Ballot Images -- Essential or Worthless?

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What are "Ballot Images"?
Modern ballot scanners create a full digital image of both sides of each ballot as they are scanned, either at the polling place or central election office. After they are scanned, the voter intent is read from the image, and not directly from the paper. Today, 97% of the nation's most populous counties (representing more than 80% of the electorate) use equipment that creates ballot images.

Are they difficult to produce or save?
Voting machines that include ballot scanners meet design criteria that includes the ability to scan and save all ballot images during the voting period. Precinct scanners save ballot images to USB "thumb drive" memory sticks[1]. Central count scanners have an internal hard drive. At the end of the election, the images and results are transferred to the election management system software program and can later be exported and easily stored. Unlike paper ballots that consume a warehouse, a one terabyte USB thumb drive costs only about $30 and can store about 2 to 5 million ballot images -- far more than most counties produce in an election.

Ballot images are valuable public records that must be preserved
Of the four major voting machine makers, only one allows ballot images to be deleted as a configuration option. Sometimes, election workers reuse memory sticks and overwrite the data, while never uploading it. Ballot images should be preserved at least as well as paper ballots are. Some claim ballot images are unnecessary and redundant, only existing briefly, "one nanosecond"[2] was a recent quote. We can note that Wall Street operates with trades taking only microseconds, and they record them all. Our votes are no less important than financial transactions.

Ballot images are an important public asset, as follows:

1. **Easy Access:** Ballot images are far easier to locate, retrieve, and review than paper ballots themselves. To review a single precinct's paper ballots, you have to go into the warehouse, locate the box of ballots, break the seal, and then look through them while ensuring the ballots aren't altered or misplaced. In contrast, ballot images can be inspected any time, by several

[1] Ballot images from ES&S or Dominion consume an average of less than 300KB for two-sided ballots, and if designed to compress well, 200KB. Thus, on a 4GB or thumb drive no fewer than 13,000 or up to 20,000 two-sided ballot sheets can be stored, and double that on an 8GB drive. During one 12-hour election day, if ballot sheets are fed continuously at 1 sheet per 15 sec, a total of 2,880 sheets can be scanned, thus able to operate continuously for nearly 14 days on one 8GB thumb drive. If early voting periods persist for longer than 14 days, then additional machines can be deployed, or a single machine can be restarted with a second thumb drive.

[2] As stated by David E. Ramba, of Ramba Consulting Group on 3/22/2021 at the Florida House Committee Hearing (https://www.youtube.com/watch?v=TTzyNydQRkA) of course not to be taken literally. Flashing an image on the screen requires at least one frame, and could be typically no less than 1/30 sec, and human perception requires several frames, usually at least 0.1 sec. In reality, the voting machines may not flash the image at all, but it still exists in memory as an important record. Contrary to his testimony, the machines are designed to save images and many districts do so on a routine basis.

people, located anywhere, using any browser, without any risk to the paper ballots themselves.

Corporations and governments already understand the facility of scanning documents and referring to the digital images instead. Courts and Secretaries of State recognize the legal standing of document images, particularly when made using "trusted systems" in the regular course of business. Indeed, most companies that receive applications or other paper documents immediately scan them and shred the originals, relying only on the images.

2. **An Important Backup:** Paper ballots are respected as original source documents completed by voters. But paper ballots can be accidentally or deliberately lost, damaged, altered, or destroyed. Indeed, paper ballots can be marked by anyone with a pen to change the vote on the vote, by causing overvotes or votes in unvoted contests. Great care must be taken to secure the ballots but these all rely on pickable locks and the honesty of election workers and government officials. Once ballot images are created, however, modification of the paper can be detected because the images are far harder to change. And ballot images can be secured with cryptographic mechanisms so any alteration of the images themselves can be detected.

3. **Cost Effective:** Some may argue that it takes too much work to preserve and upload the ballot images from voting machines. But when you consider the entire life cycle of the ballot as a document, preserving documents as images saves money and improves efficiency.

4. **Simplifies review of overvotes, undervotes, marginal marks, write-ins**
Without ballot images, reviewing overvotes, undervotes, marginal marks, and write-ins requires a full review of all the ballots to find them, opening all the ballot boxes in the process. Instead, software-based review of ballots makes these steps feasible with far less work, cost, and risk.

5. **Keeps the paper ballots secure:** The ballot images can be reviewed without ever breaking the seal on the boxes of paper ballots. This keeps them secure and sealed.

6. **Useful for Ballot Image Audits:** An extremely powerful method of auditing an election is a "ballot image audit," where ballot images are reviewed by software to create an independent evaluation of voter intent and the outcome of the election[3]. And since the images are produced very early in the process and most hacking risks occur after the ballot images are already produced, ballot image audits are very powerful for most risks. Plus, the images are not exactly the same as the paper, as they are a digital representation, and thus it is important to keep this intermediate digital representation.

7. **Inspires vendors to improve quality:** Ballot image audits deal with the details of the election down to every mark on every individual ballot, unlike "risk limiting" audits that only tally or compare a hopefully small sample of ballots. This will put pressure on election equipment vendors to improve their systems. This feedback is important even if the outcome of the elections are not challenged by the audits.

[3] Citizens' Oversight has developed AuditEngine which can perform such an audit quickly using the vast resources of cloud computing, expert systems, and deep learning technologies.
https://copswiki.org/Common/AuditEngine

8. **Original images created by the voting system can expose quality issues:** Ballot scanners sometimes do not evenly feed the ballots, due to dirt or flat spots on the rollers caused by long storage periods or misalignment. This will sometimes cause images that appear "stretched" in those places where the paper paused briefly. Dirt on the scanner window can cause streaks and lines. If the ballot images are deleted, this important evidence is lost. Reviewing the image quality can enable the formulation of recommendations on either improving cleaning and maintenance, or retiring poorly performing equipment.

9. **Improves voter confidence:** Transparency is key to voter confidence. Ballot images provide a means for voters, candidates and campaign staff to substantiate election outcomes without involving election staff or requiring court orders. The recent election season should be proof that we need more transparency and easier ways to substantiate the result.

Can Ballot Images be "hacked"?
Some claim ballot images are a waste of time because they are not absolutely trustable, but unfortunately, that can be said about anything these days. It is true that voting machines that include scanners could be manipulated through sophisticated imaging software hacks to alter the ballot images as they are being produced. In such a scenario, the ballot images would then differ from the paper, and then audits performed based on the ballot images alone could not detect such alteration.

However, almost all hacking and alteration opportunities exist *after* the ballot images are created and thus could be caught by a ballot image audit. Steps can be taken to limit the possibility of an image-altering hack, but right now, there are so many other ways to modify the results that are easier, it is hard to imagine someone going to such lengths, particularly since ballot image audits are relatively new.

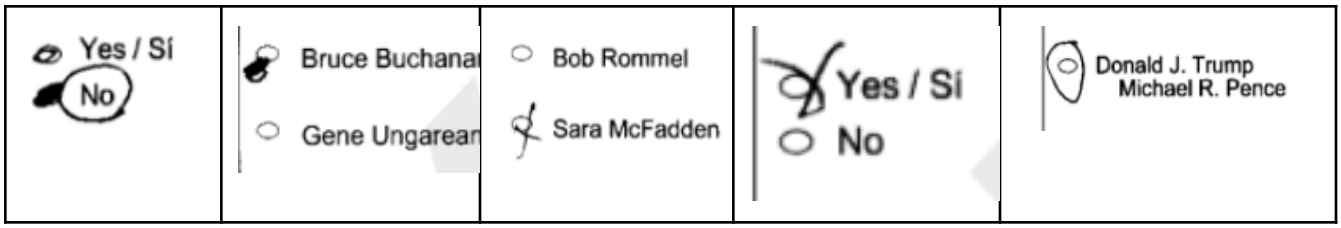
As we get better at securing ballot images the risk of such hacks will diminish to nearly zero. We have proposed improved cyber-security measures so the ballot images would be secured immediately as they are produced, thus making ballot image audits even more trusted. Yet, we agree that checking that the paper matches the ballot images is an important practice, and can be implemented as a statistical audit that directly samples paper or compares with independently scanned batches. Of course, if the ballot image audit *does* expose potential fraud, a full hand count or new election will likely result rather than conducting a statistical audit.

Ballot Images should be published for anyone to review
There is no longer any doubt that ballot images are public records. We believe these records should be made public for anyone to review, with no cost burden to the public. It is not possible to link any properly completed ballot with any voter without additional information. Distinctive marks like signatures, initials, etc. are illegal. But to be on the safe side, these marks can be redacted. A good model for transparency is San Francisco County, where they have been routinely posting all ballot images and providing an interface for the public to review them[4]. In the 2020 General Election, they posted all 1.5 million ballot images.

[4] https://ballotaudit.com/sanfrancisco/#/login

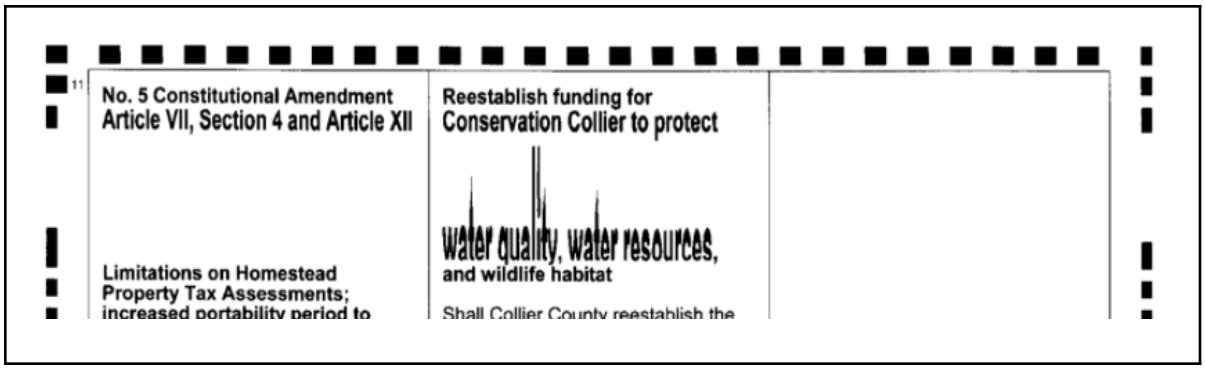
Misinterpretation by voting machines

It is useful to look at several actual examples of ballot marking which was improperly interpreted by the installed voting machines compared with the interpretation by a ballot image auditing platform, AuditEngine. These examples are from Collier County, FL in the 2020 General election, using ES&S (Election Systems & Software) equipment. In ballot images that are not stretched or corrupted, AuditEngine correctly interprets voter intent 97% of the time when there is a disagreement with the official result. Here are some typical cases where the voting system interpreted voter intent incorrectly while AuditEngine was successful.



Stretched ballot image

An example of a "stretched" ballot image, which results when the paper is briefly delayed and is not fed evenly. If such stretching occurs where voter completed ovals exist, it might cause the vote to be interpreted incorrectly. By keeping the ballot images for evidence, it is possible to improve procedures to clean and maintain the machines, particularly the rollers, and perhaps take machines out of service that have serious problems.



Bottomline

Ballot images are essential. They must be created, preserved, and made public. The benefits clearly outweigh any additional costs or considerations.

Respectfully submitted,
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Lutz, MSEE, has over 34 years of experience in high technology fields including document imaging technology, and is the creator of AuditEngine, an independent ballot image auditing system. For more information, visit: https://copswiki.org/Common/AuditEngine