

Characteristics of Optical Scan and DRE Voting Equipment: What Features Should Be Tested?¹

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The “butterfly” ballot used in Palm Beach County in the presidential election of 2000 was a convincing, highly visible display of the importance of ballot design and, more generally, of the significance of the human factor in voting. In addition to individual testimonials, the statistical evidence is almost incontrovertible in showing that a substantial number of voters failed to vote the way they intended (Wand et al. 2001). And the nature of the task was such that the probable cause was unquestionably the design of the ballot. Likewise, the difficulty of recounting ballots in Florida dramatically pointed out a major flaw in punch card voting systems. The fact that chads—a word that almost no one knew prior the 2000 election—did not always drop out the way that was intended, became a symbol of what could go wrong with punch cards.

While events in Florida were easily the most dramatic and meaningful examples, they were not the only or even the first instances of problems brought about by poor ballot design and faulty voting equipment. It has long been suspected, for example, that placement of propositions on lever machines can alter the number of votes cast on them. It is also well known that voters have problems when multiple candidates are elected to the same office, though the problem (whether one can vote for individuals on two different party lines) may be one of voter education as much as ballot design. As to equipment, various reports over the past 30 years have cited problems with punch cards (Saltman 2001, 12-13). And in 2000, the Caltech-MIT nationwide study estimated that the percentage of residual votes (uncounted, unmarked, spoiled) on punch card systems was at least 50 percent more than on optical scan systems (Caltech/MIT, 21).²

At the same time, it is not clear that new voting methods will necessarily solve the human interface problems—at least if used without considerable care. One of the most surprising findings of the Caltech-MIT study was that the residual vote percentage was about as high with electronic vote systems (DRE) as with punch cards; in fact, for gubernatorial and senatorial races, it was higher (Caltech/MIT, 21). Expressing surprise and dismay, the authors noted “we believe that the high rate of residual votes of DREs stems from the user interfaces” (Caltech/MIT, 23). They believe that electronic voting has great potential, but they are clearly

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²As a consequence, many jurisdictions have decided to phase out punch card systems. See electionline.org (2001, 8-12).

unimpressed by existing equipment, especially with respect to the mechanics of voting and the presentation of choices.

Based on these experiences and reports, it seems clear that research on the human factor in voting should focus on optical scanning and electronic (DRE) systems.³ Having made that decision, our purpose in this paper is to identify the features of the systems that should be considered in a testing program. By the time of the meeting, it is possible that we will also have identified specific machines to use for initial testing purposes.

CRITERIA FOR TESTING

Critics of voting systems have focused on identifying the problems of various systems, without specifying precisely the criteria by which one should evaluate alternative (existing or potential) equipment and ballot designs. Nonetheless, comments scattered throughout various reports suggest that research should test at least the features listed below.

For the most part, the same questions can be asked of optical scan and electronic systems. However, some are more of a concern with one than the other. Undervoting, for example, has been discussed with respect to electronic voting but seems to have been of little concern with optical scan ballots, perhaps because with the latter it is deemed less likely that a voter will unintentionally fail to see the entire ballot.

The following are among the most important questions that have been raised about voting equipment and ballot design:

- Are voters on electronic systems or optical scan system made aware of undervoting?
- Are voters using optical scan systems made aware of ballot mistakes?
- How does one change a voting decision that is inputted into the equipment before the ballot is actually cast?
- How, if at all, are voters on electronic systems made aware if they have overvoted? How does one correct for this?
- How does one cast the vote when ready?
- Is it always clear which office(s) one is voting for? Is the number of offices on a given page/screen clear?
- Is it clear how one completes a ballot? This may involve filling in a box or oval, completing a broken arrow, touching a screen location, or pushing a button.
- How are write-ins done?
- How is the ballot formatted (for a specific office) when there are many candidates—e.g., as many as 25 or more?

³Besides punch cards, the other systems in use are paper ballots and lever machines. Paper ballots, though having some desirable characteristics, are problematic for use with large electorates and numerous offices, which are frequent characteristics of elections in the U.S. Lever machines, however one evaluates them from a human interface perspective, are considered out-of-date and are no longer manufactured. We will not explicitly consider any of these three methods of voting, though some of our conclusions may well be applicable to them.

- What are instructions like when more than one candidate is to be elected?
- How much voter education is required to use the system correctly?
- How much time does it take to cast a ballot?
- Are there clear distinctions between the procedures voters use to select candidates, to move from one part of the ballot to the rest, and to finally cast a ballot?
- Are voters informed of how much of the ballot they have completed or how many offices they have yet to vote for?

Recommendation: Testing should use the above criteria for judging the performance of voting systems.

A CATALOGUE OF EXISTING VOTING SYSTEMS

In order to understand the characteristics of optical scan and electronic systems currently available, we catalogued all machines that are currently available and about which we could find information. We relied to some extent on web sites, though we also called companies and asked for written material. We think our survey is relatively comprehensive. Still, there are some problems in doing a search of this sort. This is a field of changing technology (which is, in itself, a problem for jurisdictions buying such equipment). Old web sites are not always removed or updated, making the list of relevant companies and especially of specific equipment difficult to determine. In addition, some voting equipment companies have recently merged, making it hard even to compile a list of relevant companies. Once we determine more precisely how and what we are going to test, we can deal face-to-face with companies to identify their current and most promising systems and, we hope, to arrange some use of or test of that equipment.

It is worth pointing out that we do not want to limit ourselves entirely to existing interfaces. It makes sense, however, to begin with these systems. Should we find that there are features, or combinations of features, that are worth testing but are not currently available, we will then have to see how to create them.

Based on our survey, we know that existing systems share many characteristics. For the most part, these are features that we would not want to vary. (Examples for electronic systems are the ability to program the machine for multiple languages and to disallow overvotes.) Thus, we begin by listing characteristics shared by most machines. Then we describe critical differences among them. These differences are the attributes that we are most likely to test.

We deal first with optical scan equipment and then with DRE machines.

Optical Scan Voting Systems

“Mechanical” differences.

- Whether the voter completes a broken arrow
- Whether the voter blackens a circle/oval/square

- Whether the voter puts an x or check in a circle/oval/square
- whether the ballot is checked immediately for overvoting and other invalidating errors

Recommendation: We should test each of these “mechanical” differences.

Another distinction, which may not be very important, is what device one uses to fill out the ballot (pen, pencil). From the sample ballots, it’s not always clear whether a device is always provided (though I suppose one is) and whether it has to be special (such as a #2 pencil). Given advances in technology, it may be that new optical scan machines can read almost any marks—i.e., any color ink, any pencil; this can be checked out.

Differences we think are not worth testing. These relate to very detailed instructions--e.g., “fill out the circle” when it's actually an oval; whether the sample arrow is squigly or straight.

There may be a question of how one makes corrections, but I suspect one can't ever erase, so one always has to get a new ballot. (Again, this can be checked out.)

Ballot Format Differences:

- Whether there is a straight-ticket provision (and how it is presented)
- Whether blocs of offices are distinguished (this may be partisan/nonpartisan; federal/state/county; etc.)
- Whether the voting for each office is clearly distinct from all others. (This is to some degree dependent on the number of offices to be voted on (and the number of parties with candidates). A ballot with 12 or more different offices cannot on one page show these offices as distinctly as a ballot with only 6 offices. It also depends on the total number of candidates, including whether there is provision for a write-in candidate for each office.)
- Whether each candidate’s name and the place for selecting the candidate is clearly separated from all others
- Whether write-in” or “someone else” is specified for write-in candidates.

Recommendation: The bulleted items should be tested, except for the matter of whether a ballot is checked immediately for invalidating errors, which all systems should do.

DRE Voting Machines

Characteristics of most machines:

- Use a touch screen
- Have adjustable font sizes
- Can use multiple languages
- Disallow overvotes
- Make it possible for programmers to include a straight-party vote option
- Display some or full text of referenda, along with pro/con arguments

Recommendation: Do not test the above characteristics, as they seem uniformly distributed.

Differences across machines in order of importance:

- Whether navigation buttons are the same as selection buttons
- Whether office bloc ballots, party line ballots, and party column ballots can be accommodated
- If office bloc, whether one office or more than one office is displayed at one time
- If office bloc, whether the entire ballot (or part of it) is presented and the voter can zoom to one office at a time to ease voting
- Whether one pushes a hardware button or name (or near a name) on screen to select a candidate
- Whether one can review votes before casting a ballot, and whether they can be reviewed at any time, or only at the end
- Whether there are one or more colors on the buttons and whether color differentiates functions
- Whether there is a warning for undervotes
- Whether one can vote for a candidate at any time or one has to vote for the candidates on the first page, then second, etc.
- Whether one can jump to a specific page
- Whether and how write-ins are accepted
- Whether voter is informed of how many offices are left to vote on, or how many offices are completed and left
- Whether the voter knows where on the ballot s/he is (e.g., page 1 of 2)
- Whether the display is multicolored
- Whether there is a label identifying a button's function located physically on it
- Whether voters identify themselves by inserting a card or typing in a number
- Whether in order to change a vote, one first has to deselect the previous choice
- Whether there is a help function and whether it is illustrated

Recommendation: The bulleted differences above are listed in approximate order of how important they are for testing. We should test each item down to and including whether one can jump to a specific pages.

Another set of differences across machines, especially DRE machines, is in their ability to accommodate various kinds of needs. Some features, such as the ability to use enlarged type, are built into most machines.

Recommendation: After testing the other characteristics and determining what we regard as desirable features, we should test how machines with these characteristics accommodate audio, voice voting, Braille, large type, or can be adapted for wheelchair use, moved for curbside voting, or accommodate those with motor skill problems.

VOTING SYSTEMS TO BE TESTED

Recommendation: We recommend testing based on the following machines, if possible. Collectively, they contain the widest variety of characteristics that we have identified as important for testing.

Optical Scan Machines
To be determined

DRE Machines (for a list of features of the various machines, see the appendix to this paper)
Avante Vote-trakker
Danaher ELECTronic 1242
Diebold AccuVote-TS
ES&S iVotronic
Hart eSlate

AD HOC CHARACTERISTICS OF BALLOT/VOTING ACROSS THE STATES

Ad hoc characteristics related to the legal requirements and preferences of the states and localities comprise an additional set of ballot design issues.

Ad hoc differences:

- Whether electors' names are provided alongside presidential candidates' names.
- Whether primary ballots for multiple parties are printed on one page (even though it's a closed primary) or whether they are printed as separate ballots
- The number of offices being voted on
- The number of propositions being voted on
- Whether "additional" information is given about candidates—e.g., place of residence, profession, incumbency status
- Whether "additional" information is given about the office—e.g., length of term
- The length and complexity of instructions printed on the ballot—some as simple as "vote for one" versus "vote for no more than one" and some that are quite long (most often connected with straight-ticket voting or with write-ins)
- Whether unopposed candidates are shown on the ballot and whether votes are cast for them
- Whether (and which) party symbols are shown

Recommendation: Discuss the advisability of testing these features. Added information lengthens the ballot and has the potential to cause or reduce confusion. Variations across states can also add confusion as people move. Nonetheless, these features are perhaps secondary issues for our research; states and localities are unlikely to change them if they provide advantages to one or more candidates or parties or if they are simply state traditions. Yet if we don't test them and make recommendations, election officials and state legislatures may never even think about these things.

Goals for the meeting: Discuss each of the recommendations above. Specifically, this includes discussing and evaluating:

- a) the criteria to be used for testing;
- b) the characteristics of optical scan machines that should be tested;
- c) the characteristics of DRE machines that should be tested;
- d) determining whether there are other features not listed above that should be tested;
- e) the number and variety of machines to be tested;
- f) deciding whether to test ad hoc features.

In each case, this includes the possibility that some criteria/features should not be part of a testing program. For example, we have not suggested testing help functions; we think they are only likely to slow down or confuse voters and that educational efforts would better serve the same purpose. In addition, the discussion and evaluation need to recognize the possibility that there are tradeoffs (e.g., between ease of use and the amount of time needed for voting, the accuracy of vote casting, and so on).

ATTACHMENTS

Table 1. Characteristics of DRE Machines

Codebook for Table 1

References

- Caltech/MIT. 2001. Voting: What Is, What Can Be. Caltech/MIT Voting Technology Project. www.vote.caltech.edu.
- “What’s Changed, What Hasn’t, and Why: Election Reform since November 2000.” 2001. Washington, DC: Election Reform Information Project. www.electionline.org.
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Table 1 is in the form of a separate EXCEL file.

CODEBOOK FOR TABLE 1

U.S. based company? 1 U.S. 2 International	Colors differentiate functions? 1 Yes 2 No
What is our information source? 1 Internet 2 Brochure	Is display multi-colored? 1 Yes 2 No, two-tone
Does it use a touch screen? 1 Yes 2 No	Where do you push select button? 1 Hardware button 2 Name on screen 3 Screen area near name 4 Name or area near name
Screen size: As shown	How do you change a vote? 1 Directly push new choice 2 Unselect current choice first 3 Either directly push or unselect first
Device dimensions As shown	Are write-ins possible? 1 Yes, hardware QWERTY keyboard 2 Yes, hardware ABC keyboard 3 Yes, software QWERTY keyboard 4 Yes, software ABC keyboard 5 Handwritten on paper 6 No
Is the font size adjustable? 1 Yes 2 No	Can you review votes before voting? 1 Yes, on-screen-anytime 2 Yes, on-screen-end 3 Yes, paper-end 4 Yes. on-screen/paper-end 5 No
Is the font type adjustable? 1 Yes 2 No	Is there a help function? 1 Yes, context-sensitive, relevant to current screen 2 Yes, static, general help menu 3 Yes, context-sensitive and static (general help and current screen) 4 No
Type of buttons used 1 Hardware, on device 2 Software, on screen 3 Hardware and software	Is the help function illustrated? 1 Yes 2 No 3 NA—no help function
Do buttons serve one function? 1 All serve more than one function 2 All serve only one function 3 Mix of one and more than one function	
Navigation buttons separate? 1 Yes 2 No 3 NA—no navigation buttons (one large display)	
Physical labels on buttons? 1 Yes, at least one but not all 2 Yes, all buttons are labeled 3 No	
Are buttons colored? 1 Yes, one color 2 Yes, more than one color 3 No	

Voter knows ballot length?

- 1 How many pages completed
- 2 How many pages left
- 3 Completed and left
- 4 All races displayed at once
- 5 No

Can one jump to a specific page?

- 1 Yes
- 2 No
- 3 NA—entire ballot displayed at once

Accommodate audio?

- 1 Yes
- 2 No

Accommodate braille?

- 1 Yes
- 2 No

Accommodate curbside?

- 1 Yes
- 2 No

Adjust for wheelchairs?

- 1 Yes
- 2 No

Can one change language?

- 1 Yes
- 2 No

How are voters identified?

- 1 Insert card
- 2 Type ID number
- 3 Either/or
- 4 Poll worker controls on/off

Are overvotes allowed?

- 1 Yes
- 2 No

Is there a warning for undervotes?

- 1 Yes
- 2 No

How is the ballot displayed?

- 1 Party column
- 2 Party line
- 3 Office block, one office displayed at a time
- 4 Office block, more than one office displayed
- 5 Office block, more than one/or zoom to one

Is there a straight party option?

- 1 Yes
- 2 No

How are referenda displayed?

- 1 Full text of question
- 2 Abbreviated text of question
- 3 Both full and abbreviated
- 4 Some/full text with arguments pro and con
- 5 None