Tactile Keypads for Disability Voting:

What functions are available to voters using certified voting systems?

September 2023

Lynn Baumeister
Whitney Quesenbery
Center for Civic Design

Abstract

All accessible voting systems must include tactile keypads – a collection of buttons or other interactive devices that allow voters to mark a ballot without relying on a touch screen that does not allow for discovery through tactile exploration. An important access feature is that each button or other control can be identified by touching it and determining both the shape and location of the button on the keypad.

Although typically used with the audio output feature of a voting system, these devices are used by both blind/low vision voters and those with dexterity disabilities that limit use of their hands. To support identification, they often include Braille labels, in addition to printed text on the device, and use different colors to help with visual discrimination between the buttons or functions they support.

The Voluntary Voting System Guidelines 2.0 includes only performance standards for the arrangement of controls and functions of these devices. This means that each voting system has their own designs, developed independently, or based on a commercial keypad incorporated into the voting system.

This paper is an analysis of the design of the tactile keypads, including the functions for the keys and how consistent they are in supporting voters as they mark their ballot.

Keywords

accessible voting; ballot marking devices; assistive technology; tactile controller; tactile keypads; manual dexterity; visual disability; disability voting rights

Table of Contents

Summary

The Help America Vote Act (HAVA)[1] says that voting systems have to enable millions of voters with disabilities to mark, verify, and cast their ballot privately and independently. When all forms of voting are accessible, voters with disabilities have the same options for where and how they vote as others do. The Voluntary Voting System Guidelines (VVSG) 2.0[2], published by the Election Assistance Commission includes requirements for tactile controls for voters who cannot use a touch screen because of low dexterity or visual disabilities.

All accessible voting systems must include tactile keypads – a collection of buttons or other interactive devices that allow voters to mark a ballot without relying on a touch screen that does not allow for discovery through tactile exploration. An important access feature is that each button or other control can be identified by touching it and determining both the shape and location of the button on the keypad.

Although typically used with the audio output feature of a voting system, these devices are used by both blind/low vision voters and those with dexterity disabilities that limit use of their hands. To support identification, they often include Braille labels, in addition to printed text on the device, and use different colors to help with visual discrimination between the buttons or functions they support.

The VVSG 2.0 only includes requirements for functions that must be available to voters using the tactile input. It does not prescribe the physical arrangement of controls on these devices. This means that each voting system has their own designs, developed independently, or based on a commercial keypad incorporated into the voting system.

This paper is an analysis of the design of the tactile keypads, including the functions for the keys and how consistent they are in supporting voters as they mark their ballot. It includes:

- A summary of the basic navigation keys found on all voting system tactile keypads
- A comparison of the layout and appearance of the basic navigation keys
- Additional functions found on tactile keypads for the systems reviewed
- Unique designs found on current or future systems

The final section discusses whether there are any aspects of the tactile keypads that can be improved through updated requirements in the VVSG in the future and other research questions.

[1] https://www.govinfo.gov/content/pkg/PLAW-107publ252/pdf/PLAW-107publ252.pdf
[2] https://www.eac.gov/voting-equipment/voluntary-voting-system-guidelines

Introduction

The VVSG 2.0 requires that voting system include a way to operate the input using a tactile keypad, often as an alternative to a touch screen. This document looks at current voting systems to identify common features or navigational models among them as well as areas where there are unique features in different systems. Specifically, it catalogs the controls and functions provided on the tactile keypad: the number of individual controls, the shapes of tactilely discernable buttons, and how the buttons for navigation or operational functions are arranged.

The goal of this report is to provide a description of the current landscape of the accessible keypads on voting systems,

The review and analysis of accessible keypads for voting systems is useful for those interested in election design as well as for advocates and elections offices in creating voter outreach and education. It also provides a brief overview of novel keypads used in other commercial technology that may have application for voting system design.

Accessible voting and modes of interaction in VVSG 2.0

Two principles in the VVSG emphasize the need for voters to have access to a variety of display formats and interaction modes:

- Principal 5.1 includes requirements for equivalent and consistent access, with requirements covering voting methods and interaction modes. 5.1-A says that all interaction modes must have "the same functionality as the visual format and touch mode including voting, verification, and casting."
- Principle 7.1-A defines a set of display formats and interaction modes that includes an audio "display" format and a limited dexterity mode. Because voters can choose the combination that works for them, the tactile keypads for limited dexterity mode work for both voters who can see them and voters who identify the controls only by feel.

This report focuses on the interaction with the tactile controls in three possible display/interaction combinations.

- Audio + Tactile. Used by people who need audio to hear information and voting options and use a tactile keypad to navigate and make selections
- Visual + Tactile. Used by people with vision, but limited or no use of their hands. This mode is also helpful for voters who cannot reach the screen.
- Audio + Visual + Touch. Listening to the audio while looking at the screen, to help with language access or reading comprehension

It presumes that the controls meet requirements for the force needed to activate them and that because the keypads can be held in a voter's hand that they meet the requirements for reach and touch.

VVSG 2.0 requirements for tactile controls

Principle 7 includes the requirements for the design and interaction of the tactile keys, including that keys be "distinguishable by both shape and color for visual and tactile perception" (7.1—P). All mechanical controls "available to the voter must"

1. be tactilely discernible without activating those controls or keys;
2. include a Unified English Braille, Contracted label if there is a text label; and
3. not require sequential, timed, or simultaneous presses or activations, unless using a full keyboard. (7.1—N).

The requirements relating to the interaction with tactile keypad include:

- 5.1-A – Voting methods and interaction modes
- 7.1-N – Tactile keys
- 7.1-O – Toggle keys
- 7.2-A – Display and interaction options
- 7.2-H – Accidental activation
- 7.2-K – Key operability

Four requirements cover how controls are identified by visually and by feel:

- 7.1-P – Identifying controls
- 7.2-R – Control labels visible
- 7.2-M – No repetitive activation
- 7.3-L – Icon labels

There are also requirements that suggest functions that a tactile keypad can include to provide equivalent access to those functions as an alternative to navigating through all of the selectable area on the screen to an on-screen control

- 6.1-C – Enabling or disabling output
- 7.2-B – Navigation between contests
- 7.2-G – Voter control of audio
- 7.3-N – Instructions for voters

Functions available on the tactile keypad

It is possible to navigate most ballot marking devices with just two buttons: one to move through the selectable objects on the screen; one to select or deselect the highlighted button or candidate. Most tactile keypads, however have at least the minimum 5 navigation buttons (up/down/left/right) and a select button.

Beyond that, there is a lot of variation in both how many additional functions area available from the keypad, and in the selection of which ones are offered. They include dedicated buttons for functions in VVSG requirements including direct access to help, settings, and audio controls.

Layout and colors for the basic navigation keys

The 5 basic navigation keys have similar functions on most of the systems.

The "Up" and "Down" buttons meet the core requirement that the voter be able to navigate to all selectable options on the screen, including candidates or other vote selections, and functional buttons or menus

The "Select" button makes it possible for voters to select (and deselect, when appropriate) choices.

The "Back" and "Next" buttons meet the requirement in 7.2-B – Navigation between contests that the voter be allowed to "advance to the next contest or go back to the previous contest." These buttons are also used for general navigation between screens while voting allowing the same direct access that a voter using the touchscreen would have (without requiring a voter using the tactile keypad to navigate through selectable options one at a time).

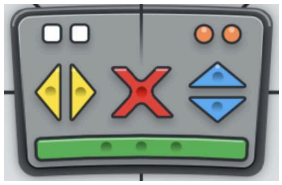
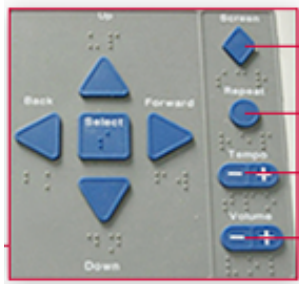
Basic navigation keys and their functions

Key	Function	Typical Appearance
Down	Move through the selections on the screen, including contest selections and other buttons, generally working from left to right on the top menu, down through the contest options	A triangular button, pointing down A pentagon, pointing down
Up	Move through selections on the screen in the reverse order from the Down button	A triangular button, pointing up A pentagon, pointing up
Next	Go to the next screen in the working flow of the voting systems interface, for example to the next contest or screen	A triangular button, pointing right A pentagon, pointing right
Back	Go to the previous screen	A triangular button, pointing left A pentagon, pointing left
Select	Select or deselect the current highlighted option, including a candidate or menu button	Square button Round button X-shaped button

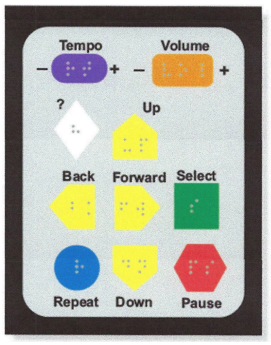
They are always the most prominent keys, placed in the center of the keypad. And they have similar functions within the ballot marking interaction.

Despite this general consistency in the functions of these buttons, the layout and relationships among the buttons are varied, as shown in the table below.

Basic navigation keys layout and visual appearance

Voting System	Image	Up/Down	Back/Next	Select
ClearBallot ClearAccess BMD[3]		**Triangles Yellow** Stacked with the Up button on top Center bottom of the keypad	**Pentagons White** Side by side with the Back button on the left Above center at outside edges of the keypad	**Round Green** To the right of Down button Bottom right corner of the keypad
Dominion ImageCast X		**Triangles Blue** Stacked with the Up button on top Right center of the keypad	**Triangles Yellow** Side-by-side with the Back button on the left Left center of the keypad	**X-Shaped Red** Between the Next/Back and Up/Down butyons Center of the keypad
ES&S AutoMARK		**Triangles Blue** Above and below the Select button with the Up button on top	**Triangles Blue** Right and left of the Select button, with the Back button on the left	**Square Blue** Centered between the 4 navigation buttons Left side of the keypad

[3] The ClearBallot tactile keypad designed and provided by the University of Maryland Initiative for Digital Accessibility Trace RERC (Rehabilitation Research Center). https://trace.umd.edu/ez/

Voting System	Image	Up/Down	Back/Next	Select
ES&S ExpressVote		**Triangles** **Yellow** Above and below the Select button with the Up button on top	**Triangles** **Yellow** Right and left of the Select button, with the Back button on the left	**Square** **Blue** Centered between the 4 navigation buttons Left side of the keypad
ES&S ExpressVote XL		**Triangles** **Yellow** Above and below the Select button with the Up button on top	**Triangles** **Yellow** Right and left of the Select button, with the Back button on the left	**Square** **Blue** Centered between the 4 navigation buttons Center top of the keypad
Unisyn Freedom Voting Tablet[4]		**Pentagons** **Yellow** Above (Up) and below (Down) Back/Next buttons Center of the keypad	**Pentagons** **Yellow** Side-by-side with the Back button on the left Center and center-left side of the keypad	**Square** **Green** To the right of the Next button Center right of the keypad
Los Angeles County VSAP and Smartmatic BMD		**Triangles** **Grey** Stacked around an empty space with the Up button on top Center of the keypad	**Triangles** **Grey** Right and left an empty space, with the Back button on the left Center of the keypad	**Square** **Blue** (Smartmatic) **Yellow** (VSAP) To the right of the Next button Left side of the keypad

[4] The arrangement of the keys was changed in XXXX, with the Select button moved from between the Back and Forward keys to the right of them, according to an Engineering Change Order Analysis document for OVS 2.0.1 in 2018. https://www.eac.gov/sites/default/files/eoc-documents/ECO%20Analysis-Unisyn%20Keypad.pdf

Other functions on the keypad

In addition to the basic navigation keys, most of the tactile keypads include other functions. They usually provide direct access for functions required in VVSG 2.0

Additional functions and their labels on the keypad

Function	**VVSG Requirement**	ClearBallot ClearAccess	Dominion ICX	ES&S EV / XL	Unisyn FVT	VSAP – LA / Smartmatic
Help	7.3-N	?	Help	Home	?	Help
Volume	7.2-G	<< + Up << + Dn	Vol	Volume	Volume	Volume
Speech Rate	7.2-G	<< + Left << + Right	Rate	Tempo	Tempo	Rate
Repeat	7.2-G	<< + >> << + ?	--	Repeat	Repeat	--
Pause	7.2-G	<< + Enter	--	Pause	Pause	Pause
Settings[1]		>>	--	--	--	--
Blank Screen	6.1-C	--	--	Screen	--	--

[1] Settings includes screen blanking, and access to audio functions

Placement of additional functions

The additional function keys are arranged around the basic navigation keys. Their placement on the keypad is limited by the need for space for and around the keys, and by the ability to wire the keys to the circuit board. The smaller keypads are a square, with buttons arranged in 3-4 rows and columns.

Not only is there little consistency in the placement of the additional function keys, there is no easily discerned consistent logic in how they are arranged around the remaining spaces on the keypad.

- The ES&S ExpressVote and Automark reserve a column on the right for additional functions giving them a clear area of the keypad.
- The ClearAccess keypad places the three additional function keys at the top.
- The Dominion ICX has additional functions in the top corners., with the help button across the bottom of the device.

- The ES&S ExpressVote XL uses a larger keypad, placing the additional controls in a U-shape around the basic navigation keys.
- The Unisyn FVT keypad puts Volume and Rate at the top, with Pause and Repeat at the bottom where they are easier to access during voting. The Help button fills a blank space on the 2nd row.
- The VSAP/Smartmatic keypad puts Volume and Rate in the right corners, with Help and Pause on the left.

Locations, shapes, and colors of additional function keys

Voting System	Help	Volume/Rate	Play/Pause	Other
ClearBallot ClearAccess	Center top Blue diamond	Volume, Rate, Pause [1] Left top Black rectangle	n/a	Settings Right top Red rectangle
Dominion ICX	Bottom Green bar	Volume Left top White small squares Rate Right top Orange small squares	n/a	n/a
ES&S AutoMark	n/a	Volume (-/+) Right bottom Rocker switch Rate (-/+) Right middle bottom Rocker switch	Repeat Right middle top Circle	Screen Right top Diamond
ES&S ExpressVote	Left bottom White pentagon [2]	Volume Right bottom Orange rocker Rate [Tempo] Right middle Purple rocker	Pause Center bottom Blue octagon Repeat Right middle Green circle	Screen Right top Black diamond
ES&S ExpressVote XL	Info Left top Blue circle	Volume Left bottom Purple triangles Rate Right middle bottom White ovals	Pause Center right bottom Blue octagon Repeat Right middle top Orange square	Home [3] White pentagon Center left bottom

Voting System	Help	Volume/Rate	Play/Pause	Other
VSAP/Smartmatic	Left top Square	Volume (+/-) Right top Small squares Rate (^/v) Right bottom Small squares	Pause (||) Left bottom Small square	n/a

[1] The black key is pressed in combination with other keys
[2] The label says “Home”
[3] “Home” returns to the top of the contest or, with a double press, to the first contest

Labels in Braille

All of the keypads include labels in Braille. The Braille text is often an abbreviation, given the relatively small size of the keypad enclosures. Braille is written as a series of dots arranged in an area called a “cell.” There are standard dimensions for the size of a cell[5]. Changing the size and spacing of the cells makes Braille difficult to read or unreadable, even for experienced users.

Labels on tactile keypads are often abbreviations, for example, “RT” for Rate or “DN” for Down.

The Unisyn OpenElect keys have Braille embossed on the key cap. Others place the Braille near the button, except for the Select key on the ES&S ExpressVote keypad.

Tactile properties of the keys

There are a few unique properties of the physical keys that appear to be designed to make them more discernable either by touch or visual inspection.

- Dark borders around the buttons so that they stand out from the keypad background
- “Dimples” in the button to help fingers find the center of the touch area
- Unique shapes for a button that are easy to discern
- Rocker switches, especially for paired functions like Volume and Rate

The ES&S ExpressVote XL keypad is the largest one – 2-4 times the size of the others. It has thick bezels around the buttons. They may make the shapes easier to discern, but usability test reports[6] suggest that they also make the buttons themselves harder to press, especially for the smaller buttons for additional functions.

[5] https://brailleauthority.org/size-and-spacing-braille-characters
[6] EVS 6021 Secretary’s Report Signed
https://www.dos.pa.gov/VotingElections/Documents/Voting%20Systems/ESS%20EVS%206021/EVS%206021%20Secretary%27s%20Report%20Signed%20-%20Including%20Attachments.pdf (page 78)

Headset and auxiliary jacks for assistive technologies

Many of the keypads include standard 3.5 mm jacks so that headsets can be attached to the keypad (rather than directly to the main enclosure for the voting systems.

Some also have a second 3.5 mm jack to enable voters to attach their own assistive technology, such as custom switches.

Placing these inputs on the keypad makes it easier for voters to plug in their own devices independently. It is also an advantage for voters who need to sit at a distance or in a semi-reclined posture, because the cords can be placed in a way that does not interfere with using the keypad

Unique designs

In addition to the more common layout for a tactile keypad there are a few examples of alternative designs, both in certified voting systems and concept demos or other prototypes.

Hart VerityAccess for Touchwriter and Duo

The Hart tactile keypad works very differently from the others included in this analysis. It is similar to a game controller and can be held in both hands, or placed on a surface.

The VerityAccess keypad

On the right side of the keypad, the black “Move” wheel supports the functions of both the Up/Down and Back/Next buttons. The motion of the wheel provides continuous navigation between all contests and screens in the voting interface.

- Turning the wheel clockwise is the equivalent of the Down and Next buttons.
- Turning the wheel counterclockwise is the equivalent of the Up and Back buttons.

On the left side of the keypad, the green, rectangular “Select” button provides the Select function.

- In text elements, it can also be used to pause and restart the audio

In the middle, a single blue, triangular “Help” button provides access to both instructions and settings

ElectionGuard prototype with the XBox Adaptive Controller

In 2019, Microsoft commissioned a prototype of the physical design for a ballot marking device using the XBox Adaptive Controller (XBox AC)[7] as it’s physical input. This device was initially designed to meet the needs of gamers with limited mobility, and developed with the Inclusive Tech Lab.

The primary interface consists of two large switches that can be pressed anywhere on their surface, and a 4-way rocker switch on the left. This allows it to be used for a voting tactile keypad with one of the large

[7] https://www.xbox.com/en-US/accessories/controllers/xbox-adaptive-controller

switches used for “Down” and the other for “Enter.” Other functions can be assigned to the rocker switch, or to the round menu button just above the rocker switch. It also has a jack for an audio headset.

Top of the XBox AC, showing the primary keys

In addition to its built-in input controls, The XBox AC can also function as a hub for other assistive technology that can map to the main controls through dedicated inputs on the back plane of the device. This means that voters could bring their own customized assistive switches to use while voting.

In the concept prototype, the XBox AC was built into an enclosure, hiding controls not used by the system. The input connections for the 5 basic navigation keys are on the right side of the base, making them easy to access.

The Microsoft ballot marking device concept.
Industrial design by Tucker Viermeister.