2.2.7 Human Factors

The importance of human factors in the design of voting systems has become increasingly apparent. It is not sufficient that the internal operation of these systems be correct; in addition, voters and poll workers must be able to use them effectively. There are some special difficulties in the design of usable and accessible voting systems:

- The voting task itself can be fairly complex; the voter may have to navigate an electronic ballot, choose multiple candidates in a single race or decide on abstrusely worded referenda.

- Voting is performed infrequently, so learning and familiarity are lower than for more frequent tasks, such as use of an ATM.

- Jurisdictions may change voting equipment, thus obviating whatever familiarity the voter might have acquired.

- Once the voting session has been completed by the voter, there is never a chance for later correction.

- Voting must be accessible to all eligible citizens, whatever their age, physical abilities, language skills, or experience with technology.

The challenge, then, is to provide a voting system and voting environment that all voters can use comfortably, efficiently, and with justified confidence that they have cast their votes correctly. The requirements within this section are intended to serve that goal.

Although there are many detailed requirements, three broad principles motivate this section on human factors:

1. **ALL ELIGIBLE AND POTENTIALLY ELIGIBLE VOTERS SHALL HAVE ACCESS TO THE VOTING PROCESS WITHOUT DISCRIMINATION.**

   The voting process shall allow eligible voters of whatever age, condition, or background to be able to go through the entire voting process with the same degree of independence, privacy, and confidence, insofar as technology will allow. Note that the voting process includes access to the polling place, instructions on how to vote, initiating the voting session, choosing candidates, getting help as needed, review of the ballot, VVPAT, if applicable, and final submission of the ballot.

2. **EACH CAST BALLOT SHALL CAPTURE THE INTENT OF THE VOTER WHO CAST THAT BALLOT.**
2.2.7 Human Factors

Voters have the right to have the ballot presented to them in a manner that is clear and usable. Voters should encounter no difficulty or confusion in recording their choices.

3. THE VOTING PROCESS SHALL PRESERVE THE SECRECY OF THE BALLOT.

The voting process shall preclude anyone else from determining the content of a voter's ballot, with or without the voter's cooperation. If such a determination is made against the wishes of the voter, then his or her privacy has been violated. The process must also preclude the voter from disclosing the content of the ballot to anyone else.

All the requirements within Section 2.2.7 have the purpose of improving the quality of interaction between voters and voting systems.

- Requirements that are likely to be relevant only to those with some disability are listed under Section 2.2.7.1, although they may also assist those not usually described as having a disability, e.g. voters with poor eyesight or somewhat limited dexterity.

- Requirements that are likely to be relevant only to those with limited English proficiency are listed in Section 2.2.7.2.

- Finally, requirements for general usability make up Section 2.2.7.3 and those for privacy, Section 2.2.7.4.

Certain abbreviations and terms are used extensively throughout Section 2.2.7:

- CIF: Common Industry Format: Refers to the format described in ANSI/INCITS 354-2001 "Common Industry Format (CIF) for Usability Test Reports."

- Acc-VS: Accessible Voting Station - the voting station equipped for individuals with disabilities referred to in HAVA 301 (a)(3)(B).

- ATI: Audio-Tactile Interface - a voter interface designed so as not to require visual reading of a ballot. Audio is used to convey information to the voter and sensitive tactile controls allow the voter to convey information to the voting system.

- ALVS: Alternative Language Voting Station - a voting station designed to be usable by voters who have limited English proficiency.

This section also uses common terms as defined in the updated Glossary. Note in particular, the distinctions among "voting system," "voting station," and "voting process."
2.2.7 Human Factors

Section 1: Accessibility

1. The voting process shall be accessible to voters with disabilities. As a minimum, every polling place shall have at least one voting station equipped for individuals with disabilities, as provided in HAVA 301 (a)(3)(B). A station so equipped is referred to herein as an accessible voting station (Acc-VS).

HAVA Section 301 (a)(3) reads in part:

"ACCESSIBILITY FOR INDIVIDUALS WITH DISABILITIES.--The voting system shall—

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

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

The requirements within Section 2.2.7.1 are intended to address this mandate. Ideally every voter would be able to vote independently and privately. As a practical matter, there may be a small number of voters whose disabilities are so severe that they will need personal assistance. Nonetheless, the requirements of this section are meant to make the voting system directly accessible to as many voters as possible.

Note that this section does not replace requirements of other sections, but adds to them. In particular, the requirements of Section 2.2.7.3 on usability apply either to all voting stations or, in some cases, to all DRE voting stations; many of these requirements support accessibility as well as general usability.

Certain accessibility features that are likely to be useful to a wide range of voters are required on all voting stations, not just the Acc-VS. Finally, note that the Acc-VS is not necessarily a full-fledged DRE; for instance, an implementation may provide an ATI that generates an optiscan ballot.

The outline for Section 2.2.7.1 is:

2.2.7.1 Accessibility

2.2.7.1.1 Voters with Disabilities - General

2.2.7.1.2 Vision

2.2.7.1.2.1 Partial Vision

2.2.7.1.2.2 Blind

2.2.7.1.3 Dexterity

2.2.7.1.4 Mobility
2.2.7 Human Factors

Section 1: Accessibility

1. The voting process shall incorporate features that are applicable to several types of disability.

Discussion: These features span the disability categories within requirement # 2.2.7.1 (e.g., vision, dexterity).

1.1 When the provision of accessibility involves an alternative format for ballot presentation, then all the other information presented to voters in the case of non-disabled English-literate voters (including instructions, warnings, messages, and ballot choices) shall also be presented in that alternative format.

Discussion: This is a general principle to be followed for any alternative format presentation. Two particular cases, (a) audio formats and (b) non-English formats, are the subject of specific requirements in later sections.

[Best Practice for Voting Officials] When the provision of accessibility involves an alternative format for ballot presentation, then all the other information presented to voters in the case of non-disabled English-literate voters (including instructions, warnings, messages, and ballot choices) is also presented in that alternative format.

1.2 An Acc-VS shall provide direct accessibility such that voters' personal assistive devices are not required for voting.

Discussion: Voters are not to be obliged to supply any special equipment in order to vote. This requirement does not preclude the Acc-VS from providing interfaces to assistive technology.
2.2.7 Human Factors

1.3 When the primary means of voter identification or authentication uses biometric measures that require a voter to possess particular biological characteristics, the voting process shall provide a secondary means that does not depend on those characteristics.

Discussion: For example, if fingerprints were used for identification, there would have to be another mechanism for voters without usable fingerprints.

[Best Practice for Voting Officials] When the primary means of voter identification or authentication uses biometric measures that require a voter to possess particular biological characteristics, the voting process provides a secondary means that does not depend on those characteristics.

[Best Practice for Voting Officials] Polling places are subject to the appropriate guidelines of the Americans with Disabilities Act (ADA) of 1990 and of the Architectural Barriers Act (ABA) of 1968. This requirement does not stem from HAVA, but rather is a reminder of other legal obligations. For more details, see http://www.access-board.gov/ada-aba.htm and http://www.usdoj.gov/crt/ada/votingck.htm.

2. The voting process shall be accessible to voters with visual disabilities.

Discussion: Note that all aspects of the voting process are to be accessible, not just the voting station.

2.1 The Acc-VS shall be accessible to voters with partial vision.

2.1.1 The vendor should conduct summative usability tests on the Acc-VS using partially sighted subjects and report the test results to the appropriate testing authority according to the Common Industry Format (CIF).

Discussion: This requirement is meant to encourage Acc-VS designers to conduct some realistic usability tests on the final product. For
2.2.7 Human Factors

Section 1: Accessibility

now, it is purely a documentation recommendation. Future versions of the VVSG will include requirements for usability testing to be conducted by the testing authority, with specific performance benchmarks.

2.1.2 The Acc-VS and any voting station with an electronic image display shall be capable of showing all information in at least two font sizes, (a) 3.0-4.0 mm and (b) 6.3-9.0 mm, under control of the voter or poll worker.

Discussion: While larger font sizes may assist most voters with poor vision, certain disabilities such as tunnel vision are best addressed by smaller font sizes. It is anticipated that future versions of the VVSG will require font size to be under the independent control of the voter.

2.1.3 All voting stations using paper ballots should make provisions for voters with poor reading vision.

Discussion: Possible solutions include: (a) providing paper ballots in at least two font sizes, 3.0-4.0mm and 6.3-9.0mm and (b) providing a magnifying device.

2.1.4 An Acc-VS and any voting station with a black-and-white-only electronic image display shall be capable of showing all information in high contrast either by default or under the control of the voter or poll worker. High contrast is a figure-to-ground ambient contrast ratio for text and informational graphics of at least 6:1.

Discussion: It is anticipated that future versions of the VVSG will require contrast to be under the independent control of the voter.
2.2.7 Human Factors

Section 1: Accessibility

2.1.5 An Acc-VS with a color electronic image display shall allow the voter or poll worker to adjust the color or the figure-to-ground ambient contrast ratio.

Discussion: See NASED Technical Guide #1 for examples of how a voting station may meet this requirement by offering a limited number of discrete choices. In particular, it is not required that the station offer a continuous range of color or contrast values.

2.1.6 On all voting stations, the default color coding shall maximize correct perception by voters and operators with color blindness.

[Best Practice for Voting Officials] On all voting stations, the default color coding maximizes correct perception by voters and operators with color blindness.

2.1.7 On all voting stations, color coding shall not be used as the sole means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.

Discussion: This implies that although color can be used for emphasis, some other non-color mode must also be used to convey the information, such as a shape or text style. For example, red can be enclosed in an octagon shape.
2.2.7 Human Factors

Section 1: Accessibility

2.1.8 Buttons and controls on all voting stations should be distinguishable by both shape and color.

Discussion: The redundant cues have been found to be helpful to those with partial vision.

2.1.9 Any voting station using an electronic image display should also provide synchronized audio output to convey the same information as that on the screen.

Discussion: Synchronized presentation of information in both visual and aural modes is a recommendation in this version of the VVSG, but it is anticipated that this will become a requirement in future versions.

2.2 The Acc-VS shall be accessible to voters who are blind.

Discussion: Of course, many of the features under this requirement are also useful for voters with partial vision (see requirement # 2.2.7.2.1) and for voters who cannot read English for other reasons (see requirement # 2.2.7.2).

2.2.1 The vendor should conduct summative usability tests on the Acc-VS using subjects who are blind and report the test results to the appropriate testing authority according to the Common Industry Format (CIF).

Discussion: This requirement is meant to encourage Acc-VS designers to conduct some realistic usability tests on the final product. For now, it is purely a documentation recommendation. Future versions of the VVSG will include requirements for usability
testing to be conducted by the testing authority, with specific performance benchmarks.

2.2.2 The Acc-VS shall provide an audio-tactile interface (ATI) that supports the full functionality of a normal ballot interface, as specified in Section 2.4.

Discussion: Note the necessity of both audio output and tactilely discernible controls for voter input. Full functionality includes at least:

- Instructions and feedback on initial activation of the ballot (such as insertion of a smart card), if this is normally performed by the voter on comparable voting stations,
- Instructions and feedback to the voter on how to operate the Acc-VS, including settings and options (e.g. volume control, repetition),
- Instructions and feedback for navigation of the ballot,
- Instructions and feedback for voter selections in races and referenda, including write-in candidates,
- Instructions and feedback on confirming and changing selections, and
- Instructions and feedback on final submission of ballot.

2.2.2.1 The ATI of the Acc-VS shall provide the same capabilities to vote and cast a ballot as are provided by the other voting stations or by the visual interface of the Acc-VS. Therefore, functional features that exceed the requirements of Section 2.4 must be provided on a non-discriminatory basis.
2.2.7 Human Factors

Discussion: For example, if a "normal" ballot supports voting a straight party ticket and then changing the choice in a single race, so must the ATI. This requirement is a special case of the more general requirement #2.2.7.1.1.1.

2.2.2.2 The ATI shall allow the voter to have any information provided by the system repeated.

2.2.2.3 The ATI shall allow the voter to pause and resume the audio presentation.

2.2.2.4 The ATI shall allow the voter to skip to the next contest or return to previous contests.

Discussion: This is analogous to the ability of sighted voters to move on to the next race once they have made a selection or to abstain from voting on a contest.

2.2.2.5 The ATI should allow the voter to skip over the reading of a referendum so as to be able to vote on it immediately.

Discussion: This is analogous to the ability of sighted voters to skip over the wording of a referendum on which they have already made a decision prior to the voting session (e.g. “Vote yes on proposition..."
2.2.7 Human Factors

Section 1: Accessibility

#123”). It is anticipated that this recommendation will become a requirement in future versions of the VVSG.

2.2.3 All voting stations that provide audio presentation of the ballot shall conform to the following sub-requirements.

Discussion: These requirements apply to all audio output, not just to the ATI of an Acc-VS.

2.2.3.1 The ATI shall provide its audio signal through an industry standard connector for private listening using a 3.5mm stereo headphone jack to allow voters to use their own audio assistive devices.

V Voting System Vendor

2.2.3.2 When a voting station utilizes a telephone style handset/headset to provide audio information, it shall provide a wireless T-Coil coupling for assistive hearing devices so as to provide access to that information for voters with partial hearing. That coupling shall achieve at least a category T4 rating as defined by American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids, ANSI C63.19.

V Voting System Vendor

2.2.3.3 No voting station shall cause electromagnetic interference with assistive hearing devices that would substantially degrade the performance of those devices. The station, considered as a wireless device (WD) shall achieve at least a category T4 rating as defined by American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids, ANSI C63.19.
2.2.7 Human Factors

Section 1: Accessibility

Discussion: "Hearing devices" includes hearing aids and cochlear implants.

2.2.3.4 A sanitized headphone or handset should be made available to each voter.

Discussion: This requirement can be achieved in various ways, including the use of "throwaway" headphones, or of sanitary coverings.

[Best Practice for Voting Officials] A sanitized headphone or handset is made available to each voter.

2.2.3.5 The voting station shall set the initial volume for each voter between 40 and 50 dB SPL.

Discussion: A voter does not "inherit" the volume as set by the previous user of the voting station.

2.2.3.6 The voting station shall provide a volume control with an adjustable amplification from a minimum of 20dB SPL up to a maximum of 105 dB SPL, in increments no greater than 20dB.
2.2.7 Human Factors

2.2.3.7 The audio system shall be able to reproduce frequencies over the audible speech range of 315 Hz to 10KHz.

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Pre-Voting | Voting | Post-Voting |

Discussion: Most users prefer real speech over synthesized speech.

2.2.3.8 The audio system should provide information via recorded human speech, rather than synthesized speech.

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Pre-Voting | Voting | Post-Voting |

Discussion: Many blind voters are accustomed to interacting with accelerated speech.

2.2.3.9 The audio system should allow voters to control, within reasonable limits, the rate of speech.

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Pre-Voting | Voting | Post-Voting |

Discussion: For example, smart cards might provide tactile cues so as to allow correct insertion.

2.2.4 If the normal procedure is to have voters initialize the activation of the ballot, the Acc-VS shall provide features that enable voters who are blind to perform this activation.

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Pre-Voting | Voting | Post-Voting |

Discussion: For example, smart cards might provide tactile cues so as to allow correct insertion.
2.2.5 If the normal procedure is for voters to submit their own ballots, then the voting process should provide features that enable voters who are blind to perform this submission.

Discussion: For example, if voters normally feed their own optiscan ballots into a reader, blind voters should also be able to do so.

[Best Practice for Voting Officials] If the normal procedure is for voters to submit their own ballots, then the voting process provides features that enable voters who are blind to perform this submission.

2.2.6 If the normal procedure includes VVPAT, the Acc-VS should provide features that enable voters who are blind to perform this verification.

Discussion: For example, the Acc-VS might provide an automated reader for the paper record that converts the contents of the paper into audio output. It is anticipated that this recommendation will become a requirement in future versions of the VVSG.

2.2.7 All mechanically operated controls or keys on an Acc-VS shall be tactiley discernible without activating those controls or keys.

2.2.8 On an Acc-VS, the status of all locking or toggle controls or keys (such as the "shift" key) shall be visually discernible, and discernible either through touch or sound.
3. The voting process shall be accessible to voters who lack fine motor control or the use of their hands.

3.1 The vendor should conduct summative usability tests on the Acc-VS with subjects lacking fine motor control and report the test results to the appropriate testing authority according to the Common Industry Format (CIF).

Discussion: This requirement is meant to encourage Acc-VS designers to conduct some realistic usability tests on the final product. For now, it is purely a documentation recommendation. Future versions of the VVSG will include requirements for usability testing to be conducted by the testing authority with specific performance benchmarks.

3.2 All keys and controls on the Acc-VS shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls and keys shall be no greater 5 lbs. (22.2 N).

Discussion: Controls are to be operable without excessive force.

3.3 The Acc-VS controls shall not require direct bodily contact or for the body to be part of any electrical circuit.

Discussion: This requirement ensures that controls are operable by individuals using prosthetic devices.
3.4 The Acc-VS should provide a mechanism to enable non-manual input that is functionally equivalent to tactile input.

Discussion: This recommendation ensures that the Acc-VS is operable by individuals who do not have the use of their hands. All the functionality of the Acc-VS (e.g. straight party voting, write-in candidates) that is available through the other forms of input, such as tactile, must also be available through the input mechanism if it is provided by the Acc-VS.

4. The voting process shall be accessible to voters who use mobility aids, including wheelchairs.

4.1 The Acc-VS shall provide a clear floor space of 30 inches (760 mm) minimum by 48 inches (1220 mm) minimum for a stationary mobility aid. The clear floor space shall be level with no slope exceeding 1:48 and positioned for a forward approach or a parallel approach.

Discussion: All dimensions are given in inches. To convert to millimeters, multiply by 25.4 and then round to the nearest multiple of 5. Note that these sub-requirements have meaningful application mainly to controls in a
fixed location. A hand-held tethered control panel is another acceptable way of providing reachable controls. All the sub-requirements inherit the "responsible entity" and "process" properties.

[Best Practice for Voting Officials] All controls, keys, audio jacks and any other part of the Acc-VS necessary for the voter to operate the voting system are within the reach regions as specified in the VVSG Volume I, Section 2.2.7.1.4.3.

4.2.1 If the Acc-VS has a forward approach with no forward reach obstruction then the high reach shall be 48 inches maximum and the low reach shall be 15 inches minimum. See Figure 2.2.7.1-1.

4.2.2 If the Acc-VS has a forward approach with a forward reach obstruction, the following sub-requirements apply. See Figure 2.2.7.1-2.

4.2.2.1 The forward obstruction shall be no greater than 25 inches in depth, its top no higher than 34 inches and its bottom surface no lower than 27 inches.

4.2.2.2 If the obstruction is no more than 20 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 44 inches.
2.2.7 Human Factors

Section 1: Accessibility

4.2.2.3 Space under the obstruction between the finish floor or ground and 9 inches (230 mm) above the finish floor or ground shall be considered toe clearance and shall comply with the following sub-requirements.

A. Toe clearance shall extend 25 inches (635 mm) maximum under the obstruction.

B. The minimum toe clearance under the obstruction shall be either 17 inches (430 mm) or the depth required to reach over the obstruction to operate the Acc-VS, whichever is greater.

C. Toe clearance shall be 30 inches (760 mm) wide minimum.

4.2.2.4 Space under the obstruction between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground shall be considered knee clearance and shall comply with the following sub-requirements.

A. Knee clearance shall extend 25 inches (635 mm) maximum under the obstruction at 9 inches (230 mm) above the finish floor or ground.
B. The minimum knee clearance at 9 inches (230 mm) above the finish floor or ground shall be either 11 inches (280 mm) or 6 inches less than the toe clearance, whichever is greater.

C. Between 9 inches (230 mm) and 27 inches (685 mm) above the finish floor or ground, the knee clearance shall be permitted to reduce at a rate of 1 inch (25 mm) in depth for each 6 inches (150 mm) in height.

Discussion: It follows that the minimum knee clearance at 27 inches above the finish floor or ground shall be 3 inches less than the minimum knee clearance at 9 inches above the floor.

D. Knee clearance shall be 30 inches (760 mm) wide minimum.

4.2.3 If the Acc-VS has a parallel approach with no side reach obstruction then the maximum high reach shall be 48 inches and the minimum low reach shall be 15 inches. See Figure 2.2.7.1-3.

4.2.4 If the Acc-VS has a parallel approach with a side reach obstruction, the following sub-requirements apply. See Figure 2.2.7.1-4.
2.2.7 Human Factors

Section 1: Accessibility

4.2.4.1 The side obstruction shall be no greater than 24 inches in depth and its top no higher than 34 inches.

Discussion: Since this is a parallel approach, no clearance under the obstruction is required.

4.2.4.2 If the obstruction is no more than 10 inches in depth, then the maximum high reach shall be 48 inches, otherwise it shall be 46 inches.

Discussion: There are a number of factors that could make relevant parts of the Acc-VS difficult to see: small lettering, controls and labels tilted at an awkward angle from the voter's viewpoint, glare from overhead lighting, etc.

4.2.5 All labels, displays, controls, keys, audio jacks, and any other part of the Acc-VS necessary for the voter to operate the voting system shall be easily legible and visible to a voter in a wheelchair with normal eyesight (no worse than 20/40, corrected) who is in an appropriate position and orientation with respect to the Acc-VS.

Discussion: There are a number of factors that could make relevant parts of the Acc-VS difficult to see: small lettering, controls and labels tilted at an awkward angle from the voter's viewpoint, glare from overhead lighting, etc.

5. The voting process shall be accessible to voters with hearing disabilities.

5.1 The Acc-VS shall incorporate the features listed under requirement #2.2.7.1.2.2.3 (audio presentation) to provide accessibility to voters with hearing disabilities.

Discussion: Note especially the requirements for volume initialization and control.
2.2.7 Human Factors

Section 1: Accessibility

[Best Practice for Voting Officials] The Acc-VS incorporates the features listed in the VVSG Volume I, Section 2.2.7.1.2.2.3 (audio presentation) to provide accessibility to voters with hearing disabilities.

5.2 If a voting station provides sound cues as a method to alert the voter, the tone shall be accompanied by a visual cue.

Discussion: For instance, the station might beep if the voter attempts to overvote. If so, there would have to be an equivalent visual cue, such as the appearance of an icon, or a blinking element.

6. The voting process shall be accessible to voters with speech disabilities.

6.1 No voting station shall require voter speech for its operation.

Discussion: This does not preclude a voting station from offering speech input as an option, but speech must not be the only means of input.

7. The voting process should be accessible to voters with cognitive disabilities.

Discussion: At present there are no design features specifically aimed at helping those with cognitive disabilities. Section 2.2.7.1.2.1.9, the synchronization of audio with the screen in a DRE, is helpful for some cognitive disabilities such as dyslexia. Section 2.2.7.3.3 also contains some relevant guidelines.

[Best Practice for Voting Officials] The voting process is made accessible to voters with cognitive disabilities.
2.2.7 Human Factors

Section 1: Accessibility

Figures for Accessibility

Figure 2.2.7.1-1
Unobstructed forward reach

Figure 2.2.7.1-2
Obstructed forward reach
(a) for an obstruction depth of up to 20 inches (508 mm)
(b) for an obstruction depth of up to 25 inches (635 mm)

Figure 2.2.7.1-3
Unobstructed side reach with an allowable obstruction less than 10 inches (254 mm) deep.

Figure 2.2.7.1-4
Obstructed side reach
(a) for an obstruction depth of up to 10 inches (254 mm)
(b) for an obstruction depth of up to 24 inches (610 mm)
2. The voting process shall be accessible to voters who are not fully literate in English. This requirement may be satisfied by providing voting stations in a polling place that accommodate those without a full command of English. See HAVA 301 (a)(4) and 241 (b)(5). Such a facility is referred to herein as an alternative language voting station (ALVS).

HAVA Section 301 (a)(4) reads:

“ALTERNATIVE LANGUAGE ACCESSIBILITY.--The voting system shall provide alternative language accessibility pursuant to the requirements of section 203 of the Voting Rights Act of 1965 (42 U.S.C. 1973aa-1a).”

The requirements within Section 2.2.7.2 are intended to address this mandate. Ideally every voter would be able to vote independently and privately, regardless of language. As a practical matter, alternative language access is mandated under the Voting Rights Act of 1975, subject to certain thresholds, e.g. if the language group exceeds 5% of the voting age citizens.

Note that the provision of an audio interface for people with visual disabilities as described in Section 2.2.7.1 may also assist voters who speak English, but are unable to read it.

The outline for section 2.2.7.2 is:

2.2.7.2. Alternative Languages
2.2.7.2.1 Complete Information
2.2.7.2.2 Spelling of Names
2.2.7.2.3 Literate Voters
2.2.7.2.4 Illiterate Voters

1. All the information presented in the normal case of English-literate voters (including instructions, warnings, messages, and ballot choices) shall also be presented by the ALVS, whether the language is written or spoken.

Voting System Vendor

Discussion: This is in keeping with general requirement # 2.2.7.1.1.1.
2. Regardless of the language, candidate names shall be displayed or pronounced in English on all ballots. For written languages that do not use Roman characters (e.g., Chinese, Japanese, Korean, Arabic), the ballot shall include transliteration of candidate names into the relevant language.

[Best Practice for Voting Officials] Regardless of the language, candidate names are displayed or pronounced in English on all ballots. For written languages that do not use Roman characters (e.g., Chinese, Japanese, Korean, Arabic), the ballot includes transliteration of candidate names into the relevant language.

3. For literate voters, the ALVS shall provide printed or displayed instructions, messages, and ballots in their preferred language, consistent with state and Federal law.

3.1 The vendor should conduct summative usability tests on the ALVS with literate subjects who neither speak nor read English and report the test results according to the Common Industry Format (CIF).

Discussion: This requirement is meant to encourage Acc-VS designers to conduct some realistic usability tests on the final product. For now, it is purely a documentation recommendation. Future versions of the VVSG will include requirements for usability testing to be conducted by the testing authority, with specific performance benchmarks.
4. For illiterate voters, the ALVS shall provide spoken instructions and ballots in the preferred language of the voter, consistent with state and Federal law. The requirements and sub-requirements of # 2.2.7.1.2.2 (Acc-VS/ATI) shall apply to this mode of interaction.

Discussion: Note that some languages have no widely accepted written form.

3. The voting process shall provide a high level of usability to the voters. Accordingly, voters shall be able to negotiate the process effectively, efficiently, and comfortably.

Discussion: The first Voting System Standards codified in HAVA relate to the interaction between the voter and the voting system. HAVA Section 301 begins:

"SEC. 301. VOTING SYSTEMS STANDARDS.

a. Requirements.--Each voting system used in an election for Federal office shall meet the following requirements:

1. In general.--

A. Except as provided in subparagraph (B), the voting system (including any lever voting system, optical scanning voting system, or direct recording electronic system) shall--

i. Permit the voter to verify (in a private and independent manner) the votes selected by the voter on the ballot before the ballot is cast and counted;

ii. Provide the voter with the opportunity (in a private and independent manner) to change the ballot or correct any error before the ballot is cast and counted (including the opportunity to correct the error through the issuance of a replacement ballot if the voter was otherwise unable to change the ballot or correct any error); and

iii. If the voter selects votes for more than one candidate for a single office—

I. Notify the voter that the voter has selected more than one candidate for a single office on the ballot;
II. Notify the voter before the ballot is cast and counted of the effect of casting multiple votes for the office; and

III. Provide the voter with the opportunity to correct the ballot before the ballot is cast and counted.

B. A State or jurisdiction that uses a paper ballot voting system, a punch card voting system, or a central count voting system (including mail-in absentee ballots and mail-in ballots), may meet the requirements of subparagraph (A)(iii) by—

i. Establishing a voter education program specific to that voting system that notifies each voter of the effect of casting multiple votes for an office; and

ii. Providing the voter with instructions on how to correct the ballot before it is cast and counted (including instructions on how to correct the error through the issuance of a replacement ballot if the voter was otherwise unable to change the ballot or correct any error).

C. The voting system shall ensure that any notification required under this paragraph preserves the privacy of the voter and the confidentiality of the ballot."

The requirements of this section supplement these basic HAVA mandates and also HAVA's support for improved usability (see Section 243 and Section 221 (e)(2)(D)).

VOTING AND USABILITY

Usability is defined generally as a measure of the effectiveness, efficiency, and satisfaction achieved by a specified set of users with a given product in the performance of specified tasks. In the context of voting, the primary users are the voters (but also poll workers), the product is the voting system, and the task is the correct representation of one's choices in the election. Additional requirements for task performance are independence and privacy: the voter should normally be able to complete the voting task without assistance from others (although the voting system itself may offer help), and the voter's choices should be private (see Section 2.2.7.4). Aside from its intrinsic undesirability, lack of independence or privacy may adversely affect effectiveness (e.g. by possibly inhibiting the voter's free choice) and efficiency (e.g. by slowing down the process).

Among the "bottom-line" metrics for usability are:

- low error rate for marking the ballot (the voter's intention is correctly conveyed to and represented within the voting system),
- efficient operation (time required to vote is not excessive), and
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• satisfaction (voter experience is safe, comfortable, free of stress, and instills confidence).

These criteria define the core of good voting system usability. The purpose of the detailed requirements listed below is to help voting systems meet the core criteria.

METHODOLOGY FOR REQUIREMENTS

It is the intention of the TGDC that in forthcoming versions of the VVSG, usability will be addressed by high-level performance-based requirements. That is, the requirements will directly address metrics for effectiveness (e.g. correct capture of voters’ intentions), efficiency (e.g. time taken to vote), and satisfaction. Until the supporting research is completed, however, the contents of this subsection are limited to a somewhat basic set of widely accepted design requirements and lower-level performance requirements. The reasons for this approach are:

• These are to serve as interim requirements, pending the issuance of high-level performance requirements.

• The actual benefit of numerous detailed design guidelines is difficult to prove or measure.

• The technical complexity and costs of a large set of detailed requirements may not be justified.

• Guidelines that are difficult to test because of insufficient specificity have been omitted.

This is not to say that an extensive set of design guidelines is without value. But we wish to distinguish between good advice to be considered by developers and strict requirements that will be enforced by a regime of formal testing. For more detail on the issue of design vs. performance standards, see Sections 2.3 and 6.1 et al. of NIST Special Publication 500-256: Improving the Usability and Accessibility of Voting Systems and Products (http://vote.nist.gov/Final%20Human%20Factors%20Report%20%205-04.pdf).

GENERAL ISSUES FOR THE USABILITY REQUIREMENTS

As mentioned in Section 2.2.7.1, many of the guidelines in this section enhance accessibility as well as general usability.

The scope of usability includes the entire voting process, although the emphasis herein is on the interface between the voter and the voting station.

The requirements in this sub-section generally assume a visual-tactile interface, but also see requirements in Sections 2.2.7.1 and Section 2.2.7.2 for alternative formats, including audio.
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The outline for Section 2.2.7.3 is:

2.2.7.3. Usability
2.2.7.3.1 Usability Testing by Vendor
2.2.7.3.2 Functional Capabilities
2.2.7.3.3 Cognitive Issues
2.2.7.3.4 Perceptual Issues
2.2.7.3.5 Interaction Issues

1. The vendor should conduct summative usability tests on the voting system using subjects representative of the general population and report the test results to the appropriate testing authority according to the Common Industry Format (CIF).

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Discussion: This requirement is meant to encourage Acc-VS designers to conduct some realistic usability tests on the final product. For now, it is purely a documentation recommendation. Future versions of the VVSG will include requirements for usability testing to be conducted by the testing authority, with specific performance benchmarks.

2. The voting process shall provide certain functional capabilities to support voter usability.

2.1 As mandated by HAVA 301 (a)(1)(A), the voting system shall support a process that allows the voter to review his or her completed ballot before final submission in order to verify that it correctly represents the intended vote and to correct the ballot if mistakes are detected.

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Discussion: Note that this review and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical (see HAVA 301 (a)(1)(B)). This requirement is a brief paraphrase of the HAVA language but of course the statutory language is determinative.
2.2 As mandated by HAVA 301 (a)(1)(A), the voting system shall support a process that notifies the voter if he or she has attempted to vote for more candidates than the maximum permitted in a given race and that provides the voter with the opportunity to correct the ballot before final submission.

Discussion: Note that this notification and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical (see HAVA 301 (a)(1)(B)). This requirement is a brief paraphrase of the HAVA language but of course the statutory language is determinative.

2.3 DRE voting stations shall allow the voter to change a vote within a race before advancing to the next race.

Discussion: The point here is that voters using a DRE should not have to wait for the final ballot review in order to change a vote.

2.4 The voting system shall support a process that notifies the voter if he or she has attempted to vote for fewer candidates than the maximum permitted in a given race and that provides the voter with the opportunity to change the ballot before final submission. The process shall also notify the voter that such an "undervote" is permitted and shall accept a ballot if the voter so chooses.

Discussion: Note that this notification and correction may be achieved by procedural means (e.g. in the case of paper ballots), as well as technical (see HAVA 301 (a)(1)(B)).
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2.5 DRE voting stations should provide navigation controls that allow the voter to advance to the next race or go back to the previous race before the completing a vote on the race or races currently being presented (whether visually or aurally).

Discussion: For example, the voter should not be forced to proceed sequentially through all the races and/or candidates before going back to check the status of a previous race.

3. The voting process shall be designed to minimize cognitive difficulties for the voter.

3.1 Consistent with election law, the voting system should support a process that does not introduce any bias for or against any of the choices to be made by the voter. In both visual and aural formats, candidates and choices shall be presented in an equivalent manner.

Discussion: Certain differences in presentation are unavoidable, such as the order in which candidates are listed, and write-in candidates are inherently more difficult to vote for. But comparable characteristics such as font size or voice volume and speed must be the same for all choices.

3.2 The voting system or related materials shall provide clear instructions and assistance so as to allow voters to successfully execute and cast their ballots independently.

Discussion: Voters should not routinely need to ask for human assistance.

3.2.1 Voting stations or related materials shall provide a means for the voter to get help at any time during the voting session.

Discussion: The voter should always be able to get help at the station if confused. DRE voting stations may provide this with a
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Section 3: Usability

distinctive "help" button. Any type of voting station may provide written instructions that are available and separate from the ballot. Note special requirements for the Acc-VS in requirement # 2.2.7.1.2.2.2 (Acc-VS/ATI).

3.2.2 The voting station shall provide instructions for all its valid operations.

Discussion: If an operation is available to the voter, it must be documented. Examples include how to change a vote, how to navigate among races, how to cast a party-line vote, and how to cast a write-in vote.

3.3 The voting system shall provide the capability to design a ballot for maximum clarity and comprehension.

3.3.1 The voting station should not visually present a single race spread over two pages or two columns.

Discussion: Such a visual separation poses the risk that the voter will perceive the race as two races. Of course, if a race has a very large number of candidates, it may be infeasible to observe this guideline.

[Best Practice for Voting Officials] The voting station does not visually present a single race spread over two pages or two columns.
3.3.2 The ballot shall clearly indicate the maximum number of candidates for which one can vote within a single race.

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[Best Practice for Voting Officials] The ballot clearly indicates the maximum number of candidates for which one can vote within a single race.

3.3.3 There shall be a consistent relationship between the name of a candidate and the mechanism used to vote for that candidate.

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Discussion: For example, if the response field where voters indicate their selections is located to the left of a candidate’s name, then each response field shall be located to the left of the associated candidate’s names.

[Best Practice for Voting Officials] The ballot presents the relationship between the name of a candidate and the mechanism used to vote for that candidate in a consistent manner.

3.4 Warnings and alerts issued by the voting station should clearly state the nature of the problem and the set of responses available to the voter. The warning should clearly state whether the voter has performed or attempted an invalid operation or whether the voting equipment itself has failed in some way.

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Discussion: In case of an equipment failure, the only action available to the voter might be to get assistance from a poll worker.
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3.5 The use of color by the voting station should agree with common conventions: (a) Green, blue or white is used for general information or as a normal status indicator; (b) Amber or yellow is used to indicate warnings or a marginal status; (c) Red is used to indicate error conditions or a problem requiring immediate attention.

4. The voting process shall be designed to minimize perceptual difficulties for the voter.

4.1 No display screen of a voting station shall flicker with a frequency between 2 Hz and 55 Hz.

4.2 Any aspect of the voting station that is adjustable by the voter or poll worker, including font size, color, contrast, and audio volume, shall automatically reset to a standard default value upon completion of that voter's session.

4.3 If any aspect of a voting station is adjustable by the voter, there should be a mechanism to reset all such aspects to their default values.
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4.4 The minimum font size for all text intended for the voter during the voting session shall be 3.0mm (measured as the height of a capital letter).

4.5 All text intended for the voter during the voting session should be presented in a sans serif font.

Discussion: Experimentation has shown that users prefer such a font and the legibility of serif and sans serif fonts is equivalent.

4.6 The minimum figure-to-ground ambient contrast ratio for all text and informational graphics (including icons) intended for the voter shall be 3:1.

5. The voting process shall be designed to minimize interaction difficulties for the voter.

5.1 Voting stations with electronic image displays shall not require page scrolling by the voter.

Discussion: This is not an intuitive operation for those unfamiliar with the use of computers. Even those experienced with computers often do not notice a scroll bar and miss information below the page. DREs may require voters to move to the next or previous "page."
5.2 The voting station shall provide unambiguous feedback regarding the voter’s selection, such as displaying a checkmark beside the selected option or conspicuously changing its appearance.

5.3 If the voting station requires a response by a voter within a specific period of time, it shall issue an alert at least 20 seconds before this time period has expired and provide a means by which the voter may receive additional time.

5.4 Input mechanisms shall be designed so as to minimize accidental activation (also, see requirement # 2.2.7.1.2.7 on tactile discernability).

5.4.1 On touch screens, the sensitive touch areas shall have a minimum height of 0.5 inches and minimum width of 0.7 inches. The vertical distance between the centers of adjacent areas shall be at least 0.6 inches, and the horizontal distance at least 0.8 inches.

5.4.2 No key or control on a voting station shall have a repeat feature enabled.

Discussion: This is to preclude accidental activation.
4. The voting process shall preclude anyone else from determining the content of a voter's ballot, with or without the voter's cooperation.

Discussion: Voter privacy is strongly supported by HAVA - see Sections 221 (e)(2)(C) and 301 (a)(1). In this subsection, we address only privacy concerns in relation to human factors issues, but not with respect to the processing of cast ballots.

Although elections in American history have sometimes been public (and certain "town-hall" questions are still voted openly), the use of the secret ballot for political office is now universal. Privacy in this context, including the property of the voter being unable to disclose his or her vote, ensures that the voter can make choices based solely on his or her own preferences without intimidation or inhibition. Among other practices, this forbids the issuance of a receipt to the voter that would provide proof to another how he or she voted.

The outline for Section 2.2.7.4 is:

2.2.7.4 Privacy
   2.2.7.4.1 Privacy at the polling place
   2.2.7.4.2 No preservation of alternative formats
   2.2.7.4.3 Absentee Balloting

1. The voting station and polling place shall be configured so as to prevent others from learning the contents of a voter's ballot.

1.1 The ballot and any input controls shall be visible only to the voter during the voting session and ballot submission.

[V] Voting System Vendor

[Pre-Voting] [Voting] [Post-Voting]

[Best Practice for Voting Officials] The ballot and any input controls are visible only to the voter during the voting session and ballot submission. Poll workers need to take into account such factors as visual barriers, windows, permitted waiting areas for other voters, and procedures for ballot submission when not performed at the voting station, e.g. submission of optiscan ballots to a central reader.
2.2.7 Human Factors

Section 4: Privacy

1.2 The audio interface shall be audible only to the voter.

Discussion: Voters who are hard of hearing but need to use an audio interface may also need to increase the volume of the audio. Such situations require headphones with low sound leakage.

[Best Practice for Voting Officials] The audio interface is audible only to the voter.

1.3 As mandated by HAVA 301 (a)(1)(C), the voting system shall notify the voter of an attempted overvote in a way that preserves the privacy of the voter and the confidentiality of the ballot.

Discussion: This requirement is a brief paraphrase of the HAVA language but of course the statutory language is determinative.

[Best Practice for Voting Officials] As mandated by HAVA 301 (a)(1)(C), the voting system notifies the voter of an attempted overvote in a way that preserves the privacy of the voter and the confidentiality of the ballot.

2. Voter anonymity shall be maintained for alternative format ballot presentation.

2.1 No information shall be kept within a non-paper-based Cast Vote Record that identifies any accessibility feature(s) used by a voter.

Discussion: Large-print paper ballots unavoidably preserve such information.
2.2.7 Human Factors

2.1.1 No information shall be kept within a non-paper-based Cast Vote Record that identifies any alternative language feature(s) used by a voter.

Discussion: Non-English paper ballots unavoidably preserve such information.

[Best Practice for Voting Officials] Appropriate procedures are needed to ensure that absentee balloting enable the voter to preserve privacy. There is no practical means to prevent a voter from revealing an absentee paper ballot to others. But the procedures should ensure that if a voter chooses to maintain privacy, it is not violated at a later stage, in particular when the ballot is received by voting officials.