

AuditEngine

Case Study Report:
**2020 Election Ballot Image Audits in Collier County,
Volusia County, and St. Lucie County Florida**

Raymond Lutz
Executive Director and Lead Developer,
Citizens' Oversight Projects

V1 May 30, 2021

V2 June 24, 2021: Editorial Corrections

V3 July 11, 2021: Editorial Corrections

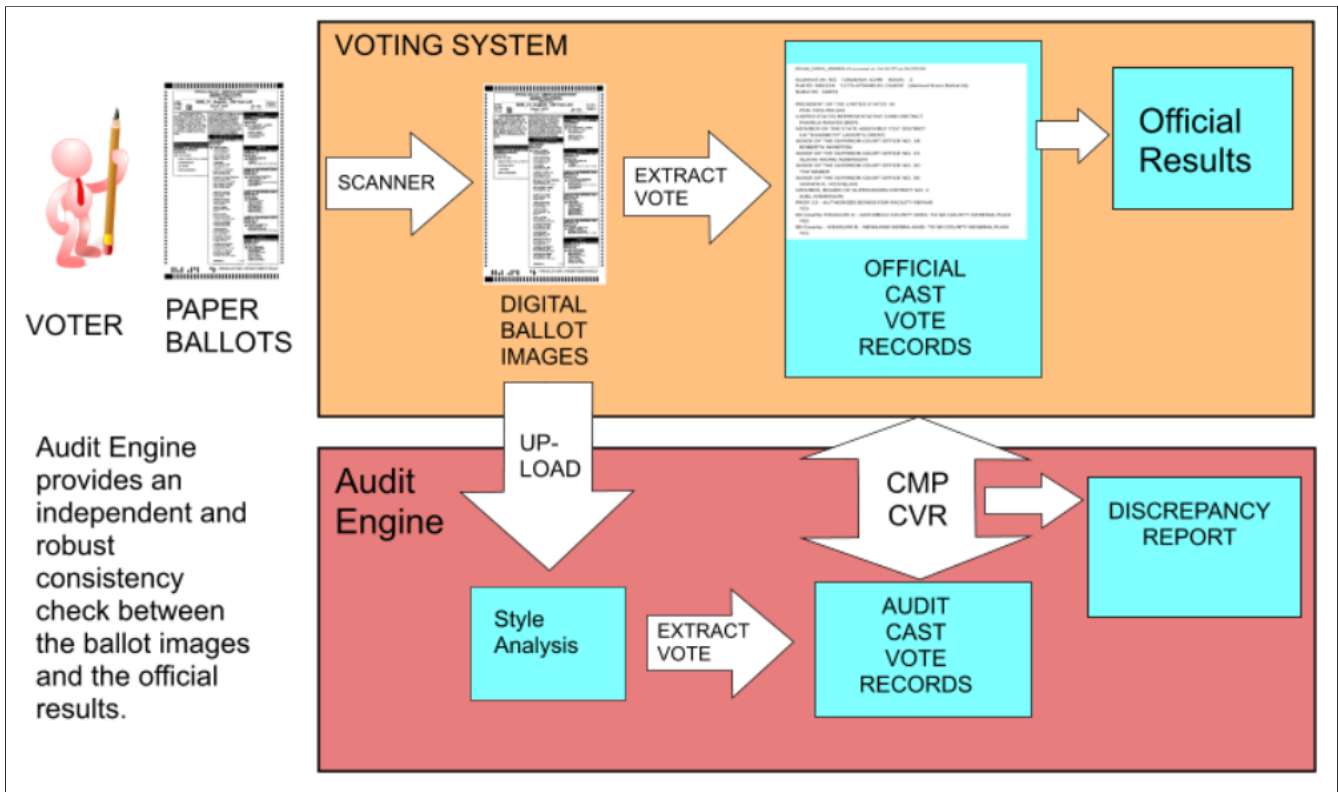
Citizens' Oversight Projects
is a 501(c)3 nonprofit and
nonpartisan organization
<http://citizenoversight.org>

Executive Summary

This document summarizes results of performing election audits of ballot images in three counties in Florida: Collier County, Volusia County, and St. Lucie County. These audits were performed using the "AuditEngine" platform being developed by Citizens' Oversight Projects, also known as "Citizens Oversight" or "COPS."

The goal of this case study report is to provide readers an understanding of the capabilities of AuditEngine and to show how ballot image audits can improve the overall quality of election processing.

At a high level, the operation of AuditEngine is simple. It interprets images of ballots created by the voting system, compares its interpretation with the official results of each ballot, and creates an independent tabulation of the results. It can find most errors and hacking scenarios because it works with the ballot image, a digital picture and the first recording of voter selections into the voting system.



Collier and Volusia Counties both use Elections Software & Systems (ES&S) voting systems whereas St. Lucie County uses Dominion Voting Systems (Dominion). For Collier and Volusia, we were able to compare the results between AuditEngine and the voting system down to the individual ballot, because those systems can provide the "Cast Vote Record" (CVR) file to ballot-level detail. In those counties, we detected disagreements at the rate of less than about

0.23% (23 disagreements per 10,000 ballots) or less. The disagreements were based on two issues:

1. Differences in how the voting system or audit system interprets voter intent.
2. Ballot images that were corrupted, usually "stretched," causing differences in interpretation by the two systems.

In no case was the outcome of the election cast into doubt due to these disagreements. When there was a disagreement between the results of the voting system and the evaluation of AuditEngine, in most cases (93% in the sample shown in Appendix 1), AuditEngine correctly interpreted voter intent (while the voting system did not). When there is a disagreement between the results of the voting system and AuditEngine's evaluation, the correct interpretation becomes clear by looking at the disputed ballot image.

Even though the outcomes of the election in these counties were not challenged, AuditEngine did find a number of discrepancies in terms of how the election was processed, and this information can be used to improve elections in the future.

In Volusia County, AuditEngine discovered a duplicate set of 4,904 ballot images, which turned out to be a result of a USB flash drive¹ failure and the subsequent rescanning of all ballots for one of the county's early voting sites. We have been told that the USB device failure and rescanning of ballots were reported on Election Day in front of the Volusia Canvassing Board, political party representatives, media, and other observers. Yet, this event was not reported in the county's statutorily required Conduct of Elections report, which is used by the state to evaluate voting system problems. The county was unaware of the duplicate set of ballot images until they were discovered by AuditEngine.

Additionally in Volusia County, one USB drive containing 537 ballot images was accidentally overlooked and not uploaded from one polling-place voting machine. The county was unaware that the USB drive had not been uploaded until it was revealed by AuditEngine.

In St. Lucie, the older Dominion system doesn't create CVR files, and we discovered that without a CVR file to provide the precinct and official interpretation of voter intent for each ballot, it is not feasible to easily diagnose discrepancies.

This table provides the overall profile of the election in these counties:

County	Collier County, Florida	Volusia County, Florida	St. Lucie County, Florida
Population in 2019	384,902	553,284	328,297
Eligible voters	231,708 (60%)	398,530 (72%)	223,640 (68%)

¹ We use the term "USB flash drive" or "flash drive" to indicate a small non-volatile memory device, which may use a USB connection, or it may be an SD memory chip, for example, or any other physical realization.

Turnout:	209,352 (90.4%)	309,367 (77.6%)	173,488 (77%)
Outcome Bias ² :	"Red": Trump 62%	"Red": Trump 56%	Even: Trump 50.38%
Voting System:	ES&S	ES&S	Dominion
BMD Ballots	39	132	(none)
Sheets	All voters received 2 sheets.	Some voters used 2 sheets.	One sheet for all voters
Ballot images	417,777	364,555	173,774

Summary of issues with each county:

Collier County, Florida

Collier county had very clean files and we were able to use automated mapping with only a couple of graphical tweaks. Although Collier was medium sized, they had the most ballot images since every voter had a two-sheet ballot with both English and Spanish included on every ballot style. The ballot styles scheme was therefore very simple, as the style would differ only if there was a change in the contests on the ballot.

There was initially an excess of 39 ballot images until we discovered that Collier County duplicated the ballot images of each BMD ballot, allocating one to the sheet 1 contests and the other to the sheet 2 contests. This was not a mistake but a way to treat the BMD ballots the same way in the CVR file. Once this duplication issue was found, the number of ballots matched exactly. There were 0.078% disagreements and 4 failed ballots.

Volusia County, Florida

In Volusia County, we initially found that the number of ballot images provided were about 41K images too few. The County then re-exported the images, which we inventoried and found that there were 4,904 additional ballot images over the number expected, and 537 missing ballot images. Volusia County did not report any issues in their "Conduct of Election Report." However, we learned that there were two issues that caused these discrepancies, one of which was reported to the Canvassing Board and one of which Volusia County was unaware of until discovered by AuditEngine.

1. First issue - More ballot images than ballots cast: As they started to tabulate votes from the New Smyrna Beach early voting site, they successfully uploaded the first USB flash

² The outcome bias is how the county voted in the presidential contest, and whether those who voted were evenly split, or "Red" (Republican) or "Blue" (Democratic) outcome. This is more than leaning, it is the actual official outcome bias.

drive, but the second one failed. Because some ballots from this early voting site had already been processed and others hadn't, the Supervisor of Elections and the Canvassing Board made a decision to start over, reset the tabulation, and rescan all the paper ballots from that early voting site. They zeroed out the results, but they did not realize that the ballot images and corresponding Cast Vote Records (CVRs) were not deleted when the results were deleted. This resulted in 4,904 duplicated ballot images (and CVR records) from the first successfully uploaded USB flash drive. These images were scattered throughout the ballot image archives, and there is no easy way to find them. We did confirm that the ballots were indeed duplicated as we could find identical ballots with distinctive marks.

2. Second issue -- more ballots cast than ballot images:

In Volusia County, as in most Florida counties, the results from all Election Day precincts are wirelessly modemed back to the central elections office on Election night after the polls close. The corresponding ballot images reside on the USB flash drive(s) in each voting machine and are not uploaded on Election Night. Instead, the USB flash drives are brought back to the central election office and uploaded into the EMS later. USB flash drive from one of the two machines was not uploaded in this second step. As a result, 537 ballots images and CVR records were not included in the data provided to AuditEngine, even though the results from this machine were included in the official results. We confirmed this by conducting an audit of the digital poll tapes produced by the election day voting machines.

This second issue was not known until we reported it as a result of our audit while the first issue was known and was dealt with transparently before the Canvassing Board and members of the public. Neither issue was included in the original Conduct of Election report.

We view these two issues as shortcomings to the ES&S EMS software because it should not be possible to keep ballot images and CVR records if the tabulation is zeroed out. Volusia County could not identify which records were duplicated, but we did prove that the duplicates were there as we found some examples. The system should notify the elections administrator if USB upload results are missing, based on the number of machines that were originally programmed.

Despite these issues, we were still able to compare the result from AuditEngine with the official result and determine an overall disagreement rate of 0.237%, or about 24 disagreements per 10,000 ballots.

St. Lucie County, Florida

St. Lucie County could not generate a ballot-level CVR report, and so we were unable to compare the result from AuditEngine with the official result on a ballot-by-ballot basis. This appears to be a common problem in Florida as the certified Dominion software that is deployed does not provide adequate functionality for detailed audits.

If we don't have the detailed CVR, then even though we can't compare ballot-to-ballot, we may be able to compare audit results to the official results on a precinct basis. However, comparing by precinct relies on accurate allocation of ballots to the appropriate precinct. We attempted to read the precinct from the ballot but it was inconsistent and unreliable to the extent we needed.

However, it was an opportunity for us to tune up our software to reliably read the proprietary Dominion bar code from the image and understand the limitations of processing such a county with inadequate detailed reports.

Since then, we have also conducted an audit of the Bartow County, GA election and have continued to improve our capabilities with Dominion ballot images and files. The Bartow County audit was not ready to be included in this report. However, we will note that in Bartow County, about 80% of the ballots were BMD ballots, and only 20% were hand-marked paper ballots. We have trained AuditEngine to parse the readable text summary on the BMD summary sheet rather than relying on the QR Code, which is not voter verifiable.

Other Results

Computer-aided mapping prevailed over "fully automated" mapping

We use the term "mapping" to refer to the process of identifying the exact location of a target (the oval a voter can fill to indicate their selection) and linking it to the contest and option it refers to.

These audits were extremely useful in the development of AuditEngine as it resulted in a significant change in our "mapping" approach. We moved from a fully automated mapping strategy to a computer-aided mapping methodology using an interactive browser application. We believe that this will be far more successful and actually require less human interaction than the so-called "fully automated" approach; and operators need not have extensive knowledge of algorithms and settings to accomplish this step. The fully automated approach actually required quite a lot of manually entered information that the computer aided method also requires but in an easier and less error-prone way. In some cases the computer aided approach may take longer, but the good news is that it will always work, whereas the automated method is not feasible in some cases.

Gray backgrounds should not be used

We discovered that gray backgrounds added to the contest title caused the size of ballot image files to be substantially larger, requiring 2 to 3 times the memory. Therefore, shaded backgrounds should be avoided.

Improved procedures for uploading flash drives from voting machines should be developed

We found that the data from the flash drive of one voting machine in Volusia County was not uploaded to the voting system, although the results (not including ballot images) were obtained for that machine using wireless modems.

Zeroing out an election should not allow orphan ballot images and CVR entries

Zeroing out results should not allow orphan ballot images and cast-vote records to remain in memory and be merged with the active set, as occurred in Volusia County.

All issues should be reported in the Conduct of Election Report

We found that issues in Volusia County were not included in the Conduct of Election Report, including the failure of a flash drive and the need to fully rescan ballots from the New Smyrna Beach early voting site.

AuditEngine does a better job of interpreting voter intent than voting system

In the discrepancy report for Collier County, Florida, we found that when there was a disagreement about a vote between the voting system and Audit Engine, excluding ballot images that were "stretched" or otherwise corrupted, AuditEngine was able to correctly interpret voter intent 93% of the time, whereas the voting system correctly interpreted voter intent only 7% of the time, without any human adjudication. This is due to our "adaptive thresholding" algorithm which is fine tuned to optimize results.

Ballot Image Audits using original ballot images can expose voting machine defects

Ballot images are sometimes distorted or "stretched" when ballot scanning is temporarily delayed in the voting machine, due to dirt or flat spots on the rollers. This problem usually only occurs in the small scanner devices in polling places rather than in the larger central count scanners. AuditEngine can be a good tool to identify distorted images, and we can recommend that these machines be removed from service if the defects can be correlated to specific voting machines. In any case, we recommend that election officials clean the rollers and make sure the voting machines are run prior to use in the election to smooth out the scanning.

Watermarks on the ballot images like "COPY" should be avoided

We found that a watermark which was added to the image caused AuditEngine to incorrectly evaluate a vote, although it did mark it as "marginal." These watermarks serve no reasonable purpose. Of course the ballot image file is not the original. Election offices should avoid adding watermarks to ballot images.

Clearly, such ballot image audits can provide an important quality check on the election. There is no claim made here that such an audit is sufficient to fully confirm the election results

as correct. Any audit of this type, or really any forensic examination, can only claim that the evidence is consistent with the results. However, if serious discrepancies are discovered, then those are sufficient to force a more thorough examination, such as a full hand count, or in some cases require a new election.

TABLE OF CONTENTS

Executive Summary	1
Summary of issues with each county:	3
Collier County, Florida	3
Volusia County, Florida	3
St. Lucie County, Florida	4
Other Results	5
2. Introduction	9
2.1 The Landscape	10
3. The Process	10
3.1 Step-by-step Overview	10
3.2 Input Files: Ballot Images	12
3.3 Cast Vote Record Files	14
3.3.1 CVR Files in General	14
3.3.2 Ballot images and CVR Files in Florida	15
3.4 Other Configuration Files	17
3.4.1 Election Information File (EIF)	17
3.4.2 Target Map	17
4 Ballot Styles	17
4.1 Styles Overview	17
4.2 Style Determinants	18
4.3 Style Designation	19
4.4 Styles and Mapping	20
4.5 Our Pursuit of Automated Mapping	20
4.6 Computer-Assisted Mapping	21
4.6.1 Overview of the TargetMapper user interface	21
5. Vote Extraction	22
5.1 The Vote Extraction Process	22
5.3 Audit Election Outcome Report	23
6 CVR Comparison	24

6.1 The CMPCVR process	24
6.2 Discrepancy Report	24
6.2.1 Disagreements	24
1. Voter intent interpretation:	24
2. Stretched or deformed ballot images:	25
7 Adjudication	25
8 Details of Three Counties in Florida	26
8.1 Collier County	26
8.1.2 Ballot Inventory: Collier County	26
8.2 Volusia County	29
8.2.2 Volusia County: Precheck Report Balance Check	30
8.2.3 Volusia County: BIF Report Balance Check	32
8.2.4 Volusia County: CVR vs Official Results Manual Check	33
8.2.5 Volusia County: Voter History File	35
8.2.6 Inquiry with Volusia County -- 4K Discrepancy -- Ballot Images vs. Ballots Cast	36
8.2.7 Volusia County: Missing Ballot Images and CVR Records -- Digital Poll Report Audit	37
8.2.8 Volusia County: Follow-up on discrepancies	39
8.2.9 Volusia County Discrepancy Report	43
8.3 St. Lucie County	45
8.3.1 St. Lucie County: Ballot Inventory	45
8.3.2 St. Lucie County: Creating the Ballot Information File without a CVR	46
8.3.3 St. Lucie County Discrepancy Report	48
9. Overall Summary and Findings	51
10. Conclusion	54
Primary Author: Raymond Lutz	55
Acknowledgments	55
How to Comment	55
APPENDIX 1 -- Disagreements in Collier County	56
APPENDIX 2 -- Links to detailed reports	67

2. Introduction

Auditing elections is an essential element in thwarting attacks on our democracy, providing solid evidence that the results are complete, honest, and trustworthy.

AuditEngine, a software platform developed by Citizens' Oversight Projects and led by Ray Lutz, is an important and powerful tool for proving consistency between ballot images created early in the process and the final tabulation. This consistency is important evidence that our election outcomes are accurate and trustworthy.

Far too often, the public finds that election evidence is processed behind closed doors, inside computers controlled by just a handful of for-profit corporations. Paper ballot evidence, if it exists, is often sealed and sequestered, and impossible to review by members of the public.

In recent years, voting machines have evolved into full-page scanners which create digital images of both sides of every ballot sheet, typically at the resolution of 200 pixels per inch. Voting machines use the ballot image, rather than the paper ballot itself, to evaluate voter intent by recognizing and interpreting the marks on the image as votes. Thus, because the images are a critical step in the operation of these machines, they are considered "public records" which must be preserved and frequently can be provided per public records and freedom of information laws, while still preserving the original paper records.

Since the ballot images are created very early in the process, they can be used to thwart all later modifications to the tabulation. The images can be secured using digital security mechanisms to ensure that any changes to the ballot images themselves can be detected³. Some may say that ballot images cannot be 100% trusted, and we agree. But paper ballots are also difficult to fully trust as they can be modified, added, subtracted, and depend on election officials' honesty and competence. We regard the use of ballot images as an important check on the paper, and the paper a check on the images. Both should be included in any complete auditing program.

Review of the ballot images to create an independent tabulation of the election can detect many types of errors or subsequent modification of the totals, either by honest mistakes, a compromised insider, or intrusion by an outside hacker.

Audit Engine provides a very detailed review of the inventory of ballots in the election which can expose processing mistakes and help elections officials and election software vendors to improve their procedures so these mistakes can be avoided in the future. Even when election

³ Although this will be possible in the future, these security mechanisms have not been standardized nor adopted by the voting machine makers.

winners are not in doubt, ballot image audits help to improve the quality of election processing.

2.1 The Landscape

Today, elections equipment and voting machines are supplied by three top vendors⁴:

1. Election Systems and Software (ES&S) -- This company holds approximately 47% of the market. ES&S serves about 1,668 county-level jurisdictions across the U.S.⁵
2. Dominion Voting Systems -- This company holds about 37% of the market, serving more than 1,300 jurisdictions, including 9 of the largest 20 counties in the USA.⁶
3. Hart Intercivic⁷ -- This company has about 10% of the market.

AuditEngine addresses election tabulation and does not at this time directly audit signature validation or voter eligibility, although the tabulation results can be compared with the number of voters that are recorded as casting a ballot. At this time, AuditEngine is compatible with ES&S and Dominion, and we are in the process of adding Hart.

We are concerned mainly with hand-marked paper ballots, but AuditEngine can also process Ballot Marking Device (BMD) ballots, which may have linear or 2-D barcodes identifying the selections by the voter, and which are read by the voting system equipment. AuditEngine uses optical character recognition (OCR) to read the human-readable portion of the ballot summary cards the BMD devices produce and does not rely on the barcodes, unlike the voting systems themselves.

3. The Process

This section provides a brief overview of the AuditEngine process. More detail follows the overview.

3.1 Step-by-step Overview

Step	Description
Gather Input Data	AuditEngine needs ballot image data and preferably "cast-vote record" (CVR) files. Ballot image files and CVR files can be uploaded directly to AuditEngine in "the cloud." If the CVR files are

⁴ Verified Voting "Verifier" provides 21 pages of results for Dominion and 64 pages of results for ES&S. But it would be more accurate to consider not the number of jurisdictions, but the number of voters using each type of voting system.

⁵ <https://www.essvote.com/faqs/>

⁶ <https://www.dominionvoting.com/about/>

⁷ <https://www.hartintercivic.com/>

	not available, then the complete list of contests and options as well as the official results must be accessed, and included in configuration files.
"Precheck" Create Ballot Image Inventory	This step conducts an inventory of the ballot images and compares it with the total number of ballots cast and also to the number of CVR File records, if available. The precheck report can help to get all the ballot image files, locate duplicate files, and perform an initial consistency check in terms of the raw number of ballot images compared with the official vote count.
Preprocess	If the CVR files are not available, it may be necessary to preprocess all the ballot images to read the frame of the ballot, so a style analysis can be performed. The style is typically encoded into proprietary barcodes. This pass does not attempt to read the vote.
Derive style templates	Templates are created for each style identified. We create the style templates from the ballots themselves rather than require that election officials provide clean masters of each style.
Map Targets	<p>It is necessary to determine, for each ballot style, the location of each contest option target that could be darkened if the voter selects that option. AuditEngine supports three approaches:</p> <ol style="list-style-type: none"> 1. Computer-assisted mapping. In this option, a graphical interface is used by a human operator to associate the targets on the ballot images with the contest options in the election. 2. Automatic segmentation, recognition of text, and mapping to the contests and options in the election. This requires pre-defined ballot formats, such as standard boxes around contests, and additional input files to provide the exact labels of contests and options if they differ substantially from the official contest and options. Our experience is that the manual information and hints required for the automatic method to work is similar to the work required for computer-assisted mapping, and the knowledge and expertise is much higher. 3. Use of exported coordinates of contests and options from the election management system. <p>In all cases, "redline" proofs of the mapping are prepared that show the targets outlined and annotated so they can be easily reviewed. These must be reviewed and approved by analysts, stakeholders, and the public. Mapping is a critical step because an error in the map can significantly alter the result.</p>

Vote Extraction	With the mapping information approved, the complete ballot image set can be processed. Each ballot is read from the ZIP archives, aligned and trimmed, the darkness of each target is evaluated, and the vote is determined. AuditEngine uses an adaptive thresholding algorithm to adjust to the habits of each user. Because AuditEngine runs in the cloud, up to 10,000 virtual computers can be used in parallel to reduce the overall time for extraction to about 15 minutes or less from nearly four months using a single computer..
Extraction Report	This report documents the extraction process itself, the number of marks detected, and the distribution of those marks.
Summary Results Report	The report of the extraction provides the overall statistics for each contest. This can be compared with the overall outcome of the election.
Discrepancy Report	If the cast-vote records (CVR) files are available broken down to the ballot, then the result of the vote extraction can be compared with the official result on a ballot-by-ballot basis. This is also performed in parallel. The result of this step is a Discrepancy Report, where the number of disagreements between the audit result and the official result are detailed, and the image of the ballots with discrepancies are provided for review.

3.2 Input Files: Ballot Images

Modern voting equipment used in most districts in the U.S. create ballot images⁸ as they process the ballots. Of the ten battleground states in the 2020 General Election, our review indicates that 93% of the most populous jurisdictions (accounting for 80% of the electorate in each state) use voting equipment that creates ballot images as the ballots are scanned. Thus, ballot images are now widespread.

It is essential that the election equipment be set so the ballot images are not deleted after they are used to extract the vote, and then the election departments should preserve them, and publish them for later review.

Ballot images are also anonymous. Typically by law, no personal information about the voter is allowed to be added to these ballots. Thus, if the voter adheres to those laws, there is no way to determine the identity of any voter by looking at the ballot images alone. Although ballots are sometimes reviewed by hand, AuditEngine minimizes human review of individual

⁸ The term "ballot image" was initially used to refer to the digital summary of a DRE (Direct Recording Electronic) AKA "touch-screen" voting machine, and was not an actual picture of a hand-marked paper ballot, which is how the term is now used. This has been reflected in the latest Voluntary Voting Systems Guidelines (VVSG) 2.0 now being processed by the Election Assistance Commission.

ballot images. Even if some personal information is included on the ballot, there is no way to link it to any particular voter. Thus, we believe any attempt to limit the release of ballot image data due to respect of voter privacy is unfounded.

Even though we believe ballot images do not provide privacy concerns, and we strive for complete openness of the data we develop during the audit process, we realize in some situations it may be necessary to maintain security, and that is one option of AuditEngine.

[We have proposed a method where the scanning equipment will cryptographically secure the ballot images as soon as they are created by calculating the SHA⁹ code of each image and signing it using the embedded private key in the voting machine, so that it is infeasible to change any ballot image without detection. Publishing SHA codes of the ballot images secures them from any modification while not actually revealing the ballot images themselves until after the election.]

These images are transferred to the "Election Management System" (EMS), typically during the processing of the election by officials. The EMS performs many aspects of election processing and is provided by the voting machine vendor.

Scanners that are located in polling places scan the paper ballots to create images, and then capture votes from the ballot images, and then the result is transferred to the election office. The transfer sometimes uses a communication link (such as cellular modem) to transmit the totals of each contest from that location to the central office so as to allow rapid reporting to the media on election night. Also, USB flash drives are used to transfer the details of the results, including ballot images. The USB flash drives are paired with each scanner and include configuration information to allow the scanners to properly interpret the vote.

Vote-by-mail (VBM) ballots and sometimes some or all of other ballots are scanned in centralized scanning operations. For such "central-count scanning," the images are typically stored in large (maybe 1TB or larger) internal hard-disk drives in the scanner, and may be transferred to the EMS using a local-area network which does not connect to the Internet.

Once the election is complete, or perhaps in phases prior to certification, the EMS can export the ballot images for use by AuditEngine or other reviewers. These should be placed into ZIP archives¹⁰ with about 10,000 to 50,000 ballots per archive, for ease of handling. AuditEngine

⁹ SHA means secure hash algorithm, which creates a distinctive bit sequence for any given ballot image which will likely differ from any other ballot image.

¹⁰ [https://en.wikipedia.org/wiki/ZIP_\(file_format\)](https://en.wikipedia.org/wiki/ZIP_(file_format))

accepts image formats as provided by the vendors, including PDF¹¹, TIFF¹², PNG¹³, PBM¹⁴, and JPG¹⁵.

Ballot images from the leading voting equipment vendors (ES&S and Dominion) consume about 200KB to 600KB to store both front and back of a single ballot sheet, when compressed in PDF (or similar) formats. BMD ballots may take substantially less space.

3.3 Cast Vote Record Files

3.3.1 CVR Files in General

The purpose of an audit is to check the official outcome of the election. The official outcome can be provided at different levels of granularity. AuditEngine can provide the most detailed reports if the Cast Vote Record files (CVR files) provide the official interpretation of the votes on each ballot. Produced by the EMS, each record of a CVR file corresponds to and is linked with a single ballot image. These files must be machine readable to avoid errors that might otherwise be introduced¹⁶. Summing the votes for each contest on each of these records should produce the officially reported outcome.

AuditEngine can provide the most feedback when the CVR Files are available because the result can be compared on a ballot-by-ballot basis and the interpretation of the marks can be reviewed if the interpretation differs. But if the CVR Files are not available, AuditEngine can produce an independent high-level or precinct level result which can be compared to the official outcome.

Frequently, CVR Files are provided in spreadsheet format, where each row is a ballot image (one sheet, front and back) and each column are the contests and options. In other cases, they may be provided as JSON¹⁷ or XML¹⁸ format or CSV¹⁹ (character separated values) files.

These files are generally non-standardized formats that vary with each vendor. The National Institute of Standards and Technology (NIST) has also recently promoted a "Common Data Format"²⁰ that may provide some standardization in the future, but at present, we accept the proprietary formats and will strive to read any reasonable file format.

¹¹ <https://en.wikipedia.org/wiki/PDF>

¹² <https://en.wikipedia.org/wiki/TIFF>

¹³ https://en.wikipedia.org/wiki/Portable_Network_Graphics

¹⁴ https://en.wikipedia.org/wiki/Netpbm#File_formats -- used only by legacy ES&S machines

¹⁵ <https://en.wikipedia.org/wiki/JPEG>

¹⁶ Dominion provides the official interpretation in a graphical image which is NOT machine readable without performing an error-prone OCR conversion, and is therefore not very useful due to the errors that are induced with that conversion.

¹⁷ <https://en.wikipedia.org/wiki/JSON>

¹⁸ <https://en.wikipedia.org/wiki/XML>

¹⁹ https://en.wikipedia.org/wiki/Comma-separated_values

²⁰ <https://www.nist.gov/publications/cast-vote-records-common-data-format-specification-version-10>

Note: The term "Cast Vote Record" can be the source of some confusion because it sometimes refers to other things. ES&S uses the term to refer to PDF files which can be produced with the ballot images. One CVR PDF file summarizes in readable format the voting-system interpretation of one ballot sheet. Dominion has a similar summary they call the "AuditMark"²¹ as the third page in the ballot image file itself. These are NOT used by AuditEngine because we believe using the files which include all the records is more secure because it puts all the images together into one unified report, which is much harder to modify. To disambiguate this term, we will always say "CVR Files" to indicate the "spreadsheet" files (typically XLSX²² or CSV, or structured JSON) that provide the interpretation of the voter intent on the ballots in a machine readable format.

There are a number of very important fields used in ballot image auditing and may be included in the CVR, although using vendor-specific nomenclature:

1. **ballotid** -- a unique identifier of ballot image. Rarely, this is imprinted on the corresponding paper ballot and then it also appears in the ballot image. Generally, there are no identifying numbers on a ballot. If the identifier is imprinted on the paper ballot when it is scanned, the identifier can be used to marry the ballot image to its physical paper ballot. The identifier may be a number but it also sometimes includes other characters.
2. **ballot_style** -- an identifier for the style of ballot. It is helpful to have the style of the ballot also listed in the cast vote record for each ballot. The ballot_style value should have a direct relationship to the code encoded on the ballot using a graphical barcode.
3. **precinct** -- the precinct to which ballots refer. This is not required for ballot image audits, but is necessary to allow comparison with other reports that group the results by precinct. Sometimes, this is provided in the ballot image archives.
4. **batch** -- If ballots are not grouped into precincts, such as when received as vote-by-mail or from voting centers that allow voters from any precinct to vote, then the ballots may be grouped into mixed-precinct batches. It is best to also denote the batch so the paper ballots can be located and reviewed if desired. Unfortunately, this is frequently not provided.

3.3.2 Ballot images and CVR Files in Florida

The availability of ballot images has been a concern in Florida, even though ballot images are embraced as disclosable public records. Even though the major vendors produce ballot

²¹ <https://www.votescount.us/Portals/16/New%20voting%20system/AuditMark%20Brochure%20-%20final.pdf>
AuditMark is a registered trademark of Dominion Voting Systems.

²² https://en.wikipedia.org/wiki/Office_Open_XML

images in the process of capturing the vote from the ballots, the feature can be disabled in ES&S machines, which offer three options: 1) Save all images, 2) Save only ballot images with write-ins, and 3) Delete the images.

We have mixed information regarding whether Dominion voting machines also have an option to **not** create and save ballot images. The newest generation appears to provide ballot images and the full cast-vote record files without an option to delete them.

The creation of ballot images by the voting equipment and audits of those ballot images is a relatively new concept. Thus, it may be met with some suspicion and confusion by election workers. As we are still refining the algorithms and tools needed to perform ballot image audits, we relish the opportunity to process any ballot image sets we can obtain, and we appreciate funding assistance for cloud computing costs.

In the 2020 General Election, officials in many Florida counties had planned to save only images with write-ins, and they felt it was not feasible to reconfigure their voting machines prior to the election. There were also claims that it would not be possible to record all the ballot images in the 4GB USB flash drives that are used in these machines during the extended early voting period. Some Florida counties, including Volusia, used 8GB flash drives.

For absentee and VBM voting, ballots are scanned using central-count scanners which can be easily reconfigured to provide essentially unlimited storage space on these machines. The DS850 high-speed scanners automatically save ballot images to a 1-terabyte hard drive that can hold up to 5 million ballot images, as well as provide some 6 USB flash drives to enable data transfer.

Just prior to the 2020 general election season, a number of Florida counties resisted the request to create and preserve ballot images²³. The settlement agreement²⁴ allowed the eight counties in the lawsuit to delete the ballot images and yet also create them only if there would be a mandatory recount, where the ballots would be rescanned. Such a recount was not required due to the fact that the margins of victory were larger than the margin that would trigger such a recount. Recounts in Florida are conducted by rescanning ballots using the same voting machines used for the election, with a manual review of ballots containing overvotes and undervotes. The mandatory recounts are based on the margin of victory.

²³ "Lawsuit seeks to force Florida counties to preserve digital ballot images -- Supervisors of elections in Pinellas and Hillsborough counties among defendants; candidate for Pinellas County elections supervisor among plaintiffs." (Tampa Bay Times, July 2, 2020)
<https://www.tampabay.com/florida-politics/buzz/2020/07/02/lawsuit-seeks-to-force-florida-counties-to-preserve-digital-ballot-images/>

²⁴ "Largest Florida counties agree to save scanned ballot images if they're needed for presidential recount" (Sun Sentinel, Aug 25, 2020)
<https://www.sun-sentinel.com/news/politics/elections/fl-ne-nsf-ballot-images-florida-voting-lawsuit-20200825-hse-casxxonfnory6kc4cfysza-story.html>

The participants in the Florida Circle of the Scrutineers community with the assistance of attorney J. Shawn Hunter and Susan Pynchon worked to request and obtain the ballot images from Florida. To operate AuditEngine, it is necessary to upload these images to "cloud" storage where they can be accessed and processed by up to 10,000 computers in parallel for rapid completion of the auditing steps. Weekly zoom meetings with election integrity experts have also helped with the audits performed and the review of this document.

AuditEngine has a first "precheck" phase where the ballot images and CVR files are checked for consistency and duplicates, and an inventory of ballot images are created. We can compare the total number of ballots with the published count of votes in the election and learn of any discrepancies in terms of simply the inventory of ballot images.

3.4 Other Configuration Files

The other files required for configuration of AuditEngine depending on the strategy for mapping, and the extent that the files, such as CVR Files, have inconsistent contest and option names.

3.4.1 Election Information File (EIF)

The EIF provides contest information, such as various forms of the contest (and option) names as would appear in the CVR, in other reports, on ballots; the number of votes allowed in the contest; how many write-in lines are there, etc. We need this file regardless of whether we have CVR Files. When we do have CVR files, they can provide the contest names and options the voter selects for each of those contests, sometimes these various files don't use consistent or unique contest names. We also need to know the text that is actually used on BMD ballots. The required information that must be accurately added to the EIF is now minimized when we use computer-assisted mapping because humans easily match the contests even if they are vastly different (or missing).

3.4.2 Target Map

For the purposes of evaluating the voter's marks on a hand-marked paper ballot, it is necessary to know the location of the "target" i.e. the oval or rectangle that corresponds to each option of a given contest. To select the option, the voter darkens the target with a pen. Establishing the correspondence of target location and the contest option is the mapping process.

If we can get the target map from the EMS, this can reduce the work involved in generating the map using the interactive tools provided by AuditEngine. However, there are no standards among voting equipment vendors for providing this data and we have yet to see any examples. So at this time, we do not generally get this information. Yet, we must say that there is an activity studying this in a NIST-sponsored study group that may provide such

standards. Even if we could get this information, we would still need to review it, which amounts to almost the same amount of work in small elections.

4 Ballot Styles

4.1 Styles Overview

The Target Map mentioned above varies due to the various ballot "styles." Each ballot style is at least a unique set of target locations and their correspondence to available options. But there may be more styles defined that go beyond just the layout. Undoubtedly, the "Ballot Styles" issue is far more complex than most people understand when they first encounter the election field.

4.2 Style Determinants

Ballot styles are governed by a number of variables, as follows:

1. **Geographical Location:** The residential address of any specific voter is the primary factor that determines the set of contests that are included on the ballot. The footprint of the regions of the various elected positions from U. S. Congress to local mayors and school boards, have boundaries which have been frequently gerrymandered down to very fine detail, and overlap with unconstrained variety.
2. **Party Affiliation:** The voter may also have a different set of contests based on party affiliation. This is normally a concern in primary elections where a different ballot is needed for each party. In general elections, this is not an issue.
3. **Language:** There may be a number of languages supported. It is preferred that all ballots be at least bi-lingual, with the official language (English) as one of the languages. This is to allow the ballots to be easily audited and understood by others. With multiple languages included on the ballot of the same style, those ballots can be issued to many English voters as well as the other language(s), thereby diluting the ability of anyone to link the ballot to the voter.
4. **Sheet:** There may be a number of sheets included in the overall "ballot" completed by the voter. These different sheets are normally processed separately by the voting system and are not kept together. If there is more than one sheet, voters may not return all the sheets, particularly the "down-ballot" sheets, so the total number of full multi-page ballots returned can become difficult to calculate. Each sheet is generally treated as a separate style. In some cases, when there are a number of contests that are jurisdiction wide and have options that are not shuffled, these contests can be isolated on a separate sheet which has one or just a few styles (for language) for everyone.

5. **Option Rotation:** In some states, it is required that the options in contests are shuffled or "rotated" so the order in which candidates are listed varies on different styles that include the same contest in the same election. This is not true for yes/no type contests where Yes is always first. Florida does not rotate ballot options.
6. **Precincts and groups.** The style may be exactly the same from a target layout standpoint for tabulation and auditing, but may still have some additional printed designations such as for precinct, early, VBM, or other groupings. These may result in the creation of different styles that are actually only different in terms of these marks or groups.

4.3 Style Designation

The voting system may encourage election officials to identify every precinct with a different style, or perhaps several styles due to language or party difference. This precinct style may appear printed on the ballot. But this is not necessarily the same as the styles identified by the voting system based on the determining factors listed above in items 1-5, and which may be provided in the CVR Files.

ES&S and Dominion use proprietary "barcode" graphics that are printed on the ballot. These barcode structures have no error correction and little or no error detection included in their design. This is in contrast with most industry standard barcodes, especially 2-D barcodes²⁵ that are very tolerant of damage or misprinting. Hart uses industry standard barcodes that anyone can read with a smartphone.

The result of these barcodes is a numeric designation we call the "card_code". We have to give the number shown on the card a special name because this code may or may not correspond to the "Ballot Style" number in the CVR, if that value is provided for each ballot, and it frequently differs from other designations on the ballot. We view this complexity as a real problem in transparency as the style systems used by different vendors and jurisdictions vary widely.

Also printed on the ballot may be the precinct or a printed style designator. These are inconsistent from county to county and even within the same county on different ballot styles.²⁶

If the CVR is available, it generally can be used to determine the contests included on each ballot. If the ballots do not have variations due to languages, and if the options are not shuffled in different styles, then the set of contests on the ballot is sufficient to determine the style.

²⁵ <https://en.wikipedia.org/wiki/Barcode>

²⁶ This is definitely an opportunity for standardization, but at least election officials should use consistent locations of these designations within their jurisdiction.

For the purposes of AuditEngine, as long as the targets are in the same place and are mapped to the same contest options, then those can be considered equivalent, so sometimes the styles as defined by the election software can be reduced but this process could also induce errors if some styles are treated as equivalent when it is not the case.

If no CVR is available, Audit Engine can still analyze the style situation by preprocessing the ballot images to extract the card_code, precinct, and any printed style number. These can be compared by the analyst to determine if ballots with different card_codes can be treated as equivalent or if they must be processed separately.

In a simple ballot style scheme, the card_code will be equal to the "Ballot Style" value in the CVR. If few ballot styles are used, this will improve the anonymity of the ballot. In our experience, the number of ballot styles identified with different card codes is very commonly much larger than the minimum number needed to encompass the variations of contests, language, and option shuffling. This mapping of card_code to CVR Ballot Style is not standardized and may be a difficult stumbling block to completing the audit if the number of style numbers are vast. However, it is best to not try to reduce the number of styles unless it is truly known that the reduction is possible, because the computer aided mapping approach is pretty easy for each style.

4.4 Styles and Mapping

In Florida, ballot styles and therefore mapping is simpler as there is no rotation of options in contests. If multiple languages are supported and they are provided on every ballot, that eliminates the language variation. Knowing the contests in each style is then sufficient to reduce the styles to match the variations of target locations on the ballots.

For Collier and Volusia Counties, this approach was used to suppress variations in style due only to marking on the ballots to determine what precinct they are in, for example. This is not true in St. Lucie County, however, due to variations in language.

The map created from the mapping process provides the location on the ballot of the target darkened by the voter using a pen and links that to the contest and selected contest option.

4.5 Our Pursuit of Automated Mapping

We have focused our efforts on developing an automatic mapping process. Our goal was to automatically create the map by using OCR and matching up the contest names and options to the official list. Although this can work very well, it requires additional information to get a mapping solution. Unfortunately, we have found that due to the vast number of variations in the actual layout of the ballot, limitations on the reliability of image segmentation and character recognition, and the lack of ballot format standards, this approach still requires significant manual effort providing information and "tweaking" of settings and graphical hints.

If automated mapping does not work right away, the knowledge required to modify the settings and provide graphical hints requires understanding the segmentation and mapping algorithms, which is beyond what most people would be able to provide. We were able to use automated mapping for Collier County and partially for Volusia County. St. Lucie County was not feasible because of several issues regarding the ballot layout, creases, and missing lines. Using **computer-assisted manual mapping**, we re-mapped Volusia to include all contests and styles and did the same for St. Lucie. This will now be our primary approach as it appears that it will always work, and surprisingly, the amount of manual operations can be less than with the automated mapping process.

We find this to be a very interesting balance in the man-machine partnership for accomplishing these tasks as human perception and pattern matching far outstrip what computers can offer (using economical solutions).

4.6 Computer-Assisted Mapping

Computer-assisted mapping provides a computer interface to assist the user to directly map contest options to targets. The AuditEngine user will first run the precheck, create the BIF tables, and create the basic templates for each style. Then the computer assisted mapping process can actually be accomplished by team member "mappers" who are specifically trained for this step and may not understand the whole of the auditing process. The fact that this can be easily delegated to team members is an important design aspect.

The mapper is presented with a list of contests and options, which are always known for each election in advance. This information can be captured from the CVR or if that is not available, it can be provided in the Election Information File (EIF) manually. We have mouse-based functions to copy and paste mapping from one style to another.

The process is simple and does not require any particular user knowledge, such as computer algorithms or a vast number of settings. And it doesn't require the mapper to provide hints or tweaks in the form of settings or code changes. Manual mapping will always work. The only time it may be problematic is when there are a vast number of styles, such as were defined in San Francisco in the recent primary, where there were more than 10,000 styles assigned. We expect that in those cases we can reduce the styles down to a much lower number through an analysis process.

Even if a vendor provides the mapping for a large number of ballot styles, it must be checked carefully prior to being used, which is almost as much work as doing the mapping from the start.

4.6.1 Overview of the TargetMapper user interface

The manual mapping process is summarized here. Please refer to the following image showing the user interface which was current as of this writing, but likely has been further enhanced by the time of your reading.

The actions of the operator are fairly simple. Select a style template from the Style List on the top-right. This displays a template in the window. Select an item in the Contest/Option list, then click the target on the ballot. Continue until all are assigned.

Since subsequent styles are likely very similar, copy and paste operations can duplicate the full set of mapped contest options to other styles, and each can be tweaked slightly so it is correct. When each template is fully verified, it is checked off.

This assignment process also means that the review of proofs is not as important, since the human mapper and the process of assigning contest options to targets includes the process of checking that the assignment is correct. However, the review of redline proofs is still regarded as quite important to double-check this critical configuration of the system.

The screenshot displays the AuditEngine TargetMapper interface. At the top, there is a navigation bar with 'AuditEngine' logo, 'File', 'Project Information', and 'Settings' menus. Below this is a toolbar with 'Copy', 'Paste', 'Clear', 'Paste Rest', 'Clear Rest', and 'Save All' buttons. The main area shows a ballot template for '901A Official General Election Ballot / Papeleta Oficial de Elección General' for November 3, 2020, in Volusia County, Florida. The ballot is divided into three columns: 'President and Vice President', 'Court of Appeal', and 'No. 1 Constitutional Amendment'. The 'President and Vice President' column lists candidates like Donald J. Trump, Michael R. Pence, Joseph R. Biden, Kamala D. Harris, Jo Jorgensen, and Jeremy 'Spike' Cohen. The 'Court of Appeal' column contains questions about retaining judges in office. The 'No. 1 Constitutional Amendment' column discusses citizenship requirements for voting. On the right side, there is a 'Vendor' dropdown set to 'Dominion', a 'Style List' with three templates, and a 'Contest/Option List' with various options like 'President and Vice President', 'Representative in Congress District 6', etc., each with an 'Edit' button.

5. Vote Extraction

5.1 The Vote Extraction Process

Once the target maps are available, the vote extraction process can be launched. AuditEngine splits the ballots in each archive into "chunks" of perhaps 200 ballots each, and each one of these chunks is delegated to a separate computer in the cloud. As we are using

Amazon Web Services (AWS)²⁷, we use their "Lambda" service²⁸, which offers virtual computers that can be quickly configured and the task executed. We are authorized at this time to run up to 10,000 Lambdas concurrently, and thus we can accomplish the extraction task of up to 2 million ballots in the time it takes to complete one chunk on a single computer, which is less than 15 minutes. In contrast, processing 2 million ballots on a single computer might take over three weeks. (Lambdas are limited to a lifespan of only 15 minutes each.)

But even though the extraction process itself can be accelerated in this fashion, it means the data must exist "in the cloud" prior to the start of the process. Thus, we must upload ballot images to the "S3" (Simple Storage Service)²⁹ within the same data center where the Lambdas will process them.

The extraction process of traditional hand-marked paper ballots requires the map but does not use the CVR file at all. AuditEngine does not reference the official results during the extraction process.

When the marks are recognized, there is the need to determine "voter intent" and whether a mark exists or not. (Whether voter-intent is used as the criteria varies among the states.)

AuditEngine features an "adaptive thresholding" algorithm which sets the threshold based on the density of the marks on that ballot, as we find that mark density can vary significantly when scanned by precinct-based scanners. This approach is unique to AuditEngine and we find that it tends to do a better job, on average, than the popular voting equipment being used. In the disagreements from Collier County, when there was no stretching of the ballot image, AuditEngine correctly determined voter intent 93% of the time while the ES&S voting machines failed to correctly interpret voter intent in those cases. We must also say that the results from AuditEngine agreed with the official results more than 99.77% of the time. So the 93% applies to the 0.23% of ballots where there was disagreement (and no image corruption), giving us about 99.9998+% accuracy of interpreting voter intent, assuming the cases where the voting system agreed with the audit results were also correctly interpreted.

5.2 Vote Extraction: BMD Ballots

BMD ballots are processed by performing optical character recognition (OCR) of the human-readable summary printed on the paper ballot summary sheet. Although we can decode the bar codes to check our result, reading the human readable text is better in terms of the audit because the voter at least had the opportunity to review it, even though most voters do not.

²⁷ <https://aws.amazon.com/>

²⁸ <https://aws.amazon.com/lambda/>

²⁹ <https://aws.amazon.com/s3/?c=s&sec=svr>

In the sets of ballots we processed in FL, there were very few BMD ballots, with only 78 ballot images in Collier County and 132 in Volusia County. However, we have learned that the BMD ballot images are sometimes duplicated, and in Collier County, there were actually only 39 BMD ballots cast even though they each create two ballot images and two CVR records.

During the extraction process, all ballot images are processed. If they cannot be aligned or barcodes successfully read, then the ballot is logged as 'failed.' At the present time, we encountered a few stretched ballots or damaged ballot images that cannot be processed at all. These are included in the statistics of the subsequent reports. In Collier county, only 4 ballots failed alignment, a rate of less than 1/100,000. It is our goal to eventually be able to process all ballot images by adding additional heuristics to align these stretched ballots, but review of ballots that are corrupted in that manner will likely still be required.

We must note that at this time, some ballots are stretched or damaged not so much that they fail right away, but fail later and those are then included in the disagreement list. It is a continuing development process on our part to be able to correctly identify and process corrupted ballots.

5.3 Audit Election Outcome Report

An independent report of the outcome of the election can be produced, and which can be compared with similar reports that are generally available from election administrators. The outcome report can be generated even if there is no ballot-level CVR available. Because we did not have the CVR Files for St. Lucie County, we produced this report for comparison.

6 CVR Comparison

The most powerful way to use AuditEngine is to compare the interpretation of each and every ballot with the official interpretation of that ballot. As mentioned, this requires that we have the official CVR Files broken down to the ballot, and identified so we can pair each CVR entry with the ballot image.

6.1 The CMPCVR process

The CMPCVR process operates on the same chunks that were processed in the vote extraction process and is also spread out to a number of Lambda computers in parallel. If the interpretation of the vote by AuditEngine fully agrees with the interpretation by the voting system, then the ballot is "agreed" and one comparison record is created for the entire ballot. If not, then a separate record is created for each contest that is in disagreement. These comparison records can then be used to produce the discrepancy report. Additional records are provided also if the ballot is agreed and there are overvotes or if the ballot is blank. In those cases, there are up to two records, one in each set.

6.2 Discrepancy Report

Finally, the discrepancy report can be generated, based on the comparison records. We will take a look at a healthy sample of the typical discrepancies in Collier County in the section on that county below, detailed in Appendix 1.

We will look mainly at the disagreements. The report can also include all the agreed overvotes, because these are sometimes misinterpreted.

6.2.1 Disagreements

There are two classes of disagreements:

1. Voter intent interpretation:

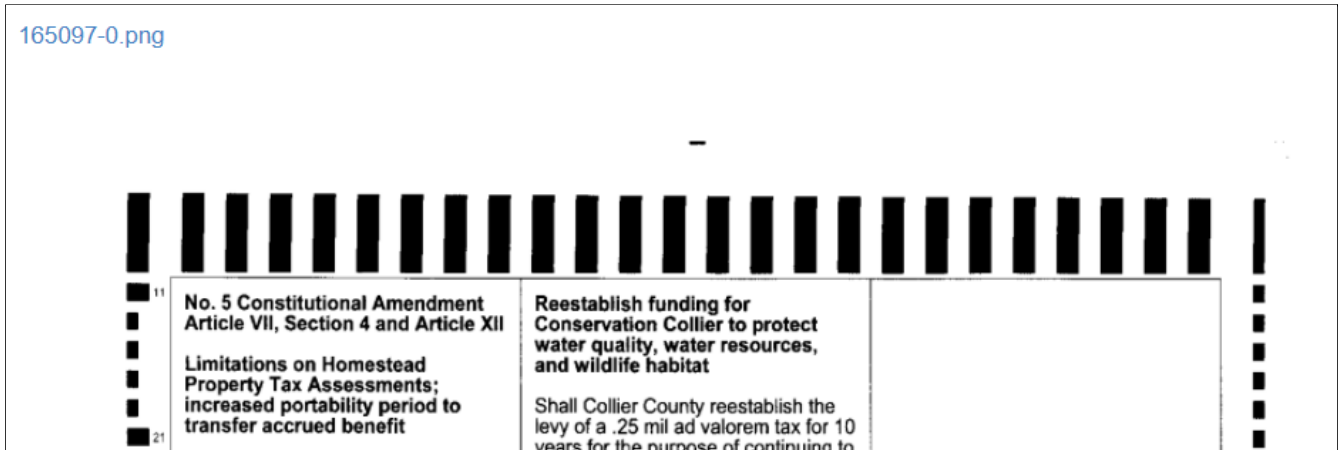
AuditEngine uses dynamic thresholding and will opt to allow a very dark vote to be accepted over a much lighter vote in the case of a possible overvote. AuditEngine uses a slightly larger inspection region as well. In almost all of the cases that were not stretched or deformed, AuditEngine does a better job (97%) interpreting voter intent than the ES&S election equipment.

2. Stretched or deformed ballot images:

We believe AuditEngine in the near future will be able to handle most cases in which the stretch point does not actually distort the region where the marks are located. However, at this time we are setting these aside as "failures" which can be reviewed in detail.

The ballot images in this category were distorted (i.e. "stretched") when the page was not evenly pulled across the scanner. This can occur if the rollers are not frequently cleaned and the page pauses as it is scanned. Such corrupted ballot scans should be minimized by improving cleaning, maintenance, or perhaps removing some equipment from service.

The following image shows a typical example of stretching. Notice the top timing marks are normally the same height as the marks along the sides. But these have been vertically stretched to about five times their normal height.



For now, if we need to resolve the failed ballots, we can inspect them and enter adjudication information to fully include them in the audit.

7 Adjudication

AuditEngine offers an adjudication module "AdjudicatorApp" which provides a graphical interface for reviewing the disagreements in the discrepancy report, and providing a means to select the correct evaluation of voter intent for any contest that is included in the disagreement list, as well as to adjust any other contest on that ballot. This tool can also review any ballot.

In this case study, this component was not reviewed because it was not necessary to confirm the election based on the consistency of the tabulation.

The primary screen of the Adjudicator is shown below. In addition to confirming whether the Voting System or AuditEngine is correct, the user can directly enter to make corrections to any of the other contests. This is needed when, for example, a voter has a habit of circling the desired options, and some of these were located as disagreements, but not all. This application is being actively enhanced to improve user efficiency, and it can also be used as a general tool to review any ballot, including those special cases, like failed ballots, overvotes,

etc.

Ballot list

140025
161361
21271
21655
21655
21655
22492
22492
72731
207383
207383
237822
238020
330645
18039
343828
349723
352378
20756
21249
121368
239562
239577
330402
345438

Cast Vote Record Direct Entry Page1 Page2

Deltona Commissioner District 6
413 0x707fe3c1001fe0000

VERIFY

Options	VotingSystem	AuditEngine	Options
Julio David	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Sosa	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Jody Lee	0	0	<input type="checkbox"/>
Storozuk	1	0	<input type="checkbox"/>
Overvotes	0	0	<input type="checkbox"/>
Undervotes			
Writes			

1 / 50

Am. 3 Constitutional Amendment
Article VI, Section 5
New, 3 Expanded Constitutional Article VI, Section 5

Am. 4 Constitutional Amendment
Article VI, Sections 5 and 7

Am. 5 Constitutional Amendment
Article VI, Section 5 and Article III
New, 6 Expanded Constitutional Article VI, Section 5 and Article III

8 Details of Three Counties in Florida

In the following sections, we cover how we have applied Audit Engine to three counties in Florida: Collier County, Volusia County, and St. Lucie County. These counties were chosen primarily due to the availability of ballot images and CVR files rather than any suspicion that there was any malfeasance or error. Florida has been a "battleground" state where the outcome is typically very significant in the outcome of the presidential contest.

Collier and Volusia are ES&S counties and St. Lucie is a Dominion county.

8.1 Collier County

Collier County had a population in 2019 of 384,902. In the 2020 General Election under study, they had 231,708 eligible voters and had 209,352 ballots cast, turnout of 90.4%. Thus, the number of ballots cast was 54% of the published population. This county is also a "Red" county, with Trump receiving nearly 62% of the vote.

In this election, there were two ballot sheets for every voter.

8.1.2 Ballot Inventory: Collier County

Of the three test counties, Collier County provided the cleanest and most complete set of ballot images and CVR Files and we can congratulate Collier County for a job very well done.

Since Collier County uses ES&S equipment, we can perform an initial analysis based on file sizes. We can frequently determine the sheet number and whether the image is of a BMD ballot, simply by reviewing the file sizes. This is a great time-saving tactic because we can

perform a high-level review of the inventory of ballots without inspecting all the ballot images themselves.

This does not always work as well as it did in this case, where we have the following average size and counts breakdown:

Ballot Image	Average Size (bytes)	Count
Sheet 1	191,374	209,313
Sheet 2	55,581	208,386
BMD	21,160	78
All	123,609	417,777

These size differences are due to the fact that Sheet 1 is consistently filled with content on both sides, while Sheet 2 has only 1 side which is partially used. BMD ballots are only one side as well but are even smaller than hand-marked ballots. If Sheet 2 were also filled on both sides, then it would not be possible to differentiate by size alone.

We can estimate the minimum number of voters by adding the count of Sheet 1 with the count of BMD ballot files, which results in $209,313 + 78 = 209,391$ ballots, which is 39 ballots more than the published total of ballots cast (209,352). We discovered that the reason for this difference is the fact that the election workers (and perhaps the EMS software) duplicates each BMD ballot image and treats the two images like a first and second page even though the BMD ballot includes all contests. So there were actually only 39 BMD ballots cast. Thus, the total is $209,313 + 39 = 209,352$, which is the published number of ballots cast. Good work Collier County!

There were no duplicate images detected in the image set (except for the duplicated BMD ballots), and there were no missing images. The set was consistent with the CVR Files. The CVR Files did not provide the "Ballot Style" designation, which we find helpful when it is provided.

Based on the image file counts, we have $209,313 - 208,386 = 927$ second sheets that were not returned. This is not surprising given that the second sheet contains down-ballot contests that are frequently not voted, and even when returned, there were a large number of blank 'Sheet 2' sheets.

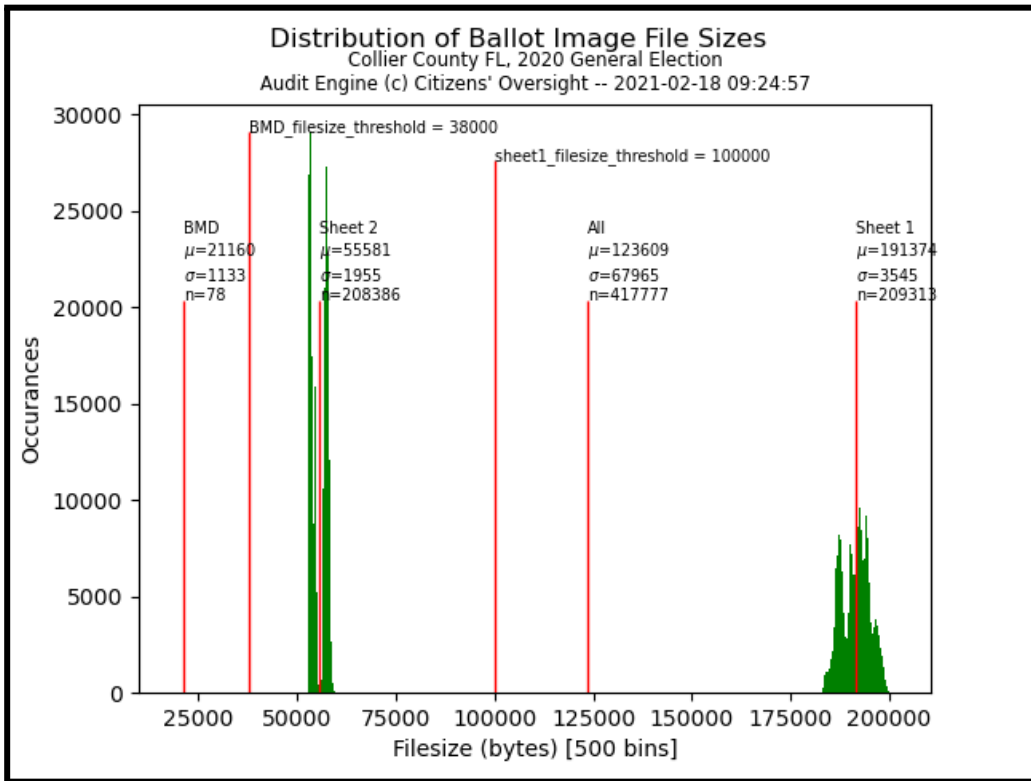
The precheck report for this case can be reviewed at this link:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_2020_1103-02/reports/precheck_report.html

When analyzed by size, the groups of ballots are widely spaced and there is no chance of mixing them up. But also, since we do have the CVR, the different sheets can be determined

just by looking at the contests included in the CVR record. The Sheet number was not included in the CVR.

The following chart provides the grouping analysis described above. Note that the two groups of ballots are very distinct, showing that the size criteria is useful in identifying the sheet number in this case. (The graph is a histogram showing the prevalence of ballots at different sizes, with 500 bins in the range shown. The green bars show the number of ballots in each of the bins, and the red lines are the manually-set thresholds and averages.)



8.3.1 Collier County Disagreements

The Discrepancy Report includes first a high-level overview of the discrepancies.

Record Type	Sheets	Contests
agreed	416,833	
blanks	7,243	
overvotes	764	792
disagreed	324	528
failed	4	

Disagreed %	0.078%	
Failed %	0.00096%	

The full discrepancy report for Collier County is at this URL:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_2020_1103-02/reports/Discrepancy_Report.html

The report breaks down each precinct to allow any issues that are related to the precinct to be easily noticed. From this report, the consistency between the ballot image data and the final results is confirmed.

The total number of ballots sheets, 417,777, must be reduced by the number of BMD images (78) and failed sheets (4). We must also remember that the BMD images were duplicated, and only 39 BMD ballots were cast.

There were 324 ballot sheets with disagreements out of the 417,777 images processed. The report groups these by precinct so it will be possible to determine if a scanner might be improperly adjusted. A sample of the disagreements are provided in Appendix 1.

8.2 Volusia County

In the 2020 general election, Volusia County had 398,530 registered voters and a total of 309,367 ballots cast. The population of Volusia County in 2019 was 553,284, substantially larger than Collier County. The raw population based turnout was 56%. Volusia is also a "Red" county where Trump received 56% to Biden's 42%.

Volusia County has a very interesting election integrity history, most particularly due to its role in the 2000 presidential election.³⁰ It was featured in the Emmy-nominated 2006 HBO documentary film "Hacking Democracy"³¹, and in 2000, there were 16,022 negative votes reported for Al Gore in a precinct where only 219 people voted. Almost 3,000 votes were added for George Bush in the same precinct and over 10,000 votes were added for a little-known candidate.

Volusia County has a new Supervisor of Elections, Lisa Lewis, as of 2016. We appreciate the helpful attitude of the SOE and her staff, and the transparency, open dialogue, and high level of cooperation they provided.

8.2.1 Volusia County: Ballot Inventory

Regarding the 2020 General Election, we had some initial difficulty in getting all the ballot image archives. Initially, we had 24 archives and one of the archives had duplicated image

³⁰ Deannie Lowe was SOE during the 2000 and 2004 elections and Ann McFall was SOE from 2004 until 2016.

³¹ https://en.wikipedia.org/wiki/Hacking_Democracy

files in it. These archives were also initially double-zipped, which means we have to first unzip the outer zip to get to the inner zip archive. There is a slight reduction in size when they are double-zipped but it is not worth the additional processing required.

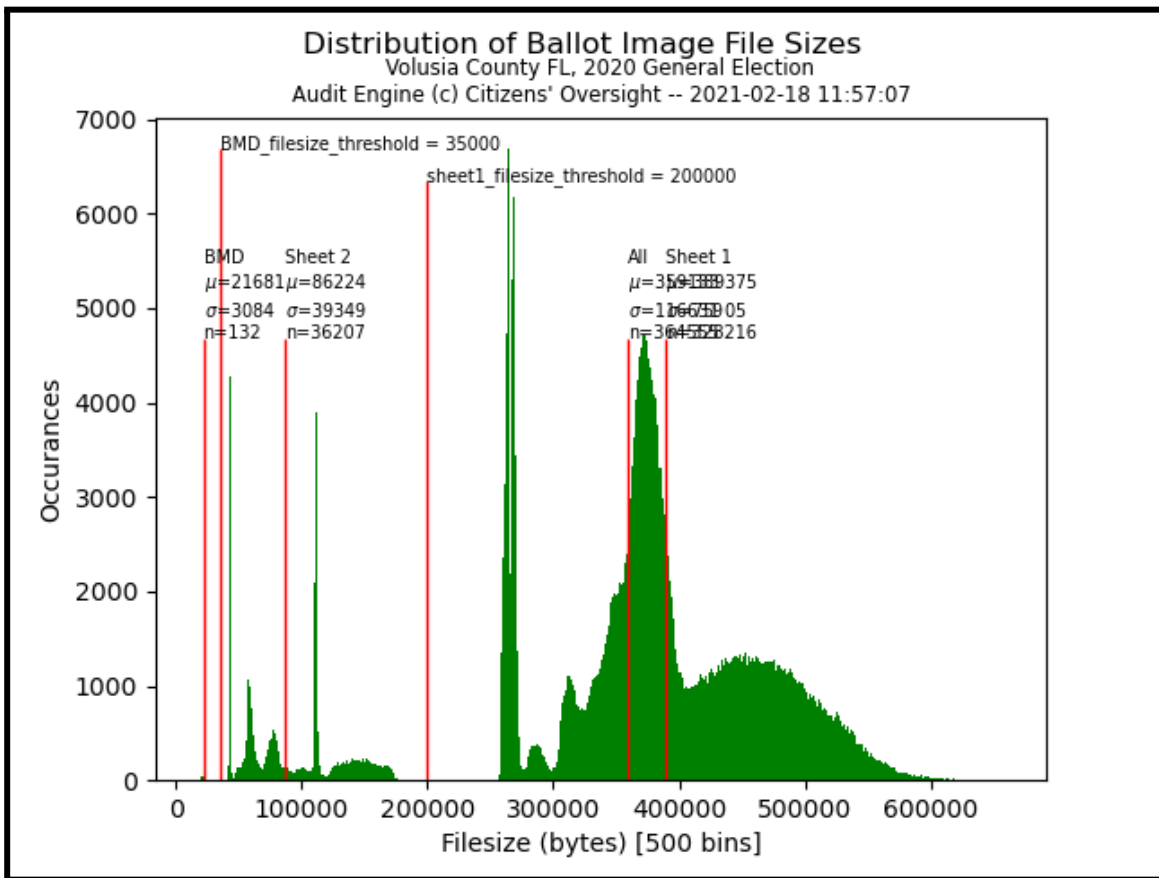
Volusia reprocessed their archives, eventually producing 34 total zip archives with each being about 4GB without double-zipping.

8.2.2 Volusia County: Precheck Report Balance Check

The precheck report as produced by AuditEngine for Volusia County is at this URL:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_General_2020_1103/reports/precheck_report.html

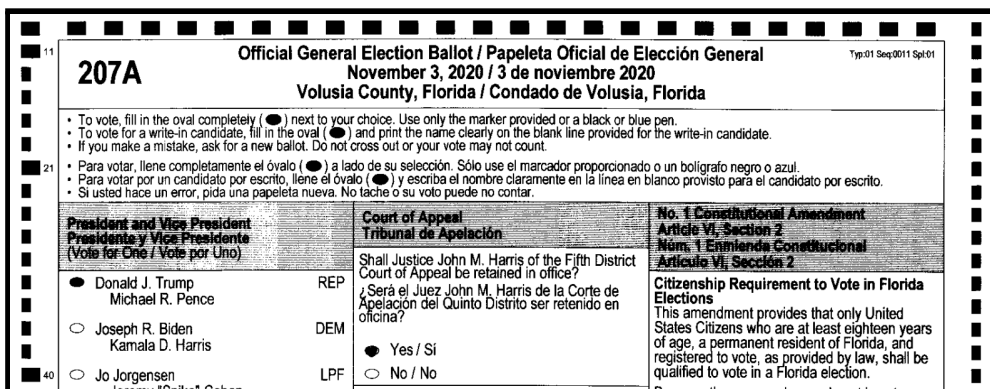
As with Collier County, we can get a good idea of the counts of the different types of ballots by looking at the size. In this case, Sheet 1 is almost exactly the same for all voters, and most voters received only Sheet 1. In some cases where local contests were also included, a Sheet 2 was included.



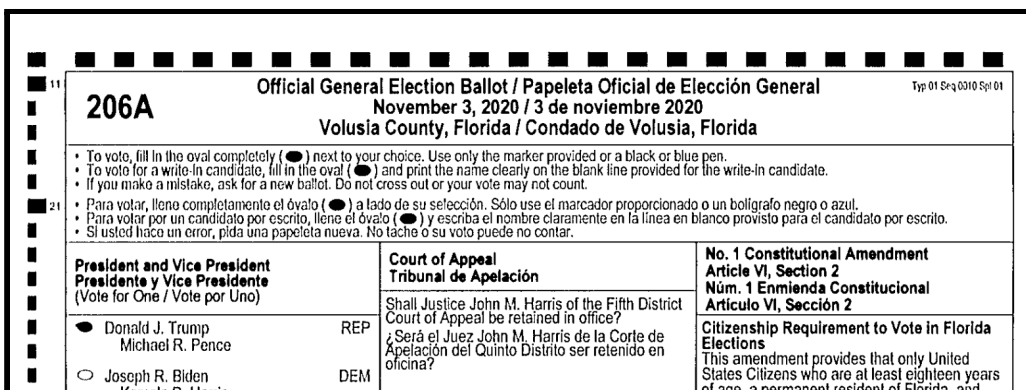
The larger blob on the right side of this chart is usually the Sheet 1 statistical distribution. Compared with Collier County, it is much wider and there is a big spike at the very lowest size. This is due to a change in the design of the ballots where in some cases, there is a gray

background behind the contest title text, and others had no gray background. We recommend not using any gray background, which was the case in Collier County where there was a much tighter distribution of sizes.

The image below is a snippet of a ballot with a size over 600KB with gray shading of contest names accounting for the large size.



And this one, without shading, is only 260KB -- less than half the size.



Again, other than the shading, these sheets were almost identical.

In this case, the amount of text and contests on these two ballots is the same. The gray background is the only big difference. To put this in context, if a voting machine has a 4GB USB flash drive for storage, it can hold 6,666 images with gray backgrounds or 20,000 of the same images without the gray.

RULE FOR OFFICIALS: NO GRAYSCALE BACKGROUNDS. This is the opposite recommendation provided by some ease-of-use experts. But we believe the clear backgrounds should be preferred particularly by those voters with poor eyesight. We prefer

the white backgrounds because, as you can see, the gray backgrounds can become obscured in the scan³².

Looking at the counts of sheets and ballot types for Volusia County, we have the following breakdown.

Ballot Image	Count	Average Size (bytes)	StdDev
Sheet 1	328,216	389,375	75,905
Sheet 2	36,207	86,224	39,349
BMD	132	21,681	3,084
All	364,555	359,133	11,631

This is determined by the same sort of simplistic separation of sheet 1 and sheet 2 by size, just like we used in Collier County. But in this case, it does NOT result in an accurate calculation, because one of the Sheet 2 styles includes content on both sides, making it just as large as Sheet 1. Knowing that this is not accurate, this approach says that the Minimum Ballots Cast = 'Sheet 1' + 'BMD' = 328,348, which is 18,981 more ballots than the published total of 309,367 ballots cast. Again, this is not a mistake, but rather a known limitation of this estimation method.

8.2.3 Volusia County: BIF Report Balance Check

AuditEngine creates the "Ballot Information File" (BIF) report which identifies the contests included on each sheet, so it can inform a more accurate calculation regarding the count of each sheet type. Using this information results in the following breakdown.

Sheet	non-BMD Count	BMD Count
Sheet 1	313,611	123
Sheet 2	50,812	9
All	364,423	132

The difference between this breakdown and the prior table has to do with one Sheet 2 style with 14,614 ballot images, which was regarded as Sheet 1 in the prior analysis. We reviewed the BMD ballots and they do not appear to be duplicated as they were in Collier County.

³² The Center for Civic Design says in rule No. 09 to "Use contrast and color to support meaning" and they say to "use color and shading consistently -- on paper ballots, to separate instructions from contests and contests from each other". Also, "Do not rely on color as the only way to communicate important information." We believe it is best to consistently avoid background shading, and this will satisfy both their design recommendations and result in the smallest image files. <https://civicdesign.org/fieldguides/designing-usable-ballots/>

Minimum Ballots Cast = 'Sheet 1':(313,611) + 'BMD':(123) = 313,734, a **net of 4,367 more ballot images than the published total of 309,367 ballots cast.** (Note that we are not talking about just ballot images here but calculating the number of ballots cast, which in some cases includes two sheets.) We will show later that that there were 537 too few ballots as well, and those would need to be added to the discrepancy, so that in reality, there are 4,367 + 537 = 4,904 additional ballot images (and matching CVR entries) and at the same time 537 too few ballot images (and matching CVR entries), resulting in the net of 4,367.

We also have a review of the records in the CVR files in the precheck report:

CVR File	Record Count
Cast Vote Records.xlsx	99,999
Cast Vote Records - 1.xlsx	99,999
Cast Vote Records - 2.xlsx	99,999
Cast Vote Records - 3.xlsx	64,558
Total	364,555

The cast vote records files have the same number of records as the ballot images, and all the ballotids are matching between the two.

8.2.4 Volusia County: CVR vs Official Results Manual Check

In an attempt to track down the net 4,367 additional ballot images (and CVR records) when compared with the official result, and to eliminate the possibility that this was due to our software, the entries in the CVR files were compared with the EL30A report, which is the report of the official results from Volusia County. This is detailed in the table shown below.

(The reason the totals are slightly different in this case, different from the 4,367 ballot sheets mentioned earlier, is because this was a total of just the most consequential contest, Trump vs. Biden, and some ballots did not register votes for those two candidates, thus resulting in the 4,351 shown.)

The pink cells are the precincts that had **more ballot images** and correspondingly **more CVR entries** than shown in the official reports (all figures are negative in the pink cells). Two precincts in yellow, 415 and 416, had fewer ballot images and CVR records than the official report. (That table includes only those precincts that differed between the CVR and "official result" report called the EL30). In all cases the CVR records corresponded to the ballot images. Obviously, as these two reports are both from Volusia County, they should match.

Note that the precincts in series 800 and 900 had the larger differences, while other precincts had mostly single-digit differences.

PRECINCT	CVR TRUMP	CVR BIDEN	EL30A TRUMP	EL30A BIDEN	DELTA TRUMP	DELTA BIDEN
201	2600	1393	2599	1393	-1	0
202	2021	1111	2020	1111	-1	0
206	1293	874	1292	874	-1	0
208	2508	1378	2507	1378	-1	0
215	2825	2322	2824	2322	-1	0
222	1537	792	1535	791	-2	-1
224	1722	1160	1721	1160	-1	0
303	1586	1063	1585	1063	-1	0
304	1946	1200	1944	1200	-2	0
305	2615	1449	2613	1449	-2	0
306	2475	1390	2471	1390	-4	0
307	1594	943	1594	942	0	-1
404	1087	286	1080	284	-7	-2
405	956	1059	955	1059	-1	0
406	2125	2273	2124	2273	-1	0
411	1433	1266	1432	1266	-1	0
412	1280	397	1222	384	-58	-13
415	1153	1343	1291	1419	138	76
416	1521	1947	1715	2056	194	109
421	1408	765	1407	765	-1	0
422	1067	1148	1067	1147	0	-1
427	1188	1206	1187	1206	-1	0
501	1720	874	1719	874	-1	0
504	1145	817	1143	817	-2	0
511	641	227	640	227	-1	0
512	2091	1586	2089	1586	-2	0
515	1308	1171	1307	1171	-1	0
522	1879	1317	1878	1317	-1	0
523	1201	772	1200	771	-1	-1
526	747	682	747	681	0	-1
532	1612	816	1611	816	-1	0
602	3266	2365	3261	2363	-5	-2
603	775	2069	775	2068	0	-1
607	2012	1435	2011	1435	-1	0
614	558	2255	558	2254	0	-1
633	1290	1743	1288	1742	-2	-1
638	1199	789	1198	789	-1	0
641	2104	1767	2100	1767	-4	0
701	2151	1478	2147	1477	-4	-1
703	1705	1354	1702	1353	-3	-1
705	805	429	804	429	-1	0
706	2500	1352	2491	1352	-9	0
709	1670	1054	1667	1051	-3	-3
711	2123	1470	2123	1467	0	-3
712	971	743	969	743	-2	0
714	1718	1278	1718	1277	0	-1
716	1749	637	1731	634	-18	-3
717	974	683	973	683	-1	0
718	1852	1261	1847	1259	-5	-2
719	1061	645	1059	645	-2	0
720	484	284	479	283	-5	-1
722	1356	752	1346	752	-10	0
725	1155	794	1150	794	-5	0
726	1927	950	1924	950	-3	0
728	2152	1329	2147	1325	-5	-4
729	2716	1591	2691	1585	-25	-6
732	2893	1733	2890	1733	-3	0
803	1884	959	1678	888	-206	-71
804	2151	1207	1893	1121	-258	-86
805	2738	1694	2434	1585	-304	-109
807	1051	573	914	526	-137	-47
808	4196	2639	3694	2474	-502	-165
809	428	314	375	285	-53	-29
810	888	768	772	691	-116	-77
812	1495	1086	1312	1027	-183	-59
813	1290	784	1152	741	-138	-43
814	1642	796	1442	737	-200	-59
816	1443	359	1386	342	-57	-17
901	1263	777	1137	733	-126	-44
902	2236	1178	2019	1099	-217	-79
903	2255	1216	1969	1116	-286	-100
904	2974	1525	2651	1439	-323	-86
907	1717	620	1564	577	-153	-43
909	999	444	902	420	-97	-24
910	773	403	686	380	-87	-23
			Column Total		-3325	-1026
			Grand Total			-4351

The table above shows only precincts that differed.
Those that had no difference were not included
Total Precincts 125
Precincts with dif 75
% Precincts with dif 60.00%

Table: Volusia Precincts with Discrepancies

A full report of all contests and all precincts between the CVR and EL30A was prepared and is available at this URL:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_General_2020_1103/reports/CVR_Totals_Report_by_Contest_Detailed_by_Precinct_Compared_EL30.html

The official results are provided in the report EL-30A:

https://us-east-1-audit-engine-election-data.s3.amazonaws.com/US/FL/US_FL_Volusia_General_20201103/GEN+2020+-+Official+Results+-+EL30A+-+Precinct+Summary.pdf

8.2.5 Volusia County: Voter History File

We also reviewed the total count of voters in the voter history file, and found that 309,433 voters were recorded as voting in the election. This is similar to the official number of ballots cast of 309,367 ballots cast. The 66 more voters than ballots cast could possibly be explained as voters who walked into the polling place and walked out without casting their ballot, but we are not sure. The point of this check was to determine if the CVR and ballot images were more correct, or was the official report more correct.

Here is a transcript using Python and Pandas interactively to count all the records among the 2.8 million lines of the voter history file to determine the number of voters who voted on November 3, 2020, with the result being 309,433. This implies that 66 voters checked in but left without casting their ballot. These numbers are similar, and not off by 4,904, for example.

```
>>> df =
pd.read_csv("R:\\z\\Dev\\AuditEngine\\Audits\\Volusia20201103\\20201208_VoterHistory\\VOL_H_20201208.tsv", sep="\t", header=0,
names=['vol', 'vid', 'date', 'type', 'chr'])
>>> df
   vol      vid      date type chr
0    VOL  100036348  05/21/2019  OTH  A
1    VOL  100051300  05/21/2019  OTH  A
2    VOL  100076366  03/17/2020  PPP  A
3    VOL  100097421  05/21/2019  OTH  A
4    VOL  100098324  08/30/2016  PRI  A
...    ...    ...    ...    ...  ..
2812812  VOL  129043826  11/03/2020  GEN  E
2812813  VOL  129044490  11/03/2020  GEN  E
2812814  VOL  129079216  11/03/2020  GEN  Y
2812815  VOL  129080293  11/03/2020  GEN  E
2812816  VOL  129090095  11/03/2020  GEN  E

[2812817 rows x 5 columns]
>>> dfgen=df.loc[df['date'] == '11/03/2020']
>>> len(dfgen.index)
309433
```

8.2.6 Inquiry with Volusia County -- 4K Discrepancy -- Ballot Images vs. Ballots Cast

This 4,367-ballot discrepancy between images/CVRs and published number of ballots cast was broached with Volusia County election officials. After investigating, they said that the additional ballot images and CVR records (the pink negative values in the comparison table) could be explained due to a voting machine device upload failure and subsequent re-scan of ballots from the New Smyrna Beach early voting site.

It is useful to know that election day polling places transmit vote totals by modem to the central office so they can be combined by the central tabulator very rapidly on election night. The vote totals are a subset of the CVR data, including only the records from this voting machine, and do not include the ballot images.

Later, USB flash drives are returned to the office and the results and ballot images are uploaded from those USB flash drives using the "Acquire" module of the ES&S EMS. Each USB flash drive is paired with only one voting machine (ES&S DS200 ballot scanner). They cannot be moved from machine to machine because of codes that make them operational only with one voting machine. (To make sure that the machines will operate, a backup USB flash drive is provided for each DS200 machine, but in Volusia only one is used at a time. The second USB flash drive port in the DS200 machines is not used with the rationale that the paper ballots can always be scanned if there is a problem.)

At early voting sites, however, the results are NOT transmitted by modem to the central office. Instead, the results are obtained only from the USB flash drives. This can be done prior to the close of election day polls, according to Florida law, and the election officials are allowed to know the results from those sites, as long as they do not transmit the results to anyone else. We understand these results were acquired prior to the close of polls on election day.

Volusia election officials said they uploaded the data from the first USB flash drive and then attempted to read the second, which failed to read. Then they deleted the first flash drive's results from the EMS in order to zero out the count and start again. Then, they rescanned all the paper ballots from the New Smyrna Beach early voting site using the central count scanner. They thought the ballot images would be automatically deleted when they deleted the results from the EMS, but they were not. **The ballot images and CVR entries captured from the first flash drive were actually NOT deleted**, even though the corresponding vote totals *were* deleted from the combined tabulation results.

During the early voting period, any voters can go to any early voting site. This explains the reason that a few voters from other precincts were included in the additional ballot images and CVR entries.

Volusia said that ES&S did not realize it was possible to zero the tabulation without also deleting the corresponding ballot images or CVR records. In this case, it is now essentially not possible to identify which records were duplicated in the set of ballot images and CVR records.

In all cases, this rescanning can explain the additional ballot images and CVR files, although the mechanism of allowing the duplicate images to persist has not been explained.

We believe this is a defect in the ES&S EMS which does not have sufficient checks to disallow this duplication of records to occur.

We confirmed that some of the ballot images were duplicates where one image was generated from the original upload and its twin from the rescan. We were able to find some with distinctive marks that were classified as overvotes.

In the example below, the two ballot images are from two different scans, but to the eye, they are definitely of the same ballot. We note that the left hand image (Ballotid:151363) has vertical streaks through the image. This may be indicative of dirt on the scanning window and is probably from the scanner in the polling place which may not be cleaned as carefully. The other ballot image (Ballotid: 360143) does not have these streaks. We searched the adjacent ballots in the vicinity of this one, both by number and location in the archives, but those adjacent ballots were not duplicated. So it was not possible to easily find the entire block of ballots which were duplicated by searching the ballots near the example shown.

Ballotid:151363	Ballotid: 360143
<p>vinculados a la votación en la Florida, no habrá impacto en los impuestos o tarifas gubernamentales.</p> <p>EL IMPACTO FINANCIERO DE ESTA ENMIENDA NO SE PUEDE DETERMINAR DEBIDO A LAS AMBIGÜEDADES E INCERTIDUMBRES RELACIONADAS AL IMPACTO DE LA ENMIENDA.</p> <p><input type="radio"/> Yes / Sí</p>	<p>vinculados a la votación en la Florida, no habrá impacto en los impuestos o tarifas gubernamentales.</p> <p>EL IMPACTO FINANCIERO DE ESTA ENMIENDA NO SE PUEDE DETERMINAR DEBIDO A LAS AMBIGÜEDADES E INCERTIDUMBRES RELACIONADAS AL IMPACTO DE LA ENMIENDA.</p> <p><input type="radio"/> Yes / Sí</p>
<p>1/5 millones gravado durante 20 años, sujeto a la plena divulgación pública por medio de auditorías anuales?</p> <p><input checked="" type="radio"/> Yes (For Bonds) / Si (A Favor de los Bonos)</p> <p><input type="radio"/> No (Against Bonds) / No (En Contra de los Bonos)</p> <p>Volusia Forever: Acquisition and Improvement of Environmentally Sensitive</p>	<p>1/5 millones gravado durante 20 años, sujeto a la plena divulgación pública por medio de auditorías anuales?</p> <p><input checked="" type="radio"/> Yes (For Bonds) / Si (A Favor de los Bonos)</p> <p><input type="radio"/> No (Against Bonds) / No (En Contra de los Bonos)</p> <p>Volusia Forever: Acquisition and Improvement of Environmentally Sensitive</p>

8.2.7 Volusia County: Missing Ballot Images and CVR Records -- Digital Poll Report Audit

In precincts 415 and 416, ballot images and corresponding CVR files are missing, as shown in the previous [Volusia Precincts with Discrepancies](#) table (the entries highlighted in yellow). We must note that those precincts may also have records that were duplicated per the rescanning described above.

Precincts 415 and 416 were combined into a single polling location with two ES&S DS200 voting machines³³. To diagnose this issue, we utilized a feature of AuditEngine which performs a "Digital Poll Tapes Audit."

The DS200 ES&S voting machines produce a report at the end of election day called a poll tape. This is a long tape, like a cash register tape, and is signed at the bottom by polling place workers. Indeed, Volusia County was featured in the 2006 HBO Documentary "Hacking Democracy" where the polling place tapes were found in the trash, and different tapes were created later and given to citizens providing election oversight. Given this history, Volusia is likely to be careful with poll tape protocols.

We have discovered that the election night report tapes can be obtained in digital form so they are easier to process. This is not quite as trustworthy as the original paper source tapes produced on election night, but for our purposes, digital records are much easier to process and are certainly useful if they reveal discrepancies.

This "Digital Poll Tapes Audit" compares two sets of records:

1. the official results broken down by precinct, contest, and group (the EL30A) versus
2. the "digital poll tapes," which are a collection of separate pdf or txt files, one per machine, that contain the equivalent of what is printed on the tape (but not signatures). In this case, these were pdf files.

The digital poll tapes files are created from data downloaded from the flash drives transported from voting machines at polling places, and there is no digital poll tape file if the data was not downloaded from the flash drives. We appreciate the cooperation of Volusia County in providing the digital poll tapes files and being instrumental in discovering that this data was available.

The full report of the "Digital Poll Tapes Audit" for Volusia County is at this link.

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_General_2020_1103/reports/Poll_Tapes_Audit_Report.html

When this report is generated, AuditEngine combines polling tape reports from multiple voting machines that are located in the same polling location. But in the file listing, we find only one file for the 415/416 polling place, even though two machines were used there. Compare with the 410/411/427 polling place for which there are two files each corresponding to the two voting machines located there.

³³ <https://www.essvote.com/products/ds200/>

2020 General - Results - 410 - 411 - 427 - Unit 1.pdf
 2020 General - Results - 410 - 411 - 427 - Unit 2.pdf
 2020 General - Results - 413 - 414.pdf
 2020 General - Results - 415 - 416.pdf
 2020 General - Results - 419 - 421 - 429.pdf
 2020 General - Results - 423.pdf

For precinct 415, for example, the Digital Poll Tapes Audit provides these details for Trump and Biden:

415	ERROR	President and Vice President	Donald J. Trump	280	142	138 too few votes reported vs result
415	ERROR	President and Vice President	Joseph R. Biden	168	92	76 too few votes reported vs result

Precinct 415 shows that Trump received 142 votes according to the single poll report, while the EL30A (the official report) lists 280 votes; thus, there are 138 votes missing for Trump. For Biden, the poll report lists 92 votes but the EL30A shows 168 votes, indicating 76 missing for Biden.

Looking back at the [Volusia Precincts with Discrepancies](#) table for precinct 415, we can see that indeed, the discrepancies are the same--138 missing votes for Trump and 76 missing votes for Biden.

To determine the total number of ballot records that were not uploaded, we looked at the total ballots cast in precinct 415 (225) and in precinct 416 (312), resulting in a total of 537 ballot images and cast vote records that were not uploaded.

Thus, it appears that the ES&S EMS allowed the operators to omit the data from the USB flash drive from one of the machines used in the polling place that serviced precincts 415 and 416. Since the results were transmitted by modem from that machine, the official results are likely correct only due to this fact. But it also means that the results relied solely on the data transmitted by modem rather than the results in the USB flash drive. (It is possible that Volusia compared modemed results to the paper poll tapes but there is no way to tell by looking at any records we have obtained.)

This is a defect in the ES&S EMS if it allows the operators to skip receiving data from one of the machines. Clearly, since each USB flash drive is programmed for only one machine, the EMS knows about every machine in the election. We assume also that it also received data transmission from that machine because they did report the results. So it is inconceivable that the EMS did not also know that it did not acquire any votecount data from the USB flash drive

that it should expect, since it issued the flash drive, and received data from that same machine.

8.2.8 Volusia County: Follow-up on discrepancies

We are continuing to investigate these discrepancies, which indicate several key issues:

1. It is apparently possible to delete just the tabulated results, but not delete (or mark as unused) the corresponding ballot images and CVR records. This appears to be a defect in the ES&S EMS software.
2. Early voting sites do not transmit their results by modem, but rely only on the USB flash drive. Because of a failed USB drive, the county had to rescan the ballots. Perhaps using the second USB port in early voting machines would be a good backup protocol. In general, this failure points out the necessity of having the paper ballots that could be rescanned, thereby avoiding a complete failure of capturing these votes.
3. When data is being collected from USB flash drives, it is apparently possible to skip a USB flash drive and rely solely on the results transmitted by modem. This raises the question: Does the EMS routinely compare the results from each USB flash drive with the results transmitted by modem? How could it miss acquiring from one of the USB flash drives? And is the claim that they don't rely on the modemed results actually true?

Frequently, election officials have reassured the public that the "Internet" is not used, or at least is not relied upon. Hacking experts point out that modem transmissions across the telephone network or Internet are risky, and using USB flash drives and "sneakernet" is considered a practice that can thwart those attacks³⁴. The evidence we see here, however, is that the results transmitted by modem are relied upon, and there is no evidence that ES&S software compares the modemed results with the USB flash drive data.

ES&S mentions their policy regarding use of modems to transmit unofficial results in their FAQs³⁵ document (underlining added):

³⁴ <https://www.wsj.com/articles/sneakernet-helps-election-officials-process-results-11604440573> "'Sneakernet' Helps Election Officials Process Results -- With the internet representing a cyber risk, hand-carrying voting data is often the norm" The Wall Street Journal, 2020-11-03

³⁵ <https://www.essvote.com/faqs/>

Why are modems allowed to transmit results?

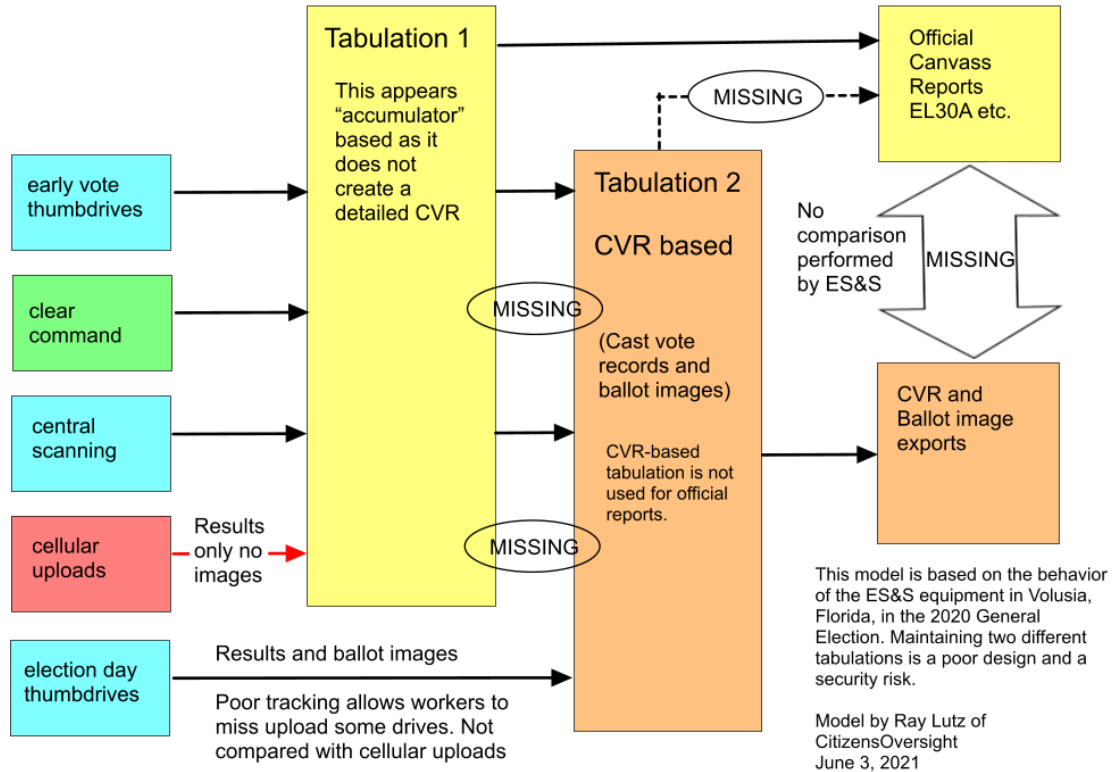
In a few states it is a legal practice to use cellular modems to transmit unofficial election results after the polls are officially closed and all voting has ended. ES&S uses mobile private network connectivity, industry best practices, and numerous security safeguards to protect the transfer of these unofficial election night results. Final official results are physically uploaded at election headquarters prior to final certification. The physical ballots and printed results tapes are always protected.

Clearly, in this case, the results were not physically uploaded at election headquarters prior to certification, and we do not know what happened to the USB flash drive and why it was not uploaded. Did it also fail, as did the drive from New Smyrna Beach?

4. We are very surprised that there is a discrepancy in the "results" tabulation (the official summary report known as the EL30A) and the cast-vote-records (CVR). The CVR is supposed to be the official record of the election, yet there were both duplicate records and missing records. (Note that CVR records matched one-to-one with their corresponding ballot images.). This means there are effectively two voting system tabulations rather than just one, which represents a security risk, again due to the design of the ES&S software. We hope that as a result of our case study, ES&S will explain how these two different tabulations can coexist at the same time.

The following schematic model is suggested by the evidence obtained in this case, indicating that two different tabulations do indeed exist in the ES&S EMS.

TWO DIFFERENT TABULATIONS EXIST IN ES&S EQUIPMENT



Referring to the graphic above, starting in the upper left corner: The early vote thumb drives were read in, and this apparently affected both tabulations. Then, a clear command was given, which cleared only Tabulation 1. They scanned the ballots from the early voting site and this again affected both tabulations. The cellular uploads from the voting machine only affect Tabulation 1, and did not provide images. Then the uploads of election day thumb drives only affect Tabulation 2. There is no comparison done by ES&S software of the EL-30A official report and the CVR files.

5. Short of updating the ES&S EMS software to prevent these mistakes from recurring, election officials should institute checklists to ensure that duplicate ballot images and CVR entries are not created, and ALL USB flash drives are uploaded and accounted for. Corrections to the EMS software may require recertification and this may take quite a while to complete.
6. Volusia County completed the "Conduct of Election Report" per Section 102.141(9) of Florida Statutes.³⁶ This statute includes the provision that the report should include

³⁶ The "Conduct of Election Report" as certified by the Volusia SEO.

https://us-east-1-audit-engine-election-data.s3.amazonaws.com/US/FL/US_FL_Volusia_General_20201103/VOL20201113_COER_125262.pdf

"All equipment or software malfunctions at the precinct level, at a counting location, or within computer and telecommunications networks supporting a county location, and the steps that were taken to address the malfunctions."

In their report under "Election Management -- Problem uploading results or creating reports," there is no checkmark or comments regarding the failure of the USB flash drive and the need to rescan all the ballots from the New Smyrna Beach early voting site. Also absent are notes regarding the need to rely on only the modem-transmitted results and the lost USB flash drive. Although we have been told that the re-scanning process was transparent because it was conducted in front of the Canvassing Board and the public, there is no report of that process. The failure of the device and rescanning was a major event that most definitely should have been included on the Conduct of Election Report.

This lack of transparency in their Conduct of Elections Report is extremely distressing and even though the responsibility for the duplicated ballot images (and CVR records) and the missing data from one of the machines is correctly attributed to a failure of the ES&S software, these problems should have been reported as required by law although we do understand such reports may be missed in the rush to complete them.

We understand that the problem with the flash drive from the New Smyrna Beach early voting site was reported to representatives from the media, the parties, and interested organizations (such as FFEC) at the time. The fact that this important event was not included in the Conduct of Election report is astounding. We believe the report should be amended and reissued, because we believe the accuracy of that report is extremely important, particularly since not everyone was "in the loop" of those earlier disclosures.

Below is a clip of their "Conduct of Election" report which omits these issues. Unfortunately, it is clear that election officials would rather have a clean report than be transparent about each of these issues.

Election Management	
<input type="checkbox"/>	Problem uploading results or creating reports
<input type="checkbox"/>	Other – Provide the description

8.2.9 Volusia County Discrepancy Report

After the vote extraction, we were able to compare with the ES&S CVR, even for those records that were duplicated.

The Volusia County Discrepancy Report can be viewed at this URL:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_General_2020_1103/reports/Discrepancy_Report.html

The highest level figures are as follows:

Record Type	Sheets	Contests	Percent
agreed	363,533		99.77%
blanks	3,480		0.955%
overvotes	1,855	2,070	0.509%
disagreed	864	1,239	0.237%
failed	26		0.007%
total	364,555		100%

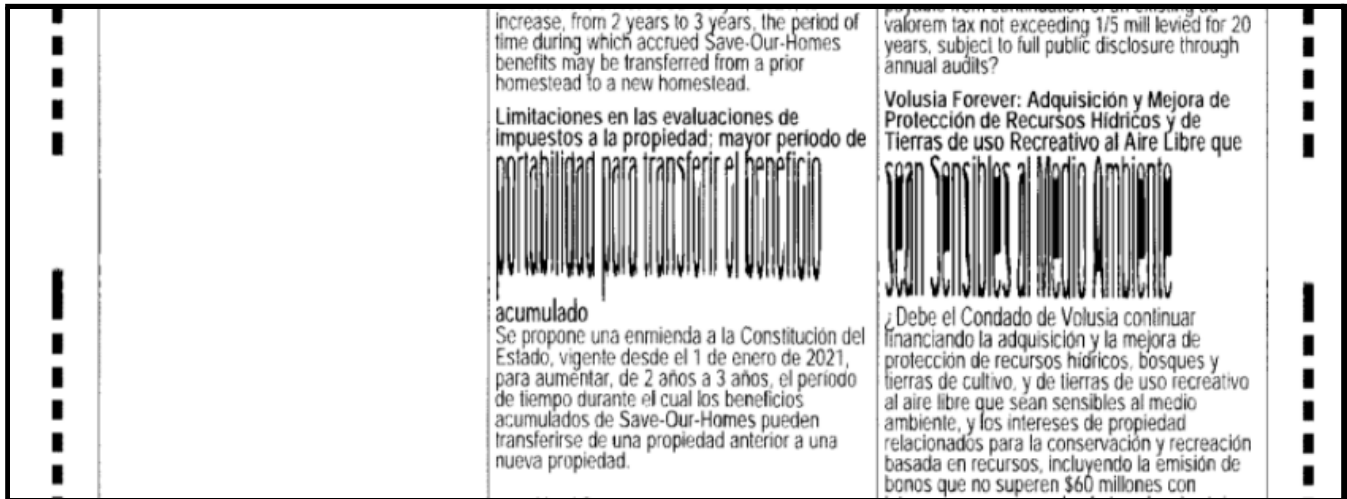
To see if there are sufficient discrepancies to question the outcome, we must consider the number of disagreed ballots (864) and failed ballots (26) and assume the worst, that the votes on those ballots were flipped, resulting in a vote difference of no more than 1,780. This quick estimate will also ignore all dilution of the contests if they do not appear on all ballot styles. As you can see in the top county-wide contests, the margin is far larger than this difference.

Contest	Margin of Victory
President and Vice President	43,246
Representative in Congress District 6	52,949
State Attorney 7th Judicial Circuit	11,424

The number of disagreed sheets and contests is slightly larger than would otherwise be the case due to the 4,904 duplicated ballots, and so some of those duplicated ballots would have disagreements reported twice.

All of the 26 failed ballots were failed due to excessive stretching. Many of the disagreed sheets were also due to the same issue but did not rise to the level where the ballot had to be regarded as failed.

Ballot 2473 is a good example of extreme stretching. This occurs when the ballot stalls briefly due to dirt or wear while the scanner continues to scan the same position over and over.



We are investigating improvements to our mapping algorithm so we can deal with this sort of stretching and still allow us to correctly extract the vote from the ballot. But even if we do a great job extracting votes, each stretched ballot will still require inspection in close elections. At this time, it is useful for AuditEngine to have failed these stretched ballots, rather than include them with the disagreements. Later, if we can enhance our algorithm to extract data from them, we can include them in the agreed set. But still knowing the number of stretched images is an important aspect of AuditEngine. The full set of reports for Volusia County are listed in this high-level "Audit Status" report:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_General_2020_1103/reports/audit_status_report.html

8.3 St. Lucie County

St. Lucie County had 223,640 registered voters and a total of 173,488 ballots cast. The population of St. Lucie County in 2019 was 328,297. The raw population-based turnout was 52.8%. St. Lucie is a battleground county where Trump received 86,831 votes (50.38%) to Biden's 84,137 (48.82%), a vote margin of victory of only 2,694 votes. It has 64 precincts, and uses equipment from Dominion Voting systems.

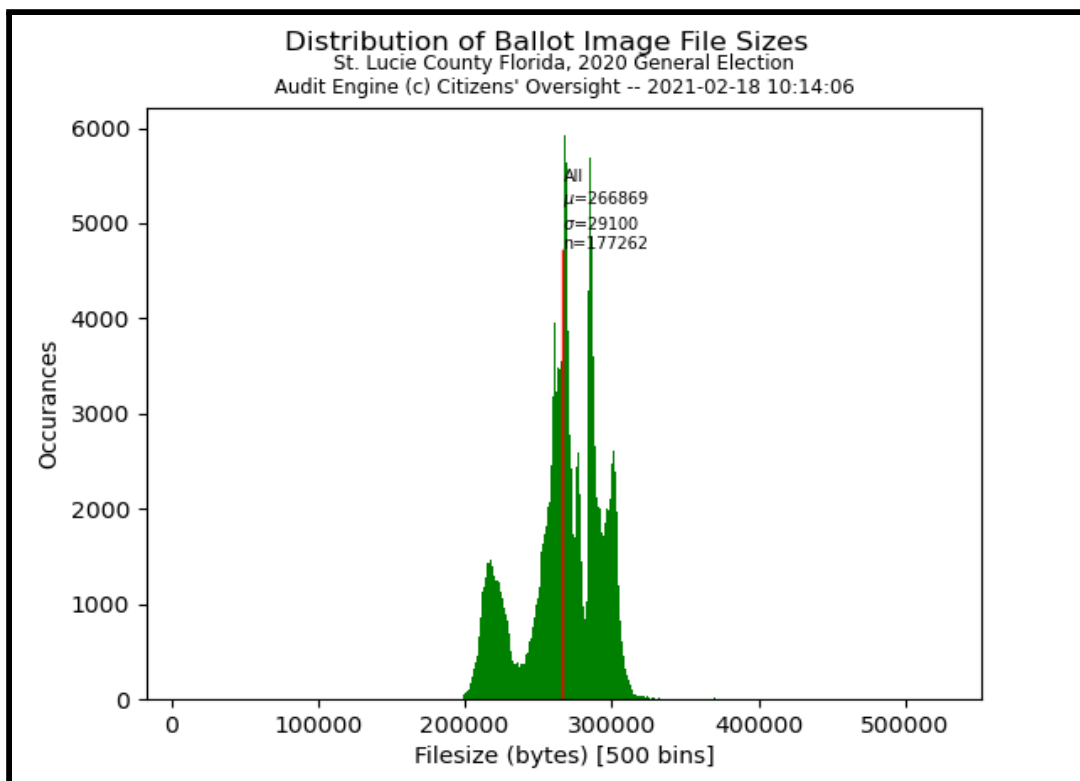
8.3.1 St. Lucie County: Ballot Inventory

St. Lucie provided 8 ballot image archives. Archives 1-7 were provided in conventional ZIP format, which is an open public standard and widely used, and is the type we need. Archive 8 was provided in RAR archive format³⁷, which is a proprietary archive file format developed in 1993 by Russian software engineer Eugene Roshal. It was also larger than usual, 24GB, which exceeds the 10GB limit of the file sharing services we sometimes use. The RAR file was split up into three ZIP archives, 8a, 8b, and 8c. We recommend that election officials do not use RAR but use ZIP.

In the initial review of these archives, it was discovered that archive 8a, the first portion of the RAR archive, was an exact duplicate of the ballot image files included with archive 7. This was astounding because archive 8 was split into three smaller files without knowing the content of archive 7 in advance (we didn't try to match it so the first third of archive 8 was exactly archive 7). This could be explained by the fact that the splitting process does tend to be based on internal folder structures, and thus an exact match could be a logical consequence rather than any sort of red flag. The precheck report was helpful in navigating these initial issues. Yet, we believe the election officials should strive to create accurate ballot image archives and avoid duplications. (Unlike Volusia where the ballots were duplicated and had new ballot_id numbers, in this case, the ballot ID numbers were the same as were the files themselves.)

Ballots in this election had only one sheet, so we did not have to split up the sheets and BMD ballots to determine how many ballots were cast.

³⁷ [https://en.wikipedia.org/wiki/RAR_\(file_format\)](https://en.wikipedia.org/wiki/RAR_(file_format))



One unusual issue with these ballot images is the existence of many ballots that are marked "NotCast". The total number of ballot images is 178,828 but the net number without the "NotCast" ballots is 173,974, meaning that 4,854 were marked as "NotCast". The official number of cast ballots as reported by the supervisor of elections is 173,448.

That means that there are **526 more ballot images than the number of ballots officially cast**. We don't have an explanation for this discrepancy at this time.

8.3.2 St. Lucie County: Creating the Ballot Information File without a CVR

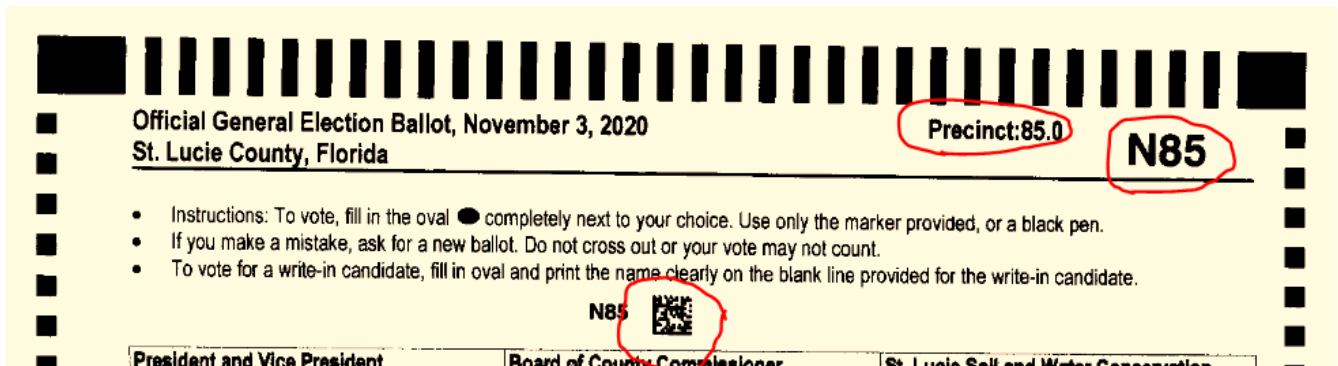
The next step in processing an election is for AuditEngine to construct the ballot information file (BIF). If we have the CVR data detailed to the ballot level (which was the case with Collier and Volusia), then AuditEngine reviews the CVR in conjunction with the ballot image archives to determine the style of each ballot so that we can perform our style analysis, create templates, and map the various styles.

However, St. Lucie County was unable to provide any CVR files broken down by ballot. Using the CVR can shortcut the analysis of the contests in each style.

Without the CVR, AuditEngine determines the styles in the election by performing a full review of all ballot images and extracts the "card_code" style designator on the ballot, which on ES&S and Dominion ballots are proprietary barcode graphical elements. Frequently, we also need to extract the precinct designation from the barcode or by using OCR (optical character

recognition)³⁸. However, OCR of printed text has a failure rate that is too high for our exacting needs.

The image clip below shows the precinct identifiers that AuditEngine interprets. The datamatrix code (similar to a QR Code) in the center encodes the string "N85", meaning the nonpartisan ballot for precinct 85. (In this election, all ballots were nonpartisan.) Then there are two other identifiers, the strings "Precinct:85.0" and the large "N85".



The codes were used differently depending on the type of ballot:

1. Datamatrix Code: Only absentee (vote-by-mail) ballots included a datamatrix 2-D barcode printed on the front. These ballots, printed by the printing-and-mailing vendor, were pre-stuffed in envelopes that had small cutout windows to view the datamatrix code. This enabled the vendor to easily keep track of the style of the ballot inside.
2. Large "N85": This element also does not appear on all ballots. It seems to have been used only on ballots that were handed to voters in person, so election staff could more easily choose the correct ballot style.
3. Smaller "Precinct:85.0": This element appeared on all the ballots but not always in the same location. Sometimes it shifted to the right if the large N85 was not also printed. On ballots printed in Spanish, "Precincto:85.0" was used. These numbers are difficult for AuditEngine to reliably read if there are streaks, dirt, etc. to the low error rate needed so we can be sure we are working with the right precinct, for comparison purposes.

Although converting the datamatrix was performed very reliably, the code did not exist on all ballots. Absent the code, we attempted to read the "Precinct:85.0" string. That string was generally read correctly, but streaks or other defects caused a failure rate that was too high to be used in the precinct-based comparison for which AuditEngine needs very high accuracy.

³⁸ https://en.wikipedia.org/wiki/Optical_character_recognition

Because of these problems, we concluded that it was not feasible at this time to make a precinct-based comparison, and adapting the system to do so would be wasted effort as these older Dominion systems are being rapidly upgraded. The bottom line is that to do the best job, we need the ballot-level CVR.

8.3.3 St. Lucie County Discrepancy Report

The Dominion EMS version used by St. Lucie is an older generation which does not offer key items, that we know of, compared with later versions of the EMS:

1. CVR files with ballot-level details are not available. The lowest-level detail is down to the precinct further broken out by group (early voting, election day, etc.)
2. Dominion does not export poll tape data in digital format, so a "Digital Poll Reports Audit" is not feasible.

Regarding the first issue, without CVR data broken down to the ballot, it is not possible to compare the results of the audit of a specific ballot to the official results. There are several options to deal with this issue and each has its own challenges, described as follows:

1. St. Lucie County does provide official results that are broken down to the precinct level. This report can be used to compare the totals of each precinct to official results. However, to do this we need to know the precinct of each ballot image so we can tabulate each precinct separately and then compare with the official results. Without the CVR providing the precinct for each ballot, we can read the precinct from the ballot image. Unfortunately, we have found that extracting this information was more difficult than we anticipated because St. Lucie county does not provide the designation consistently across all ballots. Depending on the type of ballot, the precinct may be printed in different locations on the ballot face. There may also be mistakes in the OCR conversion, which is unlikely but can be an issue when processing many ballots which are the case in jurisdictions in question.
2. Another option is to extract the official result from the "AuditMark," which is the third page in the ballot image. This page provides the official interpretation of the vote on the ballot image in graphical form. This would have the benefit of providing the data needed for a ballot-by-ballot discrepancy report.

Unfortunately, the "AuditMark" is a graphical rendering of the selections on each ballot rather than a digital representation.

The AuditMark is the third page in the ballot image set, and it is initially incorporated as part of a very tall image where the pages are combined in St. Lucie. The following figure shows the AuditMark for ballot 09996_00001_00001.

09996_00001_000001.tif scanned at 12:19:47 on 10/09/20.
Office of President and Vice President
Vote for Biden, Joe R.
Office of United States Representative in
Congress, District 18
Vote for Pam Keith
Office of State Senator for Senator District
25
Vote for Corinna Balderramos Robinson
Office of State Representative for House
District 84
Vote for Delores Hogan Johnson
Office of Clerk of Circuit Court
Vote for Joseph E. "Joe" Smith
Office of Sheriff
Vote for Ken J. Mascara
Office of Property Appraiser
Vote for Michelle Franklin
Office of County Commissioner, District 1
Vote for Chris Dzadoovsky
Office of County Commissioner District 3
Vote for Linda Bartz
Office of County Commissioner, District 5
Vote for Henry M. Duhart
Office of Justice of the Supreme Court #1
Vote for No
Office of Fourth District Court of Appeal #1
Vote for No
Office of Fourth District Court of Appeal #2
Vote for No
Office of Fourth District Court of Appeal #3
Vote for Yes
Office of School Board, District 2
Vote for Jack Kelly
Office of School Board, District 4
Vote for Jennifer Richardson
Office of St. Lucie Soil and Water, Seat 4
BLANK CONTEST
Office of No. 1 Constitutional Amendment
BLANK CONTEST
Office of No. 2 Constitutional Amendment
Vote for Yes
Office of No. 3 Constitutional Amendment
Vote for Yes
Office of No. 4 Constitutional Amendment
Vote for Yes
Office of No. 5 Constitutional Amendment
Vote for Yes
Office of No. 6 Constitutional Amendment
Vote for Yes

Because this is a graphic rendering rather than data in digital form, OCR must be used to recognize the text. OCR always has some error inherent in the process which we would like to avoid. It makes it difficult to know if the official result is wrong or if it is just the conversion of the AuditMark information. We have experimented with this process and have not found an error rate low enough to be viable. This is an area where we may do some additional work.

3. The third option is to extract what we believe is the summary of the official results of each ballot from the binary encoded ".res" files or ".dvd" files. These files are included in at least some of the ballot images archives. The process of learning to read these files is in process but the format is not public that we know of.

We must also consider that the newer generation of equipment from Dominion DOES have the capability of producing ballot-level CVR reports in a format similar to the NIST "Common Data Format" CVR standard.

In any case, at this time for St. Lucie, we cannot provide a ballot-by-ballot discrepancy report. Precinct-level comparison of the ballots to the official precinct totals has too much error in the OCR conversion to support the precision we need to challenge voting system results.

8.3.4 St. Lucie County Summary Results Report

Despite not having the detailed CVR files, we can compare the final results of the contests with the certified election results.

We must mention that we did not attempt to adjudicate AuditEngine’s results by manually reviewing ballot images. If adjudication were done, then some changes would occur. We must state, however, that AuditEngine has proven to evaluate voter intent more accurately than the certified voting systems from ES&S and Dominion due to our "adaptive thresholding" algorithm.

We believe the ballot image audit does indicate consistency with the results of the voting system. But we still have open questions related to the additional 526 ballot images and we would like to compare the results down to the ballot level. The differences shown in the following table are likely due to differences in voter intent that we could review further if we had the detailed CVR files. We hope that St. Lucie County will consider upgrading to equipment that produces detailed CVRs.

	Voting System	AuditEngine	Difference
Total ballots cast	173,488	173,623	+135
Undervotes	1,029	1,038	+9
Overvotes	110	110	0
Donald J. Trump	86,831	86,828	-3
Biden, Joe R.	84,137	84,260	+123
Jo Jorgensen	768	771	+3
Roque "Rocky" De La Fuente	71	71	0
Gloria La Riva	82	82	0
Howie Hawkins	209	210	+1
Don Blakenship	61	63	+2

Writeins	(not reported)	190	+290
----------	----------------	-----	------

OFFICIAL TOTALS REPORT for St. Lucie County (Presidential Contest):

President and Vice President (Vote for 1)			
Precincts Reported: 64 of 64 (100.00%)			
		Total	
Times Cast		173,488 / 223,640	77.57%
Undervotes		1,029	
Overvotes		110	
Candidate	Party	Total	
Donald J. Trump	REP	86,831	50.38%
Biden, Joe R.	DEM	84,137	48.82%
Jo Jorgensen	LPF	768	0.45%
Roque "Rocky" De La Fuente	REF	71	0.04%
Gloria La Riva	PSL	82	0.05%
Howie Hawkins	GRE	209	0.12%
Don Blankenship	CPF	61	0.04%
Total Votes		172,159	

AuditEngine TOTALS REPORT for St. Lucie County (Presidential Contest):

<table border="1"> <thead> <tr> <th>contest</th> <th>President</th> </tr> </thead> <tbody> <tr> <td>overvotes</td> <td>110</td> </tr> <tr> <td>undervotes</td> <td>1038</td> </tr> <tr> <td>num_ballots</td> <td>173623</td> </tr> <tr> <td>writeins</td> <td>190</td> </tr> <tr> <td>tot_votes</td> <td>172285</td> </tr> </tbody> </table>	contest	President	overvotes	110	undervotes	1038	num_ballots	173623	writeins	190	tot_votes	172285	<table border="1"> <thead> <tr> <th>option</th> <th>votes</th> <th>share</th> </tr> </thead> <tbody> <tr> <td>Donald J. Trump</td> <td>86828</td> <td>50.40%</td> </tr> <tr> <td>Joseph R. Biden</td> <td>84260</td> <td>48.91%</td> </tr> <tr> <td>Jo Jorgensen</td> <td>771</td> <td>0.45%</td> </tr> <tr> <td>Roque "Rocky" De La Fuente</td> <td>71</td> <td>0.04%</td> </tr> <tr> <td>Gloria La Riva</td> <td>82</td> <td>0.05%</td> </tr> <tr> <td>Howie Hawkins</td> <td>210</td> <td>0.12%</td> </tr> <tr> <td>Don Blankenship</td> <td>63</td> <td>0.04%</td> </tr> </tbody> </table>	option	votes	share	Donald J. Trump	86828	50.40%	Joseph R. Biden	84260	48.91%	Jo Jorgensen	771	0.45%	Roque "Rocky" De La Fuente	71	0.04%	Gloria La Riva	82	0.05%	Howie Hawkins	210	0.12%	Don Blankenship	63	0.04%
contest	President																																				
overvotes	110																																				
undervotes	1038																																				
num_ballots	173623																																				
writeins	190																																				
tot_votes	172285																																				
option	votes	share																																			
Donald J. Trump	86828	50.40%																																			
Joseph R. Biden	84260	48.91%																																			
Jo Jorgensen	771	0.45%																																			
Roque "Rocky" De La Fuente	71	0.04%																																			
Gloria La Riva	82	0.05%																																			
Howie Hawkins	210	0.12%																																			
Don Blankenship	63	0.04%																																			

9. Overall Summary and Findings

Overall, AuditEngine did not find any indications that the outcome should be questioned. However, we did learn a great deal from this effort which led us to implement significant enhancements to the software to improve our ability to diagnose the issues. Our findings are summarized below:

- 1. Computer Assisted "TargetMapper App" is superior to "automated" mapping.**

We found that using our existing automated mapping technology would require extra effort on the part of both user and software. In order for the mapping algorithm to complete, users must manually enter a significant amount of information and customize various settings. The operator would have to provide graphical hints to guide the software algorithm to completion, such as adding lines or providing explicit mapping instructions. Users also would need an understanding of the algorithm at a level beyond the level possible for an average operator. That said, we were able to fully map Collier County and most of Volusia with this method.

To reduce user burden, we introduced the Computer Assisted Manual Mapping feature, a browser-based tool called "TargetMapper." The feature enables the user to identify targets on ballot templates using the mouse. This worked well, allowing us to fully map Volusia and St. Lucie, and will be our primary approach moving forward.

2. Collier County had excellent data

Collier County deserves our best of study award due to their excellent data set that AuditEngine fully mapped using the existing automated algorithm and that had no issues regarding the number of ballot images, cast vote records, and ballots cast. The ballot image audit found no inconsistencies between the ballot images and the official outcome.

3. Collier County duplicated BMD ballot images when a two-sheet ballot was used.

We noted that in Collier County, the number of ballot images (and ballot numbers) exceeded the number of ballots cast by 39 ballots. This issue was resolved when we discovered that they duplicated the ballot images for the BMD ballots (total of 39) so that the CVR records would have two records per ballot, just like hand-marked ballots, which have two sheets each. We learned also that although these files were duplicated and not rescanned, the hash codes for the entire PDF files differed but the images in those PDF files had identical hash codes. Thus, it is not sufficient to compare the hash codes of the PDF files to check for duplicated ballot image files.

4. Failures omitted from the Conduct of Election Report in Volusia County.

Volusia's election was complex and we had some concerns about the consistency between the ballot images/CVR data and the official result. There was a failure of the second USB flash drive in the New Smyrna Beach early voting center and the election officials decided to "zero out" the election (to remove the results captured from the first flash drive) and then rescan all the ballots from that early voting site. Although the rescanning occurred openly in public, it was not noted in the county's "Conduct of Election" report. Surprisingly, the ballot images and corresponding CVR entries were not deleted when officials zeroed out the election, which meant duplicate images/CVR

entries were created when the ballots were rescanned. Though we could not locate all the duplicate ballot images we did find some because they had markings that were easy to recognize, proving that they were duplicated (with different ballot id numbers and the image data was similar to the eye, but was not digitally comparable because they were from two different scans.)

5. Two Tabulations in ES&S Equipment

We believe sufficient evidence exists that confirms that two independent tabulations exist in the ES&S EMS, one that can be both zeroed out while keeping the not zeroing CVR and ballot images, and which contains the modem transmitted results and not the uploaded results. We believe this may represent a major security flaw, but certainly is a poor design by the manufacturer. WE call on the manufacturer to explain how one tabulation can be zeroed out while not affecting the CVR and ballot images, and why the election could be certified while an upload of a USB flash drive was missed.

6. ES&S EMS allows mistakes to be made

The ballot images were not appropriately deleted with zeroing out of the tally, so rescanning the ballots created an additional 4904 ballot images and CVR records over the number of ballots cast. Additionally, we discovered that the results and digital images were not uploaded from one voting machine in the polling place serving precincts 415 and 416. Both these incidents were excluded from the Conduct of Elections report. We believe it is a failure of the ES&S EMS to allow the election to be certified without uploading this data, and to allow the ballot images to be left in memory when officials "zeroed out" the election. Despite these issues, we believe that the audited result was consistent with the official outcome.

7. Dominion software unable to produce ballot-level CVRs

In St. Lucie County, we processed the Dominion ballot images but were not able to compare the tabulation by AuditEngine with the official result on a ballot-by-ballot basis. We noticed that there were 526 additional ballot images over the official number of ballots cast which remain unexplained. Nevertheless, the audit result was consistent with the official outcome.

8. Gray background increased file size of ballot image

We noticed that ballot images with contest names that were shaded with gray-scale backgrounds were larger in file size by two or three times those without backgrounds. Officials concerned about storage space should eliminate grayscale backgrounds. Unhighlighted contest names also create clearer scans and are more readable by those with poor eyesight.

9. AuditEngine is more accurate than the voting systems.

In the discrepancy report for Collier County, we found that when there was a disagreement between the voting system and Audit Engine, excluding ballot images that were "stretched" or otherwise corrupted, AuditEngine was able to correctly interpret voter intent 93% of the time whereas the voting system interpreted voter intent only 7% of the time. This was from a small sample but is a positive indication of the accuracy of AuditEngine.

10. Stretched ballots

Ballot images are sometimes distorted or "stretched" when the ballot is temporarily stalled in the machine due to dirt or flat spots on the roller, usually only in small scanner devices in polling places. We could not correlate these issues to specific machines in this case. AuditEngine can help identify corrupt images and thus avoid potential improper vote interpretation by the voting system. Also, if the defects can be correlated to specific machines, we can recommend that these machines be removed from service. Regardless, we recommend that election officials clean scanner rollers and make sure the voting machines are run prior to use in the election to smooth out the scanning and at least partially resolve flat spots. These defects were not as prevalent in central count scanning operations.

11. Watermarks on the ballot images like "COPY" should be avoided

We found that watermarks added to the images caused AuditEngine to incorrectly evaluate one vote, although it was marked as "marginal." These watermarks have little or no real purpose because there is little risk that ballot image files will be confused with original paper ballots. Election offices should avoid adding watermarks to ballot images.

10. Conclusion

These case studies show the value of performing ballot image audits to check on the tabulation of elections from modern voting systems that utilize ballot images. We must caution the reader that finding consistency between the ballot images and the official reported results is not sufficient to fully audit an election, as there are still concerns regarding voter eligibility, chain of custody, whether the ballot images are a faithful representation of the ballots, and other factors.

Our audit of Volusia County revealed instances of both duplicated images and missing images, neither of which were correctly reported in the Conduct of Election Report. We believe that the ES&S EMS Software should not allow duplicate images or missed uploads, and we suggest that Volusia County ask ES&S to explain these failures and describe what they will do to correct them.

We appreciate the cooperation of the three counties that participated in this case study. We especially acknowledge Collier County for having spotless data exports which we had no trouble processing. St. Lucie County answered our requests with all the available data, but the county's voting system does not create the reports we needed for a thorough "down to the ballot" review. Volusia County was very responsive to our inquiries, but should be accountable for not reporting the rescanning of the first two machines from the New Smyrna Beach voting site in the Conduct of Election Report.

We hope that the counties see the value of such a review of ballot images to increase voter confidence in election results.

Primary Author: Raymond Lutz



Raymond Lutz is the founder and executive director of Citizens' Oversight Projects, a 501(c)3 nonpartisan nonprofit organization that has been involved in providing oversight to elections for over 15 years. Lutz has a Masters degree in electronics and software engineering, with experience in the document management and printer/scanner/fax/copier industry, and medical device industry. He is the lead developer of AuditEngine.

Acknowledgments

The following people and organizations contributed their time and efforts to assist in the completion of the audit and the report:

- Susan Pynchon, Florida Fair Elections Coalition, ffec.org
- Kitty Garber, Florida Fair Elections Coalition, ffec.org
- April Smith
- Harvie Branscomb, electionquality.com
- John Brakey, AUDIT USA, auditelectionsusa.org
- Dale Axelrod, nvrta.org
- Paul Burke, VoteWell.net
- Garrett Lutz
- Darlene Little
- Tim White
- Susan Shamblin
- Justin LeBlanc

How to Comment

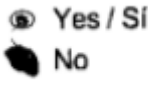
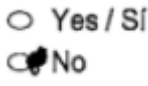
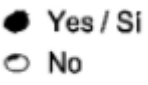
Please send questions and comments about this report to support@citizenoversight.org

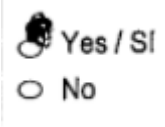


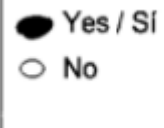

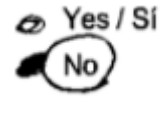
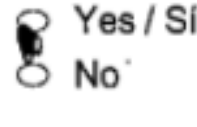
APPENDIX 1 -- Disagreements in Collier County

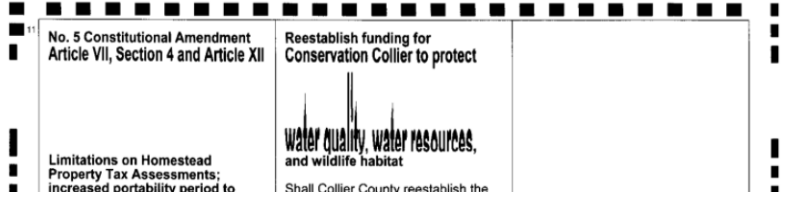
The following table lists a representative sampling of ballots with disagreements between AuditEngine and the voting system. The sampling is meant to demonstrate the types of issues found in practice. The full discrepancy report for Collier County is at this URL:

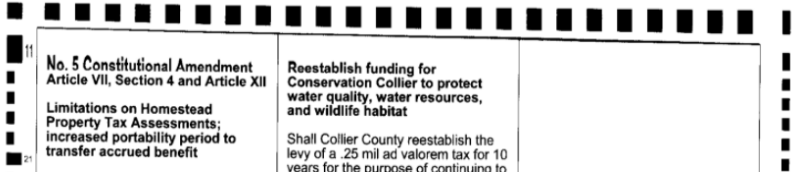
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_2020_1103-02/reports/Discrepancy_Report.html

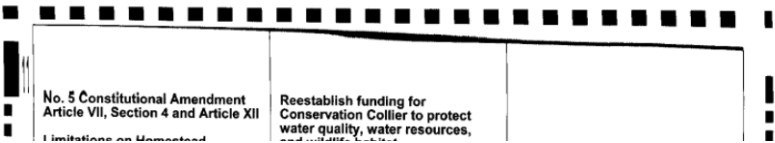
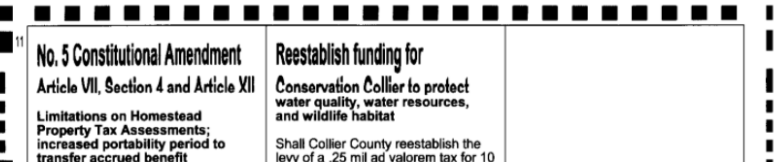
Each row represents a ballot and includes the mismatched contest. The “Comparison Details” column includes which system (AuditEngine or the voting system) correctly interpreted the vote in that contest. Each successive row keeps a running total of three scores: the number of votes correctly interpreted by AuditEngine (“Audit Correct”), the number of votes correctly interpreted by the voting system (“CVR Correct”), and whether the ballot is stretched or otherwise corrupted (“Stretch”).

Comparison Details (bold text shows the correct interpretation)	Image
1. ballot_id 102382 Precinct 101 Contest: No. 1 Constitutional Amendment Audit says: 1 Vote, "No" <-- Correct CVR says Overvote Audit Correct 1 CVR Correct 0 Stretch 0	
2. ballot_id 492464 Precinct 101 contest FL Supreme Justice Muniz Audit says: 1 Vote, "No" <-- Correct CVR says: Undervote Audit Correct 2 CVR Correct 0 Stretch 0	
3. ballot_id 561555 precinct 101 contest No. 6 Constitutional Amendment Audit says 1 Vote, "Yes" <-- Correct CVR says Overvote Audit Correct 3 CVR Correct 0 Stretch 0	

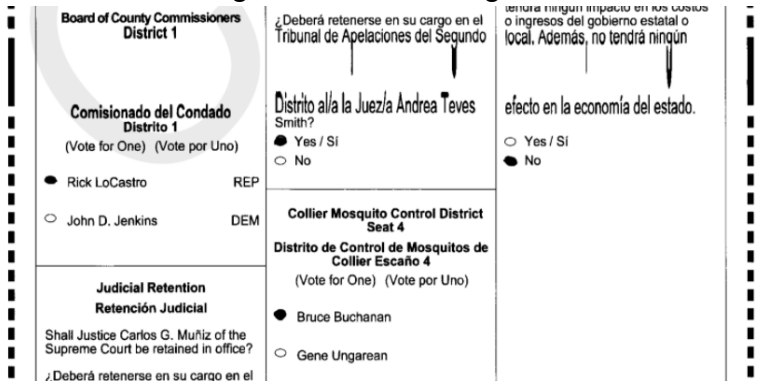
<p>4. ballot_id 433202 precinct 102 contest No. 2 Constitutional Amendment Audit says 1 Vote, "Yes" <-- Correct CVR says Undervote</p> <p>Audit Correct 4 CVR Correct 0 Stretch 0</p>				
<p>5. ballot_id 101902 precinct 103 contest No. 2 Constitutional Amendment Audit says Undervote, (Incorrect) CVR says 1 Vote, "Yes"</p> <p>Note: This ballot has a stretched top and failed to read the other two contests correctly.</p> <table border="1" data-bbox="170 861 950 1018"> <tr> <td style="text-align: center;">  No. 2 Constitutional Amendment Article X, Section 24 Raising Florida's Minimum Wage Raises minimum wage to \$10.00 per hour effective September 30th, 2021. Each September 30th thereafter </td> <td style="text-align: center;"> No. 3 Constitutional Amendment Article VI, Section 5 All Voters Vote in Primary Elections for State Legislature, Governor, and Cabinet All voters will cast their votes in </td> <td style="text-align: center;"> No. 4 Constitutional Amendment Article XI, Sections 5 and 7 Voter Approval of Constitutional Amendments Requires all proposed amendments </td> </tr> </table> <p>Audit Correct 4 CVR Correct 1 Stretch 1</p>	 No. 2 Constitutional Amendment Article X, Section 24 Raising Florida's Minimum Wage Raises minimum wage to \$10.00 per hour effective September 30th, 2021. Each September 30th thereafter	No. 3 Constitutional Amendment Article VI, Section 5 All Voters Vote in Primary Elections for State Legislature, Governor, and Cabinet All voters will cast their votes in	No. 4 Constitutional Amendment Article XI, Sections 5 and 7 Voter Approval of Constitutional Amendments Requires all proposed amendments	
 No. 2 Constitutional Amendment Article X, Section 24 Raising Florida's Minimum Wage Raises minimum wage to \$10.00 per hour effective September 30th, 2021. Each September 30th thereafter	No. 3 Constitutional Amendment Article VI, Section 5 All Voters Vote in Primary Elections for State Legislature, Governor, and Cabinet All voters will cast their votes in	No. 4 Constitutional Amendment Article XI, Sections 5 and 7 Voter Approval of Constitutional Amendments Requires all proposed amendments		
<p>6. ballot_id 101924 precinct 135 contest No. 2 Constitutional Amendment Audit says 1 Vote, "No" <-- Correct CVR says Overvote</p> <p>Audit Correct 5 CVR Correct 1 Stretch 1</p>				
<p>7. ballot_id 496450 precinct 135 contest FL Appellate Dist 2 Judge Atkinson Audit says 1 Vote, "Yes" <-- Correct CVR says Undervote</p> <p>Audit Correct 6 CVR Correct 1 Stretch 1</p>				

<p>8. ballot_id 162517 precinct 139 contest No. 1 Constitutional Amendment Audit says Undervote <-- Correct CVR says 1 Vote, "Yes" Other marks by this voter were solid.</p> <p>Audit Correct 7 CVR Correct 1 Stretch 1</p>	<input checked="" type="radio"/> Yes / Si <input type="radio"/> No
<p>9. ballot_id 162756 precinct 139 contest Collier Mosquito Control District Seat 4 Audit says 1 Vote, "Bruce Buchanan" CVR says Undervote</p> <p>Audit Correct 8 CVR Correct 1 Stretch 1</p>	<input checked="" type="radio"/> Bruce Buchanan <input type="radio"/> Gene Ungarean
<p>10. ballot_id 162018 precinct 141 contest Conservation Collier Funding Audit says Undervote CVR says 1 Vote, "Yes" Ballot Stretched. The other two contests on this side also were not extracted correctly by AuditEngine.</p>  <p>Audit Correct 8 CVR Correct 2 Stretch 2</p>	<input checked="" type="radio"/> Yes / Si <input type="radio"/> No
<p>11. ballot_id 162056 precinct 141 contest US House FL 19 Audit says 1 Vote, "writein" CVR says Overvote Nothing was written in, and so there was no net change,</p>	<input type="radio"/> Byron Donalds REP <input type="radio"/> Cindy Lyn Banyai DEM <input checked="" type="radio"/> Write-in Por Escrito

<p>but the vote should have been classified as a blank write-in and not an overvote. Audit Correct 9 CVR Correct 2 Stretch 2</p>	
<p>12. ballot_id 162171 precinct 141 contest Conservation Collier Funding Audit says Undervote</p> <p>CVR says 1 Vote, "Yes" Top of the ballot was stretched. Two other contests were also not correctly interpreted.</p>  <p>Audit Correct 9 CVR Correct 3 Stretch 3</p>	<p><input checked="" type="radio"/> Yes / Si <input type="radio"/> No</p>
<p>13. ballot_id 162366 precinct 141 contest FL State Rep Dist 106 Audit says 1 Vote, "Sara McFadden" CVR says Undervote</p> <p>Audit Correct 10 CVR Correct 3 Stretch 3</p>	<p><input type="radio"/> Bob Rommel <input checked="" type="radio"/> Sara McFadden</p>
<p>14. ballot_id 574927 precinct 141 contest FL Appellate Dist 2 Judge Atkinson Audit says 1 Vote, "Yes" CVR says Undervote</p> <p>Audit Correct 11 CVR Correct 3 Stretch 3</p>	<p><input checked="" type="radio"/> Yes / Si <input type="radio"/> No</p>
<p>15. ballot_id 574927 precinct 141 contest Greater Naples Fire Rescue District Seat 2 Audit says 1 Vote, "Al Duffy"</p>	<p><input checked="" type="radio"/> Al Duffy <input type="radio"/> Jeff Page</p>

<p>CVR says Undervote</p> <p>Audit Correct 12 CVR Correct 3 Stretch 3</p>	
<p>16.</p> <p>ballot_id 650227</p> <p>precinct 141</p> <p>contest Conservation Collier Funding</p> <p>Audit says 1 Vote, "Yes"</p> <p>CVR says Undervote</p> <p>Audit Correct 13 CVR Correct 3 Stretch 3</p>	<p><input checked="" type="radio"/> Yes / SI</p> <p><input type="radio"/> No</p>
<p>17.</p> <p>ballot_id 662106</p> <p>precinct 141</p> <p>contest Greater Naples Fire Rescue District Seat 2</p> <p>Audit says 1 Vote, "Jeff Page" (marginal)</p> <p>CVR says Undervote</p> <p>Marginal vote was caused by "COPY" watermarking on ballot images. This was be flagged as marginal vote that would need adjudication</p> <p>Audit Correct 13 CVR Correct 4 Stretch 3</p>	<p><input type="radio"/> Al Duffy</p> <p><input type="radio"/> Jeff Page</p>
<p>18.</p> <p>ballot_id 160830</p> <p>precinct 142</p> <p>contest Conservation Collier Funding</p>  <p>Audit Correct 13; CVR Correct 5; Stretch 4</p>	<p>Stretched top of the ballot resulted in three votes not correctly interpreted by AuditEngine.</p>
<p>19.</p> <p>ballot_id 569673</p> <p>precinct 142</p> <p>contest Conservation Collier Funding</p>  <p>Audit Correct 13; CVR Correct 6; Stretch 5</p>	<p>Stretched top of the ballot resulted in three votes not correctly interpreted by AuditEngine.</p>

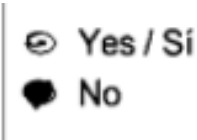

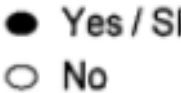
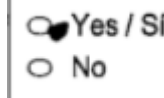
<p>20. ballot_id 570874 precinct 142 contest No. 6 Constitutional Amendment Audit says 1 Vote, "Yes" CVR says Overvote</p> <p>Audit Correct 14; CVR Correct 6; Stretch 5</p>	<p><input checked="" type="radio"/> Yes / Si <input type="radio"/> No</p>
---	--

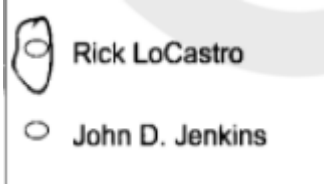
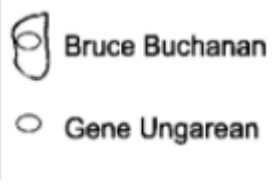

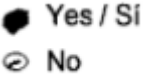
<p>21. ballot_id 100138 precinct 144 contest Collier Mosquito Control District Seat 4</p> <p>Stretched ballot in middle causes extraction to improperly interpret several votes on this ballot. Stretch is not in the same location on front and back, but closer to the top on the front, indicating that the scanning elements are offset.</p>  <p>Audit Correct 14; CVR Correct 7; Stretch 6</p>	<p>Stretched ballot would require manual adjudication if the results were very close.</p>
--	---

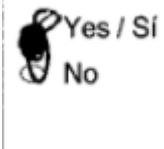
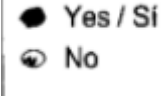
<p>22. ballot_id 159587 precinct 144 contest No. 4 Constitutional Amendment Audit says 1 Vote, "No" CVR says Overvote</p> <p>Audit Correct 15; CVR Correct 7; Stretch 6</p>	<p><input type="radio"/> Yes / Si <input checked="" type="radio"/> No</p>
--	--

<p>23. ballot_id 159847 precinct 144 contest No. 4 Constitutional Amendment Audit says 1 Vote, "No" CVR says Overvote</p>	<p><input type="radio"/> Yes / Si <input checked="" type="radio"/> No</p>
--	--

<p>Audit Correct 16; CVR Correct 7; Stretch 6</p>	
<p>24. ballot_id 160516 precinct 144 contest FL Appellate Dist 2 Judge Smith Audit says 1 Vote, "No" CVR says Overvote</p> <p>Audit Correct 17; CVR Correct 7; Stretch 6</p>	<p><input checked="" type="radio"/> Yes / Si <input type="radio"/> No</p>
<p>25. ballot_id 502606 precinct 144 contest Collier County Commissioner Dist 1 Audit says Undervote CVR says Rick LoCastro</p> <p>This voter used very light marks but we believe this should have been considered a vote by AuditEngine so we will research this case. Two other votes were considered too light that were legitimate.</p> <p>Audit Correct 17; CVR Correct 8; Stretch 6</p>	<p><input checked="" type="radio"/> Rick LoCastro <input type="radio"/> John D. Jenkins</p>
<p>26. ballot_id 535682 precinct 144 contest Greater Naples Fire Rescue District Seat 5 Audit says undervote CVR says Dominick "Nick" Biondo</p> <p>This ballot image is not "stretched" but is tilted quite a bit and perhaps the initial alignment was not good. But only this one contest was disagreed. This is classified as a stretch.</p> <p>Audit Correct 17; CVR Correct 9; Stretch 7</p>	<p><input checked="" type="radio"/> Dominick "Nick" Biondo <input type="radio"/> Tom Henning</p>
<p>27. ballot_id 577508 precinct 144 contest Collier County Commissioner Dist 1 Audit says Rick LoCastro CVR says Undervote</p>	<p><input checked="" type="radio"/> Rick LoCastro <input type="radio"/> John D. Jenkins</p>

<p>Audit Correct 18; CVR Correct 9; Stretch 7</p>	
<p>28. ballot_id 607467 precinct 144 contest No. 4 Constitutional Amendment Audit says 1 Vote, "No" CVR says Overvote</p> <p>Audit Correct 19; CVR Correct 9; Stretch 7</p>	
<p>29. ballot_id 619397 precinct 144 contest Conservation Collier Funding Audit says Undervote CVR says Yes</p> <p>This ballot may not have aligned properly due to the corrupted corner in the image, although AuditEngine is normally immune to this failure mode. This is classified as a stretch but it is actually an alignment error.</p>  <p>Audit Correct 19; CVR Correct 10; Stretch 8</p>	
<p>30. ballot_id 674939 precinct 144 contest FL Appellate Dist 2 Judge Smith Audit says 1 Vote, "Yes" CVR says Undervote</p> <p>Audit Correct 20; CVR Correct 10; Stretch 8</p>	

<p>31. ballot_id 100366 precinct 155 contest Collier County Commissioner Dist 1 Audit says 1 Vote, "Rick LoCastro" CVR says Undervote This voter circled all the ovals instead of filling them in. In a very close election, this ballot would be fully reviewed but normal review procedures do not review undervotes, and these would normally not be reviewed in Florida. Audit Correct 21; CVR Correct 10; Stretch 8</p>	 <p>Rick LoCastro John D. Jenkins</p>
<p>32. ballot_id 100366 (SAME BALLOT) precinct 155 contest Collier Mosquito Control District Seat 4 Audit says 1 Vote, "Bruce Buchanan" CVR says Undervote In several other cases, AuditEngine was able to interpret these correctly per voter intent guidelines. Audit Correct 22; CVR Correct 10; Stretch 8</p>	 <p>Bruce Buchanan Gene Ungarean</p>
<p>33. ballot_id 100366 precinct 155 contest President Audit says: 1 Vote, "Donald J. Trump" CVR says: Undervote State law would determine how these are interpreted but most states and Florida judge these by voter intent. Audit Correct 23; CVR Correct 10; Stretch 8</p>	 <p>Donald J. Trump Michael R. Pence</p>
<p>34. ballot_id 101336 precinct 155 contest No. 2 Constitutional Amendment Audit says 1 Vote, "Yes" CVR says Overvote Audit Correct 24; CVR Correct 10; Stretch 8</p>	 <p>Yes / Sí No</p>

<p>35. ballot_id 159191 precinct 155 contest No. 2 Constitutional Amendment Audit says 1 Vote, "Yes" CVR says Overvote Audit Correct 25; CVR Correct 10; Stretch 8</p>	
<p>36. ballot_id 554712 precinct 155 contest No. 5 Constitutional Amendment Audit says 1 Vote, "Yes" CVR says Overvote Audit Correct 26; CVR Correct 10; Stretch 8</p>	

Summary of the sample of disagreements shown above:

	Samples	% of Total	% of unstretched
Total Disagreed Samples	36	100%	
Stretched or corrupted	8	22%	
Not Stretched or corrupted	28	77%	100%
Audit Correct (CVR not)	26	72%	93%
CVR Correct	10	28%	
CVR Correct (Audit Not) not stretched	2	5.5%	7%

The reason we are considering only the unstretched ballots is to demonstrate the ability of AuditEngine to correctly interpret voter intent if the ballots are not stretched or corrupted. For unstretched ballots, AuditEngine correctly interprets voter intent 93% of the time, when there is a disagreement.

We are considering improving our software to correctly interpret "stretched" ballot images as long as the stretched portion of the image does not corrupt the target areas, while still classifying these as stretched, so that they can be reviewed later if the election is close. The current system of just reporting these and producing a larger number of disagreements (when

it may be the case that a large number of contests are shifted due to the stretch) will still result in the ballots being reviewed in a close election and thus the current behavior is conservative.

Thus, at this time, we are not enabling the stretch-fix code to allow AuditEngine to correctly interpret the stretched or corrupted ballots.

DISCLAIMER -- The analysis provided above is approximate as no attempt was made to analyze the results based on a sufficient sample to ensure significance, and we admit that a larger set of samples is needed. There is an assumption being made that when AuditEngine agrees with the Voting system, then they are both right, while in some cases they will both be wrong. Nevertheless, we believe this does provide a sense for how well the "adaptive thresholding" algorithm works, in the absence of other ballot defects such as stretching.

APPENDIX 2 -- Links to detailed reports

Collier County

- Precheck Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_20201103-02/reports/precheck_report.html
- BIF Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_20201103-02/reports/bif_report.html
- Styles Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_20201103-02/reports/Styles_Report.html
- Discrepancy Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Collier_General_20201103-02/reports/Discrepancy_Report.html

Volusia County

- Precheck Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/precheck_report.html
- BIF Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/bif_report.html
- Styles Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/Styles_Report.html
- Totals Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/Totals_Report.html
- Discrepancy Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/Discrepancy_Report.html
- Poll Tapes Audit Report (election day):
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_Volusia_Genera|_20201103/reports/Poll_Tapes_Audit_Report.html

St. Lucie County

- Precheck Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_St.Lucie_General_20201103-02/reports/precheck_report.html
- BIF Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_St.Lucie_General_20201103-02/reports/bif_report.html
- Styles Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_St.Lucie_General_20201103-02/reports/Styles_Report.html
- Totals Report:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/FL/US_FL_St.Lucie_General_20201103-02/reports/Totals_Report.html
- Official Voting System Results:
<https://www.slcelections.com/ELECTION-INFORMATION/Election-Results/Historical-Election-Results-2020-2029/FileId/206282>