviewing the ballot before submitting it
TBI	Sensitivity to light	Voters may experience difficulty with completing or be unable to complete the following tasks: • Viewing a display that emits light • Viewing brightly colored objects such as a bright white paper ballot
TBI, Other	Hearing loss or tinnitus	Voters may experience difficulty with completing or be unable to complete the following tasks: • Hearing auditory cues (such as beeps) • Hearing speech output (from a device or the voting assistance officer)
TBI, PTSD	Difficulty concentrating	Voters may experience difficulty with completing or be unable to complete the following tasks: • Maintaining focus on the voting process • Ignoring distracting stimuli • Keeping track of progress • Completing the ballot in a potentially limited amount of time • Paying attention to and comprehending instructions

Injury	Impairment	Impact on Voting
TBI, PTSD	Memory problems	Voters may experience difficulty with completing or be unable to complete the following tasks: • Remembering to vote • Remembering and comprehending the instructions for completing the ballot • Recognizing the name of the candidate or option he/she wishes to vote for • Comprehending long passages of text • Keeping track of progress • Completing the ballot in a potentially limited amount of time
TBI	Learning new tasks	Voters may experience difficulty with completing or be unable to complete the following tasks: • Learning how to use new voting technology • For first time voters, learning about the voting process • Assembling the components of a ballot for submission
Upper body injuries, TBI, SCI, Other	Loss of dexterity and fine motor control; loss of sensation	Voters may experience difficulty with completing or be unable to complete the following tasks: • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Selecting or marking a small target (e.g., filling in a small oval) • Handling voting materials such as paper ballots, other voting paperwork, and security and mailing envelopes
Upper body injuries, SCI, Other	Amputation requiring the use of a prosthetic hand or arm	Voters may experience difficulty with completing or be unable to complete the following tasks: • Using a touchscreen (depending on the type of touchscreen) • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Selecting or marking a small target (e.g., filling in a small oval) • Handling voting materials such as paper ballots, other voting paperwork, and security and mailing envelopes

Injury	Impairment	Impact on Voting
Upper body injuries, TBI, SCI, Other	Limitations in endurance	Voters may experience difficulty with completing or be unable to complete the following tasks: • Completing lengthy ballots
Lower body injuries, TBI, SCI, Other	Loss of mobility requiring the use of a wheelchair	Voters may experience difficulty with completing or be unable to complete the following tasks: • Reaching an installed device (e.g., a voting kiosk)
Lower body injuries, upper body injuries, TBI, Other	Pain	Voters may experience difficulty with completing or be unable to complete the following tasks: • Concentrating on the voting process • Grasping and manipulating a tool for marking a ballot (e.g., a pencil or stylus) • Completing lengthy ballots