NIST Voting Technology Series
NIST VTS 400-5

Handbook for VVSG 2.0 Usability and Accessibility Test Strategies

A report on guidance and resources for how to test voting systems

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Abstract

This document provides guidance and resources for how to test voting systems against the usability and accessibility requirements in the Voluntary Voting System Guidelines (VVSG) 2.0. The requirements include Principles 2.2 and 5 through 8. The goal of those requirements is to ensure that voting systems certified to VVSG 2.0 are accessible and usable for election workers and voters—including voters with disabilities—so that every voter can mark, review, cast, and verify their ballot independently and privately.

The primary audiences for this guide are the voting system test laboratory organizations who perform certification testing, to help them understand some of the specialized tests required, and organizations in the design and development process as they build and prepare a voting system for certification testing.

Keywords

accessibility testing; human factors; user-centered design; usability testing; Voluntary Voting System Guidelines; voting systems; voting system certification; VVSG.

Executive Summary

This handbook is an overview of what you need to know to meet the accessibility and usability requirements in the Voluntary Voting System Guidelines (VVSG) 2.0 under Section 202 of the Help America Vote Act of 2002, which directs the U.S. Election Assistance Commission (EAC) to provide for the testing, certification, decertification, and recertification of voting system hardware and software. It is a compilation of NIST research in support of the development of the VVSG and input from the NIST Human Factors Public Working Group, which included many usability, accessibility and voting experts who participated in discussions and provided expertise from 2015-2020.

The requirements covered in the document include VVSG 2.0 Principles 2.2 and 5 through 8. The goal of those requirements is to ensure that voting systems certified to VVSG 2.0 are accessible and usable for election workers and voters—including voters with disabilities—so that every voter can mark, review, cast, and verify their ballot independently and privately.

The primary audiences for this guide are (1) the voting system test laboratory organizations who perform certification testing, to help them understand some of the specialized tests required and (2) organizations in the design and development process as they build and prepare a voting system for certification testing.

The information in this guide includes explanation of the concepts and terminology about accessibility and usability used in VVSG 2.0 and how they apply to voting systems. The handbook is in five parts:

Part 1: Introduction to accessibility and usability in VVSG 2.0
Part 2: User-centered design for voting systems
Part 3: Usability testing for voting systems
Part 4: Testing VVSG 2.0 requirements
Part 5: Companion documents and resources

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Part 1
Introduction to accessibility and usability in VVSG 2.0

Overview and definitions

About the Voluntary Voting System Guidelines

The Help America Vote Act of 2002 (HAVA) established the U.S. Election Assistance Commission (EAC) with the mission of providing guidance to the states in their efforts to comply with the HAVA administrative requirements. Section 202 of HAVA directs the EAC to adopt voluntary voting system guidelines, and to provide for the testing, certification, decertification, and recertification of voting system hardware and software. The first version of the Voluntary Voting System Guidelines (VVSG) was adopted in 2005.

HAVA also says that voting systems must support millions of voters with disabilities so that they have the same options for where and how they vote as others do and can mark, verify, and cast their ballot privately and independently.

> The voting system shall 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.
> - HAVA Section 301(a)(3)

VVSG 2.0 is the third version of national voting system standards under HAVA. One of the biggest changes is that this version is organized into 15 major principles for election systems, rather than technical features. Within those principles there are 63 associated guidelines that cover voting system design, development, and operations, each with specific, testable requirements.

Usability and accessibility requirements in VVSG 2.0

The usability and accessibility chapter of VVSG 1.0 and 1.1 has also been reorganized into 4 principles, with 11 guidelines, and one guideline under Principle 2:

- **Principle 2 Guideline 2 User-Centered Design Process**
  Under Principle 2: High Quality Implementation: The voting system is implemented using high quality best practices, Guideline 2 states: The voting system is implemented using best practice user-centered design methods that consider a wide range of representative voters, including those with and without disabilities, and election workers.
- **Principle 5 Equivalent and Consistent Voter Access**
  All voters can access and use the voting system regardless of their abilities.
- **Principle 6 Voter Privacy**
  Voters can mark, verify, and cast their ballot privately and independently.

- **Principle 7 Marked, Verified, and Cast as Intended**
  Ballots and vote selections are presented in a perceivable, operable, and understandable way and can be marked, verified, and cast by all voters.
- **Principle 8 Robust, Safe, Usable, and Accessible**
  The voting system and voting processes provide a robust, safe, usable, and accessible experience.

This reorganization means that there is no longer a separate section for accessibility, with subsections by disability. Instead, all of the requirements support accessibility. It also includes new and updated requirements for usability and accessibility.

What's new in VVSG 2.0

The primary goal for accessibility in VVSG 2.0 is to meet the requirement in the Help America Vote Act (HAVA) that voting systems must enable the millions of voters with disabilities to mark, verify, and cast their ballots privately and independently.

VVSG 2.0 includes new and updated requirements for usability and accessibility that:

- Address accessibility issues that voters encounter with current systems
- Catch up to best practices in election design and accessibility
- Cover new technologies in common use
- Match updated laws and standards including the Federal "Section 508" regulations

When all forms of voting are accessible, voters with disabilities have the same options for where and how they vote as others do. This includes voting in person at an early vote center or Election Day polling place as well as voting by mail, and other options such as curbside voting or election services that bring portable voting systems to places like nursing homes and hospitals.

VVSG 2.0 requirements support this goal for voters with vision, hearing, dexterity, mobility, and cognitive disabilities. The underlying framework for voting is based on modes of perception (visual and audio) and interaction (touch and tactile controls and non-manual interactions).

Definitions of usability and accessibility

The principles, guidelines, and requirements in the VVSG 2.0 draw on an existing body of work on how people interact with products, services, and systems. Broadly called human factors, the work draws on fields including computer science, cognitive and behavioral psychology, industrial design, visual design, and occupational therapy.

As a field that emerged in the middle of the 20th century with such a broad set of sources, there are many areas of specialization, such as human-computer interaction, user-centered design (also called human-centered design), user experience (UX), service design, accessibility, and usability.

Two key terms to understanding the requirements in Principles 2.2 and 5-8 are ***usability*** and ***accessibility***. These words are defined in International Standards Organization (ISO) standards, dating back to the 1990s. The use of these terms in VVSG 2.0 draws on that history, which is more specific than the casual use of the terms.

Accessibility, for example does not simply mean "can be accessed" but is a term of art used to refer to "access for people with disabilities." Similarly, *usability* is a measurable characteristic of a product or service about the quality of use in an appropriate context. This use of these terms is similar to the way *security* has precise meaning as a quality of a voting system.

In addition, there are key concepts used to guide design decisions and processes that were considered in the VVSG 2.0 usability and accessibility requirements. Both have long histories in use and are applied to both physical and digital interactions.

Usability

Usability is a feature or attribute of a product. VVSG 2.0 defines usability as

> **Usability:** Effectiveness, efficiency, and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment.
>
> Usability in the context of voting refers to voters being able to cast valid votes as they intended, quickly, without errors, and with confidence that their contest selections were recorded correctly. It also refers to the usability of the setup and operation of voting equipment in the polling place.

This definition is based on the definition of usability in ISO 9241[1], the first sentence of the definition above. As used in the ISO standard, the key terms mean:

- **Effectiveness**: the accuracy and completeness with which specified users can achieve specified goals in particular environments
- **Efficiency:** the resources expended in relation to the accuracy and completeness of goals
- **Satisfaction:** the comfort and acceptability of the work system to its users and other people affected by its use

→ **Part 3: *Usability testing for voting systems* covers requirements and test methods**

Accessibility

Accessibility is the term used to refer to whether people with disabilities can use a product. ISO 9241 Part 20 defines accessibility as a specific application of usability. The standard accessibility addresses the full range of user capabilities and is not limited to users who are formally recognized as having a disability.

> The usability of a product, service, environment or facility by people with the wide range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use,
>
> – ISO 9241-20:2021: 3.1[2]

The definition in VVSG 2.0 focuses on voters with specific disabilities that have faced barriers to voting and the role of the VVSG in setting testable requirements:

> **Accessibility:** Measurable characteristics that indicate the degree to which a system is available to, and usable by, individuals with disabilities. The most common disabilities include those associated with vision, hearing, mobility, and cognition.

In VVSG 2.0, usability and accessibility work together so that a single set of requirements ensures that all voters are able to use a voting system.

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[1] **ISO 9241-11:2018(en)** Ergonomics of human-system interaction — Part 11: Usability: Definitions and concepts. **https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en**

[2] **ISO 9241-20:2021(en)** Ergonomics of human-system interaction — Part 20: An ergonomic approach to accessibility within the ISO 9241 series **https://www.iso.org/obp/ui/#iso:std:iso:9241:-20:ed-2:v1:en**

This single set of requirements also acknowledges that there is no single line of separation between usability and accessibility: features of good usability are often part of accessibility for specific disabilities.

As Clayton Lewis, a leader in work on accessibility for people with cognitive disabilities put it:

> Studies suggest that many barriers to cognitive *accessibility* are the same as *usability* problems for a general user audience… *but more severe*.[3]

This means that accessibility features can often help people who do not think of themselves as having a disability, such as older adults experiencing changes in their vision, dexterity, or cognitive function.

Combining usability and accessibility is a significant change from VVSG 1.0 and VVSG 1.1 which had separate sections, and further divided the accessibility section to focus on four types of disability: blindness, low vision, mobility, and dexterity.

[3] Lewis, C.(2007) *Cognitive impairment and accessibility*. Presentation to TEITAC (Telecommunications and Electronic and Information Technology Advisory Committee of the US Access Board), Washington, DC, February 7, 2007.

Key concepts in usability and accessibility

User-centered design

User-centered design (UCD) is an approach to building systems focused on meeting users' own goals. UCD includes activities and methods for discovering what users need, and what meets those needs.

In UCD, designers use these methods before development starts and on each new iteration of a system. This iterative, user-need-driven approach is an established best practice in public and private product development.

UCD is also called *human-centered design* and is closely related to the ideas in *design thinking*.

Universal design

Designers can aim for accessibility through the ***Principles of Universal Design***[4]***,*** or designing a product or service so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability. Systems with universal design follow seven principles.

- Equitable Use
- Flexibility in Use
- Simple and Intuitive Use
- Perceptible Information
- Tolerance for Error
- Low Physical Effort
- Size and Space for Approach and Use

These principles are a specific approach to design in which multiple ways of interacting with a system are built in and allow flexibility for a range of user needs. These principles are incorporated into the requirements in VVSG 2.0.

Universal design for voting systems, in this context, does **not** mean one interface that everyone must use. Quite the opposite. It assumes that voters may have different needs for how they interact with the voting system. They may also rely on assistive technology for interacting with technology. Assistive technology (AT) is the umbrella term for hardware and software tools used by people with disabilities. AT includes things like software that reads a

[4] The Principles of Universal Design are seven general principles to guide the design process or evaluate existing designs. You can find the principles and more information at the Center for Universal Design at North Carolina State University at **https://design.ncsu.edu/research/center-for-universal-design/**

digital screen and all interactions in audio, magnifiers, specialized physical buttons or switches that meet physical dexterity needs, and many other specialized tools.

Many systems combine a universal design approach and an implementation that works well with AT. As one article explains it,

> (1) The products must be designed so that their operation and controls are adjustable (or so that the user can choose between alternate ways of operating) so that the products are directly usable by people with widely varying abilities.
>
> (2) The products must also be designed so that they are compatible with personal assistive technologies that an individual (who cannot use the products directly) might carry with them.
>
> Gregg Vanderheiden, *Universal Design and Assistive Technology*[5]

The VVSG 2.0 requirements also do this, though with limited use of AT possible because a voting system is not a general-purpose device. For example, *7.1-G – Text Size (Electronic display)* requires that the system include a variety of text sizes, rather than providing just one size. It also requires that the system provide a way for voters to select the one that works best for them. Having this kind of flexibility built into the voter experience supports independent voting.

→ **Part 2: *User-centered design for voting systems* discusses how UCD is used in developing high quality voting systems**

The POUR Principles of accessibility

The accessibility requirements in VVSG 2.0 incorporate guidelines from federal legislation known as "Section 508"[6] and the international standard for accessibility, the Web Content Accessibility Guidelines (WCAG) 2.0,[7] which is incorporated by reference. This means that the entire WCAG 2.0 is considered part of the Section 508 requirements.

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[5] Vanderheiden, G. C. (1998). Universal Design and Assistive Technology in Communication and Information Technologies: Alternatives or Complements? *Assistive Technology, 10*(1), 29-36. DOI: 10.1080/10400435.1998.10131958

[6] US Access Board (2018). Section 508 Information and Communication Technology (ICT) Final Standards and Guidelines (36 CFR Parts 1193 and 1194, RIN 3014-AA37, Final Rule, March 23, 2018)

[7] W3C (2008) Web Content Accessibility Guidelines (WCAG) 2.0, W3C Recommendation 11, December 2008. **https://www.w3.org/TR/WCAG20/**

The requirements in WCAG 2.0 are organized into four principles, which address different aspects of interacting that need special consideration for people with disabilities. They are known as the POUR Principles for the first initials of the principle names.

- **Perceivable** - Information and user interface components must be presentable to users in ways they can perceive.
- **Operable** – User interface components and navigation must be operable.
- **Understandable** – Information and the operation of the user interface must be understandable.
- **Robust** - Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies

As a standard used for a wide range of technologies, WCAG 2.0 addresses the goals or outcomes needed for accessibility but does not include specific techniques in the guidelines. WCAG 2.0 supporting documents discuss ways to successfully implement each guideline.

Many of the requirements in Principles 5-8 (especially in Principle 7) are based on WCAG 2.0. This relationship is noted in the Discussion for each requirement.

Goals and scope of accessibility in VVSG 2.0

Four key concepts in VVSG 2.0 are used as the foundation for accessibility in the many detailed technical requirements. They define the goals and scope of the accessibility-focused requirements.

Principle 7.1 - Marked, Verified, and Cast as Intended

The requirements in 7.1 echo the fundamental principle of universal design with the goal of having the default voting system settings present a ballot usable for the widest range of voters and of having the most common settings available within the voting system itself.

As an example, the default text size in 7.1-G is not the smallest of the required size, but a medium size that research and experience with existing voting systems showed is a comfortable size for many voters. By setting it as the default, fewer voters need to adjust the system settings.

7.2-A – Display and interaction options

This requirement identifies the key display formats and interaction modes that voting systems must provide.

> The voting system must provide at least the following display format and interaction mode options to enable voters to mark their ballot to vote, and verify and cast their ballot, supporting the full functionality in each mode:
>
> 1. Visual format;
> 2. Enhanced visual format;
> 3. Audio format;
> 4. Touch mode; and
> 5. Limited dexterity mode.

5.1-A – Voting methods and interaction modes

This requirement makes explicit that each method of voting must support all functions in all display formats and interaction modes.

> Within any method of voting, all display formats including enhanced visual and audio and all interaction modes including tactile and limited dexterity must have the same functionality as the visual format and touch mode including voting, verification, and casting.

8.1-A – Federal standards for accessibility

This requirement recognizes the broader federal laws and standards for accessibility. VVSG 2.0 requirements for specific features of voting systems were written to harmonize the "Section 508" standards (including the Web Content Accessibility Guidelines (WCAG), which are included by reference).

> Voting systems must meet federal standards for accessibility, including the version of *Section 508 Information and Communication Technology (ICT) Final Standards and Guidelines [USAB18]*, in effect as of January 18, 2018, and the *WCAG 2.0 Level AA checkpoints [W3C10]* included in that standard.

Section 508/WCAG standards apply to any aspect of the accessibility of a voting system that is not explicitly covered in VVSG 2.0. This helps make the VVSG robust by using a general technology standard to cover possible future innovations.

There are also some cases where the VVSG 2.0 has a more stringent requirement than WCAG. For example, 7.1-C requires a minimum of a 10:1 figure-to-ground contrast ratio for ballot contents, where WCAG only requires a 7:0 contrast.

Interacting with a voting system

When the display formats and interaction modes are combined, there are four primary combinations:

Visual format + touch mode

Voters read the ballot on screen and use touchscreen controls or physical buttons to make selections and navigate the ballot.

Enhanced visual format + any interaction mode

Options to change the text size and contrast help voters with low vision, who don't read well, or who can't get close enough to the screen to read it easily. This includes large text and contrast options.

Visual format + limited dexterity mode

Voters with limited use of their hands use special buttons or switches that are easier to press, with either the audio, reading the screen, or both. Voters with no use of their hands might use head-controlled switches or technology like "sip and puff" that uses breath to press buttons or move around the screen.

Audio format + limited dexterity mode

Voters listen as the ballot is read through private headphones. Audio helps voters with limited or no vision, who don't read well, or as part of alternative language access. Physical buttons to make selections, enter write-ins, and navigate the ballot replace or augment touch screen controls that are not accessible for people with visual or dexterity disabilities.

Types of disabilities

Unlike VVSG 1.0 and 1.5, VVSG 2.0 requirements are not organized by disability. Instead, they take a universal approach, applying to all voters.

Principle 5.1 sets out the requirement that all voters have a consistent experience throughout the voting process within any method of voting. It focuses on display formats (including visual, enhanced visual and audio) and interaction modes (including touch, tactile controls, and other modes for limited dexterity). These display formats and interaction modes allow voters to choose the combination that works best for them, no matter what their ability (or disability) or preferred assistive technology.

The VVSG 2.0 requirements specifically mention:

- **Blindness,** with no functional use of vision for voting
- **Low vision,** which includes poor reading vision that requires larger text or overall magnification and needs for adjustments to the color and contrast on the screen.
- **Deafness,** with no functional use of hearing for voting
- **Hard of Hearing**, including voters who use hearing aids
- **Mobility,** including the need to reach or touch the voting system from a seated position in a wheelchair, scooter, or other mobility aid
- **Dexterity**, including any difficulty in grasping, pressing, or handling the voting system or ballot
- **Cognitive,** including any difficulty in understanding instructions, information, or interactions in the voting system because of a developmental, cognitive, or learning disability

Print disabilities

The concept of print disabilities combines several different types of disabilities that an individual may have singly or in combination. It is an important term for discussions of voting system accessibility because it affects the ability to vote independently, either in person or by voting by mail when the voting process includes reading or handling printed materials—especially a ballot.

Two definitions of someone with a print disability are:

> A person who is unable to read or use regular print materials as a result of temporary or permanent visual or physical limitations… this includes those who are blind or have a visual or physical disability that prevents them from reading or handling print materials.[8]

> A person who cannot effectively read print because of a visual, physical, perceptual, developmental, cognitive, or learning disability.[9]

[8] National Library Service for the Blind and Print Disabled (2021). *Eligibility*. Available at **https://www.loc.gov/nls/about/eligibility-for-nls-services/**

[9] Reading Rights Coalition (2013). *The Definition of "Print Disabled."* Available at **https://web.archive.org/web/20131024195135/http://readingrights.org/definition-print-disabled**

Part 2
User-centered design for voting systems

High quality implementation for voting systems

What is user-centered design?

User-centered design is defined in an ISO standard, ***Human-centered design for interactive systems***,[10] validated by more than a dozen years of use, as:

> … an approach to interactive systems that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors /ergonomics, and usability knowledge and techniques.

User-centered design (UCD) is no longer novel. It is widely adopted in government and incorporated into the principles and playbooks of leading federal agencies including the U.S. Digital Service,[11] 18F in the U.S. Government Services Administration (GSA),[12] and the Lab at Office of Personnel Management (OPM).[13]

The requirements in VVSG 2.0 pay special attention to how voting system developers include voters with disabilities and collect feedback while developing a new system.[14] Principle 2.2 requires voting system manufacturers to report on their user-centered design methods for certification.

This section offers suggestions on conducting and documenting UCD to meet this requirement. It describes key user-centered design elements and outputs and suggests user-centered design methods to use during systems development.

UCD is an approach to building systems focused on meeting users' own goals. UCD includes activities and methods for discovering what users need, and what meets those needs.[15] In UCD, designers use these methods before development starts and on each new iteration of a

[10] ISO 9241-210:2019(en) Ergonomics of human-system interaction — Part 210: Human-centered design for interactive systems. **https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en**

[11] US Digital Service. *How we work.* **https://www.usds.gov/how-we-work**

[12] 18F. *How we work*. **https://18f.gsa.gov/how-we-work/**

[13] The Lab at OPM. *About Us.* **https://lab.opm.gov/about-us/**

[14] For an overview of the barriers voters with disabilities face and recommendations, see Buchanan, K., Mangold, K., and Laskowski, S. (2022). Promoting Access to Voting: Recommendations for Addressing Barriers to Private and Independent Voting for People with Disabilities. (National Institute of Standards and Technology, Gaithersburg, MD), NIST Special Publication (SP) 1273. **https://doi.org/10.6028/NIST.SP.1273**

[15] UCD has a long and deep history in technology development (See *Foundations for Designing User-Centered* by F.E Ritter, Springer 2014). This definition of UCD is taken from World Wide Web Consortium's definition (**https://www.w3.org/WAI/redesign/ucd**) and the human-centered design ISO standard (ISO 9241-210:2010). The U.S. Department of Health and Human Service's "Evidence-based guidelines for website usability" review much of the foundational literature in UCD (**https://guidelines.usability.gov**).

system. This iterative, user-need-driven approach is an established best practice in public and private product development.[16]

UCD is sometimes called *human-centered design.* It is also closely related to the body of practices known as *design thinking*.[17]

Unlike usability and accessibility, which are characteristics of products, UCD is a process for design and development incorporating practices and methodology that has been shown to lead to more usable and accessible products.

Principles of human-centered design

The ISO 9241-201 standard outlines six principles for human-centered design

- The design is based upon an explicit understanding of users, tasks, and environments
- Users are involved throughout design and development
- The design is driven and refined by user-centered evaluation
- The process is iterative
- The design addresses the whole user experience
- The design team includes multidisciplinary skills and perspectives

This is illustrated in Figure 1 as a cyclical process with the cycle from understanding the context of use and needs, specifying broad goals, proposing design solutions, and evaluating the design repeated until the product meets its goals.

Applied to election systems, a voting system development team would use this cyclical, iterative process to:

- Understand the full range of requirements, from election laws and administration to the voter experience, and technical requirements.
- Specify the goals for the new system or feature, how it will work and the detailed requirements it must meet
- Design the feature or product
- Evaluate the product with voters, elections workers, and other stakeholders to see if it meets both the detailed requirements and broader goals.

The product design is only considered complete when the evaluation is successful.

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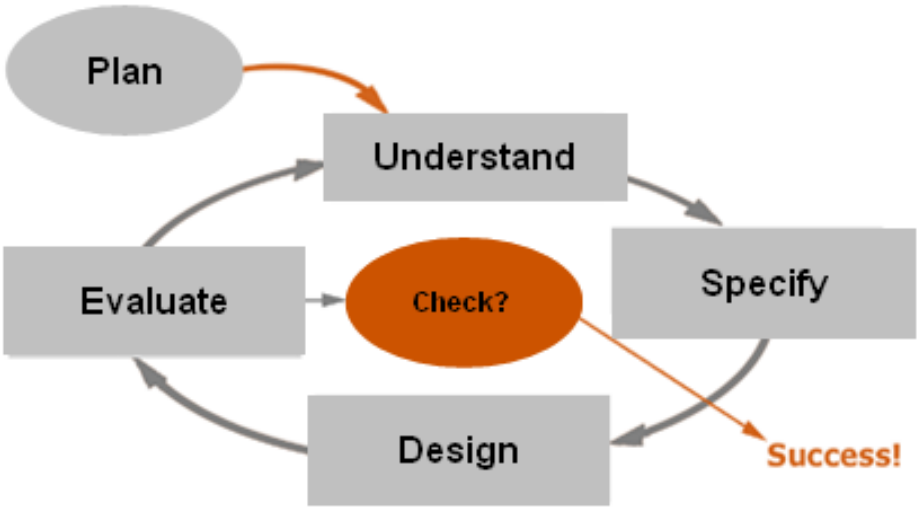
[16]See Usability.gov's summary of UCD's benefits (**https://www.usability.gov/what-and-why/benefits-of-ucd.html**). Also see an analysis showing how "industry standard" UCD has become: Vredenburg, K., Mao, J. Y., Smith, P. W., & Carey, T. (2002, April). A survey of user-centered design practice. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 471-478).

[17] The term *design thinking* was introduced in the 1990s and popularized by the industrial design consultancy IDEO as the basis for their design and innovation process.

Figure 1 *Diagram of the UCD process*



International standards for UCD

The VVSG 2.0 requirement builds on current professional practice in user-centered design and usability and international standards, applying these practices to voting systems. The ISO has defined UCD's methods in each of these categories in standards, including:

- Ergonomics of human-system interaction (ISO 9241)
- Common Industry Format (CIF) for usability test reports (ISO/IEC 25062)
- Context of use description (ISO/IEC 25063)
- User needs report (ISO/IEC 25064)
- User requirements specification (ISO/IEC 25065)
- Evaluation reports (ISO/IEC 25066)

UCD approach to design and development

UCD includes methods to conduct at each phase of a product's development. These methods fall into three categories.

Conducting research to understand what users need

In UCD, the best way to learn what users need is asking or observing them. UCD includes methods for conducting qualitative and quantitative research about what people need. This research is meant to help designers better understand user goals, preferences, environments,

and constraints. This research need not be as robust as academic or peer-reviewed research. It should be just robust enough to decide what to start building.

Evaluating system iterations against user needs

In UCD, the best way to learn whether a system meets user needs is having users try to use it. UCD focuses on continuously asking users to try using systems or prototypes. Their experience is the best indication about whether a feature will work well. Repeated evaluation identifies what works and what doesn't.

Changing your system to better align with what users need

In UCD, the best way to build a user-centered system is to continuously improve it. UCD only accomplishes its goals if designers change their system based on what they learn in research and evaluation. Designers should change the system based on what users say is easy and hard. They should remove features that don't meet user needs and hone features that do.

UCD takes place throughout design and development

UCD can and should happen anywhere and everywhere during the process of creating a VVSG-certified voting system.

- **Before development starts,** designers conduct initial research about what voters, election workers and election administrators need to generate ideas for the new system or system update. This research might include interviews, observations of existing systems, or customer satisfaction surveys.
- **As development continues**, designers ask users to try using prototypes (rough, basic versions) of potential product ideas. These prototypes can be as simple as paper sketches attached to cardboard boxes.
- **As the system takes shape,** designers usability test individual features (like selecting a candidate in a context). When it's possible to use the system for an "end to end task" (like voting and casting a ballot), designers can test individual features.
- **When the system is ready for deployment,** designers conduct a final usability test, covering all types of voters and election workers.

UCD should include all types of voters and election workers

To realize its benefits, UCD activities, especially in the *understand* and *evaluate* stages should include all the people who use a system, both voters and election workers, specifically:

Voters, including those who:

- Interact with the voting system in a variety of ways, including using assistive technology
- Use the system in a language other than English
- Are experienced voters and inexperienced voters
- Represent a range of demographics such as age

And election workers, including those who:

- Interact with the system to set it up, run the election and close the elections
- Support voters with materials and instructions
- Are experienced workers and inexperienced workers

Adopting UCD ultimately reduces risk for election administration by exposing systems to a few people at a time throughout development, instead of entire jurisdictions as systems are adopted. Voters and election workers are less likely to make mistakes on usable systems. Universally designed systems allow almost all people to vote independently and limit election worker involvement in the voting booth. Attention to user needs early in development solves upstream and downstream problems. Purchasers feel confident that they will not encounter problems of usability or accessibility for users.

User-centered design in VVSG 2.0

UCD helps meet the VVSG's broader principles. With the help of UCD, voting systems should be:

- **Equivalent and consistent:** All voters have access to mark and cast their ballot without discrimination.
- **Marked as intended**: Ballots and vote selections are presented in a clear, understandable, and operable way, and are verifiable by all voters.
- **Cast as marked:** Ballots are cast as marked, both secretly and privately.
- **Usability tested:** Meet performance standards for usability and accessibility.
- **Meet web accessibility standards:** Browser-based systems meet web accessibility standards, in addition to voting standards.

UCD is part of Principle 2: High Quality Implementation along with requirements for best practices in software, system logic, structure, and reliability in the physical environment.

> Principle 2.2: The voting system is implemented using best practice user-centered design methods, for a wide range of representative voters, including those with and without disabilities, and election workers.

This section offers suggestions on conducting and documenting UCD to meet this requirement. It describes key user-centered design elements and outputs. The companion documents listed in Part 5 suggest participant user-centered design methods to use during systems development.

What does VVSG 2.0 require

Requirement 2.2-A says

> **2.2-A – User-centered design process**
>
> The manufacturer must submit a report providing documentation that the system was developed following a user-centered design process.
>
> The report must include, at a minimum:
>
> 1. a listing of user-centered design methods used;
> 2. the types of voters and election workers included in those methods;
> 3. how those methods were integrated into the overall implementation process; and
> 4. how the results of those methods contributed to developing the final features and design of the voting system.

VVSG 2.0 requires manufacturers to incorporate UCD methods into voting system development and report on their process

To meet this requirement, manufacturers must submit a report describing: the user-centered design methods used, the types of voters and election workers included in those methods, how those methods were integrated into the overall implementation process, how the results of those methods contributed to developing the final features and design of the voting system.

Meeting VVSG system usability testing requirements is part of user-centered design

VVSG 2.0 Principles 8.3 and 8.4 require manufacturers to report on a usability test of the voting system, conducted with both voters and election workers.

Meeting these requirements is one part of incorporating UCD into development as part of the *evaluate* stage but could also be used in the *understand* stage to identify requirements for a new or updated system.

Usability testing ready-to-deploy systems is an important way to demonstrate their strengths. The final test can provide information about the final product, such as typical time to vote on the standard NIST ballot. The final test also provides a baseline to compare against other systems or to show improvements when a system is updated.

Importantly, there's more to UCD than usability testing ready-to-deploy systems. Manufacturers should include UCD methods throughout their entire development process, not just at the end. Good results from the usability testing on the final product is a sign of a good user-centered design process conducted throughout design and development.

Other VVSG requirements still apply

Adopting UCD methods does not exempt manufacturers from other VVSG requirements. Development choices based on UCD still must meet VVSG requirements.

User-centered design methods can also help to demonstrate systems meet VVSG requirements. Think of UCD as an approach to gathering evidence that a voting system meets the VVSG's requirements.

Planning for user-centered design

The best sign of user-centered design is a usable, accessible system. However, documents, data, and other artifacts can also demonstrate UCD. Different documents are appropriate for different phases of a project.

During each development phase, internal documents help track progress towards the final product.

- Early user research (with methods like surveys or interviews) might produce a list of user needs, preferences, and constraints.
- Usability testing during the product development life cycle might produce a list of issues to address in future iterations.

Developers can ask themselves these questions to evaluate their UCD process.

- How were users included in the process of designing and developing the product?
- How many hours of exposure did the product team have with directly observing users of the systems during the development of this release of the product?
- What kinds of inspection, evaluation, and observation did the product team engage in with users?
- What were the major insights the product team gained from each of the activities they included users in?

Self-assessment for UCD

The self-assessment in Table 1 suggests ways of reviewing your internal processes to determine if you are meeting requirements for high quality implementation. In this self-assessment, “team” means everyone in the company who influences design decisions, from business analysts to legal and compliance. In Table 1, moving from minimal to strong indicates an increasing level of process maturity; *each assessment level encompasses and extends the lower-level assessments.*

This is not required for VVSG certification but can help you determine whether your UCD program will meet the requirements in VVSG Principle 2.2.

Table 1 *UCD self-assessment*

Assessment > Objective	**Minimal 1**	**Acceptable 2 + level 1**	**Good 3 + levels 1 & 2**	**Strong 4 + levels 1,2 & 3**
Users were included	Company employees in the beginning of the lifecycle	Community advisory groups at every phase	Range of individual users at every phase	Diverse, large, geographically distributed range of users
Team direct observation of use	Only occasional observation of use	2 hours per person every 6 weeks	Regular part of UCD activities	Planned, central part of UCD activities
Methods used to learn about and understand users' needs	Surveys, focus groups, demos, presentations only	Basic usability testing of features and functionality	Field research, observing voters and election workers in polling places	Co-design, small and large usability tests with diverse users

Key UCD methods for voting systems

Building usable, robust systems requires a range of user-centered methods. Although UCD encompasses a range of methods (see ISO/IEC/IEEE 15288:2015[18]), five are particularly relevant to voting systems design.

- **Inspection** to identify usability defects and potential usability problems
- **User surveys** and **interviews** that elicit problems, opinions, and impressions from users and potential users
- **Observation** of users in a controlled or field setting
- **Usability testing** of prototypes, features or systems

These methods can be used at many parts of the development process. For example, a developer might:

- Observe users in the field during election preparations
- Interview and survey voters and election administrators about specific questions that arise from the observation
- Repeatedly usability test low-fidelity prototypes of new systems
- Inspect near-finished software for usability problems.
- Conduct large-sample usability tests to establish a system's general usability

Each method and stage requires different documentation. Early research might generate a list of user needs and requirements, while later usability tests might generate reports. Final system usability testing reports use the Common Industry Format (CIF) for usability test results (ISO/IEC 25062)[19] which has been modified for voting systems. (See Part 5 of this report).

→ **Part 5: *Companion documents and resources* has links to required templates**

User-centered methods

There is a wide variety of design research methods included in a robust UCD process. This section describes some of the most common, including interviews, observations, surveys, inspection, and usability testing.

[18] ISO/IEC/IEEE 15288:2015(en) Systems and software engineering – System lifecycle processes. **https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:15288:ed-1:v1:en**

[19] ISO/IEC 25062:2006(en) Software engineering — Software product Quality Requirements and Evaluation (SQuaRE) — Common Industry Format (CIF) for usability test reports. **https://www.iso.org/obp/ui/#iso:std:iso-iec:25062:ed-1:v2:en**

When to use each method

UCD methods should shape products at all their phases. UCD can join linear, agile, rapid, and other development approaches, as described by ISO/IEC/IEEE 12207:2017[20]. Regardless of your development approach, choose a method based on the goals of a development stage as described in Table 2.

Table 2 *Choosing UCD methods for development stage goals*

Goal	Related methods		
Develop voting system requirements and understand user needs	**Observation** of current or potential people using existing voting systems	**Interviews** with voters and election administrators	**Surveys** of existing customers about how they use their current systems
Validate initial feature ideas and prototypes	**Usability testing** of rough prototypes with a small group	**Interviews** exploring new ideas after testing	
Identify usability problems in features under-development	**Usability testing** of in-development software, focusing on particular features	**Inspection** of nearly completed features by experts for common usability issues	
Establish evidence of finished system usability	**Usability testing** with a diverse set of potential users	**Surveys** of people using the new system to identify usability issues discovered in the wild	

[20] ISO/IEC/IEEE 12207:2017 Systems and software engineering – Software life cycle processes. **https://www.iso.org/standard/63712.html**

Method: Inspection

About	To use this method
Goal	Identify large usability problems in an existing system or prototype. This method is less useful for identifying minor or subtle problems or gathering user needs.
Process	Recruit a group of three to five people familiar with usability best practices. These people aren't necessarily designers, but they might be people who know a lot about designing usable voting systems. 1. Create a checklist of "heuristics" or general usability best practices the system should meet. Heuristics can be system specific or broad. For example: ○ "The system should speak the user's language, with words, phrases and concepts familiar to the user, rather than system-oriented terms." ○ "Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue." • Ask each evaluator to individually use the system and go through the checklist. • After individual inspections, gather evaluators to compare checklists. Note issues that multiple people observed. Go back to the system and confirm the problems. (Based on the Heuristic Evaluation in the U.S. General Services Administration's 18F Method Cards[21])
Related standards	ISO/IEC/IEEE 15288:2015 – System life cycle processes
Selected references	• "Heuristic Evaluations and Expert Reviews" from Usability.gov. **https://www.usability.gov/how-to-and-tools/methods/heuristic-evaluation.html** • "Heuristic Evaluation" in *Usability Inspection Methods* by Jakob Nielsen (John Wiley & Sons 1994). • "Heuristic evaluation of user interfaces" J. Nielsen and R. Molich in *Proceedings of the ACM CHI'90 Conference*, pp. 249-256.

[21] Heuristic Evaluation. *18F Design Method Cards*. **https://methods.18f.gov/discover/heuristic-evaluation/**

Method: Interviews

About	To use this method
Goal	To better understand the variety of user needs, challenges and contexts (e.g., voters or election workers). Less useful for establishing quantitative estimates of how many users have what needs and use what features, or for validating specific designs.
Process	1. Write down some topics you'd like to ask about, and then some specific questions for each topic. Good topics might include the individual's history with elections, how they prepare for elections, what they do on election day and what challenges they encounter. 2. Recruit interviewees best able to discuss your topics of interest. If you are asking about voter's experiences, you might look for people new to voting. If you want to learn about election officials without experience with your system, you might look for new election workers. 3. Sit down one-on-one with each interviewee. (Or two-on-one: a participant, interviewer, and note-taker.) Introduce yourself. Explain why you're conducting the interview. 4. Let the conversation flow freely but keep coming back to your topics. Be comfortable with silences that let your interviewee elaborate. Ask lots of "why is that", "tell me more about that", and "how do you do that" questions. Take thorough notes. 5. After you've interviewed several people, compare notes. Look for common goals, challenges, and environments. (Based on Stakeholder and user interviews in the U.S. General Services Administration's 18F Method Cards[22])
Related standards	ISO/IEC/IEEE 15288:2015 – System life cycle processes
Selected references	• "Individual interviews" from Usability.gov **https://www.usability.gov/how-to-and-tools/methods/individual-interviews.html** • "Tips for capturing the best data from user interviews" by Ryan Sibley from the 18F blog. **https://18f.gsa.gov/2016/02/09/tips-for-capturing-the-best-data-from-user-interviews/** • ***Interviewing Users*** by Steve Portigal (Rosenfeld 2013)

[22] Stakeholder and user interviews. *18F Design Method Cards.* **https://methods.18f.gov/discover/stakeholder-and-user-interviews/**

Method: Surveys

About	To use this method
Goal	To measure how many users report having certain opinions or behaviors. Less useful for understanding why participants have those opinions or how they might respond to a particular design.
Process	1. Identify the goals of your survey. In particular, select the type of people you want to learn about (for example, election administrators unfamiliar with your voting system). Then decide what you want to learn about them (for example, what type of voting system they prefer). 2. Prepare survey questions related to your goals. Write a couple questions for each goal. Try to make them as fast to answer as possible. Use mostly fill-in-the-blank or multiple-choice questions. Ask only a couple open-ended questions. 3. Pilot test or ask a colleague or friend to take your survey. Ask them what they thought each question meant. Edit any unclear questions. 4. Distribute your survey to an appropriate sample of people. See the references for more suggestions on survey sampling. 5. Use appropriate statistics to summarize your results. If you choose to present inferential statistics (like significance test results or p-values), explain what they mean.
Related standards	ISO/IEC/IEEE 15288:2015 – System life cycle processes
Selected references	• "Four Tips for Survey Design" from Digital.gov **https://digital.gov/2014/11/10/4-tips-on-great-survey-design/** • "Surveys" in Observing the User Experience: A Practitioner's Guide to User Research by Elizabeth Goodman, et al. (Elsevier 2012) • "Using self-report questionnaires in OB research: A comment on the use of a controversial method" by P.E. Specter in *Journal of Organizational Behavior* (1994) (*15*, 385-392).

Method: Observation

About	To use this method
Goal	To see how users actually complete a task (as opposed to how they describe it). Less useful for eliciting users' feelings and reflections on a task.
Process	1. Decide what task you want to observe. Then figure out who conducts that task. For example, you might decide to observe voting machine set up. Election workers normally do that, so you might want to observe them. 2. Arrange to go to the place where people complete the task. For example, you might want to go to election worker training to see how election workers learn. Make sure you have permission from the person being observed and their supervisor, if applicable. 3. While observing, ask the participant to act normally. Pretend you're a student learning how to do the job. Ask questions to help you understand what the person is doing and why. 4. At the end of the session, explain what you have learned and check for errors. 5. Immediately after, write up your notes. When you've observed several people doing the same task, try writing a step-by-step description of how people complete the task and what challenges they encounter. (Based on Stakeholder and user interviews in the U.S. General Services Administration's 18F Method Cards[23])
Related standards	ISO/IEC/IEEE 15288:2015 – System life cycle processes
Selected references	• "Task analysis and observation" from Usability.gov **https://www.usability.gov/how-to-and-tools/methods/task-analysis.html** • "Contextual inquiry" in Observing the User Experience: A Practitioner's Guide to User Research by Elizabeth Goodman, et al. (Elsevier 2012)

[23] Stakeholder and user interviews. *18F Design Method Cards.* **https://methods.18f.gov/discover/stakeholder-and-user-interviews/**

Method: Usability testing

About	To use this method
Goal	Learning what works well for users (and doesn't) about a current prototype, feature or system.
Process	1. Decide why you're conducting the usability test. For example, you might want to learn how easily voters/election workers can use your system, what mistakes they make, or whether the system works like they expect. 2. Schedule one-on-one sessions with a few real users. For example, find five voters or five election workers. Pick people who haven't been involved in developing the system. 3. When people arrive for the test: a. Go over what will happen. b. Ask them to complete a couple tasks, like voting or setting up the machine. Watch, listen for questions (don't answer them) and comments (write them down). c. When they are done voting, ask them to walk you through what they did and why. 4. After you have completed a few sessions, look for patterns in what challenges people had. Compile a list of issues. (Based on Usability testing in the U.S. General Services Administration's 18F Method Cards[24])
Related standards	ISO/IEC/IEEE 15288:2015 – System life cycle processes
Selected references	• See "Usability testing and voting systems" later in this handbook • "Usability testing" from Usability.gov. https://www.usability.gov/how-to-and-tools/methods/usability-testing.html • ***Rocket Surgery Made Easy: The Do-It-Yourself Guide to Finding and Fixing Usability Problems*** by Steve Krug (New Riders, 2009)

[24] Usability testing. *18F Design Method Cards*. **https://methods.18f.gov/validate/usability-testing/**

Documenting UCD for system certification

Because user-centered design is a *process*, it is including in Principle 2 – High Quality Implementation. The VVSG 2.0 requirement for certification is that the voting system manufacturer document that process. The documentation shows that they have included activities in the design and development process to understand the context of use and needs of voters and elections workers, set goals for the system, and then evaluated the system against those goals.

The scope of the documentation of a user-centered design process depends on the system being tested.

- For a completely new system, the UCD process and documentation will start at the beginning of the work to design that system.
- For an update or new feature to an existing certified voting system, it will start with the planning for the changes from the previous certification.

This handbook includes templates and sample report formats that can be used to provide the documentation for user-centered design. These templates make it easier for manufacturers to assess the contents and level of detail in their documentation, they support a more consistent evaluation across products, and purchasers can use these reports to compare systems.

→ **Part 5: *Companion documents and resources* has samples of these templates**

How to document UCD for certification

Documenting UCD serves dual purposes:

- Recording your understanding of users and their needs to inform future product development work
- Generating evidence that you used a UCD process throughout systems development

A product should have its own UCD portfolio of related documentation. The portfolio should have artifacts, diagrams, and reports that describe plans, data, and findings (following ISO/IEC standards). Include all of these in user needs reports to show that your team uses an iterative, UCD process.

User needs inventory and testing documents

Develop lists and narratives of what you know about user needs from your observations, interviews, and surveying. These documents should focus on the ***context of use*:** who the

users are, what their tasks are, what their surroundings are like as they perform the tasks (ISO/IEC/IEEE 15288:2015).[25]

Prototypes and sketches

Demonstrate early ideas through prototypes of progressive fidelity. They should be tested iteratively with a wide range of users (ISO/IEC/IEEE 15288:2015) and annotated with what you learned from each.[26]

Issues lists

As product development progresses, document the results of inspection and small-scale usability testing with a list of issues discovered. You can prioritize the issues, describe their effects on the user experience and note which matter to whom. Note which issues were solved and which weren't.[27]

Simplified reports

Summarize mid-project usability tests with simple reports. Such a report should be detailed enough to give outsiders a sense of what you did. It starts by describing the test itself and what you learned from it.[28] Figure 2 describes the sections that might be in a simplified report.

[25] See the 18F method cards for journey mapping, mental modeling and personas at **https://methods.18f.gov/**.

[26] See Usability.gov's prototyping page for more information **https://www.usability.gov/how-to-and-tools/methods/prototyping.html**. Also see *Presumptive Design: Design Provocations for Innovation* by L. Frishberg and C. Lambdin (New Riders, 2017).

[27] See "Rolling issues lists" in *Handbook of UsabilityTtesting: How to Plan, Design and Conduct Effective Tests* by J. Rubin and D. Chisnell and J. (John Wiley & Sons, 2008). Also see "Reporting results" *in Rocket Surgery Made Easy: The Do-It-Yourself Guide to Finding and Fixing Usability Problems* by S. Krug (New Riders, 2009).

[28] You can download a template for this simplified report and see an example at **electiontools.org** as part of the Usability Testing Kit. This template is roughly the same as the Common Industry Format for Usability in ISO/IEC 25062. Also see "Reporting usability test results" from usability.gov **https://www.usability.gov/how-to-and-tools/methods/reporting-usability-test-results.html**

Suggested headings for a simplified usability report

Figure 2 *Simplified usability report headings*

Executive summary

About the method (method: inspection, survey, observation, evaluation)

- Who participated
- What did we test and why
- Materials tested (short description)
- Tasks performed by participants (list of users' tasks)
- Test facilitator tools (script, demographic questionnaire, usability questionnaire such as the **System Usability Scale** (SUS), etc.)

Results

- What did participants find confusing or difficult?
- General issues (bulleted list)
- Issues specific to features, functionality, or platform (bulleted list and / or screenshots / illustrations with descriptions of issues)
- Suggested changes to improve user performance (screenshots, mockups, or other illustrations of recommended changes)
- Changes implemented (description and screenshots or other illustrations)

Part 3
Usability testing for voting systems

Evidence that the voting system meets VVSG 2.0 requirements for usability and accessibility

What is usability testing?

Evaluation of usability and accessibility is a key practice in user-centered design (UCD)—and a key requirement in the Voluntary Voting System Guidelines (VVSG) 2.0—ensuring that the product you've made is usable by the end users, in this case, voters and election workers.

One way to do this is through directly observing users like voters as they perform typical tasks to reach their own goals. This is called **usability testing**.

Usability testing provides evidence that the voting system design meets the goals of the VVSG to be usable and accessible for voters and election workers through a systematic way to observe people as they use the voting system devices to complete basic activities like marking a ballot or setting up and shutting down the voting system. Usability testing, reported in the Common Industry Format (CIF) for usability test results (ISO/IEC 25062), builds confidence that a voting system will work as intended when it is deployed.

Usability testing and the VVSG

VVSG 2.0 (8.3A and 8.4A) requires manufacturers to report on a system usability test with voters and election workers.

The usability tests to meet these requirements are not a system's only usability tests. VVSG Requirement 2.2 requires systems be implemented with best practice UCD methods. Usability tests during development are also key to building usable systems.

Usability tests are not new to the VVSG. In VVSG 2.0, testing is consolidated into two requirements. Test participants include people who use accessibility and language access features, such as:

- Blind voters
- Voters with low vision
- Voters with limited dexterity
- Voters who are native speakers of alternative languages

Usability testing–testing the voting system with voters and election workers–is not the same as the conformance testing[29] to specific usability and accessibility requirements in VVSG 2.0. It is also different from beta testing, quality assurance or user acceptance testing (UAT):

- Unlike beta testing, usability testing involves a structured session with a user and a facilitator and observers, not just gathering feedback after a limited release.

[29] Note that manufacturers are encouraged to also do a pre-certification trial run to examine the voting system for conformance to all requirements in preparation for the VSTL conformity testing.

- Quality assurance (QA) focuses on testing whether the product meets its specifications. Usability testing focuses on whether the system meets its users' needs. Usability testing can identify some bugs that QA would. However, its real power is testing whether the system created is useful for users.
- User acceptance testing (UAT) focuses on whether a system meets the designer's assumptions about what users need. Typical UAT involves project managers stepping through new features with a user's needs in mind. UAT is a helpful tool but does not substitute for having actual users test a new feature or system.

Types of usability testing for voting systems

There are several types of usability tests you might want to run on voting systems in development. The culmination of these tests is the VVSG-required usability test, but there are several other types of usability tests to make systems more usable.

Characteristics of types of tests

Table 3 describes the characteristics for each type of usability test in terms of what is being tested, what can be learned from the test, and the output of the test.

Table 3 *Types of usability tests*

Type of test	What you test	What you learn	Common outputs
Early-stage prototype tests	Prototypes of possible systems or features (made from paper or digital prototyping tools)	What works or doesn't about a rough pre-development idea	Prototypes annotated with findings; revised user needs documents
Feature-specific testing during development	A particular screen, function, or feature of an in-development voting system	What elements of the current design work (and don't)	Issues lists or simple usability testing reports
"End-to-end" testing during development	The entire system a user would need to complete a task like "voting" or "setting up a voting system"	How the components of the system work well together for users (and don't)	Issues lists or simple usability testing reports
Pre-certification usability testing	A ready-to-deploy voting system	How your system will work in use in a live election with real voters	Usability test report that follows the Common Industry Format (CIF) for usability test results (ISO/IEC 25062) modified for voting systems

An overview of running a usability test

At its most basic, planning and running a usability test includes:

- Finding a group of people similar to the voters and election workers who will use the system
- Asking participants to complete tasks and activities that will reveal potential problems
- Observing what's hard (or easy) for them
- Identifying patterns or problems, with particular attention to problems that affect the most vulnerable and those that, even if rare, could affect election integrity
- Reporting the test results using a custom template, such as Common Industry Format (CIF) for usability test results (ISO/IEC 25062) modified for Voting Systems, designed for VVSG testing

Activities during usability testing

Activities for usability testing include typical tasks for the people whose experience is being tested.

For usability testing with voters, this might include

- Completing an entire voting session including activation, marking, review and verification, and casting the ballot
- Using the accessibility features or other options for the voting session

For usability testing with election workers, this might include

- Opening the polls
- Conducting polling including all accessibility features
- Closing the polls

People to include in usability testing

Include voters:

- In the general population, using the visual interface
- Who speak a system-supported language as their primary language
- Who are blind, using the audio-tactile interface
- With low vision, using the enhanced visual features with or without audio
- With low dexterity, using the visual-tactile or non-manual interface

Include election workers:

- With different levels of experience
- From different sizes of election jurisdictions

When to do usability testing

Usability testing to meet VVSG 2.0 requirements is done by the manufacturer to make sure the system is ready for the final certification test. Testing can include:

- Early-stage prototype testing
- Feature-specific testing during development
- Complete voting session testing
- Documentation or voter instructions testing
- Pre-certification testing

Usability testing can also be done by election officials as a way to:

- Learn about a new system in their environment
- Test election worker training and manuals
- Explore voter education needs in making the transition to the new system
- Explore accessibility features for voter outreach and education

Getting started: run a simple usability test

Start applying UCD wherever your product is in its lifecycle. The only way to reach deep understanding of users' needs is by observing users' behavior and how they interact with voting systems. Most teams start by conducting a simple, first usability test on a product or feature. This can be informal. At its essence, usability testing is simple.

All you need for a usability test is:

- a person who is like your target user
- a version of the product you want to test
- a quiet and comfortable space to be with the participant
- someone to moderate the interview
- someone to take notes

For example, it does not need a usability lab. Instead, you can invite voters or election workers to your offices and set up the least equipment needed for what you want to test. You need not set up a situation that is exactly like a polling place.

Everyone on the product team should observe the individual sessions. After each session, the team should discuss what they heard and saw.

After you have done one or two informal usability studies, it is likely that you will have more questions about users. At that point, you will branch out to other methods.

If you are starting from scratch on a product, the process might have a different starting point. You might want to start with market research and surveys to understand the problems your

customers are feeling pain on. After that, graduate to observing someone performing the task in the current way. In these sessions, you can ask follow-up questions to understand users' goals and tasks.

Why conduct usability tests on voting systems?

Usability testing throughout development is key to developing usable systems. It is particularly important for voting systems because:

- Robust usability testing generates evidence a voting system will work as intended when it's deployed. Usability testing, reported in the Common Industry Format (CIF) for usability test results (ISO/IEC 25062), can build state and local jurisdiction confidence.
- Mid-development usability testing is an easy way for designers--who are usually very comfortable with technology--to find what works with people who are less comfortable. Voters and election workers have diverse technical skills and language abilities, and it is important voting systems work for everyone.
- Many voting systems require voters and election workers to interact with multiple devices simultaneously. Multi-device systems open a new range of possible usability problems. "End-to-end" usability testing identifies those issues.
- Like most hardware systems, voting systems are complicated and time-consuming to manufacture. Usability testing early prototypes can save development time and money later.

Important elements of voting system usability tests

There are numerous introductions to usability testing and guidelines for usability testing with voting systems (See, for example, **General Accessibility and Usability Resources** and **Research Published by NIST** at the end of this report). The guidance in this section focuses on important elements of usability testing for voting systems.

Finding a range of people like your systems' eventual users

Voting systems have a particularly wide range of potential users. To make systems usable for all of them, usability tests have to include all of them. When designing usability tests, at any stage of development, make sure your participants have a diversity of:

- **Experience voting or administering elections.** People new to voting or election administration behave differently than experienced voters or administrators. If your test participants have many degrees of experience, you'll find problems specific to new users as well as the nuanced needs of experts.

- **Experience with different styles and brands of voting systems.** People experienced with a particular voting machine style (direct recording electronic (DRE), ballot marking device (BMD), etc.) or brand will compare your system with what they're using now. If your system is similar to what they're used to, they'll often find it easier to use. Make sure you include people whose previous experiences will help and not help them navigate your system.
- **Comfort and proficiency with technology.** People's comfort with technology in general has a large effect on their attitudes towards new voting systems. Your usability test should include people who are excited to use new technology, as well as people who are hesitant to try it.
- **Assistive technology users.** People who use assistive technology should be able to independently use your system. "Assistive technology" is a large umbrella, so consider testing with at least one member of each of the following groups:
  - People who use screen readers
  - People who use screen magnification
  - People who have limited use of their hands
  - People who use only tactile keypads or dual-switch controls (without screen readers)
  - People who use wheelchairs
- **Language preferences.** Make sure your test includes people who want to use your system in languages other than English. Usability test your systems' alternative language interface with speakers of several other languages to catch problems switching languages, translations of system messages, or other language-specific issues.
- **Literacy.** People read their language(s) with varying degrees of fluency. Usability testing a system with low- and high-literacy people ensures the text and formatting are simple enough for everyone to follow.

Ask people to complete tasks that will reveal potential problems

Usability testing centers on asking users to complete tasks with the system. The main voting system tasks are relatively simple: select candidates (and vote yes or no on ballot measures), cast ballots, set up the system, etc. Just asking people to complete simple tasks with the system often doesn't conjure real world scenarios voting systems must handle. To elicit the subtle complexity of elections, try these strategies:

- **Give participants instructions about who to vote for.** Tell voters to vote for particular candidates, change their previous votes, overvote, undervote. Otherwise, many will take the simplest route through the system and not surface common problems.

- **Use the NIST standard test ballot specification for usability testing.** One way to surface problems is using a test ballot designed with contests that can elicit common voting system problems, including types of contests, contests that are very long or very short, contests with similar names, and other complexities. NIST has created a standard ballot specification with realistic names you can use or adapt. (See the companion documents in Part 5.)

Observe what's hard for people, not what they say they want

In usability testing sessions, people often say what they like and dislike without reference to the system. In voting system usability testing, likes and dislikes can be driven by what is similar to their current voting system. Focus on people's behaviors and understanding instead of their stated preferences. Explore questions like:

- What tasks do they struggle to complete? Are there tasks they can't complete at all?
- Do they understand what they've selected or entered?
- Does their understanding of what's happening match what the system is actually doing?

Respond to patterns across users

Usability testing elicits all sorts of idiosyncratic behavior. Voting system usability tests are no exception. You probably don't have time to solve every problem you see users encounter. Instead, focus on identifying:

- **Problems many participants have.** If many types of people struggle to complete a task, the root problem is probably wide-spread and worth addressing.
- **Problems that most affect the most vulnerable users.** Look for issues disproportionately experienced by users who can't ask for help without violating their own privacy, such as assistive technology users who have to invite election workers into their voting booth. Also look for problems for people who can't easily ask for help, including people who aren't comfortable speaking English or who have a speech disability.
- **Problems that, even if rare, could have severe effects on data integrity.** For voters, these problems might be somewhat unclear instructions about casting or discarding ballots. Even if a small percentage of users experience the problem, the election effect could be severe. For election workers, these problems might be inadvertently misconfiguring tabulation systems. Even if only one precinct misconfigured a tabulator, it could have severe election day results.

Reporting usability test results

As noted in *Part 2: User-centered design (UCD) for voting systems*, usability test results can take a variety of formats. What's most important is that the format matches the goal of the test. For example:

- Early usability tests might capture their results in **issues lists**. To enable quick iteration, early usability tests might put less emphasis on documenting process and focus more on documenting key findings.
- Key "end-to-end" usability tests might be documented with a **simple report** detailed enough to give outsiders a sense of what you did. See the suggested headings in Figure 2 of Part 2.
  Final usability testing reports used to meet VVSG 2.0 requirements for certification must follow the Common Industry Format for usability test results (**https://www.iso.org/obp/ui/#iso:std:iso-iec:25062:ed-1:v2:en**) described in ISO/IEC 25062. NIST has developed a modified Common Industry Format template specifically for reporting on the usability testing of voting systems. (See Part 5 of this document.)

→ **Part 5: *Companion documents and resources* has samples of these templates**

Part 4
Testing VVSG 2.0 requirements

Guidance for testing the requirements for usability and accessibility in Principles 5 - 8

What's new in VVSG 2.0 requirements

Although reorganized into the new principles and guidelines, many of the requirements in Principles 5-8 are similar to those in VVSG 1.0 and VVSG 1.1.

A few requirements, however, are new or expanded. They include changes in visual presentation, a change in how plain language is included, new requirements for usability testing, user-centered design, and accessibility standards. Some of the most prominent are summarized here because those changes affect testing.

Text size and contrast

There are 6 requirements in VVSG 2.0 about how information and text is presented.

7.1-C – Default contrast
7.1-D – Contrast options
7.1-G – Text size (electronic display)
7.1-H – Scaling and zooming (electronic)
7.1-I – Text size (paper)
7.1-J – Sans-serif font

Text size

One of the most common complaints about ballots is that they are hard to read because the text is too small. This is true of both paper ballots and digital marking interfaces.

VVSG 2.0 updates the text size requirements to help more voters read the ballot easily. It includes 4 sizes as illustrated in Table 4, or the option to have a continuous scaling tool within the range from 3.5mm to 25mm. It also requires a larger default text size than VVSG 1.1 so more people can read the ballot easily.

All text on the ballot does not have to be the same size:

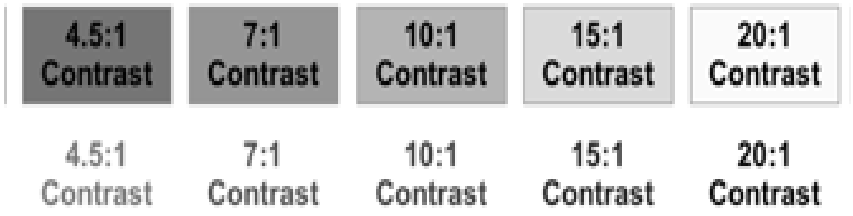
- Candidate names must be in the default size, but other information can be smaller or larger.
- At the largest size, an electronic ballot can have horizontal scrolling or panning to fit all the information on the screen with the same layout.
- Text also has to be in a sans-serif font because it is easier to read on-screen and for people who read English as a second language.

Table 4 *Samples of text sizes*

Sizes	Samples in Noto Sans[30]
Smallest 10-12 points (3.5 to 4.2 mm)	Official ballot → Official ballot
Default 14-16 points (4.8-5.6 mm)	Official ballot → Official ballot
Large 18-20 points (6.4-7.1 mm)	Official ballot → Official ballot
Large 24-25 points (8.5-9.0 mm)	Official ballot → Official ballot

Color contrast

Color contrast is the difference between the text and the background color. VVSG 2.0 also updates color contrast requirements to be more precise and adds support for low contrast. Contrast varies depending on the combination of the lightness and darkness of the background and the text as illustrated here:



All ballot information must be 10:1. This VVSG 2.0 requirement is higher than general Web guidelines because the information is critical for voting. Electronic ballots need both high and low contrast options.

Giving voters options for high and low contrast on electronic displays helps everyone adjust to different lighting conditions. It also helps people with visual disabilities that make screens hard to look at read the ballot more easily.

[30] Noto Sans is a free font from Google Fonts, available at **https://fonts.google.com/noto/specimen/Noto+Sans**

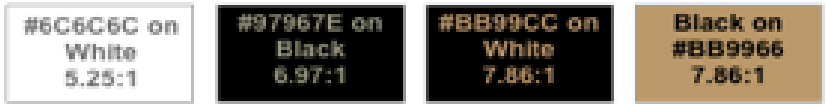
There are three required options that voters can choose:

A 20:1 high contrast option with a white background
This is text very close to black on a white screen.

An option with a black background at least 15:1
This helps people who need a lot of contrast, but who also need a less bright screen.

Sample color	Yellow on black	Cyan on black	Cyan on black	Grey on black
Color Hex codes	#FFFF99	#00FFFF	#64FFFD	#FAFAFA
Contrast	20:01:1	16.7:1	17.26:1	20.1:1

A low contrast option from 4.5:1 to 8:1
This helps people who need less contrast and brightness. Some people with dyslexia find low contrast screens easier to read, too.



Sample color	Grey on white	Grey on black	Tan on black	Black on tan
Color Hex codes	#6C6C6C	#97967E	#BB99CC	#BB99CC
Contrast	5.25:1	6.97:1	7.86:1	7.86:1

Scrolling and gestures

There are 4 requirements in VVSG 2.0 that ensure that scrolling and navigation actions are accessible.

7.2-D – Scrolling
7.2-E – Touch screen gestures

7.2-H – Accidental activation
7.2-I – Touch area size

Scrolling or paging

Long contests with many candidates or lengthy ballot question text may not fit on a single screen.

Voting systems need a way to handle contests that are too large to fit on a single screen. This might happen when:

- There are many candidates
- The ballot question text is long
- The ballot marking device has a small screen
- The voter is using large text

In the past, options for handling long contests were limited. For example, scroll bars were not allowed as the only way to navigate a ballot in VVSG 1.1 because they are typically a usability and accessibility challenge.

- They do not work consistently on all devices
- Scrolling is a complex interaction that requires dexterity
- They are often hidden on the side of the screen

In VVSG 2.0, voting systems can use either paging or scrolling to move through a contest. Either way, the controls can be designed for touch systems and for accessibility and a fixed header and footer helps voters know what contest they are on.

- Buttons can replace scroll bars providing a simple control that is also a cue that there is more to see.
- Scroll buttons must meet requirements for control minimum sizes.

Gestures

Voting systems can use gestures as an alternative way of navigation.

Mobile devices are widely used by people with disabilities and are often the only computer that many voters own. The new VVSG 2.0 requirements take advantage of this wide familiarity with simple, basic touch screens to allow options that can make it easier and more intuitive to mark a ballot on an electronic interface.

Touch screen gestures like swiping to scroll and tapping to select are nearly ubiquitous, so some gestures are now allowed in VVSG 2.0 while still recognizing that voting systems have to work for everyone. Thus, the VVSG 2.0 requirements for gestures are limited. For example:

Gestures cannot be the only way to complete an action. For example, to scroll down the page, a voting system might offer three options:

- On-screen buttons to scroll up or down
- Physical controls on a tactile keypad
- Swiping up or down

Gestures have to be consistent throughout the entire voting session.

Gestures have to be simple. No complex gestures that require actions in a sequence, that are timed, or which must be done simultaneously. That means no:

- Double tapping
- Multiple-finger swiping
- Touch and hold

Gestures have to be limited to well-known gestures. They can't require advanced knowledge or memorizing specific meanings.

Gestures cannot be used to navigate between contests. It is too easy to accidentally swipe sideways and jump to a new contest without noticing the change.

Audio for ballot information

The audio format, used with tactile controls, is a critical part of making voting accessible to people who are blind or have very low vision.

Audio can also be important for voters who do not read English well or with low literacy.

Audio settings

People listen to audio at different volumes and understand it differently when the information is read at different speeds.

VVSG 2.0 updated the requirements for audio settings to make them easier to implement using common text-to-speech engines.

The audio must sound natural

- Proper enunciation, normal intonation, accurate pronunciation
- Low background noise
- Same audio information in both ears
- Playing without distortion even when the volume or speed changes.

There are two settings for voters. These settings must be available throughout the voting session:

- **Volume:** from 20 20dB SPL to 100 dB
- **Rate of speech:** from the default of 120-125 words-per-minute the speed can range from 60-70 wpm (50%) to 240-250 wpm (200%)

Headsets

Sanitized headsets for audio are supplied with the voting system, but there is also a standard ⅛" jack, so voters can bring their own.

This is especially helpful for people who use hearing aids with an external connector, so all of their personalized settings are available.

User-centered design and usability testing

Requirements 2.2-A, 8.3-A, and 8.4-A includes requirements for manufacturers to submit documentation of their design process and usability testing with voters and election workers.

→ **Part 2: *User-centered design for voting systems* covers guidance on the user-centered design requirement in 2.2-A**

→ **Part 3: *Usability testing for voting systems* covers guidance on the usability testing requirements in 8.3-A and 8.4-A**

→ **Part 5: *Companion documents and resources* includes templates and guidance for required documentation**

About the Human Factors Test Approach

The **Human Factors Test Approach for VVSG 2.0** is a collection of test cases for all of the human factors requirements, that is, primarily usability and accessibility, but also a few safety and voter privacy requirements, in Principle 2.2 and Principles 5-8.

The EAC administers a **voting system testing and certification program**. This also includes Voting System Test Laboratory (VSTL) accreditation through **the NIST Laboratory Accreditation Program (NVLAP)**. The VSTLs conduct the testing of voting systems to determine if the VVSG requirements are met. The **EAC's Voting Equipment FAQ** has additional details.

To supplement the EAC's testing and certification process, NIST developed this test approach for the VVSG 2.0 human factors requirements that provides a set of test cases – a way of determining conformity to one or more requirements – and a methodology designed to be an efficient and consistent way of conducting testing.

For testing many of the requirements, interaction with the voter interface using a test ballot and a script is needed in order to fully examine all possible interaction modes, navigation paths, error notifications, etc. that a voter could encounter to ensure conformance. This approach is unique to the human factors requirements because a static look at the voter interface is not sufficient for testing conformance to the requirements in all possible interaction configurations and navigation paths throughout the voting process.

Three foundational test cases focus on the interactions required by voters through the process, covering accessible ballot activation, ballot marking, and accessible ballot verification and casting. The methodology includes walking through the process, as a voter, in all possible accessibility and interaction configurations using the script and an actual test ballot such as the NIST standard test ballot specification.

Some of the other test cases also rely on a more limited interaction with the ballot, sufficient to determine whether the system meets specific requirements.

Other test cases require inspection or measurement without an interactive walk-through of the system.

→ **Part 5: *Companion documents and resources* includes a full set of test cases**

Structure of the test method and test cases

In this section, the test method and test case structure are described in more detail with examples. See the test approach companion document listed in Part 5 for the complete details.

The test case descriptions use a consistent structure that includes:

- A listing of the requirements they cover
- Preparation to run the test case
- Testers needed
- Tests for all systems and for specific parts of a system, such as the audio-tactile interface, any electronic interface, etc.
- The pass and fail condition for each action in the case, with the case under which a system can pass or fail and the requirement(s) affected

Preparation to run the test case

This section of the method includes:

Any information to be reviewed or equipment needed to prepare

> Set up the system according to the manufacturer's documentation.
>
> Use a motorized wheelchair or a large chair with markings to occupy similar space to a wheelchair, including footrests.
>
> Example from *Clear Space for Assistant*

> This test requires the use of a video system with an accurate on-screen timer to record the voting session. The timer must have a precision of at least 0.1 seconds.
>
> • Position the camera so there is a clear view of the screen.
>
> • Connect an external speaker to the audio jack so the audio can be recorded.
>
> The test team should familiarize themselves with the response of the screens and tactile controls, so they can be as consistent as possible in how controls are activated to avoid variation in the timings.
>
> Example from *Response – System Response Time*

Testers needed

This section of the method includes:

Any special qualifications or configuration of testers

> This test requires two testers:
>
> Tester A completes any actions performed by election workers for all testers for each mode. Tester B, with knowledge of capabilities of voters with disabilities (including low vision, blindness, low dexterity, and no use of their hands) completes the voter actions.
>
> Example *from Interaction Mode: Part 1. Accessible Ballot Activation*

> For each language, if the primary tester is not fluent in that language, there must be a second tester who is fluent.
>
> Example from *Alternative Languages*

Testing the setup

This section of the method includes:

Any special set up of the system under test

> Set up the voting station according to the instructions of the manufacturer (including lighting).
>
> Example from *Controls – Visibility of Displays and Controls*

> Prepare (or select) an electronic and a sample paper ballot laid out following the best practices in the documentation and the NIST standard test ballot specification (Appendix A), which includes contests that test the full design capabilities of the system.
>
> Example from *Ballot Design*

Test actions and pass/fail conditions

The actions needed to conduct the test are described in detail. Actions may be used for all systems, or for specific types of systems, such as electronic ballot interfaces, paper-based systems, systems with a telephone-style handset, and so on.

Actions may be single step or have several steps before a pass/fail condition is reached. The pass/fail conditions are listed within the method:

> Open the settings control and determine how many different volume settings are available in the system.
>
> **Fail Condition**
>
> • The system fails if there is no mechanism for adjusting volume.
>
> Using the default volume setting, proceed through the voting session to contest #1 (President and Vice-President) and measure this volume using one of the methods below
>
> **Pass/Fail Conditions**
>
> • The system passes if the speech rate is between 60 and 70 dB SPL.
>
> • Otherwise, the system fails.
>
> Example from *Audio – Settings for Volume*

Test cases that cover more than one requirement list which requirements are covered by each condition:

> While voting for contest #3 (US Representative), attempt to overvote to cause the system to notify the voter of the error. If at any time, an audio cue is used as a warning or alert, there must also be a corresponding visual cue. Any visual cues must have a corresponding cue in audio.
>
> **Pass/Fail Conditions**
>
> • The system passes 5.2-C if any visual information is also presented in audio.
>
> • The system passes 5.2-E if aural cues are accompanied by visual cues and all visual cues are accompanied by an audio cue.
>
> • Otherwise, the system fails
>
> Example from *Audio – Visual Redundancy for Sound Cues*

Summary of the test cases

Instead of a single test case for each requirement, they are grouped for efficiency, to minimize the number of times the tester has to run through a complete ballot. Similarly, some requirements are covered in more than one test case, either to cover specific parts of the

requirement or because several test cases are relevant. A failure in any of the test cases fails the requirement.

There are 3 test cases that work through a sample ballot from activation through casting that cover a total of 16 requirements.

Interaction Modes:

- Part 1. Accessible Ballot Activation
- Part 2. Ballot Marking
- Part 3. Accessible Ballot Verification and Casting

In addition, 6 test cases cover making changes and reporting errors during marking and casting.

Marking and Casting:

- Correcting a Ballot
- Reviewing a Ballot
- Notification of Ballot Casting Failure
- Notification of Blank Ballot
- Notifications of Effect of Over-Voting
- Under Voting to be Permitted

Other groups of test cases cover requirements for:

- Alternative Languages
- Audio
- Ballot Design
- Clear Floor Space
- Controls
- Instructions
- Navigation
- Privacy
- Response
- Safety Certification
- Screen Characteristics
- Settings

The case, Usability Testing Reports, provides a test method for reviewing the reports required in:

- 8.3-A – Usability testing with voters
- 8.4-A – Usability testing with election workers
- 2.2-A – User-centered design

The test approach document notes but does not provide a detailed method for Testing for Federal Accessibility Standards. There are many other sources of tests for meeting Section 508 of the Rehabilitation Act as of January 18, 2018, and the WCAG 2.0 Level AA checkpoints included in that standard, both from federal government sources, the Web Accessibility Initiative, and other organizations:

- 8.2-A – Federal standards for accessibility

Finally, there are notes on three test cases that overlap with requirements outside of Principles 5-8:

- Personal Technology Jacks
- Secrecy of Cast Vote Record (and whether alternative languages or voter preferences are recorded)
- Secrecy (no receipt with proof of ballot selections)

The Test Approach document also includes the NIST standard test ballot specification intended to be implemented in the voting system being tested in order to perform the test cases. This is a list of contests, voting rules, and candidate names for 20 contests with 28 voting options. It can be adjusted for testing specific features of the voting system or different election methods, such as adding a straight party voting option.

Finally, there is a table with each VVSG 2.0 requirement in Principles 2.2 and 5-8 with the list of the test cases that apply to them.

List of VVSG 2.0 requirements and test cases

This list is from Appendix B: Test cases by requirement in ***Human Factors Test Approach for VVSG 2.0***

#	Requirement	VVSG 2.0 Test Cases
5.1-A	Interaction modes	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting • Instructions - Accessibility Documentation
5.1-B	Languages	• Alternative Languages
5.1-C	Vote records	• Alternative Languages
5.1-D	Accessibility features	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting
5.1-E	Reading paper ballots	• Interaction Modes: Part 3: Ballot Verification and Casting
5.1-F	Accessibility documentation	• Instructions - Accessibility Documentation
5.2-A	No bias	• No bias among choices
5.2-B	Presenting content in all languages	• Alternative Languages
5.2-C	All information in all modes	• Interaction Modes: Part 2: Ballot Marking • Audio - Visual Redundancy for Sound Cues • Instructions – Assistance from System • Instructions – Completeness of Instructions
5.2-D	Audio synchronized	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting • Alternative languages • Instructions – Assistance from System
5.2-E	Sound cues	• Audio - Visual Redundancy for Sound Cues
5.2-F	Preserving votes	• Alternative Languages
6.1-A	Preserving privacy for voters	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting • Privacy of Voting Session • Privacy of Cast Vote Record
6.1-B	Warnings	• Privacy of Voting Session

#	Requirement	VVSG 2.0 Test Cases
6.1-C	Enabling or disabling output	• Interaction Modes: Part 1. Ballot Activation • Settings—Audio and Visual Mode • Settings – Default Settings
6.1-D	Audio privacy	• Privacy of Voting Session
6.2-A	Voter independence	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting • Audio – Voter Speech Not Required
7.1-A	Reset to default settings	• Settings - Default Settings
7.1-B	Reset by voter	• Settings - Default Settings
7.1-C	Default contrast	• Ballot Design – Color Contrast
7.1-D	Contrast options	• Ballot Design – Color Contrast
7.1-E	Color conventions	• Ballot design – Use of Color
7.1-F	Using color	• Ballot design – Use of Color
7.1-G	Text size (electronic display)	• Ballot Design – Text Size
7.1-H	Scaling and zooming (electronic display)	• Ballot Design – Text Size
7.1-I	Text size (paper)	• Ballot Design – Text Size • Interaction Modes: Part 3: Ballot Verification and Casting
7.1-J	Sans-serif font	• Ballot Design – Fonts used • Accessible Ballot Verification and Casting
7.1-K	Audio settings	• Audio Settings - Volume • Audio Settings - Rate of Speech
7.1-L	Speech frequencies	• Audio Range of Frequency
7.1-M	Audio comprehension	• Audio Intelligibility
7.1-N	Tactile keys	• Audio – Standard Audio Connector • Controls – Discernible by Touch and Vision
7.1-O	Toggle keys	• Controls – Discernible by Touch and Vision
7.1-P	Identifying controls	• Controls – Discernible by Touch and Vision

#	Requirement	VVSG 2.0 Test Cases
7.2-A	Display and interaction options	• Controls – Discernible by Touch and Vision
7.2-B	Navigation between contests	• Navigation – Between contests • Navigation – Touch gestures
7.2-C	Voter control	• Marking and Casting – Correcting the ballot
7.2-D	Scrolling	• Navigation – Scrolling or paging within a contest
7.2-E	Touch gestures	• Navigation – Between contests • Navigation – Scrolling or paging within a contest • Navigation – Touch Gestures
7.2-F	Voter speech	• Audio – Voter Speech Not Required
7.2-G	Voter control of audio	• Audio – Voter control of audio
7.2-H	Accidental activation	• Controls – Size and Placement • Scrolling or Paging Within a Contest
7.2-I	Touch area size	• Controls – Size and Placement
7.2-J	Paper ballot target areas	• Controls – Size and Placement
7.2-K	Key operability	• Controls - Operable
7.2-L	Bodily contact	• Controls – No dependence on direct bodily contact
7.2-M	No repetitive activation	• Controls – Size and Placement
7.2-N	System response time	• Response – System response time
7.2-O	Inactivity alerts	• Response - Inactivity Time
7.2-P	Floor space	• Clear Floor Space
7.2-Q	Physical dimensions	• Controls – Reach and Touch
7.2-R	Control labels visible	• Controls – Visibility of controls and displays
7.3-A	System-related errors	• Interaction Modes: Part 2: Ballot Marking
7.3-B	No split contests	• Ballot design
7.3-C	Contest information	• Ballot design
7.3-D	Consistent relationship	• No bias among choices
7.3-E	Feedback	• Ballot design
7-3-F	Correcting the ballot	• Marking and casting - Correcting a Ballot
7.3-G	Full ballot selections review	• Marking and casting - Reviewing a Ballot

#	Requirement	VVSG 2.0 Test Cases
7.3-H	Overvotes	• Marking and casting – Notification of Effect of Over-Voting
7.3-I	Undervotes	• Marking and casting – Under Voting to be Permitted
7.3-J	Notification of casting	• Marking and casting - Ballot Casting Failure • Marking and casting - Blank Ballot Notification
7.3-K	Warnings, alerts, and instructions	• Instructions - Language clarity
7.3-L	Icons labels	• Audio – Standard Audio Connector • Instructions - Language clarity
7.3-M	Identifying languages	• Alternative languages
7.3-N	Instructions for voters	• Instructions – Completeness of instructions • Instructions - Language clarity • Instructions – Assistance from System
7.3-O	Instructions for election workers	• Instructions - Language clarity • Instructions – Completeness of instructions • Instructions - Accessibility Documentation
7.3-P	Plain language	• Instructions - Language clarity • Instructions - Accessibility Documentation
8.1-A	Electronic display screens	• Screen characteristics
8.1-B	Flashing	• Screen flashes
8.1-C	Personal assistive technology (PAT)	• Interaction Modes: Part 1. Ballot Activation • Interaction Modes: Part 2: Ballot Marking • Interaction Modes: Part 3: Ballot Verification and Casting
8.1-D	Secondary ID and biometrics	• Interaction Modes: Part 1. Ballot Activation
8.1-E	Standard audio connectors	• Audio - Standard audio connector
8.1-F	Discernable audio jacks	• Interaction Modes: Part 1. Ballot Activation • Audio – Standard Audio Connector
8.1-G	Telephone style handset	• Audio – No interference with heading aids
8.1-H	Sanitized headphones	• Audio - Sanitized Headphone or Handset

#	Requirement	VVSG 2.0 Test Cases
8.1-I	Standard PAT jacks	• Interaction Modes: Part 1. Accessible Ballot Activation • Controls - Personal Technology Input • Controls – Personal Technology Jacks
8.1-J	Hearing aids	• Audio – No interference with hearing aids
8.1-K	Eliminating hazards	• Safety Certification
8.2-A	Federal standards for accessibility	• Testing for Federal Accessibility Standards
8.3-A	Usability testing with voters	• Usability Testing Reports
8.4-A	Usability testing with election workers	• Usability Testing Reports
2.2-A	User-centered design process	• Usability Testing Reports

Part 5
Companion documents and resources

Templates, forms, sample materials, and resources for usability and accessibility testing of voting systems for VVSG 2.0 certification

Companion documents for the Handbook

All companion documents listed below are available on the NIST Voting Program website at **https://www.nist.gov/itl/voting/vts-400-5-documents**.

User-Centered Design documentation

For VVSG 2.2-A – User-centered design

- Template for reporting on the user-centered design process used for voting systems
- Sample report on the user-centered design process used for voting systems

Usability testing documentation

For VVSG 8-3-A – Usability tests with voters

- CIF for Voting Systems: Guidelines on how to complete the modified CIF template for voting manufacturers
- CIF for Voting Systems: A modified CIF Template for reporting on usability testing of voting systems
- CIF for Voting Systems: NIST Standard Test Ballot Specification and Instructions for Participants
- CIF for Voting Systems: Appendixes of Sample Forms
- Additional sample forms for usability testing voting systems

For VVSG 8-4-A – Usability tests with election workers

- Guidelines for testing voting systems for election worker usability
- Sample forms for election worker usability testing

  This document contains a number of sample forms used for election worker usability testing for voting system setup, operation, and shutdown following instructions in voting system manuals, including: a participant screener, pre-session checklist, script for usability test administrators, informed consent form, test instructions, task scenarios, and a pass-fail checklist.

Test Approach for VVSG 2.0 human factors requirements

- The Human Factors Test Approach for VVSG 2.0

  The complete human factors test approach, with test cases for all requirements in Principles 2.2 and 5-8.

Other research and resources

General accessibility and usability resources

Videos

Webinars on the VVSG 2.0 draft Requirements:
Improving the Accessibility and Usability of Voting Systems (2019)

- **Part 1: Introducing the Human Factors Requirements** (Slides: **PPT** or **PDF**)
- **Part 2: Updates to Best Practices and New Technologies for Voting Systems** (Slides: **PPT** or **PDF**)

Books

Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests, 2nd Edition by Jeffrey Rubin and Dana Chisnell (Wiley, 2008)

Moderating Usability Tests - Principles & Practices for Interacting by Joe Dumas and Beth Loring (Morgan Kauffman, 2008)

Rocket Surgery Made Easy: The Do-It-Yourself Guide to Finding and Fixing Usability Problems by Steve Krug (New Riders, 2009)

Usability Testing Essentials: Ready, Set...Test! by Carol M. Barnum (Morgan Kauffman, 2010)

Forms that Work: Designing Web Forms for Usability by Caroline Jarrett (Morgan Kauffman, 2009)

Letting Go of the Words: Writing Web Content that Works, 2nd Edition by Janice (Ginny) Redish (Morgan Kauffman, 2012)

A Web for Everyone: Designing Accessible User Experiences by Sarah Horton and Whitney Quesenbery (Rosenfeld Media, 2014)

Just Ask: Integrating Accessibility Throughout Design by Shawn Lawton Henry (Lulu.com, 2007)

Websites

Usability.gov - https://www.usability.gov/

Tools, information, and resources about usability and UCD. Includes templates and forms for usability testing

18F Method Cards - https://methods.18f.gov/

A collection of tools to bring human-centered design into your project.

18F Accessibility Guide - https://accessibility.18f.gov/

A good set of basics that explain what and why as well as how.

Accessibility for Teams - https://accessibility.digital.gov/

Quick start guide from digital.gov with a focus on roles for accessibility.

Plainlanguage.gov - https://www.plainlanguage.gov/

Home of the federal plain language guidelines, including information about testing content and documentation. Includes checklists for plain language and writing tips.

WebAIM - https://webaim.org/

Resource site for web and digital accessibility from the Center for Persons with Disabilities and Utah State University. Includes checklists for WCAG 2.0 and Section 508.

W3C Internationalization - https://www.w3.org/standards/webdesign/i18n

Guidance on designing for multiple languages or writing systems

Research published by NIST

NIST SP 1273 - Promoting Access to Voting: Recommendations for Addressing Barriers to Private and Independent Voting for People with Disabilities

This report examines barriers across the voting process for people with disabilities. It offers recommendations for state and local election officials, the federal government, and other non-governmental organizations to eliminate or mitigate those barriers.
https://doi.org/10.6028/NIST.SP.1273

NISTIR 7596 - Guidelines for Writing Clear Instructions and Messages for Voters and Poll Workers Style

Focused on system messages in voting systems and is the basis for the VVSG plain language standard, but is applicable to any system message.
https://www.nist.gov/publications/guidelines-writing-clear-instructions-and-messages-voters-and-poll-workers

NISTIR 7556 - Report of Findings: Use of Language in Ballot Instructions

Research behind the Guidelines for Writing Clear Instructions. In a study of 45 voters in three geographic locations, we compared a ballot with traditional language instructions to a ballot with plain language instructions, participants voted more accurately on the ballot with plain language instructions.
https://www.nist.gov/publications/report-findings-use-language-ballot-instructions

NISTIR 7519 - Style Guide for Voting System Documentation

This style guide incorporates best practices for writing documentation as it applies to voting systems. The guidelines are intended for voting system manufacturers to help them to implement best practices in their products.
https://www.nist.gov/publications/style-guide-voting-system-documentation

NISTIR 7537 – Guidelines for Using Color in Voting Systems

This document is a digital color design guide for the electronic displays of voting systems. It encodes best practice for usability in general, and specifically to accommodate a wide range of color vision deficiencies. Systems that follow these guidelines will use color sparingly, yet effectively. In the words of designer and information visualization specialist Edward Tufte, they will do no harm, avoiding common misuses of color that interfere with legibility and create confusion.
https://www.nist.gov/publications/guidelines-using-color-voting-systems