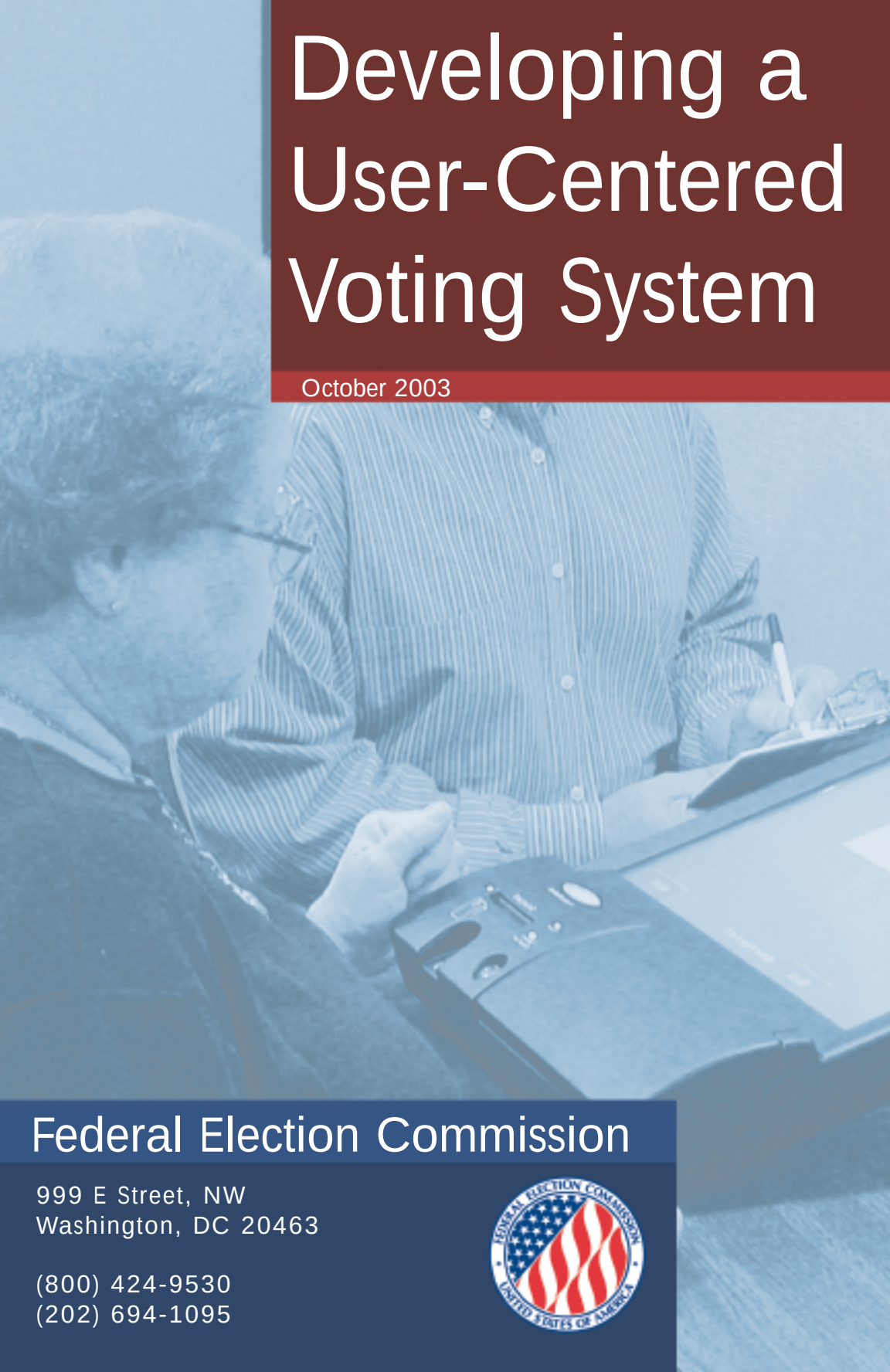
Developing a User-Centered Voting System

October 2003



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Introduction

The Federal Election Commission's Office of Election Administration (OEA) assists state and local election officials by responding to inquiries, publishing research, and conducting workshops on all matters related to election administration. Additionally, the OEA answers questions from the public and briefs foreign delegations on the U.S. election process, including voter registration and voting statistics.

In 2002, the OEA launched an effort to ensure the usability and accessibility of voting systems. This initiative generated a comprehensive set of human factors standards for voting systems. It also produced the three guides listed below to promote the development, usability testing, and procurement of user-centered voting systems:

- *Developing a User-Centered Voting System*
- *Usability Testing of Voting Systems*
- *Procuring a User-Centered Voting System*

This guide, titled Developing a User-Centered Voting System, is written for voting system developers who want to enhance their user interface design process to ensure system usability. It is also written for election officials involved in voting system procurements who seek greater insight into preferred user interface design practice. It outlines the basic steps of a user-centered design process that will help ensure a more usable and accessible voting system.

Fundamentally, this guide encourages voting system developers to adopt a user-centered approach to voting system design if they have not done so already. It also encourages voting system customers – state and local election officials – to procure voting systems that have been developed in accordance with a design process that is driven by users' needs and preferences.

The balance of this guide defines two key attributes of a user-centered voting system – usability and accessibility – and cites relevant government and industry standards on the topics. Additionally, it summarizes the basic steps in a user-centered design process.

Definitions

USABILITY

Usability is a measurable characteristic that indicates the degree to which a system is easy to use. Usable voting systems enable voters to perform tasks quickly and accurately. Ideally, voters will draw upon their existing knowledge and skills to perform all voting tasks, so that they require little, if any, instruction on how to cast their ballot. By design, a usable voting system effectively:

- Guides voters through the complete voting process.
- Presents content, such as contest information, candidates, referendums, and instructions, in a clear manner.
- Ensures that voters are able to cast their votes accurately and efficiently.
- Provides an appropriate level of guidance and feedback during the voting process, enabling voters to complete all required tasks and detect and correct any errors.
- Provides features that make it easy to navigate through the available information and options.
- Makes voters feel physically and emotionally comfortable and confident throughout the voting process.
- Enhances the productivity of the election officials who prepare for and conduct elections.

A usable voting system also facilitates election administration tasks, such as setting up and configuring the system to match the requirements of a particular election.

ACCESSIBILITY

Accessibility is a measurable characteristic that indicates the degree to which a system is available to, and usable by, individuals with disabilities. In this context, accessibility is an essential part of a system's overall usability. For example, an accessible voting system should accommodate individuals who may have a hearing, vision, mobility, or speech disability.

Regarding voting systems, accessibility may also be defined as having met the accessibility-related requirements put forth in the Voting System Standards of the Federal Election Commission (FEC).

USER-CENTERED DESIGN

User-centered design is as much a design philosophy as it is a set of integrated design activities. The common theme is ensuring that user needs and preferences are addressed in the design process, rather than shaping a system chiefly according to technological considerations. A user-centered design is achieved by applying human factors engineering methods.

HUMAN FACTORS

Human factors are the physical, sensory, cognitive, and behavioral characteristics of the user population that should be considered in the voting system design process. These traits include body size, muscle strength, methods of reading and processing information, and problem-solving strategies.

HUMAN FACTORS ENGINEERING

Human factors engineering (HFE) is the application of knowledge about human capabilities and limitations to system design. HFE ensures that the voting system design, voter tasks, and local environment in which the voting system is used are compatible with the applicable human factors of the voting population. It is worth noting that other terms are often used interchangeably with HFE, including human engineering, ergonomics, usability, usability engineering, and engineering psychology.

User-Centered Design Process

Designing a voting system that fulfills its basic functional requirements, while meeting the needs of a diverse user population, is challenging. After all, casting a ballot is just one task among many that people perform using such systems. A voting system also helps election officials perform other essential tasks, such as creating ballots, counting and processing the vote, and reporting the results. Consequently, the system requirements arising from multiple tasks to be performed by users with diverse characteristics are extensive.

A user-centered approach to voting system design is most likely to produce a final solution that is matched to users' capabilities, enables users to cast their votes with confidence, and enables election officials to conduct an efficient and effective election. The approach makes users' needs a driving force in the design process.

A user-centered voting system will accommodate the needs of a diverse user population.

As an added benefit, taking a structured, user-centered design (UCD) approach can also reduce the risk and cost of bringing new technology to market. It prevents the sort of usability problems that can plague systems developed without sufficient attention to human factors-related concerns. Such problems can damage the reputations of equipment vendors as well as election officials and can be expensive to correct. Clearly, those involved in voting system development and election administration need their voting systems to be easy, efficient, and pleasant to use as well as error resistant.

> *…taking a structured, user-centered design approach can also reduce the risk and cost of bringing new technology to market.*

Also, a systematic approach – one that draws input from the intended user population to define system requirements and establish criteria for evaluating designs in progress – is responsive to the requirements and guidance set forth in the voting system standards published by the Federal Election Commission and the Institute of Electrical and Electronics Engineers (IEEE).

Clearly, voting system developers have several incentives to invest in human factors engineering.

INVESTING IN GOOD DESIGN

The experience of other industries, such as the consumer software and consumer electronics industries, confirms that investing in UCD will pay off. But, the payoff is contingent upon several factors, including:

- A development company's top management have made a philosophical commitment to pursuing user interface design excellence.

- Necessary resources are allocated, particularly time and money, to implement a comprehensive user interface design program.

- Human factors specialists are involved in the development process, rather than rely strictly on human factors guidelines and the judgment of non-specialists to produce quality results.

- All types of voting system users and stakeholders in the election administration process should have a voice early on and throughout the development process.

The return on investment may come in the form of a reduction in overall development costs, increased sales (possibly associated with user performance claims), simpler documentation and training, and a reduced need for customer support.

THE BASIC STEPS

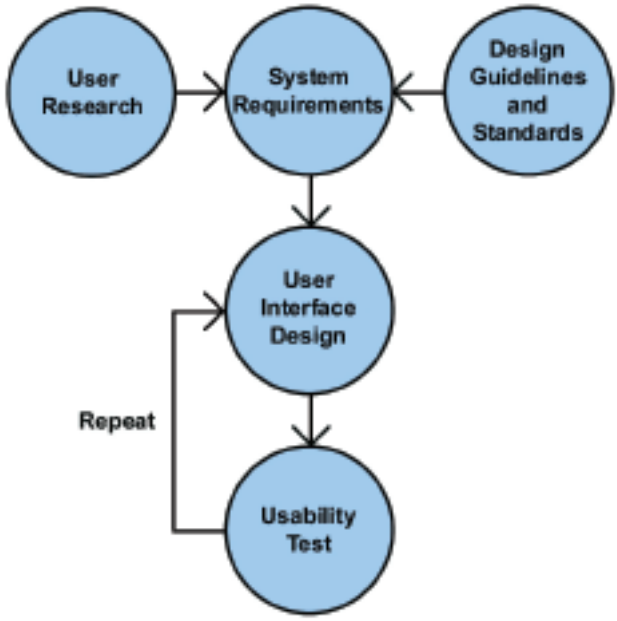
The basic steps toward producing a high-quality user interface design are:

- Define the user population's needs and preferences through research.

- Formulate system requirements based on users' needs and preferences.

- Design a user interface in a requirements-driven manner, applying appropriate design standards and principles to ensure usability.

- Conduct user tests of the evolving user interface to ensure usability and accessibility.



A typical sequence of UCD activities, including the iteration of the user interface design and testing activities.

The balance of this guide provides an overview of the UCD process steps.

User Research

There are many effective ways to define the needs of voters and election officials. Some of the more commonly used methods are introduced below.

OBSERVATIONS

Researcher observes a voter as she interacts with a touch-screen-based voting system from a seated position.

One can identify both desirable and undesirable voting system characteristics by watching people interact with existing voting systems. Such observations may have to be performed during simulated elections in order to avoid interfering with an actual election.

INTERVIEWS

Interviews, which may follow immediately after the kind of observations discussed above, provide an opportunity for users to say what they specifically liked and disliked about their interactions with an existing system and to suggest how a new system might be improved. While individual opinions may vary widely, opinion patterns usually emerge after several interviews, thereby helping to resolve key design issues.

GROUP INTERVIEWS

Conducting group interviews (also called focus groups) with different types of users is an efficient way to determine the characteristics of an optimal system. Groups of 6-12 participants tend to work best in terms of soliciting a variety of opinions and reaching consensus. Moderators normally follow a prepared script to ensure that they cover all of the topics of interest. However, the moderator may let the discussion branch out into unanticipated topics as time permits.

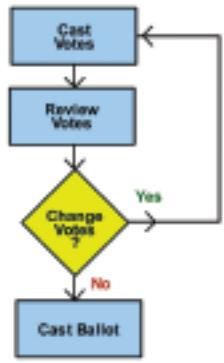
Election administration officials discuss voting system requirements during a group interview.

To address voting system accessibility issues properly, group interviews should include people who have various disabilities and perhaps even people with experience developing effective accommodations for specific disabilities.

TASK ANALYSES

A task analysis traces the detailed interactions between users and the existing or proposed system with a focus on ways to improve the process. Specifically, task analyses characterize the flow of information between the user and the system, show what decisions and actions are required, and expose logic problems, opportunities for error, and inefficiencies.

One might conduct a task analysis, such as examining how election officials create a ballot, during the research phase in order to understand how users interact with existing systems. Or, one might conduct an analysis in the course of developing system requirements or preliminary designs.



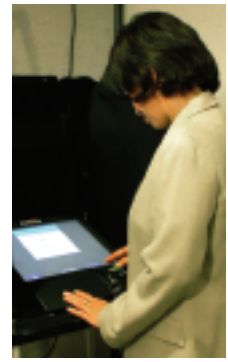
Sample high-level task analysis diagram. Such diagrams can be more detailed in order to illustrate the flow of information and user actions related to a specific voting system.

BENCHMARK AND COMPARATIVE USABILITY TESTS

Benchmark and/or comparative usability tests of existing voting systems afford the opportunity to observe users performing tasks of interest and to track the users' thought processes, presuming that they "think aloud" as they work. In addition, usability testing enables one to quantify user performance (e.g., average time required to cast a ballot) on one or more systems, thereby supporting the formation of usability goals for a system under development.

USER PROFILES

User research provides the insights necessary to write user profiles – summary descriptions of real or fictitious individuals. Profiles may describe personal characteristics such as age, occupation, education level, and familiarity with technology in general and voting systems in particular. These profiles help developers keep various types of users in mind as they develop user interface designs and make associated tradeoffs. User profiles are also helpful when the time comes to define the characteristics of the usability test participants.



Voting systems need to accommodate a wide range of voter needs and preferences to ensure a successful and satisfying voting experience.

User-Centered Requirements

User research findings can be readily translated into voting system requirements and design evaluation criteria. The same can be said of the human factors standards published by industry and government that relate to usability and accessibility.

Some of the user-related requirements may take a subjective form, such as:

- On a ballot, there should be a consistent, clear relationship between the candidates' names and the mechanisms for voting for a particular one.

- Use color consistently to communicate a specific meaning or to identify a specific type of information.

Other requirements may be expressed in a quantitative form, such as:

- Voters should be able to complete and cast a "standard ballot" within an average of five minutes or less.

- Ninety five percent of voters should be able to cast a ballot without assistance.

Data from benchmark usability tests are particularly helpful for establishing realistic, quantitative requirements. Ultimately, requirements should be derived from established government and industry standards, but may be extended to consider additional aspects of design, as described above.

These kinds of user-centered requirements, particularly the quantitative ones, encourage development teams to effectively balance users' needs with other engineering requirements. Lacking such requirements, developers may overlook or readily dismiss users' needs in an effort to meet other design goals or deal with technical constraints. Importantly, the requirements are intended for use by the development team and are not intended to place performance expectations or limitations on actual voter interactions with voting systems.

Many user-centered requirements can double as design evaluation criteria to be applied during design audits and usability tests of the evolving design.

User Interface Design

User interface design is a blend of art and science. Consequently, it is not particularly effective to take a strictly "cookbook" approach to user interface design. Such an approach is prone to produce designs that are functionally complete but not necessarily satisfying to use. An approach that blends scientific analysis, good engineering practice, and creative expression usually works best.

There are several human factors textbooks that outline effective design approaches (see Recommended Reading). None of the prescribed approaches are precisely the same, but many of them involve similar technical activities, such as:

- Create a high-level model of user interactions. The model may be expressed in several forms, including a narrative description (vision statement), and a schematic diagram that presents the "big picture" in the form of basic functions (nodes) and their interrelationships (links).

- Allocate functions as appropriate to the equipment versus the user, thereby saving users from performing unnecessary tasks while giving them control over the pace of their tasks.

- Analyze user tasks, including both primary tasks, such as casting a vote, and secondary tasks, such as navigating from one part of a ballot to the next. (See earlier discussion of task analysis.)

- Select appropriate hardware components (e.g., displays and pushbuttons) and develop layouts that facilitate the task at hand and guard against errors, such as inadvertent button presses. Ensure that the hardware is easy to operate by all potential users, including those with disabilities. Voting system design standards and guidelines, such as those developed by the FEC and IEEE, are of great help when performing this design activity.

- Develop a software user interface structure (also called a screen hierarchy) that reflects the intentions of the high-level model and enables efficient and intuitive navigation through the system's functions. Again, the use of voting system design standards and guidelines, such as those developed by the FEC and IEEE, are of great help when performing this design activity.

- Develop supporting materials, such as printed instructions, that follow established document design practices described in technical writing textbooks and guides.

- Design screen templates – the equivalent of electronic forms or molds – that establish rules for the placement and appearance of information on specific types of screens. Some user interfaces may require several templates to control the layout of screens that serve substantially different purposes.

- Develop a style guide – a narrative complement to the templates – that establishes rules for the content, appearance, and behavior of various user interface design components, such as screen titles and confirmation prompts.

- Construct a user interface prototype that potentially includes physical models, a computer-based simulation, and sample documents. By virtue of their realistic appearance and functional capabilities, such prototypes enable effective usability testing.

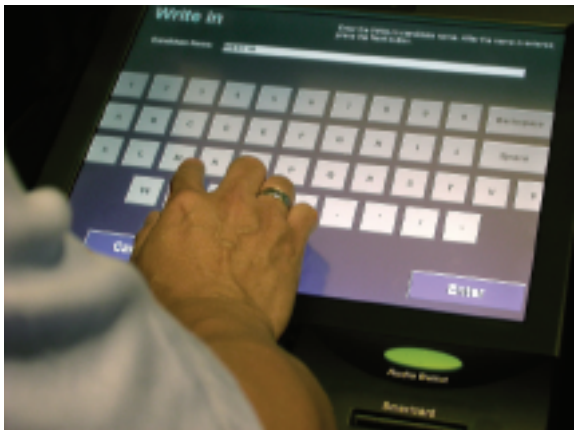
- Conduct a series of usability tests of the evolving design as it progresses from a preliminary concept to a near-final prototype (see the next section of this guide and the companion guide titled Usability Testing of Voting Systems).

It is important for developers to take an integrated approach to the design of hardware, software, and documentation because all of the associated user interface elements need to function effectively as a whole in order for a voting system to be usable and accessible. Therefore, close communication among the various individuals and/or groups responsible for each of those elements is essential.

An approach that blends scientific analysis, good engineering practice, and creative expression usually works best.

Design Evaluation

It is good practice to conduct a series of user interface design evaluations as a user interface evolves from a preliminary concept to a final solution. The two most common and complementary approaches are to conduct a usability test and/or a design audit. Formative usability testing can provide valuable feedback on a design-in-progress. Summative usability testing is essentially a final examination before the system is "polished" and put into actual use.



A usability test participant strikes touchscreen keys in the course of entering the name of a write-in candidate.

FORMATIVE USABILITY TESTING

Usability testing is arguably the most widely accepted method of dynamically evaluating the quality of interaction between people and systems. In a typical usability test, the test administrator asks people who represent the intended user population to perform a set of common tasks. The set of tasks might vary depending on the type of user (i.e., whether the participants are voters or election officials). The set of tasks might also vary to focus on different types of ballots. For example, some test sessions could focus on a ballot with a small number of races and candidates while others could focus on a ballot loaded with many races and several candidates per race. This form of structured user testing generates both subjective and objective performance data that are likely to expose the system design's strengths and weaknesses.

The methodology's popularity stems from the fact that representative users, with their individual capabilities and perspectives, will exhibit behaviors and voice opinions that provide a good basis for assessing user interaction quality. Test administrators often discover design problems that could go undetected in a design audit (see later discussion of design audits), surfacing only during the course of a simulation. That said, usability testing requires a more substantial investment of time and money than the typical design audit.

It is beneficial to conduct tests at several points in the design process, increasing the degree of rigor as the design becomes more complete and refined. This iterative approach ensures that prospective users have a strong voice in the development process. Notably, early and continuing user involvement in the design process is a hallmark of good user interface designs.

> *Usability testing is arguably the most widely accepted method of dynamically evaluating the quality of interaction between people and systems.*

A typical usability test begins with the development of a test plan describing:

- Test participant characteristics.
- Test participant recruiting method.
- Testing environment.
- Test administrators' roles.
- Task scenarios.
- Performance measures.

A sample of a dozen or so test participants is normally sufficient to produce useful findings, although the ideal number depends on several factors and is a topic of extensive debate among testing professionals. Experimental data suggest that a test involving only 5-8 participants will effectively spotlight a substantial number of the system's strengths and weaknesses. A much larger sample – perhaps 30 or more people – may be warranted in order to include representatives of a broad constituency and to validate a near-final system and/or to develop credible performance claims. The sample should include individuals with a variety of disabilities in order to judge the system's accessibility, which is an important component of its overall usability.

> *Experimental data suggest that a test involving only 5-8 participants will effectively spotlight a substantial number of the system's strengths and weaknesses.*

During a test session, the test administrator may encourage the participant to "think aloud," making it easier to track the participant's thought processes and actions – the key to uncovering usability problems. This technique is particularly helpful for diagnosing usability problems. However, this approach can corrupt task time measurements. So, the "think aloud" protocol is more appropriate during tests of preliminary designs than during a test of the final design. Importantly, tests involving disabled individuals may require the test administrator to possess special communication skills, such as

being able to use sign language. Also, test administrators will need to take an alternative approach to collecting user feedback when the “think aloud” protocol is incompatible with a test participant’s capabilities.

The test environment may be a well-equipped usability test laboratory that facilitates unobtrusive observations from behind a one-way mirror. However, it is possible to conduct an effective test in an office or conference room, for example. In some cases, the best testing environment might be one or more actual voting facilities. An actual facility provides the most realistic basis upon which to judge factors such as voting system accessibility, which can be affected by physical obstructions as well as ambient light and noise.

Development team members should observe as many of the test sessions as possible, either by attending the sessions or watching them on video. Such observations tend to generate a deeper understanding of usability issues than simply reading a report on the issues. A debriefing following each test session is advisable. Debriefings provide the opportunity for development team members to review which tasks went smoothly and which ones caused the test participant to experience difficulties that can be traced back to the system’s user interface design.

A usability specialist administers a usability test of a computer-based prototype.

It is important to avoid drawing conclusions from the first few test sessions because test participant performance and opinions do vary. However, clear patterns tend to emerge after a modest number of test sessions, which explains why formative tests may involve just a small number of test participants.

While observing the test proceedings is key, it is still valuable to document the test results in either a detailed memorandum or comprehensive report. A memorandum should focus on the key findings. Comprehensive test reports should provide background information about the test, present consolidated test data, provide a detailed analysis of the data, and include recommendations for improving the system design.

SUMMATIVE USABILITY TESTING

Summative usability testing follows a pattern similar to formative usability testing. The methodological differences are often limited to the number of test participants and the realism of the user tasks.

Election official uses a magnetic card to reset a voting machine for use by the next voter in a mock election.

A summative test, which is intended to validate a near-final or final design, may involve triple the number of test participants in order to maximize the chances of finding any remaining and particularly subtle usability problems that escaped earlier detection. It also enables one to judge the usability of the system as a whole, sometimes for the first time.

Usability testing is discussed in detail in a companion guide titled Usability Testing of Voting Systems and in the IEEE P1583 Standard for the Evaluation of Voting Equipment (Section 6.3).

DESIGN AUDITS

Design audits (also called design inspections, checklist reviews, and heuristic analyses) are a popular means of verifying compliance with standards and established design principles. Focused on the static characteristics of voting systems, such inspections are a valuable supplement to usability and accessibility testing.

For voting systems, the pertinent standards and design principles can be found in:

- IEEE P1583 Standard for the Evaluation of Voting Equipment, Section 5.3 – Usability and Accessibility Standards.

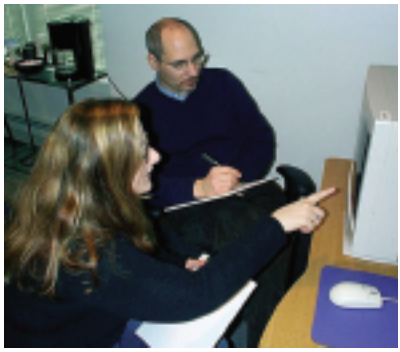
- Voting System Standards, Volume 1 – Performance Standards, Federal Election Commission, April 2002, Section 2.2.7 – Accessibility Standards.

- Voting System Standards, Volume 1 – Performance Standards, Federal Election Commission, April 2002, Appendix C – Usability.

Voting system developers or customers (e.g., state and local election officials) may choose to conduct a review based on these standards, or on a more expansive set of requirements derived from the above sources as well as related textbooks and corporate standards.

You can conduct a design audit quickly and at a modest cost.

It may be sufficient to have one expert conduct the audit. However, a popular approach is to have two or three experts contribute to the audit. The experts review the design against the selected standards to identify any areas where the design deviates from preferred practices. Sometimes, the experts take things further by classifying the severity of any deviations and suggesting possible remedies. After completing their individual audits, the experts discuss their findings and work toward a consensus view regarding the user interface design's strengths and areas in need of improvement.



Usability specialists conduct a design audit of a software user interface prototype.

You can conduct a design audit quickly and at a modest cost. However, experts may not catch subtle user interface design problems that only emerge when a representative user puts the voting system to use, such as during a usability test. Therefore, the most powerful approach to evaluating a user interface design may be to conduct both a usability test and design audit, thereby catching both static and dynamic problems. The dual approach may involve more up-front cost, and could take a bit more time. Yet, the payback could be finding and fixing serious usability problems at an earlier stage of system development when they are less costly to correct. This dual approach may also save the developer from encountering serious usability problems once the system is placed in actual use, an outcome that could affect the voting process and seriously compromise the system's marketability.

Developers should give careful consideration to who performs an audit and/or test. In-house staff may perform a credible evaluation, particularly during the formative stage of design. However, it may be necessary to draw upon outside sources of human factors engineering expertise in cases where in-house staff lack the necessary expertise, are unavailable, or may not have sufficient objectivity and independence.

Relevant Standards

Both government and industry have put considerable effort into creating standards for the development of usable, accessible voting systems.

The Institute of Electrical and Electronics Engineers publishes a consensus standard for voting systems, titled IEEE P1583 Evaluation of Voting Equipment Standard. Section 5.3 of this standard provides detailed guidance on both usability and accessibility.

> Sample of the IEEE Draft Standard's content:
>
> When possible, the system shall enable voters to see the full set of options when casting a particular vote. That is, the design shall minimize the extent to which users need to scroll or page between candidate names and vote input fields.
>
> The system shall enable voters to review their votes, including write-in votes, before submitting them. The system shall show voters for whom and for what they voted and give voters the chance to make changes before submitting the ballot. Voters shall be able to modify or change their votes before finally submitting them. Clear instructions shall be provided regarding how to change votes or obtain a replacement ballot.
>
> The voting system shall provide direct accessibility such that the use of a voter's personal assistive technology is not required to vote.

The Federal Election Commission publishes its own Voting System Standards, which draw heavily on the content of Section 508 of the Rehabilitation Act of 1973 as amended in 1998. Guidance on the design of usable voting systems can be found in Section 2.2.7 on accessibility and Appendix C – Usability.

> Sample of the FEC Standard's content:
>
> Ballot should clearly indicate the action voters must take to cast a vote and where the action must be made in order to vote for specific candidates.
>
> A clearly legible font should be utilized. Fonts should have true ascenders and descenders, uniform stroke width, and uniform aspect ratio. Preference should be given to simple styles. Script and other highly stylized fonts should be avoided.
>
> Voters should be able to modify their votes at any time before finalizing their voting session.

The International Organization for Standardization (ISO) and the American National Standards Institute (ANSI) also publish useful guidance pertaining to the overall design process and usability testing:

- ANSI (2001). Common Industry Format for Usability Test Reports (ANSI NCITS 354-2001). NY: American National Standards Institute.

- ISO (1999). Human-Centred Design Process for Interactive Systems (ISO 13407:1999). Geneva, Switzerland: International Organization for Standardization.

More information pertaining to human factors methodologies is available through the Human Factors and Ergonomics Society (www.hfes.org), which organized a special committee to support the IEEE's standards development effort.

More information pertaining to system accessibility is available from The U.S. Access Board at www.access-board.gov, www.section508.gov, and www.tracecenter.org/world/kiosks/.

System developers would be well served to draw upon these resources to guide their design efforts.

RECOMMENDED READING

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