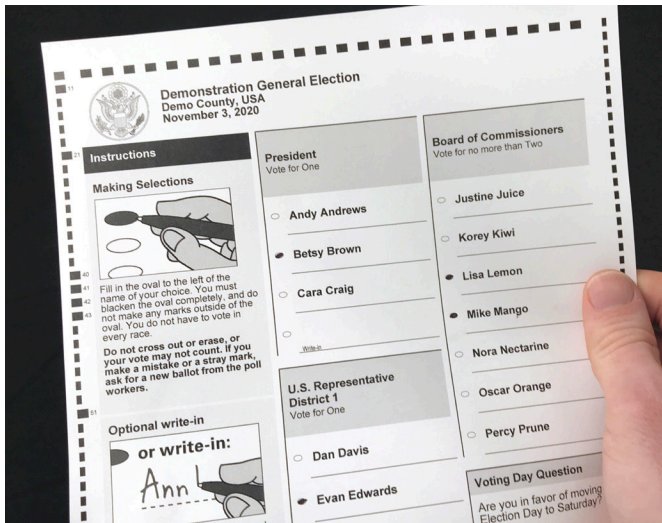


Barcodes in the Election Industry

Barcodes are used in a variety of applications across a range of industries to improve safety, accuracy, speed and efficiency. Our nation's elections systems are no different.



An example hand-marked paper ballot.



An example machine-marked paper ballot.

BARCODES COUNT AMERICA'S VOTES

Whether votes are cast on a hand-marked paper ballot or a machine-marked paper ballot, when paper ballots are tabulated by machines, barcodes are used to count votes.

Both hand-marked paper ballots and machine-marked paper ballots are secure methods of casting a vote. Post-election audits can fortify the security of the election under either voting scenario.

There are several important facts about how tabulators count hand-marked paper ballots and machine-marked paper ballots. In this paper, we examine the anatomy of a barcode, how they are used by America's voting systems, and why barcodes are both secure and accurate methods of casting and counting votes.

ANATOMY OF A BARCODE

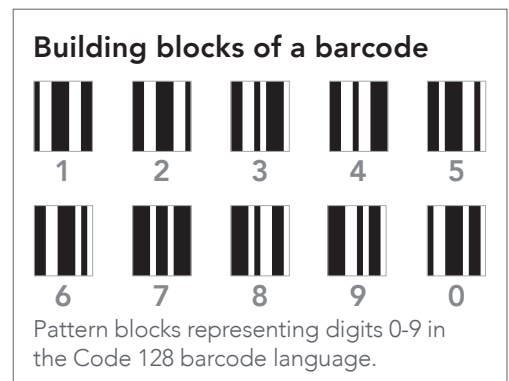
Barcodes are reliable and have been used commercially for more than 50 years. They are used extensively in the medical field where errors could be catastrophic.

A barcode is a pattern code – a group of lines and spaces that represent specific characters – which computers can read automatically to identify information in a database. For example, when an item is sold to a customer, a scanner will read the attached barcode, identify the unique number to the product and complete the sale by pulling the correct price and reducing the stock figures accordingly.¹ In the case of both hand-marked and machine-marked paper ballots, these lines translate to numbers that are grid coordinates and those grid coordinates correspond to a candidate name in a database.

Barcodes can come in various forms; however, in basic form, it's a black and white pattern. A standard UPC barcode (one of the most widely used barcode formats in the world) is made up of a series of digits, with each digit from 0-9 represented by black-and-white vertical bars that are scanned faster and more reliably than printed numerals.

Each digit is represented by a different pattern of black or white bars, designed to ensure that they accurately decode to the same number whether the barcode is scanned upside up or upside down.

Barcodes exist on both hand-marked paper ballots and machine-marked paper ballots and those barcodes are used in the same manner in both scenarios to tabulate votes.



¹ "Understanding Barcodes & the Benefits of Using Them," Orderwise™ Business Management Software, retrieved 28 May 2019 from <https://www.orderwise.co.uk/wp-content/uploads/Whitepapers/Understanding-Barcodes-And-The-Benefits-Of-Using-Them.pdf>

BARCODES ON A HAND-MARKED BALLOT

On a hand-marked paper ballot, often referred to as an oval ballot, voters make their choices by filling in ovals next to their desired selection.

When tabulating a hand-marked paper ballot, the system works like this:

- There is a master barcode along the left edge of the ballot and the top and/or bottom of a hand-marked paper ballot.
- When a voter hand marks the oval next to candidate Betsy Brown, for example, and inserts that hand-marked paper ballot into a tabulation machine, that tabulation machine is not reading the name, Betsy Brown. In fact, the tabulation machine does not recognize the text, Betsy Brown, at all. Rather, the tabulation machine first recognizes, through digital imaging technology, that an oval has been filled in. Then it uses the master barcode on the ballot to determine the grid coordinates of that filled-in oval.
- In this example, if the grid coordinates of the filled-in oval are “fifteen down, nine across,” the tabulation machine then queries the database. In essence, the tabulation machine asks the database, “what candidate’s name is associated with fifteen down, nine across?” The database, which has been pre-programmed and tested by the county/city election office, then tells the tabulation machine that “fifteen down, nine across” corresponds with Betsy Brown. At that point, the tabulation machine records a vote for the name Betsy Brown.

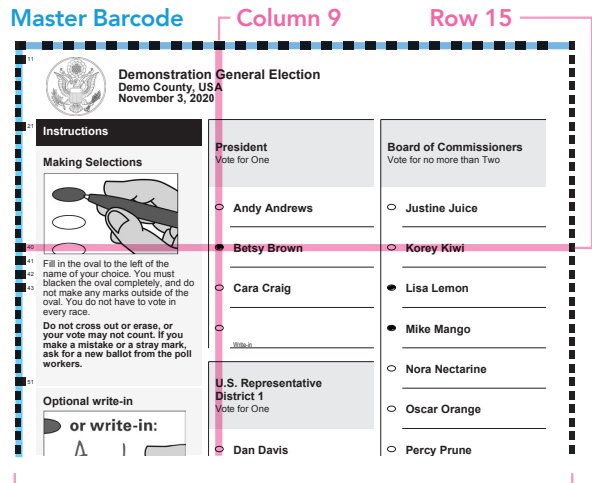
To confirm, even though Betsy Brown is the name printed next to that hand-marked oval, it’s the name Betsy Brown in the database that gets recorded.

BARCODES ON A MACHINE-MARKED BALLOT

Machine-marked paper ballots work the same way, except that the voter makes their choices by touching a screen instead of using a pen. Here’s how:

- When the voter selects Betsy Brown on the touch screen, the marking device prints out a paper record with the text Betsy Brown along with a barcode that contains the ballot coordinates of “fifteen down, nine across.”

How a tabulation machine reads a hand-marked paper ballot

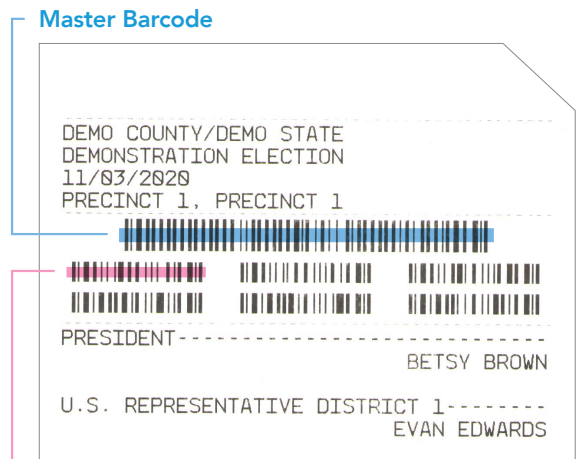


Page 1, Side 1

The tabulation machine recognizes that an oval has been filled in, then queries the database for the candidate listed for that oval’s coordinates. For example:

Column 9, Row 15, Page 1, Side 1 = 091511 = Betsy Brown

How a tabulation machine reads a machine-marked paper ballot



The tabulation machine reads the barcode which reveals grid coordinates, then queries the database for the candidate listed for those coordinates. For example:

091511 = Betsy Brown

- When that paper record is inserted into the tabulator, it performs the same actions as it does with the hand-marked paper ballot. It reads the barcode, which reveals the grid coordinates of “fifteen down, nine across” and then it queries the database on the tabulation machine (which is the same tabulation machine that counts the hand-marked paper ballot) asking which candidate name is associated with those grid coordinates.
- The database communicates to the tabulation machine that “fifteen down, nine across” corresponds to Betsy Brown. At that point, the tabulation machine records a vote for Betsy Brown.

Just as is the case with hand-marked paper ballots, the tabulation machine is only looking for the grid coordinates, and the cast vote records from both examples are identical.

BARCODES TABULATED USING OCR TECHNOLOGY

Evidence today indicates that tabulation systems that utilize Optical Character Recognition (OCR) incorporate the use of a type of barcode to count the vote. Here’s why:

It is possible that there could be two separate and distinct candidates, both named Betsy Brown, who are running for different offices on the same ballot. The system cannot use OCR to read “Betsy Brown” and record a vote reliably because it would have to know for what race the vote for “Betsy Brown” should be counted. Thus, the barcode is used to tell the tabulation machine for what race Betsy Brown should receive a vote.

In all cases, voter selections on the ballot are decoded, digitized, and used to look up the corresponding candidate in a pre-defined database.

ENSURING ACCURACY OF BARCODES IN TABULATION

For all types of ballots, jurisdictions perform pre-election logic and accuracy tests and post-election audits to ensure the accuracy of the aforementioned process.

Logic and accuracy tests verify the readiness of the system for the specific election. It is not just an equipment test. At least two elections officials or poll workers usually perform the logic and accuracy test, using the actual election definition and ballot formats.²

A post-election audit checks that the equipment and procedures used to count votes during an election worked properly, and that the election yielded the correct outcome.³ There is no single national auditing standard and methods can vary from risk limiting, fixed percentage, tiered audits, or a combination of one or more types.⁴

During both the logic and accuracy tests and the post-election audits, jurisdictions validate whether the actual text next to the filled in oval on the hand-marked paper ballot matches to the vote registered by the tabulation machine. This verification can only be done if the jurisdiction has access to the paper ballot and the cast vote record from the tabulation machine.

As noted above, logic and accuracy testing and post-election auditing provide a testable and auditable method to verify that ballots are programmed correctly and counted as the voter intended.

² “4.5 Logic and Accuracy Testing of System and Components,” U.S. Election Assistance Commission, retrieved 29 May 2019 from https://www.eac.gov/assets/1/6/ess-3011-Logic_Accuracy-use-procedures.pdf

³ “Post-Election Audits,” National Conference of State Legislatures (NCSL), retrieved 29 May 2019 from <http://www.ncsl.org/research/elections-and-campaigns/post-election-audits635926066.aspx>

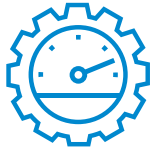
⁴ “6 Tips for Conducting Election Audits,” U.S. Election Assistance Commission, retrieved 29 May 2019 from <https://www.eac.gov/documents/2017/08/03/six-tips-for-conducting-election-audits-from-eac-audit-election-administration/>

BENEFITS OF USING BAR CODES



Greater accuracy

Accuracy is one of the most convincing arguments for using barcode technology. Studies indicate that even the best-trained data entry operator will make an error approximately every 300 key strokes. In comparison, even the simplest barcode has an error rate of less than .00025 percent.⁵



Greater speed

Using barcode scanning technology greatly increases efficiency.⁶



Reduced costs

By using barcode technology to improve accuracy and efficiency, election staff can process more ballots in a shorter amount of time, reducing manual labor costs. Using voting machines to mark ballots also reduces costs over time by utilizing blank card stock, BPA-free thermal printing paper. Unlike pre-printed ballots, jurisdictions can save the left-over stock for the next election.

SUMMARY

Barcodes are an integral part of our nation's democratic process. Tabulation machines that count paper ballots use them to determine how to properly count the vote. The security and accuracy of each method of voting is confirmed by election officials during logic and accuracy tests and in post-election audits – maintaining the integrity of America's elections.



ABOUT ES&S

Election Systems & Software's visionary approach to election equipment, software and solutions has helped improve the voting experience throughout North America for nearly 40 years. We are committed to developing integrated voting solutions that improve the marketplace and are flexible enough to meet multiple jurisdictions' needs and voter preferences. Learn more about ES&S at www.essvote.com.

⁵ "Barcode Reading and Accuracy," LabCE, retrieved 30 May 2019 from https://www.labce.com/spg650115_barcode_reading_and_accuracy.aspx

⁶ "Understanding Barcodes & the Benefits of Using Them," Orderwise™ Business Management Software, retrieved 28 May 2019 from <https://www.orderwise.co.uk/wp-content/uploads/Whitepapers/Understanding-Barcodes-And-The-Benefits-Of-Using-Them.pdf>