THE MACHINERY OF DEMOCRACY:
USABILITY OF VOTING SYSTEMS

LAWRENCE NORDEN, JEREMY M. CREELAN,
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VOTING RIGHTS
& ELECTIONS SERIES

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This paper is the third in a series, which also includes:

> *Making the List: Database Matching and Verification Processes for Voter Registration* by Justin Levitt, Wendy Weiser and Ana Muñoz.
>
> *The Machinery of Democracy: Protecting Elections in an Electronic World* by the Brennan Center Task Force on Voting System Security

Other resources on voting rights and elections, available on the Brennan Center's website, include:

> *Response to the Report of the 2005 Commission on Federal Election Reform* (2005) (co-authored with Professor Spencer Overton)
>
> *Recommendations for Improving Reliability of Direct Recording Electronic Voting Systems* (2004) (co-authored with Leadership Conference on Civil Rights)

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CONSULTING EXPERTS

The Brennan Center assembled a Task Force of consulting experts on voting system usability to assist in developing, writing and editing this report. We are grateful to them for their insight and many hours of work. They are:

Georgette Asherman, independent statistical consultant and founder of Direct Effects

Lillie Coney, Associate Director, Electronic Privacy Information Center (EPIC)

Jim Dickson, Vice President for Governmental Affairs, American Association of People with Disabilities (AAPD)

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INTRODUCTION

The performance of a voting system is measured in part by its success in allowing a voter to cast a valid ballot that reflects her intended selections without undue delays or burdens. This system quality is known as "usability."[1] Following several high-profile controversies in the last few elections – including, most notoriously, the 2000 controversy over the "butterfly ballot" in Palm Beach – voting system usability is a subject of utmost concern to both voters and election officials.

Defining Usability. In this chapter, we examine the usability of various voting systems and discuss several ways that election officials can maximize the usability of these systems. By maximizing the usability of a system, we mean ensuring, to as great a degree as possible, that voting systems: (a) effectively (correctly) record voters' intended selections, (b) complete the voting process in an efficient and timely manner, and (c) provide voters with confidence and satisfaction in the voting process.

Analysis. Our discussion of voting system usability proceeds in two stages.

- Effectiveness (or Correctness). We review original research conducted by Dr. David Kimball, which quantifies the extent to which current voting systems correctly record voters' intended selections, *i.e.,* the systems' "effectiveness." Specifically, Dr. Kimball looks at the residual vote rate for each major voting system in the 2004 presidential election. The "residual vote rate," the difference between the number of ballots cast and the number of valid votes cast in a particular contest, is viewed by many experts as the single best measure of the effectiveness of a voting system. Based on the research on voting system and general usability standards, we extract four key findings about the effectiveness of various voting systems. The findings may be found on pages 10–11.

- Efficiency and Voter Confidence. We summarize the limited research available on the efficiency of and voter confidence in the various systems.

Usability Principles. From this work and other research into usability, we then identify a series of usability principles applicable to voting systems which elections officials and advocates should use to assess and improve the usability of voting systems in their jurisdictions. The principles may be found on pages 14–21.

Usability Recommendations. Finally, we provide recommendations to assist election officials in maximizing the usability of their voting systems in the areas of ballot design and system instructions. A full discussion of the recommendations may be found on pages 22–23. They are summarized below:

- Do not assume familiarity with technology.
- Conduct usability testing on proposed ballots before finalizing their design.
- Create plain language instructions and messages in both English and other languages commonly used in the jurisdiction.
- Locate instructions so they are not confusing or ignored.
- For both ballots and instructions, incorporate standard conventions used in product interfaces to communicate a particular type of information or message.
- Do not create ballots where candidates for the same office appear in multiple columns or on multiple pages.
- Use fill-in-the-oval ballots, not connect-the-arrow ballots, for optical scan systems.
- Ensure that ballot instructions make clear that voters should not cast both a write-in and normal vote.
- Provide mechanisms for recording and reviewing votes.
- Make clear when the voter has completed each step or task in the voting process.
- Eliminate extraneous information on ballots.
- Minimize the memory load on the voter by allowing her to review, rather than remember, each of her choices during the voting process.
- Ensure that the voting system plainly notifies the voter of her errors.
- Make it easy for voters to correct their errors.

DEFINING USABILITY

In December of 2005 the Election Assistance Commission ("EAC") released the Voluntary Voting Systems Guidelines ("VVSG 2005"), which include the first set of usability requirements applicable to voting systems in this country.[2] As part of this work, the National Institute of Standards and Technology ("NIST") has undertaken to develop a set of precise performance criteria and test protocols to measure the usability of specific voting systems.

A consensus among experts as to the definition of usability of voting systems has developed out of usability research in other areas of technology. The International Organization for Standardization ("ISO") defines usability as "the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of user."[3]

Both the draft voting systems of the Institute of Electrical and Electronics Engineers ("IEEE")[4] and the VVSG 2005[5] echo these standards, noting that usable voting systems will *effectively and correctly* record voters' intended choices, operate *efficiently*, and instill *confidence* in the voter that her choice was correctly recorded and that her privacy was assured.

Before reviewing the performance of the various voting systems under the usability guidelines, it should be noted that usability is affected not solely by the type of voting system at issue, but also by the ballot and instructions designed by the vendors or elections officials for a particular jurisdiction. Indeed, any usability benefits of a particular type of voting system may be eclipsed partially, if not entirely, by a poor ballot design or confusing instructions. For this reason, the recent public debate over the strengths and weaknesses of various voting systems may have unduly obscured the importance of what should occur to improve the voting process after elections officials have made their choice of system. Although we do not yet have sufficient data to prescribe a single "best" or "most usable" ballot design for each system, there is a substantial body of research on the usability of forms (both paper and electronic), instructions, and other signage that can be used as guidance. In addition, given the variations in local laws and practices, elections officials should conduct their own usability testing where possible on their chosen system to limit design flaws that lead to voter errors.

Any usability benefits of a particular type of voting system may be eclipsed partially, if not entirely, by a poor ballot design or confusing instructions.

The failure of a voting system to protect against residual votes is likely to harm low-income and minority voters and their communities more severely than other communities.

ANALYSIS

EFFECTIVENESS (OR CORRECTNESS)

There are few published studies of usability testings that have compared the effectiveness of different voting systems in accurately recording voter intention in a controlled environment.

Absent such testing, one of the most revealing available measures of voting system effectiveness is what is referred to in the political science literature as the residual vote rate. The "residual vote rate" is the difference between the number of ballots cast and the number of valid votes cast in a particular contest. Residual votes thus occur as the result of undervotes (where voters intentionally or unintentionally record no selection) or overvotes (where voters select too many candidates, thus spoiling the ballot for that contest).[6] Exit polls and other election surveys indicate that slightly less than 1% of voters intentionally abstain from making a selection in presidential elections.[7] Thus, a residual vote rate significantly higher than 1% in a presidential election indicates the extent to which the voting system's design or the ballot's design has produced unintentional voter errors.

Significantly, several studies indicate that residual vote rates are higher in low-income and minority communities and, in addition, that improvements in voting equipment and ballot design produce substantial drops in residual vote rates in such communities.[8] As a result, the failure of a voting system to protect against residual votes is likely to harm low-income and minority voters and their communities more severely than other communities.

This section reviews research previously published by Dr. Kimball, and research that he is publishing here for the first time, on the residual vote rates for various voting systems in the 2004 elections.

METHODOLOGY

For the most part, Dr. Kimball used a cross-sectional analysis to generate the research findings discussed below. In a cross-sectional analysis, a particular characteristic is compared across jurisdictions. Here, for a given election, residual vote rates are compared across jurisdictions using a multivariate statistical analysis to control for factors other than voting system (such as demographics, the level of competition in the election, and other features of the local electoral context). Because of the decentralized nature of election administration in the United States, local elections officials generally make their own decisions about purchasing voting technology, as well as designing and printing ballots. As a result, voting technology and ballot design vary from one jurisdiction to the next, often even within the same state. This report also reviews a smaller number of studies examining residual votes and voting technology over time to take advantage of local changes in voting equipment. Examining both types of studies allows a difference-in-difference research design to provide a more rigorous estimate of the impact of voting technology.[9]

RESIDUAL VOTE RATES

Table U1 summarizes the rates of residual votes for the relevant voting systems found by Dr. Kimball in the election results for president (2000 and 2004) and governor (2002):

TABLE U1

RESIDUAL VOTE RATES BY TYPE OF VOTING TECHNOLOGY

Technology	Description	Residual Vote Rate In: 2000	2002	2004
Full-face DRE	Candidates listed on a full-face computerized screen – voter pushes button next to chosen candidate. Machine records and counts votes.	1.6%	2.2%	1.2%
Scrolling DRE	Candidates listed on a scrolling computer screen – voter touches screen next to chosen candidate. Machine records and counts votes.	—	1.2%	1.0%
Central-Count Optical Scan	Voter darkens an oval or arrow next to chosen candidate on paper ballot. Ballots counted by computer scanner at a central location.	1.8%	2.0%	1.7%
Precinct Count Optical Scan	Voter darkens an oval or arrow next to chosen candidate on paper ballot. Ballots scanned at the precinct, allowing voter to find and fix errors.	0.9%	1.3%	0.7%
Mixed	More than one voting method used.	1.1%	1.5%	1.0%
Nationwide Residual Vote Rate		1.8%	2.0%	1.1%

Based on 1755 counties analyzed in 2000,
1270 counties analyzed in 2002, and 2215 counties analyzed in 2004

DIRECT RECORDING ELECTRONIC ("DRE") SYSTEMS

Full-face DRE systems produce higher residual vote rates (1.2%) than both scrolling DRE systems (1.0%) and precinct count optical scan ("PCOS") systems (0.7%). "Full-face" DRE systems employ a ballot that displays all of the offices and candidates on a single screen, rather than in consecutive, separate screens that the voter touches to select her preferred candidates. As shown in Table U2, however, two scrolling DRE systems produced a residual vote rate of 0.7% – the same as the nationwide average rate for PCOS systems.

TABLE U2:

RESIDUAL VOTE RATES BY SCROLLING DRE BRAND
2004 PRESIDENTIAL ELECTION

Brand of Voting Machine	Residual Vote Rate
UniLect Patriot (17 counties)	6.8%
VTI VotWare (1 county)	4.1%
Fidlar-Doubleday EV 2000 (8 counties)	2.3%
Hart InterCivic eSlate (8 counties)	1.8%
MicroVote Infinity (20 counties)	1.6%
Advanced Voting Solutions WinVote (10 counties)	1.1%
Diebold AccuVote-TSX (1 county)	0.9%
Sequoia AVC Edge (24 counties)	0.8%
ES&S iVotronic (54 counties)	0.7%
Diebold AccuVote-TS (190 counties)	0.7%
Sequoia DRE with VVPT (17 counties in Nevada)	0.3%
Nationwide Scrolling DRE Residual Vote Rate	1.0%

Based on 353 counties using scrolling DREs in 2004

The performance of full-face and scrolling DRE systems diverges even more as the income level of the voters declines. Stated differently, relative to scrolling DRE systems, full-face DRE systems produced particularly high residual vote rates among voters with incomes of less than $25,000 in 2004. Similarly, full-face DREs tend to produce higher residual vote rates than scrolling DREs in counties with large Hispanic or African American populations. Indeed, only punch card systems produced a higher residual vote rate than full-face DREs in jurisdictions with a Hispanic population of over 30%. *See* Table U3.

While the residual vote rates produced by both scrolling and full-face DREs decrease slightly as the percentage of African American voters increases (1.0% to 0.8%), such rates *increase* significantly as the percentage of Hispanic voters increases beyond 30% of the population (0.9% to 1.4% for scrolling DREs). The reasons for these trends are not clear, but they suggest that additional analysis should be conducted by elections officials and vendors to determine whether and how DREs could be programmed to address the language needs of Spanish-speaking voters more effectively.

TABLE U3:

RACIAL AND ECONOMIC DISPARITY IN RESIDUAL VOTES BY VOTING TECHNOLOGY
2004 PRESIDENTIAL ELECTION

Composition of County	Votomatic Punch Cards	Optical Scan Central	Optical Scan Precinct	Full-Face DRE	Scrolling DRE
Racial/Ethnic					
Less than 10% black	1.8%	1.5%	0.8%	1.3%	1.0%
Between 10% and 30% black	1.7%	1.7%	0.5%	1.2%	0.9%
Over 30% black	2.4%	4.1%	0.9%	1.3%	0.8%
Less than 10% Hispanic	1.8%	1.7%	0.6%	1.1%	1.0%
Between 10% and 30% Hispanic	1.8%	1.1%	0.9%	1.1%	0.7%
Over 30% Hispanic	2.4%	1.9%	1.2%	2.0%	1.4%
Median Income					
Less than $25,000	4.0%	3.3%	1.4%	2.8%	1.3%
Between $25,000 and $32,499	2.3%	1.7%	0.8%	1.4%	1.1%
Between $32,500 and $40,000	2.0%	1.6%	0.7%	1.3%	1.0%
Over $40,000	1.5%	1.2%	0.7%	0.9%	0.8%

Based on 2402 counties analyzed in 2004

Researchers at the Institute for Social Research at the University of Michigan have released preliminary findings from usability testing they conducted on several DRE systems.[10] Their early findings suggest that specific model and ballot design features may lead to different incidences of voter error produced by different manufacturers' DREs. In a laboratory comparison between the Hart InterCivic eSlate and Diebold AccuVote-TS, for example, the authors found that the two manufacturers' approaches to providing the voter with an opportunity to review her selections before casting her vote produce different error rates.

Both machines present the voter with a two-page "review" screen prior to casting the vote. According to the researchers, the eSlate's "review" screen appears more distinct in both color and format from the earlier pages that the voter sees than does the AccuVote-TS review screen. In addition, if the eSlate voter activates the control to "cast" the ballot prior to reviewing both screens, that machine then shows the voter the second review screen rather than casting the ballot immediately. By contrast, the AccuVote-TS allows the voter to circumvent the review process midstream by touching the screen to "cast" her ballot.

The researchers who conducted this testing hypothesize that these two design differences may be responsible for a greater incidence of unintended voter errors from the AccuVote-TS DRE, as voters do not devote as much attention to review-

Preliminary findings demonstrate the critical importance of usability testing of specific models within a type of voting system to reduce unnecessary voter errors.

ing and correcting their selections.[11] Although preliminary in nature, such findings demonstrate the critical importance of usability testing of specific models within a type of voting system to reduce unnecessary voter errors. Although both of these systems are DREs, such differences in ballot design produce very different opportunities for voter error in each of the two machines.

DRE SYSTEMS WITH VOTER-VERIFIED PAPER TRAILS ("VVPT")

Only one state, Nevada, used a DRE system with VVPT in the 2004 election. In addition, Nevada is the only state in the country that includes a "none of the above" option on the ballot for federal and statewide elections. This option reduces undervotes, regardless of the voting system being used, because it allows voters who wish to cast a protest vote to do so without registering a "lost" vote. Because no other states used comparable systems or ballot options, the data are too limited to draw any conclusions regarding residual vote rates. The 17 Nevada counties registered a miniscule residual vote rate of 0.3% in the 2004 elections, but this figure is not directly comparable to that produced by other jurisdictions with different ballot options.

PRECINCT COUNT OPTICAL SCAN SYSTEMS

With the exception of Nevada's DRE system,[12] the specific voting systems that produced the lowest residual vote rate in the country in 2004 – both at 0.6% – were the AccuVote-OS and ES&S M100 precinct count optical scan systems. *See* Table U4. In addition, the nationwide average residual vote rate for PCOS systems was lower in 2004 than the average rate for either type of DRE system.

TABLE U4:

RESIDUAL VOTE RATES BY PRECINCT COUNT OPTICAL SCAN BRAND
2004 PRESIDENTIAL ELECTION

Brand of Voting Machine	Residual Vote Rate
ES&S Optech 3P Eagle (220 counties)	0.9%
ES&S M100 (102 counties)	0.6%
Diebold AccuVote-OS (264 counties)	0.6%
Nationwide PCOS Residual Vote Rate	0.7%

Based on 630 counties using PCOS in 2004

Unlike for scrolling DREs and central-count optical scan systems, residual vote rates for PCOS systems do not appear to correlate significantly with the percentage of African American voters within the jurisdiction. *See* Table U3. But residual vote rates for both PCOS and DRE systems increase significantly with the percentage of Hispanic voters. This conclusion suggests that neither PCOS nor

DRE systems succeed in eliminating the impact of voters' language needs on the extent of residual votes. When compared with other voting systems, however, PCOS systems and scrolling DREs appear most successful at minimizing the correlation between residual votes and the racial, ethnic, or economic composition of a county.

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Differences in ballot design for optical scan systems produce significant differences in residual vote rates. First and foremost, ballots that required voters to darken an oval produced a residual vote rate of 0.6% in the 2004 election, while those that required voters to connect an arrow with a line to a candidate produced a rate of 0.9%. *See* Table U5. Plainly, the former design is preferable to avoid spoiled ballots. In addition, other ballot design features have been found to affect error rates in optical scan systems.

TABLE U5:

RESIDUAL VOTES IN OPTICAL SCAN BALLOTS BY TYPE OF VOTING MARK
2004 PRESIDENTIAL ELECTION

	Type of Mark	
Where Ballots Are Counted	Darken an Oval	Connect an Arrow
Precinct Count (641 counties)	0.6%	0.9%
Central Count (767 counties)	1.4%	2.3%
Nationwide Optical Scan Residual Vote Rate	1.0%	

A recent pilot study of ballots from 250 counties in five states identified seven design recommendations for paper-based optical scan ballots, many of which could apply to other voting systems as well.[13] These recommendations are listed later in this report along with the usabilty principles they support.

VOTE-BY-MAIL SYSTEMS

At present, the state of Oregon is the only jurisdiction within the United States that uses a Vote-by-Mail system ("VBM") as its principal voting system. Accordingly, definitive conclusions about the residual vote rates of VBM systems must await additional studies of that state and of jurisdictions outside the United States, such as Great Britain. Studies of Oregon's experience indicate that the adoption of a statewide VBM system in 2000 had no substantial impact either on voter participation or residual vote rates in Oregon elections. For example, the residual vote rate in Oregon in the 1996 presidential election (before adoption of VBM) was 1.5%, while the residual vote rate in Oregon in 2000 was 1.6%.[14] These figures do suggest that VBM systems may produce significantly higher residual vote rates than either PCOS or scrolling DRE systems.

Although further research must be conducted to determine precise causes of this discrepancy, it may stem from the fact mail-in ballots are scanned and counted using the same technology as the centrally counted optical scan systems used in other jurisdictions. As shown in Table U1, the residual vote rate for such systems in the 2004 elections was 1.7%. By definition, such systems do not allow the voter to be notified of, or to correct, any under- or overvotes she may have unintentionally indicated on her ballot. Therefore, while VBM systems may have other benefits, these systems are not as effective in minimizing residual votes as DRE or PCOS systems.

OTHER SYSTEMS

Typically, a BMD is an accessible computer-based voting system that produces a marked ballot. The ballot is marked as the result of voter interaction with visual or audio prompts. Some jurisdictions use BMDs instead of accessible DREs.

Unfortunately, no data are yet available concerning the actual residual vote rates for Ballot Marking Devices ("BMDs") or Vote-by-Phone systems because few of these systems have yet been used in elections in this country.

LIMITS OF RESIDUAL VOTE RATE STUDIES

Measuring the residual vote rates of top-of-the-ticket races indicates how often voters interact with a particular voting system on Election Day in such manner as to produce an incorrect (or ineffective) vote that does not reflect their intended selections. But residual vote rates reflect only the frequency of voter errors; they do not provide any basis to determine the reason for the voter errors on a particular type of voting system. Moreover, few if any jurisdictions gather data concerning the number or nature of requests for assistance by voters on Election Day, how long it takes for voters to vote, or any other information that would help to assess the efficiency or confidence produced by particular voting systems. For this reason, election officials should consider ways to gather such information on Election Day in selected precincts in order to facilitate future improvements in voting system and ballot design. In the meantime, election results provide an important but limited way to assess the usability of a particular voting system.

KEY FINDINGS

Key findings from the limited available research on the effectiveness of various voting technologies are as follows:

- With few exceptions, PCOS systems and scrolling DREs produce lower rates of residual votes than central-count optical scan, full-face DRE, or mixed voting systems.

- Residual vote rates are higher on DREs with a full-face ballot design than on scrolling DREs with a scrolling or consecutive screen format. The negative impact of full-face ballot design in terms of lost votes is even greater in low-income and minority communities than in other communities.

- PCOS systems produce significantly lower residual vote rates than central-count optical scan systems because the former systems allow the voter to correct certain of her errors prior to casting her ballot.

- VBM systems produce higher residual vote rates than PCOS or DRE systems. VBM systems are comparable in this regard to central-count optical scan systems, which employ the same technology and counting process. Like central-count optical scan systems, VBM systems provide no opportunity for the voter to be notified of, or to correct, any under- or overvotes on her ballot prior to its being counted.

EFFICIENCY AND VOTER CONFIDENCE

The existing research concerning the time each system requires to complete the voting process, the burdens imposed upon voters, and the confidence each system inspires among voters remains extremely limited. We summarize that research below.

DREs

Several studies of DREs since 2000 have provided an overview of potential usability concerns based on limited testing and expert reviews, but scholars have only recently started to conduct fuller usability tests with statistical and analytical significance.[15] In addition, two economists recently analyzed voter turnout in the State of Georgia in 2002 and found a positive relationship between the proportion of elderly voters and a decrease in voter turnout from 1998 levels; the authors hypothesize that this evidence suggests that elderly voters were "apprehensive" about the statewide change in voting technology to DREs.[16]

Dr. Frederick G. Conrad of the University of Michigan, and collaborators Paul Herrnson, Ben Bederson, Dick Niemi and Mike Traugott, have recently completed one of the first major usability tests on electronic voting systems other than vendor testing. They analyze the steps required to complete voting in a single election and suggest that certain DREs require substantially more actions by a voter – *i.e.,* touches to the screen, turns to a navigation wheel, *etc.* – to select a candidate or ballot measure than other DREs. Not surprisingly, they have found that more actions mean more time to complete the voting process, as well as lower voter satisfaction with the DRE in question. In particular, Hart InterCivic's eSlate required 3.92 actions per task and 10.56 minutes on average for a voter to complete the voting process while Diebold's AccuVote-TS required only 1.89 actions per task and only 4.68 minutes to complete the process. Out of the six systems analyzed, participants in that study indicated that they were most comfortable using the AccuVote-TS and least comfortable using the eSlate.[17]

The same research suggests, however, that design elements that decrease efficiency or voter confidence may actually increase the accuracy of voters' selections. For example, eSlate's approach to facilitating the voter's review of her selections

Usability testing may be most valuable in evaluating the performance of a system as a whole and in making clear the tradeoffs elections officials must consider.

prior to voting both adds time to the voting process and increases the likelihood that a voter will catch her errors and correct them prior to casting her ballot. Accordingly, usability testing may be most valuable not in eliminating any one problematic feature of a system, but instead in evaluating the performance of a system as a whole and in making clear the tradeoffs election officials must consider in selecting a system and in designing the ballot and instructions.

In a research project sponsored by the Brennan Center for Justice and conducted by MIT Professor Ted Selker, the authors conducted a one-day simulated election test at a YMCA regularly used as a polling place. The test compared the voting experiences of people with and without reading disabilities on full-faced voting machines and a standard screen-by-screen voting machine. Three machines were tested: one DRE with a full-face ballot (ES&S's V2000 LED); one DRE with a scrolling ballot design and an LCD display (ES&S's iVotronic LCD); and a prototype DRE with a full-face ballot displayed on a lever machine-sized, high-resolution screen (iVotronic LS Full Faced DRE). 48 of 96 participants had been previously diagnosed with a reading disability, and researchers attempted to catch undiagnosed reading disabilities by testing all participants prior to the voting simulation. The results have implications for all voters. Notably, voters with undiagnosed reading disabilities and voters with no disabilities had much higher rates of undervotes on full-faced machines than on scrolling voting machines. This population also had fewer errors on the commercial DRE than on full-faced voting machines. People who had been diagnosed with reading disabilities were able to compensate for their difficulties and had fewer than other participants on full-faced voting machines. All voters took more than 3 minutes to vote but all reading disabled people took longer to vote on the scrolling DRE than the full-faced DRE.[18] These conclusions confirm the evidence of higher incidence of "roll off" produced by full-face lever and DRE voting systems in real elections.[19]

DRES w/ VVPT

Professor Selker and his team at MIT's Media Lab have attempted to assess the extent to which voters who use such machines actually review the VVPT prior to casting their votes. In their testing, the authors found that no VVPT users reported any errors during the voting process though two existed for each ballot they used. At the end of the voting process, testers asked VVPT users whether they believed any errors existed on their paper record even if they did not report them. Only 8% answered yes. In contrast, users of an audio-based verification system reported errors at higher rates. 14% of users reported errors during the voting process, and 85% of users told testers that they believed errors existed in the record although they did not all report them.[20] Additional research needs to be conducted to measure the efficiency of and voter confidence in these systems. But Dr. Selker's research suggests that VVPTs may present significant usability problems that can prevent voters from identifying errors readily.

PRECINCT COUNT OPTICAL SCAN SYSTEMS

No available research has measured the efficiency of or voter confidence in optical scan systems. This is a significant gap in the literature that hampers sound comparisons between DREs and optical scan systems and also limit public scrutiny of ballot design in these systems.

OTHER SYSTEMS

Unfortunately, no research is yet available that has measured the efficiency of or voter confidence in BMDs or Vote-by-Phone systems because few of these systems have yet been used in elections in this country. In addition, no studies have measured these variables for VBM systems, as used presently in Oregon.[21]

USABILITY PRINCIPLES

As this chapter establishes, the research into the usability of voting systems described in this chapter demonstrates that scrolling DREs and PCOS systems protect voters against their own errors more consistently than other types of systems. Still, only a few studies have compared different ballots directly or definitively determined what makes one form of ballot more usable than another – *i.e.*, less prone to producing errors, more efficient, and more confidence-inspiring.[22] To be sure, usability experts have provided valuable guidelines for elections officials and the EAC that promise to improve the basic usability of voting systems. Still, until new research correlates specific design elements with measurable accuracy, efficiency, and voter confidence, such usability guidelines for voting systems will remain a work in progress. In addition, new research should reflect the performance-based thrust of the EAC's evolving voting system certification standards and study the relationships between specific features and the combined effects of the design choices embodied in a system, rather than just one facet of a design.

For this project, we have assembled the most significant lessons drawn not only from our work with voting systems, but also from other areas in which usability has improved the interaction between humans and technology. We provide the following discussion of specific areas of concern to assist elections officials in designing both the ballots for elections and the protocol for usability testing that should be conducted prior to completing such ballot design.

■ DO NOT ASSUME FAMILIARITY WITH TECHNOLOGY.

Voting systems should rely as little as possible upon a voter's prior experience or familiarity with a particular type of technology or interface. Computer-based systems present the most obvious concerns for elderly or marginalized voters who may be unfamiliar with ATMs, computers, or other similar technologies. Even optical scan systems that rely upon the voter's familiarity with "SAT-style" bubbles to fill in present parallel problems. Where feasible, elections officials should address this concern in usability testing among likely voters to determine the precise effects of different design elements upon voters with limited familiarity with the technology in question. The results of such testing may also inform the design of voter education and outreach and poll worker training prior to the election. Even without usability testing, elections officials should select their jurisdiction's voting systems and design the ballots for those systems with the recognition that many voters, particularly elderly voters, are not fully familiar with technologies used in ATMs and computers. The VVSG 2005 echoes this general recommendation in one of its specific requirements: "Voting systems with electronic displays *shall not* require *page scrolling* by the voter [*e.g.*, with a scroll bar as against a clearer "next page" button]."[23]

FOLLOW COMMON DESIGN CONVENTIONS.

Ballots and instructions should incorporate standard conventions used in product interfaces to communicate a particular type of information or message and to avoid confusion.[24] For example, the color red is typically used to indicate an emergency or error in need of attention, while green indicates a selection to move forward or activate the function in question. Consistent use of such generic conventions throughout the voting process allows the voter to rely upon her existing experience with those conventions to streamline the process and clarify otherwise ambiguous instructions, but does so without making her success depend upon any specific prior knowledge or experience. Elections officials should be aware of such conventions if they are called upon to select color schemes in designing the ballot for an election in their jurisdictions. All usability guidelines draw on commonly accepted typographic principles. For example, Drs. Kimball and Kropf suggest using text bolding to highlight certain information on the ballot:

- Ballots should use boldfaced text to help voters differentiate between office titles and response options (candidate names).[25]

The Plain Language Guidelines also include typographic principles, such as:

- Use – but don't overuse – highlighting techniques.
- Use 8 to 10 point type for text (*i.e.*, larger than that used in most government forms at the time).
- Avoid lines of type that are too long or too short.
- Use white space and margins between sections.
- Use ragged right margins.
- Avoid using all capitals.

The VVSG 2005 also includes design guidelines that address common design issues such as color, size and contrast for information:

- The use of color should agree with common conventions, *e.g.*, red should be used to indicate errors or problems requiring immediate attention.
- The minimum font size for text intended for the voter shall be 3.0 mm, and should be in a sans-serif font.[26]
- The minimum "figure-to-ground ambient contrast ratio" for text and graphics shall be 3:1.[27]

USE PLAIN LANGUAGE IN INSTRUCTIONS AND MESSAGES.

In the late 1970s, the American Institutes for Research began a Document Design Project to promote plain language and simple design in public documents. That Project, which eventually led to the creation of the Document Design Center, conducted research into language comprehension, how real people write and read, and particular aspects of public documents that created usability problems. From this research came a set of principles called "Guidelines for Document Designers," which were intended to apply across many different disciplines.[28]

These guidelines include principles for creating instructional and informational text, such as:

- Write short sentences.
- Use the active voice.
- Use personal pronouns to address the reader.
- Avoid phrases that are long strings of nouns.
- Avoid nouns created from verbs; use action verbs.
- List conditions separately.
- Keep equivalent items parallel.
- Avoid unnecessary and difficult words.

Usability experts who focus on voting systems use these plain language guidelines in their efforts to ensure that text presented to voters at each stage of the voting process is as easy to comprehend as possible.[29] Although the benefits of most of these simple principles appear intuitively obvious, further research through usability testing of voting systems is necessary to determine the relative impacts of these rules upon the three core elements of usability (accuracy, efficiency, and voter confidence). Dr. Kimball and Dr. Kropf's findings on paper ballots represent a strong first step in this process. Based on their 2005 study, they recommend:

- Voting instructions should be short and simple, written at a low reading level so voters can read and comprehend them quickly.[30]

The VVSG 2005 echoes this suggestion:

- Voting systems "shall provide clear instructions and assistance to allow voters to successfully execute and cast their ballots independently."[31]

LOCATE INSTRUCTIONS SO THEY WILL BE CLEAR.

Proper instructions must be presented in a manner that is helpful to voters, rather than confusing or overwhelming. According to general guidelines, instructions should be placed near the process they describe. When a procedure requires several steps, instructions should be provided at each step, rather than only at the beginning.[32] In addition, research into the impact on usability of different formats for presenting on-line information has demonstrated that, particularly for users with limited literacy, information should be presented in a single-column format rather than a multi-column format to improve readability.[33] According to research conducted by Drs. Kimball and Kropf, voters using optical scan ballots often ignored text that spanned the top of a multi-column ballot. Accordingly, they recommend that:

- Voting instructions should be located in the top left corner of the ballot, just above the first contest. That is where people in Western cultures begin reading a printed page and where respondents will look for instructions on the first task.[34]

Where possible, elections officials should design usability testing that will identify the best approach to provide clear, readable instructions to voters throughout the voting process.

ELIMINATE EXTRANEOUS INFORMATION.

Ballot design should eliminate all extraneous information from the voter's field of vision and minimize visual or audio distractions from the task at hand.[35] Voters may become overwhelmed or confused by such unnecessary material. This phenomenon may explain in part the higher levels of "roll off" produced by voting systems that present the voter with all of the races and ballot questions at once on a single surface.[36] Even for paper ballots, Drs. Kimball and Kropf suggest that designers eliminate information not immediately necessary to vote:

- Ballots should avoid clutter around candidate names (such as a candidate's occupation or hometown).[37]

PROVIDE CLEAR MECHANISMS FOR RECORDING AND REVIEWING VOTES.

Voting systems should clearly indicate where a voter should mark her selections, and provide ongoing feedback to the voter to ensure that she knows which selections she has already made and which remain. This information orients the voter to avoid confusion or lost votes due to such confusion. Drs. Kimball and Kropf suggest a specific guideline to help ensure that a system offers clear and unambiguous feedback to the voter as she marks her ballot:

- To minimize ambiguity about where voters should mark their votes, ballots should avoid locating response options on both sides of candidate names (this is a common problem on optical scan ballots, where two or three columns of offices and candidate names are listed on a single page).[38]

The VVSG 2005 also includes requirements that address this issue:

- "There shall be a consistent relationship between the name of a candidate and the mechanism used to vote for that candidate," *e.g.*, the button for selecting candidates should always be on the left of the candidates.[39]

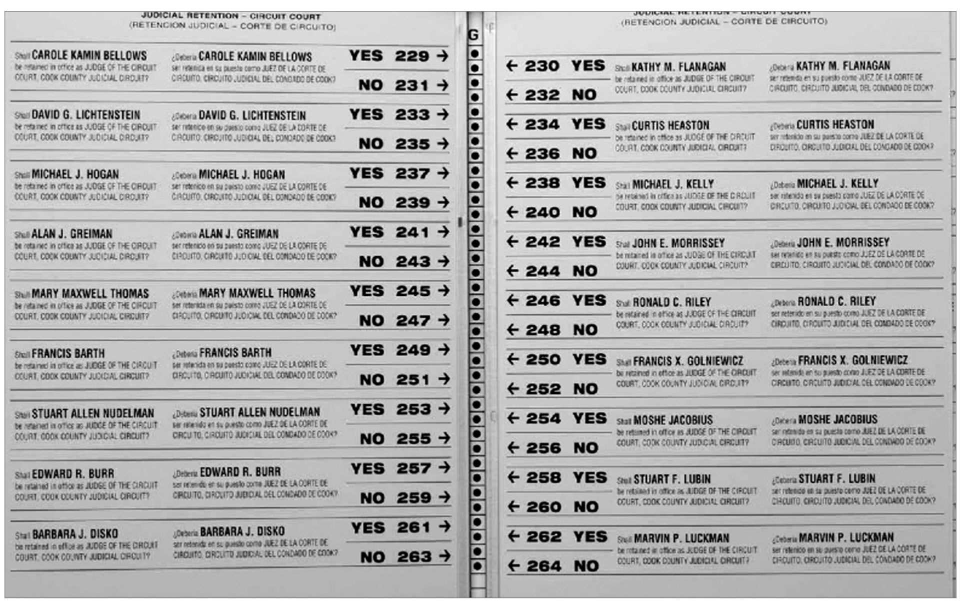
- Voting systems *shall* provide unambiguous feedback to indicate the voter's selection (*e.g.*, a checkmark beside the chosen candidate).[40]

- "Input mechanisms *shall* be designed so as to minimize accidental activation."[41]

A recent study of ballot design changes implemented in Illinois between 2000 and 2002 underscores this point.[42] In Illinois, voters must cast judicial retention votes in each election, using long lists of sitting judges for which voters must vote either "yes" or "no." In 2000, Cook County switched to a butterfly design for their punch card system, and the percentage of people who cast votes in the judicial retention elections dropped significantly.

FIGURE U1

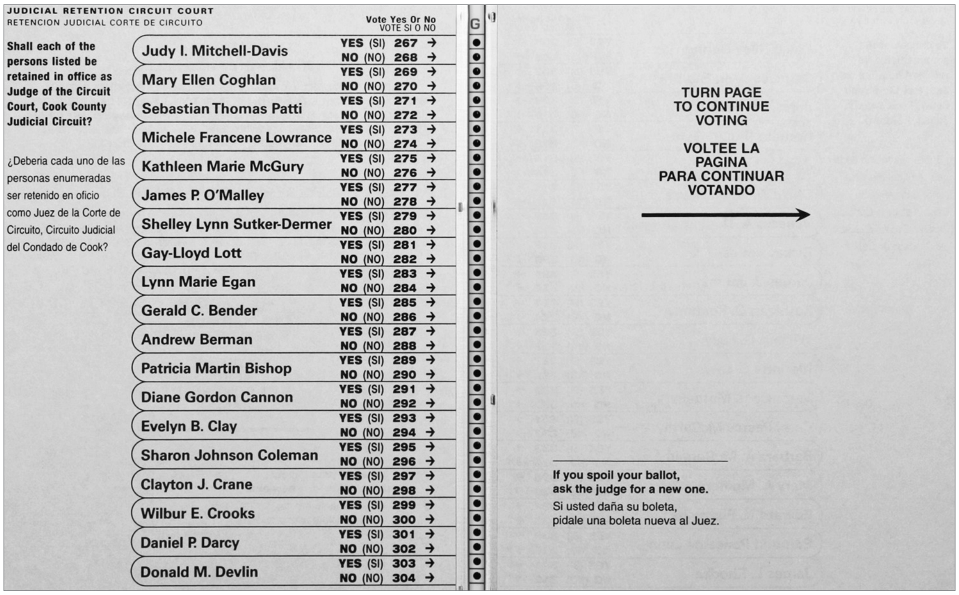
PUNCH CARD BALLOT USED IN 2000



In 2002 Marcia Lausen, of Design for Democracy, and the county election department redesigned the county's ballot. Lausen and her colleagues clarified where voters should mark their ballots by stacking all of the retention candidates in single columns on left-hand pages only.

FIGURE U2

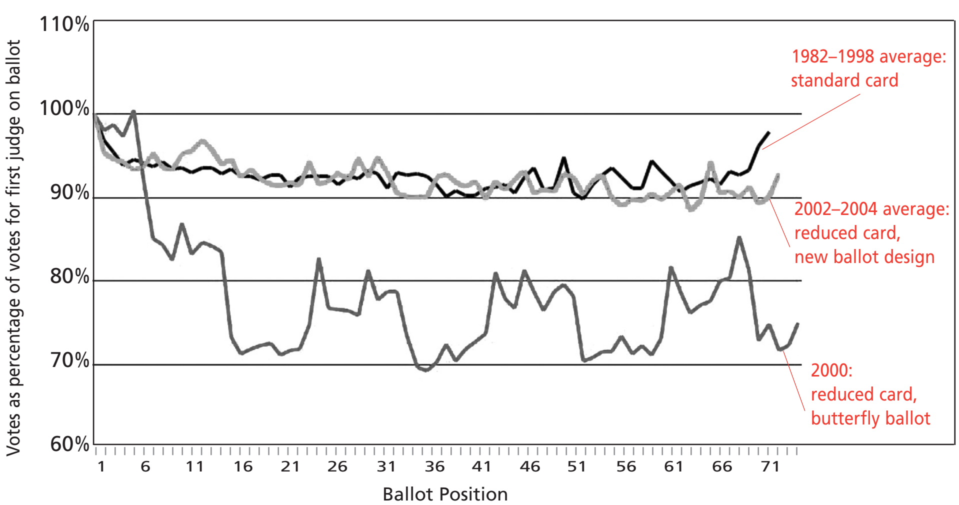
BALLOT DESIGN USED IN 2002



The improvement was dramatic. In the 2002 and 2004 elections, even while retaining the smaller-hole punch card, judicial retention voting returned to its pre-2000 levels with no abnormal loss of voters. Figure 3 shows the votes cast in sequence for Cook County retention judges before, during and after 2000. Note the peaks and valleys that correspond to page changes on the 2000 ballot. Before the change, voters would repeatedly begin again after turning the page, and then give up.

FIGURE U3

VOTES CAST FOR COOK COUNTY RETENTION JUDGES, 1982–2004



Systems that allow voters to review their choices in a clearly presented format, rather than simply asking if they are ready to cast their ballots, can reduce unintentional error.

CREATE CLEAR CLOSURE.

Where applicable, the ballot presentation should make clear when the voter has completed each step or task in the voting process. Whether through clear organization of the ballot or through express messages on a screen, the system should seek to reduce the likelihood of voter confusion or error by instructing how to complete each task and then making clear when each task has been successfully completed. This principle should apply as well to making clear to the voter when she has completed the voting process by casting her vote. Drs. Kimball and Kropf suggest that designers use shading to separate sections of the ballot:

- Ballots should use shading to help voters identify separate voting tasks and differentiate between offices.[43]

REDUCE MEMORY LOAD.

Voting systems should minimize the memory load on the voter, allowing her to review, rather than remember, each of her choices during the voting process. Undue memory burdens may confuse voters and lead to errors or delays. For example, systems that allow voters to review their choices in a clearly presented format, rather than simply asking if they are ready to cast their ballots, can reduce unintentional error. At least one requirement in the VVSG 2005 addresses the problem of memory load and possible confusion if the voter is required to track a contest from one part of the ballot to another:

- Voting systems "should not visually present a single contest spread over two pages or two columns."[44]

Elections officials should consider this principle in selecting a voting system, in developing usability testing to improve ballot design, and in designing the ballot and instructions for their jurisdiction.

NOTIFY VOTERS OF ERRORS.

The voting system should plainly notify the voter of her errors and provide a clear and easy opportunity to correct such errors. In particular, a voter should be informed of any under- or overvotes prior to casting her vote. In paper-based systems such as optical scan systems, this requirement means that the scanner must be programmed to return immediately to the voter for correction any ballot that includes such an error. In DREs, the system should notify the voter of any such error and provide an opportunity and instructions to correct it. Drs. Kimball and Kropf's guidelines include:

- Ballot instructions should warn about the consequences of casting a spoiled ballot *and* explain how to correct a spoiled ballot (required by the Help America Vote Act of 2002).[45]

The VVSG 2005 also requires notification of errors, stressing the importance of noting any under- or overvotes. The guidelines also recommend that all warnings function in a similar manner, not only stating the problem, but doing so in a comprehensible manner and offering options to address it:

- Warnings to the voter should clearly state the nature of the problem and the responses available to the voter.[46]

MAKE IT EASY TO CORRECT ERRORS.

The federal Help America Vote Act requires that voters have an opportunity to correct errors on their ballots.[47] But if correcting errors during the voting process imposes a significant burden on voters, the number of voters who choose not to make corrections increases, leading to higher residual vote rates. Accordingly, the mechanism for correcting errors must be easy both to understand and to execute. In their laboratory research on DREs, Dr. Conrad et al. found that the Diebold AccuVote-TS required the voter to de-select an erroneous candidate selection before touching her preferred candidate on the screen; this extra step caused confusion among participants and led to at least one error.[48] By contrast, other DREs under study did not require that extra step in the error correction process. The VVSG 2005 includes several requirements to provide opportunities for error correction and ensure that voters can extend a warning period if they need more time:

- DREs "shall allow the voter to change a vote within a contest before advancing to the next contest."[49]

- Voting systems "shall provide the voter the opportunity to correct the ballot for either an undervote or overvote before the ballot is cast and counted" and "shall allow the voter . . . to submit an undervoted or overvoted ballot."[50]

- If the voting system requires a response by the voter within a specified period of time, it shall issue an alert at least 20 seconds before this period expires.[51]

RECOMMENDATIONS

Our review of usability research on various technologies, including but not limited to voting systems, points us to several recommendations in the areas of ballot design and system instructions. These recommendations should assist election officials in making purchase decisions and in maximizing a voting system's usability once it is purchased and before ballot designs and instructions are finalized:

- Do not assume familiarity with technology. Where feasible, elections officials should address this concern in usability testing among likely voters to determine the precise effects of different design elements upon voters with limited familiarity with the technology in question. The results of such testing should also inform the design of voter education and outreach and poll worker training prior to the election.

- Conduct usability testing on proposed ballots before finalizing their design. Usability testing of specific models within a type of voting system is critical if election officials are to reduce unnecessary voter errors. Election officials should not assume familiarity with technology or a particular voter interface.

- Create plain language instructions and messages in both English and other languages commonly used in the jurisdiction. Use of plain language that is easy to understand quickly is critical to avoiding voter error. Both DREs and optical scan systems produce substantially higher residual vote rates in jurisdictions with a Hispanic population of at least 30%. This suggests that plain language instructions in both English and Spanish are critical to reduce voter errors, even where Spanish language ballots are not required under the Voting Rights Act.

- Locate instructions so they are not confusing or ignored. Instructions should be placed in the top left of the frame, where possible. In addition, information should be presented in a single-column format rather than a multi-column format to improve readability.

- For both ballots and instructions, incorporate standard conventions used in product interfaces to communicate a particular type of information or message Consistent use of generic conventions (*e.g.,* red = warning or error) throughout the voting process allows the voter to rely on her existing experience to streamline the process and clarify otherwise ambiguous instructions.

- Do not create ballots where candidates for the same office appear in multiple columns or on multiple pages. Listing candidates for the same office in multiple columns or on multiple pages (as in the infamous "butterfly ballot" used in Palm Beach County, Florida in 2000, or in optical scan ballots that allow a contest to continue from one column to another) produces higher rates of residual votes (both overvotes and undervotes).

- Use fill-in-the-oval ballots, not connect-the-arrow ballots, for optical scan systems. In optical scan systems, residual votes (and especially overvotes) are less common on fill-in-the-oval ballots than on connect-the-arrow ballots. The latter design should not be used.

- Eliminate extraneous information on ballots. Ballot design should eliminate all extraneous information from the voter's field of vision and minimize visual or audio distractions from the task at hand. Voters may become overwhelmed or confused by such unnecessary material.

- Ensure that ballot instructions make clear that voters should not cast both a write-in and normal vote. Write-in lines are a source of many overvotes, as many voters select a candidate whose name is printed on the ballot and then write the same name on the write-in line. Election officials should make sure that instructions clearly state voters should not cast votes in both areas of the ballot. At the same time, state laws should be amended to require that such ballots be counted rather than set aside as spoiled, as long as both the write-in vote and the normal vote are clearly cast for the same candidate.[52]

- Provide mechanisms for recording and reviewing votes. Voting systems should provide ongoing feedback to the voter to ensure that she knows which selections she has already made and which remain. This information orients the voter to avoid confusion or lost votes due to such confusion.

- Make clear when the voter has completed each step or task in the voting process. Whether through clear organization of the ballot or through express messages on a screen, the system should reduce the likelihood of confusion or error by instructing voters how to complete each task and then making clear when each task has been successfully completed.

- Minimize the memory load on the voter, allowing her to review, rather than remember, each of her choices during the voting process. Undue memory burdens reduce accuracy, and may confuse voters and lead to errors or delays.

- Ensure the voting system plainly notifies the voter of her errors. In particular, a voter should be informed of any under- or overvotes prior to casting her vote. In paper-based systems such as optical scan systems, this requirement means that the scanner must be programmed so that the ballot is immediately returned to the voter for correction of either of these kinds of error.

- Make it easy for voters to correct their errors. If voters find it difficult to correct their own errors during the voting process, then the number of voters who choose not to make corrections increases, leading to higher residual vote rates. Accordingly, the mechanism for correcting errors must be easy both to understand and to execute without any unnecessary, extra steps to complete.

ENDNOTES

[1] Although there is no firm consensus on precise benchmarks to measure the usability of voting systems, academics and industry researchers have developed design guidelines in other areas, most importantly in web-browser design, that can increase usability. *See* Sanjay J. Koyanl et al., U.S. Dept. of Health and Human Resources, *Research-Based Web Design and Usability Guidelines* (Sept. 2003), *available at* http://usability.gov/pdfs/guidelines_book.pdf.

[2] A full summary of the VVSG usability requirements is available at http://www.eac.gov/VVSG%20Volume_I.pdf.

[3] International Organization for Standardization, *Ergonomic Requirements for Office Work with Visual Display Terminals* at 11, ISO 9241 (1997); *see* Sharon Laskowski et al., National Institute of Standards and Technology, *Improving the Usability and Accessibility of Voting Systems and Products* at 8 (2004), *available at* http://vote.nist.gov/Final%20Human%20Factors%20Report%20%205-04.pdf.

[4] The IEEE has defined a usable voting system as one that allows voters to cast a ballot:

- Correctly – voters correctly use the voting system to register their intended selections with minimal errors.
- Efficiently – voters complete the voting process in a timely manner and without unproductive, unwanted interactions with the system.
- Confidently – voters are confident (1) in what actions they had to perform in order to vote, (2) that their votes were correctly recorded by the system, and (3) that their privacy is assured.

Institute of Electrical and Electronics Engineers, *Usability and Accessibility Standards* §§ 5.3, at 3, *at* http://grouper.ieee.org/groups/scc38/1583/documents_-_p1583/Sections%205.3%20Usability-Accessibility%20(March%2016,%202003).DOC (Mar. 16, 2003); *see* John M. O'Hara, Institute of Electrical and Electronics Engineers, *A Proposed Approach to Testing the IEEE Usability/Accessibility Standards*, *at* http://grouper.ieee.org/groups/scc38/1583/documents_-_p1583/Standards%20Testing%20White%20Paper,%20Rev%201.doc (Apr. 3, 2003).

[5] The 2005 VVSG mirrors the IEEE definition of a usable voting system, explaining that among the basic metrics for usability are:

- Low error rate for marking the ballot (the voter selection is correctly conveyed to and represented within the voting system)
- Efficient operation (time required to vote is not excessive)
- Satisfaction (voter experience is safe, comfortable, free of stress, and instills confidence).

Election Assistance Commission, *Voluntary Voting System Guidelines*, Volume I Version 1.0 at §§ 3.1 (2005), *available at* http://www.eac.gov/VVSG%20Volume_I.pdf, [hereinafter EAC VVSG].

[6] The residual vote rate does not include ballots that are not counted for reasons relating to a voter's ineligibility to vote.

[7] Stephen Knack and Martha Kropf, *Roll Off at the Top of the Ballot: Intentional Undervoting in American Presidential Elections,* 31 Politics & Policy 575-594 (2003); Michael Tomz & Robert P. Van Houweling, *How Does Voting Equipment Affect the Racial Gap in Voided Ballots?,* 47 American Journal of Political Science 46, 57 (Jan. 2003).

[8] *See, e.g.,* Robert Darcy and Anne Schneider, *Confusing Ballots, Roll-Off, and The Black Vote,* 42 Western Political Quarterly 347 (1989); Stephen M. Nichols, *State Referendum Voting, Ballot Roll-off, and the Effect of New Electoral Technology,* 30 State and Local Government Review 106-117 (1998); Stephen Knack and Martha Kropf, *Invalidated Ballots in the 1996 Presidential Election: A County-Level Analysis,* 65 Journal of Politics 881 (May 2001) *available at* http://www.vote.caltech.edu/media/documents/knack-kropf32.pdf; Michael C. Herron and Jasjeet S. Sekhon, *Overvoting and Representation: An Examination of Overvoted Presidential Ballots in Broward and Miami-Dade Counties*, 22 Electoral Studies 21 (Sept. 2001) *available at* http://elections.berkeley.edu/election2000/HerronSekhon.pdf; David C. Kimball *et al., Unrecorded Votes and Political Representation*, *in*

COUNTING VOTES: LESSONS FROM THE 2000 PRESIDENTIAL ELECTION IN FLORIDA at 135 (Robert P. Watson, ed., 2004) *available at* http://www.umsl.edu/~kimballd/unrep.pdf; R. Michael Alvarez, *et al.*, *Counting Ballots and the 2000 Election: What Went Wrong?* (Feb. 2004) *at* http://www.hss.caltech.edu/~betsy/papers/Chapter1.pdf; Justin Buchler *et al.*, *Punch Card Technology and the Racial Gap in Residual Votes*, 2 PERSPECTIVES ON POLITICS 517 (2004) *available at* http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=246600.

9 The data available to examine residual votes in American elections are still limited. Several states still do not collect data on the number of ballots cast in an election, which are needed to compute residual vote rates; instead, these states report the number of votes recorded for the contest at the top of the ballot. This practice requires researchers to seek data from local jurisdictions (counties or towns), which do not gather such data in some cases. In addition, most state and local elections officials do not gather and report data on the number of overvotes and undervotes.

Ideally, election officials would collect data on the number of voters who sign the poll book, the number of ballots cast, overvotes, and undervotes for each contest on the ballot at the precinct level (*i.e.*, the lowest level of aggregation possible). Beginning in 2004, the federal Election Assistance Commission requested that states begin to report this information for each local jurisdiction, and the EAC published the first Election Day Survey in September 2005.

Further, data on polling place conditions and procedures are extremely limited. In the last two years, researchers have started organizing teams of observers to measure polling place accessibility and other conditions. In addition to the huge cost of these studies, however, legal barriers limit their reach. In several states, like California, state law explicitly allows research teams to observe polling places during elections. In other states, like Missouri, state law prohibits researchers from conducting research in polling places. These limitations make it difficult to control for differences in polling place conditions when assessing the performance of voting systems.

10 The Institute's research has been conducted in association with researchers at the University of Rochester, the University of Maryland, Georgetown University, and the Maryland State Board of Elections.

11 *See* Fred Conrad *et al.*, *A Laboratory Evaluation of Six Electronic Voting Machines* (July 2, 2005) (A presentation given to the Usability Professionals Association) *available at* http://www.upassoc.org/usability_resources/conference/2005/Conrad.ppt.

12 As noted already, the results from Nevada may reflect that state's unique ballot options rather than the voting system used.

13 David C. Kimball and Martha Kropf, *Ballot Design and Unrecorded Votes on Paper-Based Ballots,* 69 PUBLIC OPINION QUARTERLY 508 (2005), *available at* http://www.umsl.edu/~kimballd/kkpoq05.pdf.

14 Michael J. Hanmer and Michael W. Traugott, *The Impact of Voting by Mail on Voter Behavior,* 32 AMERICAN POLITICS RESEARCH 375 (2004).

15 For earlier studies that depended principally on surveys of voters, expert review, and limited field testing, *see* Paul S. Herrnson, *et al.*, *Early Appraisals of Electronic Voting*, 23 SOCIAL SCIENCE COMPUTER REV. 274 (2005) (summarizing limited past research and presenting results of analysis of Diebold's AccuVote-TS DRE) *available at* http://theory.lcs.mit.edu/~rivest/voting/reports/EarlyAppraisalsOfElectronicVoting.pdf; Benjamin B. Bederson, *et al.*, *Electronic Voting System Usability Issues*, CHI 2003, at 145-162 (Paper from the Conference on Human Factors in Computing Systems sponsored by the Association for Computing Machinery's Special Interest Group on Computer-Human Interaction) (Apr. 5-10, 2003) (reviewing expert and non-expert subjective comments on usability of electronic voting system used in Maryland, Diebold's AccuVote-TS); Benjamin B. Bederson & Paul S. Herrnson, *Usability Review of the Diebold DRE System for Four Counties in the State of Maryland*, Univ. of Maryland (2003) *at* http://www.capc.umd.edu/rpts/MD_EVoteMach.pdf; Center for American Politics and Citizenship, *An Evaluation of Maryland's New Voting Machines* (Dec. 2, 2002) (summarizing results of exit poll survey in two Maryland counties), *available*

at http://www.capc.umd.edu/rpts/MD_EVoteEval.pdf.

16 *See* Gary H. Roseman, Jr. & E. Frank Stephenson, *The Effect of Voting Technology on Voter Turnout: Do Computers Scare the Elderly?*, 123 PUBLIC CHOICE 39 (2005) *available at* http://www.springerlink.com/index/K562205R35WKL415.pdf. Maryland and Florida have both shifted to DREs in recent years. An examination of the elderly population's voting patterns in these states could help test Roseman and Stephenson's findings.

17 *A Laboratory Evaluation of Six Electronic Voting Machines*, *supra* note 11, at 27.

18 Ted. Selker *et al.*, *Comparative Voting Performance of Reading Disabled Voters* (2005), *available at* http://www.vote.caltech.edu/media/documents/readingdisabledwist.doc.

19 Stephen Ansolabehere and Charles Stewart, III, "Residual Votes Attributable to Technology," *Journal of Politics* 67(2005) at 365-389; David C. Kimball and Martha Kropf, "Ballot Initiatives and Residual Ballots in the 2004 Presidential Election," paper presented at the Southern Political Science Association Annual Meeting, Atlanta, January 2006.

20 Sharon Cohen, MIT EECS MS thesis, An Active Approach to Voting Verification, http://votingtechnologyproject.org/theses/cohen-thesis_5-05.pdf.

21 The efficiency of Vote-by-Mail systems must be evaluated differently than in other systems because voters cast ballots at home and at their leisure. Thus, there are no bottlenecks at polling places to consider.

22 *See* Jonathan Goler, Ted Selker, and Lorin Wilde, *Augmenting Voting Interfaces to Improve Accessibility and Performance* (2006), *available at* http://vote.caltech.edu/reports/chi-abstract-golerselker.pdf; Ted Selker, Matt Hockenberry, Jonathan Goler, and Shawn Sullivan, *Orienting Graphical User Interfaces Reduces Errors: the Low Error Voting Machine*, *available at* http://vote.caltech.edu/media/ documents/wps/vtp_wp23.pdf.

23 EAC VVSG, *supra* note 5, at § 3.1.6(a) (emphasis added).

24 *Id.* at § 3.1.4(c)(i).

25 *Ballot Design*, *supra* note 13, at 516.

26 EAC VVSG, *supra* note 5, at § 3.1.5(d), (h).

27 *Id.* at § 3.1.5(i).

28 *See* Daniel B. Felker *et al.,* American Institutes for Research (AIR) Document Design Project, *Guidelines for Document Designers* (Nov. 1981).

29 In her work with San Francisco's Ballot Simplification Committee, for example, Dana Chisnell uses these Guidelines in preparing the instructions and digests for the Voter Information Pamphlet ("VIP") published by the Department of Elections. It is the only citizen-written VIP in the country. Most VIPs are written by attorneys who may inadvertently introduce biases into voting materials and who often are not skilled in writing plainly.

30 *Ballot Design*, *supra* note 13, at 513.

31 EAC VVSG, *supra* note 5, at § 3.1.4(b).

32 John M. Carroll and Hans Van der Meij, *Principles and Heuristics for Designing Minimalist Instructions*, *in* MINIMALISM BEYOND THE NURNBERG FUNNEL (John M. Carroll ed., MIT Press 1998).

33 *See, e.g.*, Michael Summers & Kathryn Summers, *Clear Health Communication on the Web: Making Medical Content Accessible to Low-Literacy Users* at 4 (June 2005) (unpublished paper, on file at the Brennan Center).

34 *Ballot Design*, *supra* note 13, at 516.

35 *Id.* at 528.

36 David C. Kimball, *Assessing Voting Methods in 2002* (presented at the Midwest Political Science Association Annual Meeting) (Apr. 2003) *at* http://www.umsl.edu/~kimballd/dkmpsa2.pdf..

37 *Ballot Design*, *supra* note 13, at 518; Richard G. Niemi and Paul S. Herrnson, *Beyond the Butterfly: The Complexity of U.S. Ballots*, 1 PERSPECTIVES ON POLITICS 317-326 (2003) *available at* http://www.upassoc.org/upa_projects/voting_and_usability/workshop2004/pol%20persp%20page%20proofs.pdf.

38 *Ballot Design*, *supra* note 13, at 517.

39 EAC VVSG, *supra* note 5, at § 3.1.4(c)(iii).

40 *Id.* at § 3.1.6(b) (emphasis added).

41 *Id.* at § 3.1.6(d) (emphasis added).

42 Albert J. Klumpp, *Judicial Retention Elections in Cook County: Exercise of Democracy, or Exercise in Futility* (2005) (unpublished Ph.D. dissertation, University of Illinois at Chicago) (on file with the University of Illinois at Chicago Library).

43 *Ballot Design*, *supra* note 13, at 517. Design for Democracy, a non-profit dedicated to improving ballot design, has echoed Kimball and Kropf's advice in their Election Design System. *See* Marcia Lausen, Design for Democracy, *Election Design: Models for Improvement* (Peachpit Press 2006).

44 EAC VVSG, *supra* note 5, at § 3.1.4(c)(i).

45 *Ballot Design*, *supra* note 13, at 516.

46 EAC VVSG, *supra* note 5, at § 3.1.4(d).

47 42 U.S.C. § 15481(a)(1)(A)(ii).

48 *A Laboratory Evaluation of Six Electronic Voting Machines*, *supra* note 11, at 44.

49 EAC VVSG, *supra* note 5, at § 3.1.2(f).

50 *Id.* at § 3.1.2(d), (e).

51 *Id.* at § 3.1.6(c).

52 Certain states already provide this protection for voters who mistakenly cast ballots with both a write-in vote and a normal vote for the same candidate. *See*, *e.g.*, Wis. Stat. Ann. § 7.50(2)(d) (2004).

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