

Testing Ballot Marking Devices (BMDs) in Use

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Ballot marking devices are widespread. Voters and experts mistrust their accuracy. **This paper shows a method to measure BMDs' accuracy.**¹ If there are other methods, please add them in comments.

Ballot Marking Devices (BMDs) are **machines** in polling places where a voter marks choices on a touch screen, which they can check, and the **machine prints the names chosen by the voter on paper.** Voters can (and usually don't) check the printed paper before putting it in a ballot box. For voters with disabilities the machine can read choices to the voter and accept input with buttons, paddles or on/off switches, though these can be awkward.² Some BMDs can display the ballot to the voter, and, upon approval, roll the ballot back into a ballot box so voters who cannot handle it can still vote independently.



Many voters with disabilities need BMDs.

Many election offices prefer BMDs, to save money on printed ballots³ and avoid ambiguous marks on ballots. Thousands of BMDs are in use around the country. It is crucial to monitor their accuracy, so voters with and without disabilities can get them replaced if they are inaccurate.

53% of voters checked the hard-to-read BMD paper ballot in a primary election in two Tennessee precincts, according to volunteer observers from a group opposed to BMDs. Voters checked for 1-19 seconds, with an average of 3.9 seconds.⁴

In searching text (for names they didn't vote for) the source cited by the study says people focus on an area of 12-14 letters (3 degrees) for 180-275 milliseconds, then take 30 ms to move a couple of degrees down the list.⁵ 12-14 letters is enough to check the selection in a contest. So they need 0.210 to 0.305 seconds per contest. In the average time of 3.9 seconds they can check 13-19 of the 22 contests.

Checking involved reading 59 words if they read down the printed selections, or 29 words if they just checked the candidates, not their Yes or No votes on issues. At an average adult reading speed of 238 words per minute,⁶ they would need 15 or 7 seconds to read 59 or 29 words, because reading is slower than searching.

¹ Other papers describe how to check :ballots sent to voters by internet, voter eligibility, and tallies of results.

² Awkward spoken ballot: <https://votingsystems.cdn.sos.ca.gov/vendors/dominion/dvs510aup-report.pdf>

³ Some states subsidize equipment but make local offices pay for printing, so they like BMDs which cut printing costs.

⁴ Original study: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3292208 says "We did not establish inter-rater reliability" so authors call results "preliminary." Summary, with critiques in comments: blog.citp.princeton.edu/2018/12/03/why-voters-should-mark-ballots-by-hand/

⁵ pp.1459-1460 <https://www.researchgate.net/profile/Simon-Liversedge/publication/228616958> 180-275 milliseconds is the time when they search for certain text. Searching for the absence of text may go faster or slower, but this is the citation given by the authors.

⁶ <https://osf.io/preprints/psyarxiv/xynwg/download>

One can add some moments to get oriented on the page and realize where the candidate names are, to check.⁷

00000111
ELECTION: GENERAL ELECTION
ELECTION DATE: 11/08/2016
PRECINCT: 748-050 SPG 15 050

U.S. PRESIDENT AND U.S. VICE PRESI•REP DONALD J. TRUMP
U.S. SENATE-----REP SENATOR JOHN BOOZMAN
U.S. CONGRESS DISTRICT 03-REP CONGRESSMAN STEVE WOMACK
STATE REPRESENTATIVE DISTRICT 89 DIS•REP JEFF WILLIAMS
COUNTY JUDGE-----REP JOSEPH K. WOOD
COUNTY ASSESSOR-----REP ASSESSOR RUSSELL HILL
CIRCUIT CLERK-----REP CIRCUIT CLERK KYLE SYLVESTER
CONSTABLE DISTRICT 01 DISTRI•REP CONSTABLE JOHN DUGGAR
MAYOR SPRINGDALE-----MAYOR DOUG SPROUSE
CLERK/TREASURER SPRINGDALE-----NO SELECTION MADE
ALDERMAN WARD 1 POSITION 2 SPRINGDALE-----ERIC FORD
ALDERMAN WARD 2 POSITION 2 SPRINGDALE-----RAY DOTSON
ALDERMAN WARD 3 POSITION 2 SPRINGDALE-----JEFF WATSON
ALDERMAN WARD 4 POSITION 2 SPRINGDALE-----JEREMY LYNCH
ISSUE NO. 1-----FOR ISSUE NO. 1
ISSUE NO. 2-----FOR ISSUE NO. 2
ISSUE NO. 3-----NO SELECTION MADE
ISSUE NO. 4-----FOR ISSUE NO. 4
ISSUE NO. 5-----FOR ISSUE NO. 5
ISSUE NO. 6-----FOR ISSUE NO. 6
ISSUE NO. 7-----FOR ISSUE NO. 7
UNOPPOSED CANDIDATES-----NO SELECTION MADE

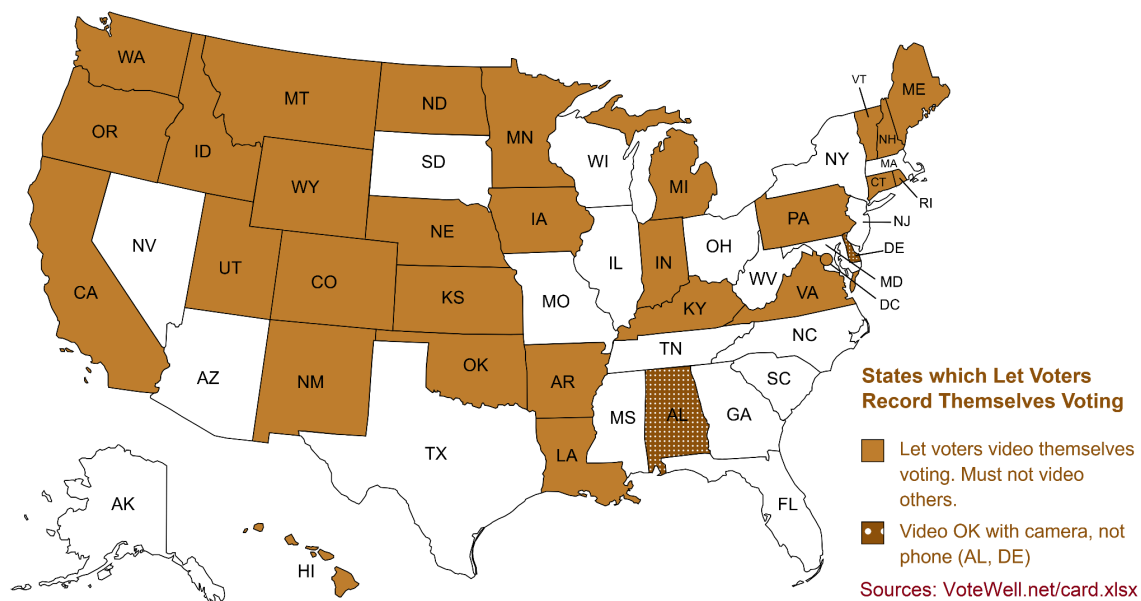
⁷ Most of the study concerns a page which the researchers showed to voters after they left the polling place. This page was formatted differently from what they voted on. It listed 2 down-ballot contests different from what they had voted on. Most voters did not notice the differences, which the authors conclude means voters cannot remember who they voted for a few minutes earlier, so cannot check their own printed ballots. However when voters go in to vote, they remember names they chose days or weeks earlier, so they are capable of remembering a few more minutes, if they choose to check.

In a mock election in a Michigan library, researchers put errors on the printed ballot, and found most voters (81%) did not find and report the errors, and had little motivation to do so.⁸ Voters who do find errors can't prove whether the machine or the voter caused a mistake. They can redo their own ballot, but can't fix errors in the system for those who don't check. Election integrity activists have opposed wide use of BMDs on the grounds that we cannot know when errors or hacks have changed the voters' choices.

In fact we can find out BMDs' accuracy in the 31 states which let voters photograph their ballot choices, including most of the West, the Plains and New England.

An issue is how to enlarge **privacy screens** around these very big BMD screens so photographs do not include other voters.

1. Standards need to require effective privacy screens. Current screens hide the back of the BMD, not its front.
2. Each enclosure needs a pocket to hold voter's phone or camera, aiming at the screen and hands, so field of view is controlled.



ACCURACY OF NAMES PRINTED ON BMDs

The 1st step in checking BMDs is to encourage people to video-record their session on the BMD, and the resulting ballot. People who use audio-readers can audio-record their session and the resulting ballot. Thirty-one states let voters photograph their ballot choices.⁹ Then people who find an error in the ballot printed by the BMD can check their video-recording to see if the machine or voter caused the error. If the machine erred, the voter documents it and improves the system for all.

⁸ 19% of registered voters report errors in BMDs: Bernhard et al. "Can Voters Detect Malicious Manipulation of Ballot Marking Devices?" <https://jhalderm.com/pub/papers/bmd-verifiability-sp20.pdf> The abstract and most citations note that only 7% of all participants in the experiments reported the errors. However the experiment included library patrons who were not registered voters, and found that participants who were registered voters were more vigilant than those who were not.

⁹ **28 states allow ballot selfies** in polling places:

10/30/20 wric.com/news/virginia-news/ballot-selfie-laws-is-it-legal-to-snap-a-photo-in-your-state/

10/19/20 fox5atlanta.com/news/ballot-selfies-here-is-a-list-of-states-where-you-can-take-a-photo-with-your-ballot

10/26/20 <https://www.snopes.com/fact-check/dont-selfie-your-ballot/>

This non-random checking is what we use for polling places and many other aspects of elections. We don't have, or need, a statistical sample to ensure polling places run well, since non-random observers go around to look wherever they can, report problems and get solutions.

Checking 31 states will not tell us what happens in the other 20 states. Activists can check if audio recording is allowed and monitor that way. We can expect to discover and report occasional flaws in the 31 states, which will make it hard for the other 20 to pretend perfection. The 20 states test machines before elections, but only voters can test them in actual use. The 20 states need to let voters record themselves using BMDs.

The Justice Department discourages videotaping other voters in polling places,¹⁰ since recording other voters could intimidate them and reduce privacy. Justice says nothing against videotaping one's own vote, though they have been misquoted saying that.¹¹

The 2nd step is to report discrepancies to the poll workers immediately, for fixing the BMD or taking it out of service.

The 3rd step is to send the records of both accurate and inaccurate BMD experiences to a national monitoring center. An app would be helpful. The national monitoring center is needed to track and report patterns of errors, by manufacturer, model and location.

This method of checking BMDs needs to be done by people who are willing to disclose their ballot choices. If the printed ballot fails to match their self-recording, participants will need to disclose both the ballot and the recording. The recording shows the choices they made on the BMD. An app could keep disclosure to a minimum. Many party activists would be proud of their choices, and willing to disclose, them. Activists can recruit volunteers as has been done to get photos of poll tapes.¹² Campaign volunteers and nonprofits include thousands of people, so the sample can be large, widespread and effective in the 31 states which allow recording one's own vote. That's the only way to monitor accuracy in the huge installed base of BMDs the country already has.

ACCURACY OF BAR CODES ON BMDs

Bar codes on BMD ballots can also be checked by a monitoring center. BMDs print voter choices in text as well as coded in a bar code or square QR code (■). The 19% of voters who check can check the text.¹³ Sending images to a central monitor lets the codes be checked too. The central monitor should have enough unique ballot images to decode any complexities and check that when the text shows a particular candidate, the bar code is consistent for that jurisdiction.¹⁴

¹⁰ In 2020 US Attorneys said, "For example, actions designed to interrupt or intimidate voters at polling places by questioning or challenging them, or by photographing or videotaping them, under the pretext that these are actions to uncover illegal voting may violate federal voting rights law." Los Angeles 2020:

<https://www.justice.gov/usao-cdca/pr/federal-prosecutors-serve-district-election-officers-seven-california-counties-during-New-Jersey>:

<https://www.justice.gov/usao-nj/pr/us-attorney-s-office-announces-election-day-program-combat-fraud-and-protect-voting>

In 1994 the Justice Department told Mississippi that "the actions of white people in videotaping black voters at or near the polls could constitute a violation" p. 436, footnote 18

https://www.google.com/books/edition/_/9_zTnOUeisYC?hl=en&gbpv=1&pg=PA436

¹¹ Alabama SoS misquotes DOJ, by omitting that DOJ is concerned about photos of *others*."The U.S. Department of Justice has advised that photography or videotaping inside a polling place does not serve any useful purpose and may instead actually intimidate voters who are exercising their right to vote." <https://www.sos.alabama.gov/alabama-votes/faqs>

¹² Reasons to photograph poll tapes and examples:

- <https://countthevote.info/>
- <https://validatethevoteusa.org/>
- <https://protectourvotes.com/photo-finish/>

¹³ Where phones are allowed, voters can scan QR codes (LA, ES&S), but do not know the right code for each candidate.

¹⁴ Sometimes QR codes have numeric codes, 1=Biden, 2=Trump,... 21=McConnell, 22=McGrath,... Sometimes codes are more complex. Tim White has found extra bits with unclear meaning in Washington. Dominion says their QR codes are encrypted, though

The central monitor can also check if the bar code identifies voters, reassuring or warning the public as the case may be.

CLOSING COMMENTS

Yes, errors happen. Election machines store candidates as numbers, and each jurisdiction has its own lookup tables to show that Biden or Trump has code 1, Trump or Biden or someone else has code 2, etc. When a BMD or other machine has incorrect lookup tables, it can display one name on the screen and print another in the ballot text or in the QR code. South Carolina has had erroneous coding in direct entry machines.¹⁵ Antrim MI and North Kingstown RI have had erroneous coding in scanners.¹⁶ The same errors can happen in BMDs too.

Other Checking: Officials (including auditors) need to check **logs and problem reports** on every machine, which may show problems not caught elsewhere. **Logic and accuracy** tests of scanners before elections need to include ballots from BMDs as well as hand-marked ballots.

The country has bought thousands of BMDs, whatever their merits. Where monitors find high BMD accuracy, that is good news. Where monitors find low accuracy, BMDs must be fixed or replaced. Monitoring will give activists the evidence they need to convince election officials or judges to improve options for voters with disabilities. There is no necessary conflict between activists on disability rights and election integrity. Everyone wants accurate votes.

This approach to checking BMDs does not usually cure errors in ballots which have already been voted. It is one of many situations where measurement may not fix the immediate problem, but it minimizes future problems. The approach is similar to prosecuting fraud, where the verdict may not come for years. Elections cannot usually be re-run when audits show problems, or prosecutions prove fraud, yet finding the truth in as many tests as possible holds election suppliers and officials to account, and improves future election systems, whether they use BMDs or some other method to address the needs of voters with disabilities.

Coverage issues: Reports by activists on BMD success and failure are an opportunity sample.¹⁷ All reports should be sent to the central office and used. There needs to be special outreach to get reports from voters using the various input methods (audio, buttons, paddles, etc.) so accuracy of votes by people with disabilities is measured as well as touchscreen votes. It is also important to encourage people to use and monitor BMDs as soon as early voting begins, to locate and fix errors early.

It is valuable to have reports when the BMD is accurate, as well as when it is not, so accuracy rates can be compared across models, places and time. When the BMD is accurate, voters who prefer not to reveal their votes do not need to send the images, but they can still send the report of a successful vote, and if they are willing to send their image of their successful BMD ballot, it is still useful, so the central office can check the bar code or QR code

court testimony has said they are not, and outside experts have read them (Jeff Carlson 12/13/2020. Years-Long Court Battle in Georgia Reveals Dominion's Security Flaws, Weak Testing
themarketswork.com/2020/12/13/years-long-court-battle-in-georgia-reveals-dominions-security-flaws-weak-testing/)

¹⁵ Inconsistent codes for candidates within one jurisdiction:

- Buell, Duncan (December 23, 2018). [Analysis of the Election Data from the 6 November 2018 General Election in South Carolina](#) *League of Women Voters of South Carolina*
- Freed, Benjamin (January 7, 2019). ["South Carolina voting machines miscounted hundreds of ballots, report finds"](#). *Scoop News Group*

¹⁶ Halderman report on Antrim 2020 election: https://www.michigan.gov/documents/sos/Antrim_720623_7.pdf
RI: providencejournal.com/news/20170914/vote-tally-audits-criminal-sentencing-overhaul-on-ri-lawmakers-agenda

¹⁷ **Opportunity sample:** <https://www.simplypsychology.org/sampling.html>