CITIZENS' OVERSIGHT PROJECTS
CitizensOversight.org

AuditEngine

2023 Election Ballot Image "Pilot" Audit of

Rockville City (2023) and Somerset County (2022) Maryland

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Executive Summary

This document summarizes results of an audit of the November 2023 election in Rockville City, in Montgomery County, Maryland and also the November 2022 (prior) election in Somerset County Maryland. The audit reviewed the ballot images and other data. This audit was performed using the "AuditEngine" platform developed by Citizens' Oversight Projects.

This audit was conducted to demonstrate the capabilities of AuditEngine to qualify for potential contracts with the state of Maryland for similar services on a statewide basis. Also, we hope to solicit comments and suggestions for enhancing AuditEngine to more closely meet the needs of the state of Maryland.

The primary audience for this report includes election officials in Rockville City and the state of Maryland, but we anticipate the general public, election experts, and other election officials across the country will also be interested in these readily accessible results.

What is AuditEngine?

AuditEngine is an election auditing platform which performs "Ballot Image Auditing" (BIA). Modern voting machine ballot scanners capture relatively high-resolution digital images of each ballot in polling places using existing voting machines, or central count operations utilizing high-speed scanners. Over 97% of large districts in the country use a voting system that has the ability to capture and save ballot images. AuditEngine processes the ballot image of every ballot to create an independent tabulation, and then it compares its evaluation with the official cast vote record (CVR). AuditEngine then produces a report of any differences with ballot-by-ballot detail.

Unlike other BIA alternatives, AuditEngine also audits all Ballot Marking Device (BMD) ballots by "reading" the voter-verifiable text and AuditEngine does not rely on barcodes for votes selected at all.

Detailed Reports

AuditEngine can provide detailed reports which list discrepancies between the official records and our independent tabulation. Comparing results from two systems can expose errors in each system which would be very hard to find otherwise. While election systems are usually accurate, various factors can

introduce problems by mistake or on purpose[1]. Software updates, changes in the election definition, or malicious activity may change the outcome.

Most voters have doubts. Only 13% of Republicans and 4% of Democrats in 2018 were "very confident that election systems are secure from hacking and other technological threats."[2] We believe that AuditEngine represents our best option to relieve doubts. AuditEngine provides sufficient information to quell concerns that the election results are not an accurate representation of ballots scanned. This is in contrast, we believe, with risk limiting audits (RLAs) and other sampling audits which examine too few ballots.

Cooperative Workflow

In this pilot project, AuditEngine was enhanced to operate in a "Cooperative Workflow" (CWF) methodology to expedite our results on a quick-turnaround basis immediately after the ballot images are available. CWF starts prior to the election and uses data available at that time to configure AuditEngine, such as the Logic and Accuracy Test (LAT) data and searchable PDF files of all ballot styles ("ballot style masters").

After the election, as soon as the ballot images are available, they are uploaded to AuditEngine, and we are able to return our initial independent results within ~24 hours.

This is followed by a comparison with the cast vote records and any investigation into discrepancies. Thus, it is possible to return our results prior to the certification deadline to allow the most accurate election results possible.

AuditEngine was originally designed around a "Public Oversight Workflow" which starts after the election and perhaps without cooperation with the election district, and possibly without sufficient data for automated mapping. In that case, the TargetMapper App which provides an interface for computer-aided manual mapping. The Public Oversight Workflow approach takes longer. Yet the mapping process can still be performed using only ballot images and we may not always have access to the pre-election data used in CWF.

AuditEngine may provide too many reports and many diagnostics that are tailored for understanding "messy" data, and therefore are not useful in the CWF methodology when we have a partner like Maryland, which has already worked to clean the data and make it compatible with BIA audits. Therefore, we have

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[1] Norden, Lawrence "Voting System Failures: A Database Solution" https://www.eac.gov/sites/default/files/document_library/files/Norden-2010-Voting_Machine_Failures_Online.pdf
[2] Pew Research: https://www.pewresearch.org/politics/2018/10/29/election-security/

simplified our reports by splitting the reports into two groups, one that is in the "main" group, useful for officials, members of the public, candidates and campaigns, and the other which is for analysts who want to dig in deeper to evaluate our proof of results.

Another aspect that will receive some attention in this report are things that will further optimize our efficiency in providing our automated audits. The report provides suggestions to simplify the configuration of AuditEngine with respect to recognition of voter-verifiable text on BMD ballots. The exact text for each contest and options on the BMD summary cards is essential to reduce errors.

IN SUMMARY:
AuditEngine's analysis of the 2023 Municipal Election in Rockville City, MD and Somerset County found:

Very Clean Data:
Maryland primarily uses hand-marked paper ballots and is a leader in providing "clean" election data, making the use of AuditEngine very easy due to the elimination of data variations. BMD data was fully processable in Rockville and we had only a couple of distorted BMD ballot summary cards that were not automatically processed in Somerset. We have a plan to improve our performance in handling BMD ballots but it is already excellent.

No Significant Discrepancies:
Among the ballots processed in the audits, there was <u>no evidence of significant inconsistencies</u> that would cast any contest into doubt.

The audit does report minor normal disagreements in voter intent. In Rockville City, we did find 19 contests on 15 ballots where we disagreed on the interpretation of the votes. In 18 of those cases, we believe that AuditEngine correctly interpreted likely voter intent, while in one case, it did not. Thus, AuditEngine matched human-eye interpretation in 18 of 19 cases, or 94.7% of the time, when the two systems, AuditEngine and the voting system, disagreed.

These cases are normal and are not indicative of any failure in the system. On the contrary, these minor disagreements on voter intent show that the auditing system can find those very few cases where there are differences in interpretation. In the case of Rockville city, with 12,637 ballots processed and 75,822 individual contests (six per ballot), the 15 cases for further review, account for about 0.02% of the contests and 0.12% of the ballots cast.

Any auditing methodology that does not find voter-intent differences at a similar rate should raise red flags, since the ES&S voting system does not attempt to interpret voter intent more than just noticing if the bubble is darkened over a threshold. AuditEngine, in contrast, does use interpretation rules to interpret most voter intent issues accurately.

We will look at all of these cases in this report.

OVERALL SUMMARY OF THE ELECTIONS BEING STUDIED:
This table provides the overall profile of each area in each election:

Attribute	Rockville City MD 2023 Municipal Election	Somerset County MD 2022 General Election
Population in 2020	67,357	24,620
Eligible voters	42,411 (est.)	14,112
Ballots Cast: (ballot images)	12,637	6,958
Voting System:	ES&S	
BMD Ballots Cast	199	1,802
Sheets	One sheet for each voter in all precincts.	
Ballot images	12,637	6,958
Repeated Ballot Images	0	20,356
Missing Ballot Images	0	0
BMD Images	199 (1.57%)	1,802 (25.8%)
Missing CVR records	0	0
Rare Styles	5	1
Rare Ballots	23	7
Total Contests	75,822	142,979

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1. Background

To reduce the size and complexity of audit reports, background information has been moved to a companion document:

"Auditing Elections Using Ballot Images and AuditEngine -- General Background"
https://docs.google.com/document/d/18A1K8mXXHnhisLqBQigx0ibboz39FAh9hOSykcR-jT4/edit?usp=sharing

If you are new to this type of auditing, this document will provide the general background which will be useful to digest the rest of this report, particularly with respect to the terminology defined.

OCR of Voter Verified Text on BMD Ballots is Important:
AuditEngine's reading of printed text (called "OCR" for optical character recognition) rather than using barcodes is an extremely important feature when considering the recently exposed "flaw" in the Georgia voting system, as reported by J. Alex Halderman, a computer science professor at the University of Michigan. This same flaw is a concern in all voting machines that use barcodes, including ES&S.

Halderman found that malicious software could be installed on BMD touch screen voting machines to change QR codes printed on paper ballots, which are then scanned to record votes, according to court documents. QR codes aren't readable by the human eye, and voters have no way to know whether they match the printed text of their choices[3].

Also, there was a recent case[4] in Northampton County, PA, with ES&S voting machines, where a user voting for one candidate was swapped with a vote in an adjacent contest, but the barcodes are said to be correct. Thus, the barcodes may differ from the voter-verifiable text but in this case, the error was detected by voters when the text did not correspond to their voted selection. It could easily be the reverse, such that the voter-verifiable text is correct but the barcodes are incorrect, and in such a case, voters would not notice that their vote is encoded improperly. In Northampton, they reassured the public that the barcodes were correct and the

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[3] "Secret report finds flaw in Georgia voting system, but state in the dark"
https://www.ajc.com/politics/secret-report-on-georgia-voting-system-finds-flaws-but-state-shows-no-interest/YKFEET2WE5BBPJ7TYVOYMBTIKQ/
[4]
https://www.lehighvalleynews.com/elections/election-2023-widespread-voting-machine-problems-reported-in-northampton-county "Election 2023: County exec 'livid' at voting machine trouble but confident in accurate count"

results were correct even though text was incorrect. Unfortunately, this is not at all reassuring because it means that the opposite could also be true, that the text is correct and the barcodes are incorrect[5].

In all these cases, AuditEngine can "read" the voter-verified text to check that the voting system is providing the same results, and we bypass the barcodes that provide the votes to the voting system. Our system can detect any cases where the barcodes differ from the printed text.

A note on writing style

Throughout this document, we will use "programmer" style quotes, which always frame the terms and do not include punctuation. Also, as a matter of style, numbers are always shown in numerical form, commas will always be included in conjunctive lists, and all quotes are straight.

2. Audit Overview

1. **ES&S Voting Machines:** The voting machines used in Maryland are from Election Systems and Software (ES&S), and they primarily use hand-marked paper ballots. In Rockville, only a very few voters used ExpressVote BMD (ballot marking device) devices (1.5%) while in Somerset, a quarter (25.8%) of the ballots were BMDs.

2. **Cooperative Workflow:** We have defined a number of workflow options, and cooperative workflow is a new addition to AuditEngine. We have the following workflows defined:

   ○ **Public Oversight Workflow:** In this workflow, we obtain the ballot images, cast-vote records (CVR) and possibly ballot style masters all at the same time, after the election.

   ○ **Cooperative Workflow:** In this workflow, the data is provided in 3 phases:
      ■ **Phase 1: LAT and Ballot Style Masters** are used prior to the election to complete the "mapping" of the targets on each ballot style,

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[5] CItizens' Oversight has sent a letter to Northampton County to offer AuditEngine to help diagnose this issue because we can both read all the text and capture all the barcodes as well. We know of no other system capable of providing this complete analysis.

- **Phase 2: Ballot images** are available and the vote can be evaluated, and an independent result is provided.
- **Phase 3: CVR files** are processed to create the comparison of AuditEngine with the results of the voting system.

In the case of Somerset County, we had all the data up front, and we initially ran it under the Public Oversight Workflow, and then ran it again using the Cooperative Workflow to simulate how we would be getting the data in Maryland in real elections. In Rockville, we used only CWF because we ran it during a live election.

3. **Parsed the Logic and Accuracy Test (LAT) Data:** Prior to the election, the Logic and Accuracy Test data was utilized to obtain the complete set of contests and options in the exact order and format used by the cast vote record. In CWF, we do not have the Cast Vote Records (CVR) until after the election and we do not process it until we generate our independent results. Yet, we need the exact contest and option names so the comparison can be easily accomplished.
   - In Rockville City, there were no repeated contest names.
   - The Somerset data did have two contests with repeated names and these were manually renamed by adding uniqueness in the Election Information File (EIF). We recommend using unique names to begin with..

4. **LAT data is Insufficient:** We observed that the Logic and Accuracy test is insufficient to test for mis-mapped targets, which is one of the most important aspects of the test. The Rockville LAT was slightly improved from the Somerset Data, but still needs improvement. Ideally, every target on the ballot should have a different vote total in the final results of the LAT. This way, it is possible to know if any ovals are mistakenly assigned to the wrong names. We did not receive any actual results from the LAT test nor did we receive any actual LAT ballots. There were no BMD ballots tested that we could tell from this data, which unfortunately meant there were no BMD samples available prior to the election.

5. **Auto-mapped:** The ballot style master PDF files were parsed to determine the "target map" (the location of each "target" oval where a voter can place a mark and what it means). In this case, we used "auto-mapping" with almost no user interaction required. We noted excellent consistency maintained by the elections staff when designing the election. In both cases, it took less

than an hour to complete the mapping. Since consistency is such an important point for BIAs, for vote verification by voters, and for any type of auditing, our guidelines are provided in Appendix 3.

- In Somerset County, we had to make corrections to the options in the "Governor / Lt. Governor" contest, because of the compound names used. This was an easy process accomplished by editing a spreadsheet.

- In Rockville City, no corrections were required to contest names.

6. **Proofs Created and Reviewed:** After mapping, we reviewed "redline proofs", provided in the style report and the "Option Proofs Report" to validate the mapping. No changes were required to the map but adjustments were required to the write-in areas from what we had used in other counties. These settings will likely be about right in future elections in Maryland, depending on how consistently the ballot layout is maintained.

- This automapping process has fewer corrections required than our experience with computer-aided manual mapping, but does require the ballot style masters.
- BMD ballot string data was not available, which we need for full configuration prior to the election.
- The other files we were provided were not useful for our audit, so we may be able to reduce the files provided in that respect.

7. **Ballot Images Uploaded:** After the election, the ballot images were uploaded. In the case of Rockville City, we initially had some problems with uploading, and as a workaround, the images were uploaded to an alternative location. We had no trouble uploading the same file when we tested it from two other locations. Therefore, we will need to further investigate this issue after the election season as it appears to be something specific to the machine or network used to upload it in Montgomery County.

8. **Number of Sheets:**
The ballot image audit performed by AuditEngine processes ballots based on the sheets involved. Each sheet is processed separately, but the front and back are kept together.

- ○ **Rockville City**: 12,637 ballot sheets were processed based on our review of the images.

- ○ **Somerset County:** The ballot images in Somerset County had about 70% repeated images due to the County's desire to create snapshots to break the data into groups. The net number of sheets was 6,958.

9. **Repeated Ballots:**
    - ○ **Rockville City:** There were no repeated ballots in the image set.
    - ○ **Somerset County:** The total number of images was 27,314 with 20,356 of those repeated with the same ballot_id number and same image data. These were repeated to allow snapshots of the ballots cast based on Early-Vote, Election Day, Mail-in Ballots, and Provisional sets. The repeated ballots are not a severe problem, but this practice does result in much larger files containing the images. We have proposed a method of listing the files in each archive prior to the last (Provisional) image archive, so we can obtain the grouping data without increasing the size of the image data by nearly 4 times.
    - ○ The grouping data is nice to have, but is not essential in our process because we process all ballots, including BMD ballots. We believe the grouping was performed to facilitate BIA audits by other service providers that cannot process BMD ballots. Therefore, we can discuss whether the grouping data is required if we conduct the audit of full elections as we did in Rockville.
    - ○ If Maryland continues to use a service provider who cannot process BMD ballots, AuditEngine could be used to process only the BMD ballots that the other service provider is ignoring, which is a significant number in Somerset County (about a quarter).

10. **Repeated Images with different ballot_ids: None Detected.**
    In addition to repeated images that are fully repeated in the uploaded data, with the same ballot_id and same image data, AuditEngine also checks for the same image data with different ballot_ids, which can happen when USB thumb drives are incorrectly uploaded multiple times. None were detected.

11. **Initial Ballot Examination**
    AuditEngine reviewed all images to gather metadata, such as style, ballot type (BMD vs. nonBMD) and any other information that may be read from the ballots.

- ○ **Rockville City:**
  - ■ There were 10 styles and 10 districts.
  - ■ There were 6 contests, which appeared on all ballots.
  - ■ There was therefore 1 pattern of contests.
  - ■ There were 199 BMD ballots.
  - ■ Of the 12,637 ballots processed, 12,438 (98.4%) were hand-marked paper ballots.
- ○ **Somerset County:**
  - ■ There were 23 styles over 38 precincts.
  - ■ There were 27 contests.
  - ■ There were 5 patterns of contests.
  - ■ There were 1,802 BMD ballots.
  - ■ Of the 6,958 unique ballots processed, 5,156 (74.1%) were hand-marked paper ballots.

12. **Hand-Marked Ballots:**
    - ○ **Rockville City:**
      - ■ **One damaged ballot:** Of the 12,438 hand-marked paper ballots, only one had a hole near the timing mark and was not initially processed. An override was added to provide the style of this ballot (style 10) and this allowed the ballot to be processed. Thereafter, all ballots were successfully processed and there were no stretched or distorted ballots that could not be processed. 20 Blank ballots were detected.

13. **BMD Ballots:**

    AuditEngine processes these by reading the voter-verifiable printed text using OCR , and not relying on the barcodes.

    "Gray Flags" are set to mark cases where some additional human-eye review may be desired. It is our policy to gray flag, for further review, any case where AuditEngine used heuristics to "guess" what the voter intended.

    Initial Corrections

    There were a number of corrections we had to make initially, to resolve the Gray Flags, particularly in BMD results. At first, most of the BMD OCR results were not interpreted correctly. The fine tuning resolves edge cases when the attributes of the contest names and options vary from what we have seen before. As there is no formal specification for what is provided from the

voting system, we have to adapt to whatever is provided, and some adjustments are still required as we still encounter new variations. We anticipate this and are prepared to accommodate all variations.

- As a result of these audits, we have a plan for improved OCR operation that will not be so reliant on the OCR engine we utilize, while also decreasing the cost, which are currently about 2 to 4 times more costly to perform for BMD ballots than hand-marked ballots.
- If any issues are detected with the OCR conversion, these ballots are marked with a gray flag.
- Additional changes to option names expected on BMD summary sheets were required to obtain high confidence evaluation.
- There were some new characters not previously used in other elections we had processed, and other characters were dropped from the ballot summary cards when they were printed.
- We believe that as we perform audits for additional districts, the recognition engine that "reads" the written text will stabilize.

- **Rockville City:**
    - There were 199 ballot summary sheets, (1.6% of ballots cast).
    - The voting system dropped the Ó character found in "NO OPINION / NO OPINIÓN" and it was expressed as "NO OPINION / NO OPINI N".
    - The "No Opinion" third option was new to yes/no contests and the reports had to be adapted to handle that third option.
    - No BMD ballot images were excessively skewed or distorted so they could not be read.
    - All BMD ballots were processed with no deviation from the official result.
    - BMD Images were superior to those from Somerset County, and have similar quality to the newer ExpressVote XL machines.

- **Somerset County:**
    - There were 1,802 BMD sheets, (25.8% of ballots cast)
    - The images in Somerset were from an earlier generation of machines, and there were many more that were skewed, curved, and distorted. Some examples of these will be shown in the detailed results for Somerset County.
    - Nevertheless, there were only a few that were not readable.

- Of those BMD ballots processed, all corresponded to the official results.

14. **Independent Tabulation:** When working in the Cooperative Workflow as was done here, AuditEngine generates an independent result prior to comparison with the CVR. Before publishing this result, we spent some time reviewing "Gray Flags", "Overvotes" and "Write-ins" to attempt to resolve any that may be due to edge cases in AuditEngine. This was published and made available to the Maryland contacts before the CVR was processed for the Rockville City audit. In live operation, we see no reason we cannot meet the 24-hour goal.

15. **Voter Intent:** When the voting system and AuditEngine disagree on voter intent, the correct interpretation becomes clear by looking at the disputed ballot image. By "correct interpretation" we mean the human eye's determination of the intent of the voter, which is the deciding interpretation under Maryland election law.[6]

16. **Comparison:** After we publish the independent result from AuditEngine, we then incorporate the CVR into the process and compare the interpretation by AuditEngine with that of the voting system. By comparing the two systems against each other, we are able to detect the issues in each system.

17. Nonvariant vs. Variant: The first step in comparing is dividing completely nonvariant sheets from those that have one or more variant contests. Variant contests are individual contests on one ballot with any variation, such as overvotes, write-ins, gray-flags or disagreements. Sheets with one or more variant contests may have many other contests that are nonvariant.

18. **Nonvariant Sheets**

   - **Rockville City:**
     - 12,362, or 97.7% of all ballot sheets cast were completely agreed between AuditEngine and the voting system and had no variations, such as write-ins, overvotes, or gray-flags.

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[6] MD. Election Law Code § 11-302 (d)(1) -- "The State Board shall adopt regulations that reflect the policy that the clarity of the intent of the voter is the overriding consideration in determining the validity of an absentee ballot or the vote cast in a particular contest."

- On these sheets were 74,172 contests (with one having 6 votes allowed) out of 75,816 contests, or 97.8% were fully nonvariant.

  ○ **Somerset County:**
  - 6,523, or 93.7% of all ballot sheets cast were completely nonvariant.
  - On these sheets were 134,098 contests out of 142,979, or 93.8% were fully nonvariant and agreed.

Rockville City	Somerset County
High_Level_Reconciliation by sheets (Total: 12,657) 2023 November Municipal, Rockville City, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-14 13:00:40 2.16% 0.166% Non-Variant Sheets 12,362 (97.7)% Variants Removed Sheets 274 (2.2)% Ballot Variants 21 (0.17)% 97.7%	High_Level_Reconciliation by sheets (Total: 6,959) 2022 November General, Somerset County, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-19 17:31:22 0.0718% 6.19% Non-Variant Sheets 6,523 (93.7)% Variants Removed Sheets 431 (6.2)% Ballot Variants 5 (0.072)% 93.7%

19. **Variant-Removed Sheets:** On those "variant" sheets with one or more contests that are variant, many other contests are nonvariant and agreed. The variant contests are logically "removed" from these sheets, and these sheets are called "variant-removed sheets".

    ○ **Rockville City:**
    - 274 sheets (2.2%) had 1,328 contests (1.8%) that were non-variant and agreed
    - 316 contests (0.42% of all contests) on those same sheets were classified as "variant contests" and were "pulled" from the "Variants Removed Sheets" and individually classified in separate records for each contest instance, for categorization and further reporting.

- ○ **Somerset County:**
  - ■ 431 sheets (6.2%) had 7,888 contests (5.5%) that were non-variant and agreed.
  - ■ 993 contests (0.69% of all contests) were classified as "variant contests"

20. **Total of Nonvariant Contests:**

   - ○ **Rockville City:**
     A total of 75,500 contests, (99.8% of all contests) were interpreted the same and nonvariant in every respect by AuditEngine and the voting system, and these therefore required no additional scrutiny required due to write-ins, overvotes, or disagreements.

   - ○ **Somerset County:**
     A total of 141,986 contests (99.3% of all contests) were interpreted the same and were non-variant in the other respects.

21. **Contest Variants:** At the end of this separation process, we are left with the contest variants. Again, these are individual contest instances, each on one ballot, that had write-ins, overvotes, gray-flags, or were disagreed. A contest is "disagreed" when AuditEngine and the voting system did not interpret the vote exactly the same, usually due to voter-intent interpretation.
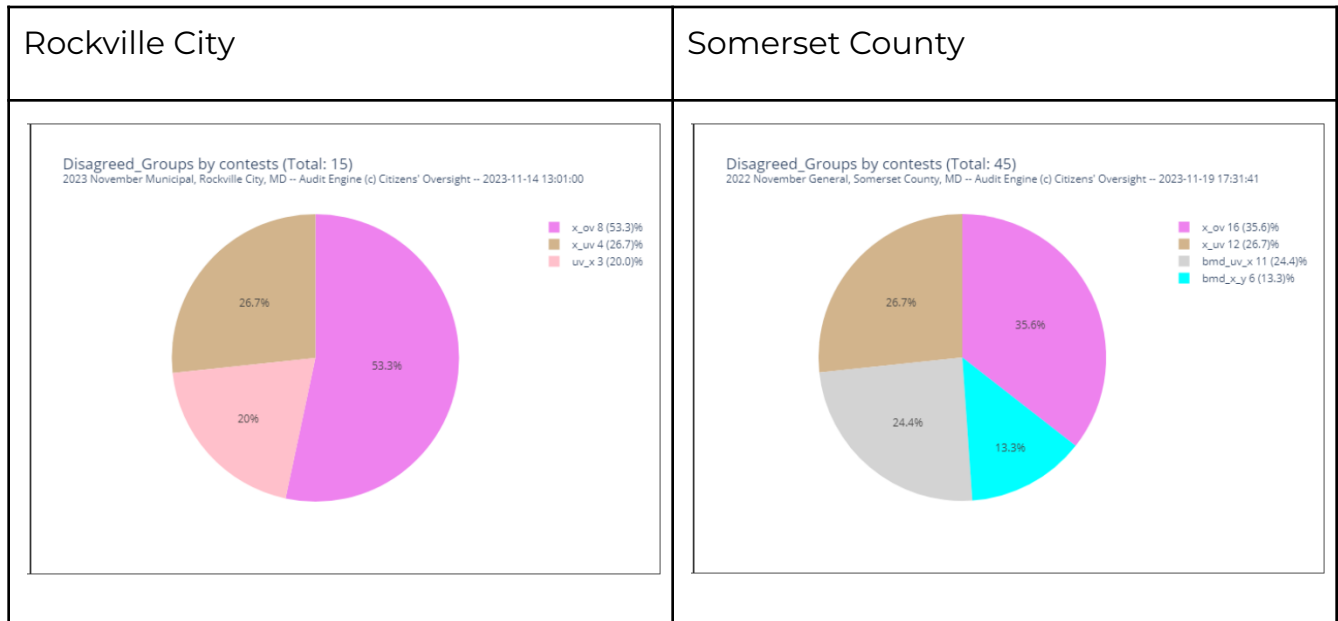
   - ○ **Rockville City:**
     - ■ The "Contest Variants" (316 contests, 0.42% of all contests) were further categorized by AuditEngine.
     - ■ These individual contests (sometimes called "votes", although one contest allowed up to 6 votes) were categorized as follows:
       - ● write-ins (226),
       - ● overvotes (65),
       - ● gray-flags (10), or
       - ● "disagreed" (15).
   - ○ **Somerset County:**
     - ■ Somerset County had 933 contests (0.69% of all contests) that were further categorized.
     - ■ The first categorization placed these into the following categories:
       - ● write-ins (602)

- overvotes (32)
- gray-flags (359) and not writeins or overvotes
- "disagreed" (45).

22. **Normal Disagreed:** These are the contests that are considered variants only because they are disagreed and may include overvotes or write-ins. All other overvotes and write-ins are agreed, but still may need further review.
    - **Rockville City:** 15 were classified as "disagreed", while the rest were write-ins and overvotes or gray only. These would require additional scrutiny in close contests. We will review them here, but this is generally not required unless the contest is close enough that these may become a concern.

    - **Somerset County:** 45 were classified as "disagreed". This larger number of disagreements is due largely to distorted BMD ballots that were hard to read as a result of the distortion. All the contests on each of those ballots were classified as "disagreed".

Rockville City	Somerset County
Disagreed_Groups by contests (Total: 15) 2023 November Municipal, Rockville City, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-14 13:01:00 x_ov 8 (53.3)% x_uv 4 (26.7)% uv_x 3 (20.0)% 53.3% / 26.7% / 20%	Disagreed_Groups by contests (Total: 45) 2022 November General, Somerset County, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-19 17:31:41 x_ov 16 (35.6)% x_uv 12 (26.7)% bmd_uv_x 11 (24.4)% bmd_x_y 6 (13.3)% 35.6% / 26.7% / 24.4% / 13.3%

23. **Closest Contests:** Contests were individually considered.

    - **Rockville City**
      The 2 most discrepant contests had disagreements between 0.05% to 0.47% of the margin of victory. This means there is no chance, from this

analysis, that any contests could be wrongly decided.

- **Rockville City Council (vote for six)**
    - Margin of victory: 851 votes (1.39%)
    - 4 votes "Disagreed" (0.47% of margin)
    - 210 contest variants (24.68% of margin)

- **Question 4, Representative Districts**
    - Margin of victory: 1,307 votes (11.52%)
    - 1 votes "Disagreed" (0.08% of margin)
    - 13 contest variants (0.99% of margin)

- **Somerset County**
  The 2 most discrepant contests had disagreements between 0.27% to 0.31% of the margin of victory. This means there is no chance, from this analysis, that any contests could be wrongly decided.

- **Governor / Lt. Governor**
    - Margin of victory: 1,637 votes (23.97%)
    - 5 votes "Disagreed" (0.31% of margin)
    - 50 contest variants (3.05% of margin)

- **Question 4, Cannabis**
    - Margin of victory: 1,092 votes (17.25%)
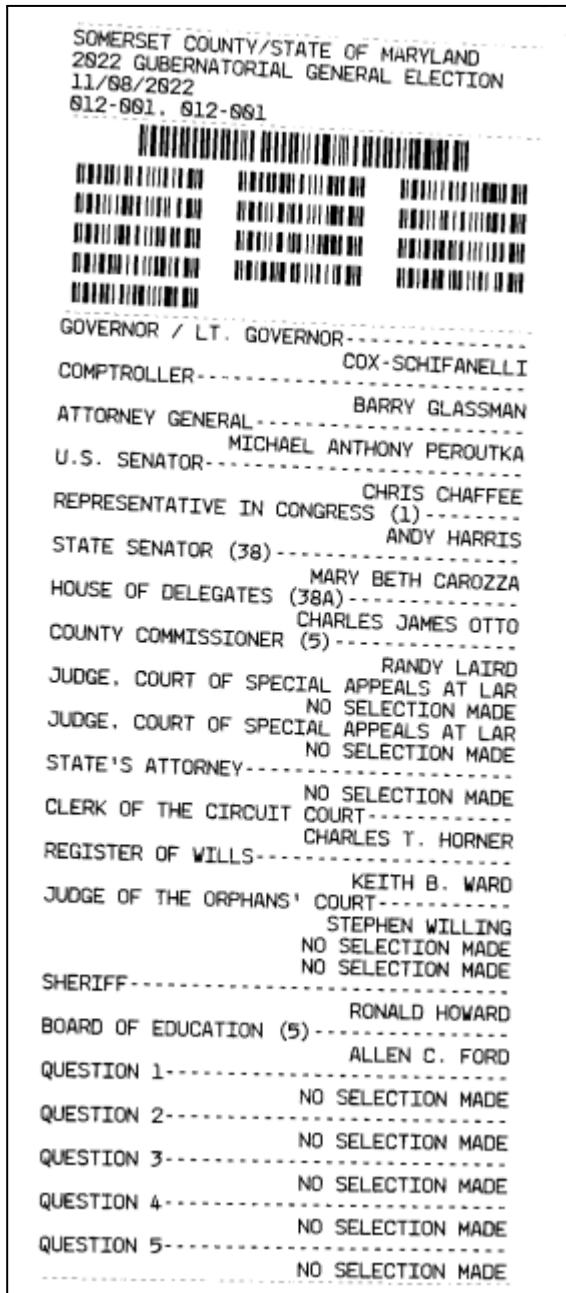   - 3 votes "Disagreed" (0.27% of margin)

24. **Unprocessed:** Sometimes, ballot images cannot be processed at all, usually due to corruption of the image or other factors.

    - **In Rockville City**, there was only one ballot that was considered unprocessed, but it was examined and found to have a hole in the ballot near the timing marks, making the system unsure of the style. An override was added to the job file to allow this ballot to be included with all other ballots. There were no other ballot images that were not fully processed.

    - **Somerset County:** There were two ballots that were distorted images and AuditEngine did not process these. For example, here is ballot

3212. The ballot scan was temporarily stalled and the same spot scanned over and over, making the image look like it is stretched.
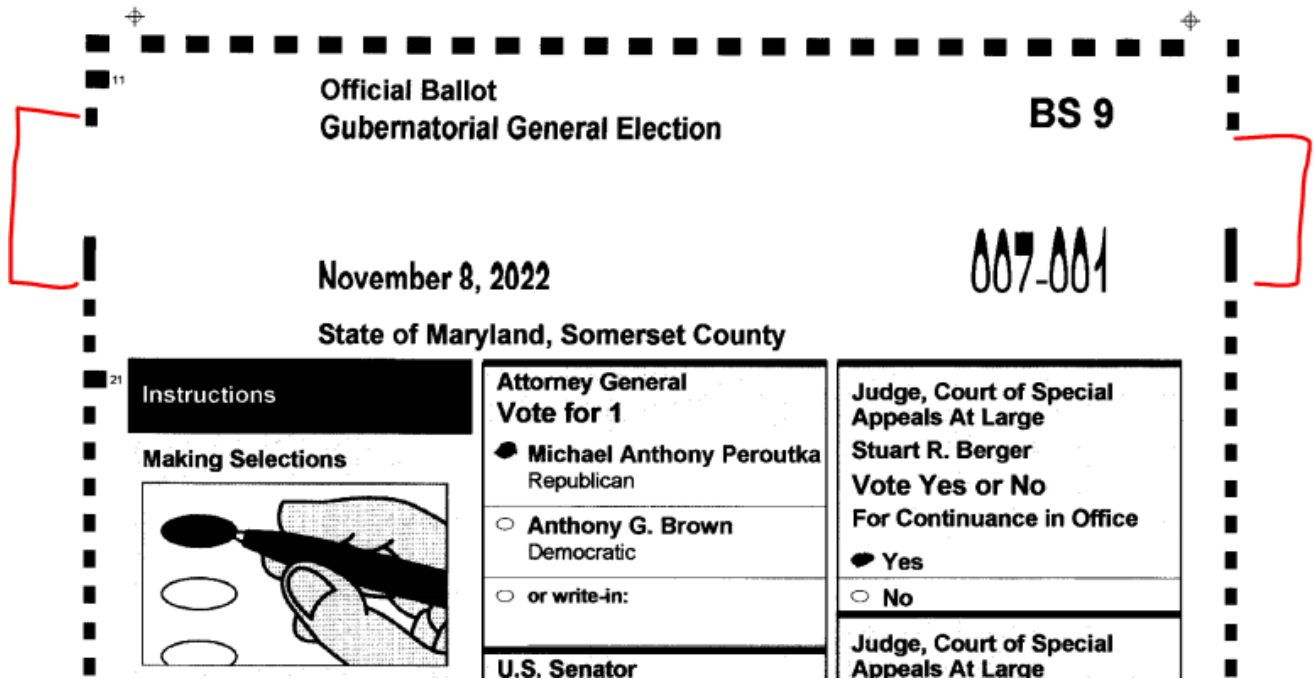
Also, we had two ballots with BMD text that was distorted too much to read. We believe we soon will have a superior method to process these.

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SOMERSET COUNTY/STATE OF MARYLAND
2022 GUBERNATORIAL GENERAL ELECTION
11/08/2022
012-001, 012-001
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GOVERNOR / LT. GOVERNOR---------------
                                    COX-SCHIFANELLI
COMPTROLLER-------------------------
                        BARRY GLASSMAN
ATTORNEY GENERAL--------------------
            MICHAEL ANTHONY PEROUTKA
U.S. SENATOR------------------------
                        CHRIS CHAFFEE
REPRESENTATIVE IN CONGRESS (1)--------
                            ANDY HARRIS
STATE SENATOR (38)------------------
                    MARY BETH CAROZZA
HOUSE OF DELEGATES (38A)-------------
                    CHARLES JAMES OTTO
COUNTY COMMISSIONER (5)--------------
                            RANDY LAIRD
JUDGE, COURT OF SPECIAL APPEALS AT LAR
                    NO SELECTION MADE
JUDGE, COURT OF SPECIAL APPEALS AT LAR
                    NO SELECTION MADE
STATE'S ATTORNEY--------------------
                    NO SELECTION MADE
CLERK OF THE CIRCUIT COURT-----------
                    CHARLES T. HORNER
REGISTER OF WILLS-------------------
                        KEITH B. WARD
JUDGE OF THE ORPHANS' COURT----------
                    STEPHEN WILLING
                    NO SELECTION MADE
                    NO SELECTION MADE
SHERIFF-----------------------------
                        RONALD HOWARD
BOARD OF EDUCATION (5)---------------
                        ALLEN C. FORD
QUESTION 1--------------------------
                    NO SELECTION MADE
QUESTION 2--------------------------
                    NO SELECTION MADE
QUESTION 3--------------------------
                    NO SELECTION MADE
QUESTION 4--------------------------
                    NO SELECTION MADE
QUESTION 5--------------------------
                    NO SELECTION MADE

Thus, the evaluation by AuditEngine of the ballot images is consistent with the CVR.

3. Final Report -- Master Report Index

For each audit, there is a "Final Report" which provides overall information, links to the most important reports for review by the public, candidates, campaigns and election officials, followed by links to reports useful for data analysts who wish to explore our proof of the result.

Rockville City 2023-11-07 Election Final Report. This contains links to all other generated reports.

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Rockvillecity_20231107/reports/Final_Report.html

Somerset County 2022-11-08 (using Cooperative Workflow) Election Final Report:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Somerset_20221108_cwf/reports/Final_Report.html

Also included on this report are links to the Ballot Viewer and AdjudiTally apps, which allow for viewing, tallying and adjudicating ballots.

4. Totals Report

Perhaps the simplest way to view the result of the audit is to view the differences at the contest level between the voting system results and the results by AuditEngine. Here is an example of one contest on this report:

Mayor

Parameter/Option	CVR	Diff	Audit
num_ballots	12,637	-1	12,636
tot_votes	12,247	1	12,248
writeins	51	0	51
overvotes	1	-1	0
undervotes	389	-1	388
margin	2,184	-3	2,181
margin_pct	17.83%	-0.020	17.81%
winners	Monique Ashton		Monique Ashton
Monique Ashton	7,190	-1	7,189
Mark Pierzchala	5,006	2	5,008

5. Discrepancy Report

The detailed discrepancy report as prepared for this election by AuditEngine is extensive and provides images of the ballots of concern. It is not intended nor recommended that this report is printed out on paper. Instead, it is best to review it in a browser so the hot links will operate and so that specific patterns can be searched for. Here, we will summarize the important points from this report. Use the link below the next paragraph to review the Rockville City report.

If there is any discrepancy between this narrative report and the machine produced report linked below, the machine produced report may have been slightly updated and should be considered the official audit result. Here is the link to the report.

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Rockvillecity_20231107/reports/Discrepancy_Report.html

5.1 Discrepancy Report -- AuditEngine "Gray Flags"

1. When using Cooperative Workflow, we do not have the CVR before AuditEngine creates an independent result. At this stage then, no comparison is possible. AuditEngine therefore uses "gray flags" to identify ballots that may need further human-eye review. To refine the results, we can take a look at the write-ins, overvotes, and contests flagged as "gray" based on the evaluation of AuditEngine alone. These are shown in the following pie chart, without reference to the CVRs.

AuditEngine_Flagged by contests (Total: 316)
2023 November Municipal, Rockville City, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-14 13:00:46

wi 219 (69.3)%
ov 65 (20.6)%
x_gry 18 (5.7)%
bmd_wi 7 (2.2)%
ae_uncategorized 7 (2.2)%
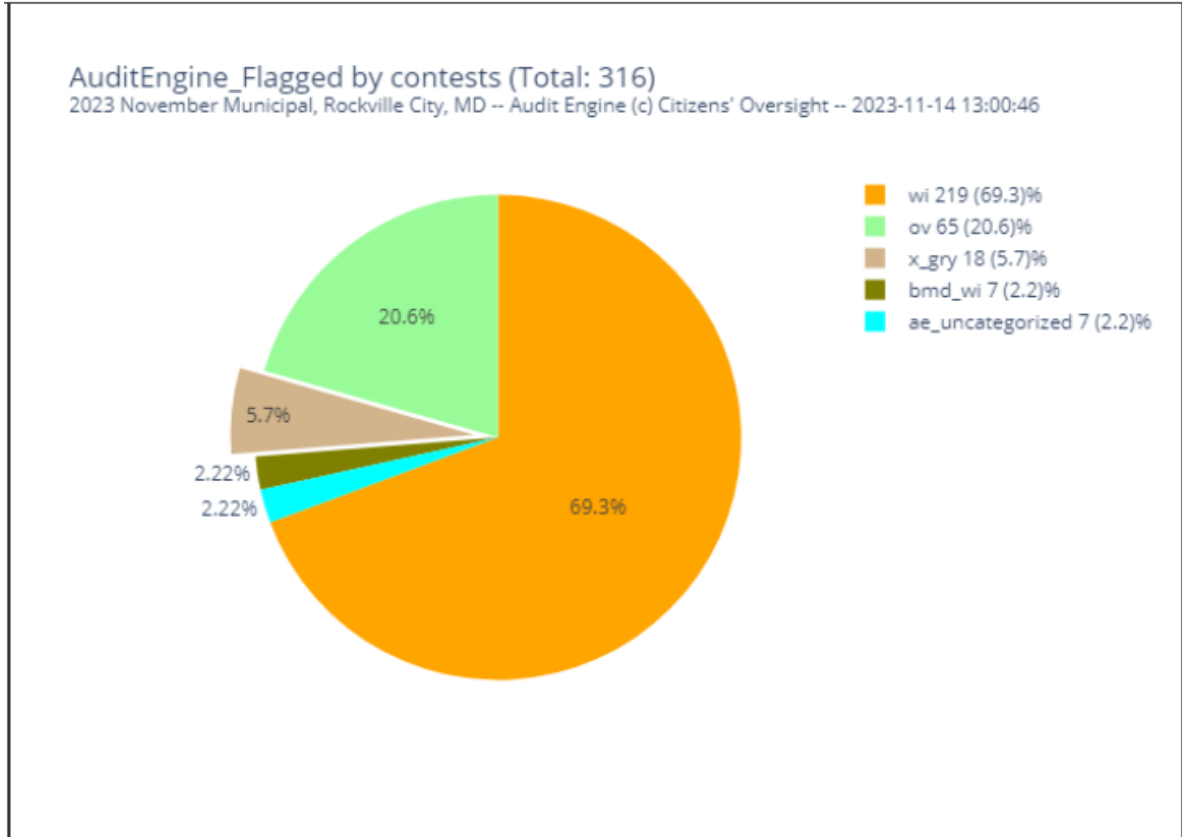
2. **Total Flagged Contests:** There were a total of 317 ballot-contests flagged for additional scrutiny, which is fewer than the margin in the closest contest, so from this feedback alone, it would be impossible to overturn the results based on review of the gray-flags alone.

5.2 Discrepancy Report -- Disagreements

Although there were 15 contests that were considered as "disagreed" between the voting system and the evaluation by AuditEngine, these are spread across all contests, and the closest contest (City Council) had a vote margin of 851 votes. Therefore, there is no chance that these disagreements could affect the outcome of any contest.

Disagreed_Groups by contests (Total: 15)
2023 November Municipal, Rockville City, MD -- Audit Engine (c) Citizens' Oversight -- 2023-11-14 13:01:00

x_ov 8 (53.3)%
x_uv 4 (26.7)%
uv_x 3 (20.0)%
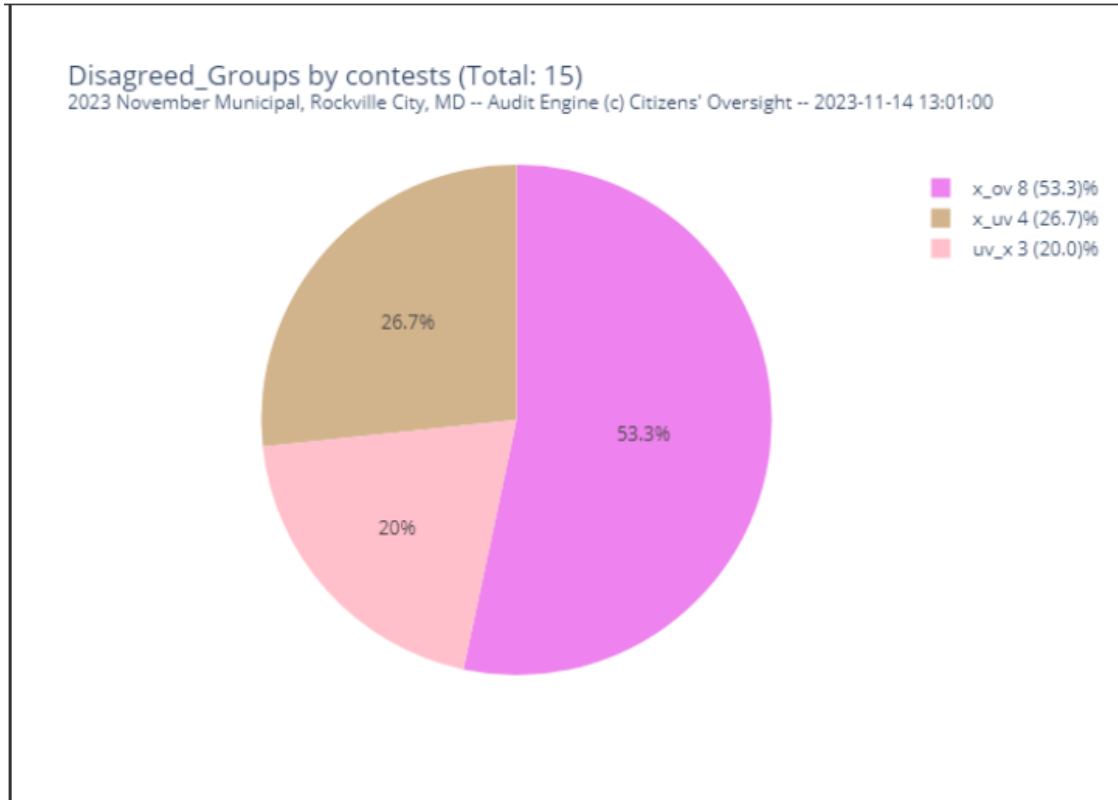
Nevertheless, these disagreed contests will be reviewed here for educational purposes, and also to diagnose any problems in either the voting system or in AuditEngine. As a matter of full disclosure, we did correct a number of issues in AuditEngine which were flagged in this process, but in these cases, we did not perform manual adjudication using the AdjudiTally app prior to this point to make any corrections. When corrections are made using the AdjudiTally app, it does not directly change any records, but simply provides corrections that are shown as a separate column in the comparison report.

We will consider these differences based on the contests they affected, below.

1. Mayor of Rockville City

The apparent winner of this contest is Monique Ashton with a margin of 2,181 votes per AuditEngine. There were two disagreed votes here:

1. **ballot_id: 2149.** The voting system did not detect a X just outside the oval, whereas AuditEngine evaluated it as a vote for Mark Pierzchala. Even though this is marked outside the bubble, marks in Maryland are evaluated based on the clear intent of the voter. Here, the X outside the oval is automatically accepted as a vote by AuditEngine, since there are no other marks in the contest. However, there is an interesting fact here: All other similar marks were colored in on the ballot, while this one was left with only a marginal mark.

2. **ballot_id: 6318**
   Here, there are two marks, and the voting system determined that this was an overvote. Admittedly, this one is close, and it is definitely

flagged for further review by AuditEngine.

Mayor Alcade	City Council Consejo de la Ciudad
Vote for 1 Vote por 1	**Vote for up to 6** Vote hasta por 6
● Monique Ashton	○ Danniel Belay
● Mark Pierzchala	● Kate Fulton
○ or write-in / o por escrito:	● Richard Gottfried
	○ Harold Hodges

In this case, AuditEngine determined that the voter intent was to identify Mark Pierzchala as the desired vote because it is not marked as a "scratch out". With this contest not being close it is not important to fully decide voter intent because it is certainly a difficult call.

There are a number of parameters that can be adjusted to control how AuditEngine will decide overvotes. If one mark is sufficiently smaller than the larger mark, then it can be considered a hesitation mark and the vote awarded to the larger mark. The difference in darkness detected can be set as a parameter.

Another condition commonly encountered but not in this audit, is when a voter scratches out the undesired mark with only one other mark being normal darkness. In that case, AuditEngine considers the larger mark as a scratch out and awards the vote to the smaller mark.

In either case, although the overvote is changed to a vote, a gray flag persists to allow for later review.

2. City Council

The city council contest was a vote-for 6 contest. The winners determined by AuditEngine matched the winners as described in the CVR provided by the voting system. The competitive seat is between the sixth-place candidate, Marissa Valeri,

and the 7th place candidate, Paul Scott. The vote margin between these two seats is 852 votes or 1.39% of all votes cast.

There were 4 contests considered "disagreed" and flagged for no other reason in the comparison, plus one that is a disagreed overvote, as follows:

1. **ballot_id: 2184**
   This ballot is one that we find quite fascinating. There are 7 marks on the ballot and normally, this would be considered an overvote, and AuditEngine did evaluate it that way. The voting system dropped the mark for Adam Van Grack. Admittedly, it is the lightest mark, but it is not light enough to be considered a hesitation mark, particularly when you compare with other evaluations by the voting system.

City Council
Consejo de la Ciudad

Vote for up to 6
Vote hasta por 6

- **Danniel Belay**

- Kate Fulton

- **Richard Gottfried**

- Harold Hodges

- Barry Jackson

- Ricky F. Mui

- David Myles

- Anita Neal Powell

- Paul Scott

- Izola (Zola) Shaw

- Marissa Valeri

- Adam Van Grack

2. **ballot_id: 2760**

   Here, we find a very tiny hesitation mark for Richard Gottfried and it was accepted as a vote. We believe this is definitely a hesitation mark. We note that this tiny mark was awarded a vote in this case, and it is far smaller than the one above.

   City Council
   Consejo de la Ciudad

   Vote for up to 6
   Vote hasta por 6

   ○ **Danniel Belay**

   ● **Kate Fulton**

   ○ **Richard Gottfried**

   ○ **Harold Hodges**

   ○ **Barry Jackson**

   ○ **Ricky F. Mui**

   ○ **David Myles**

   ○ **Anita Neal Powell**

   ● **Paul Scott**

   ● **Izola (Zola) Shaw**

   ○ **Marissa Valeri**

   ● **Adam Van Grack**

3. **ballot_id: 11050**

   In one case, AuditEngine definitely made the wrong call by accepting this "scratch out" as a vote while the Voting System did not. AuditEngine uses a slightly larger evaluation area than the oval to detect circles and X marks that don't go inside the oval, and in this case, the scratch-out got close to the oval without going into it. This is flagged as gray to prompt additional scrutiny.

   City Council
   Consejo de la Ciudad

   Vote for up to 6
   Vote hasta por 6

   ○ **Danniel Belay**

   ○ **Kate Fulton**

   ○ **Richard Gottfried**

   ○ **Harold Hodges**

   ○ **Barry Jackson**

   ○ **Ricky F. Mui**

   ○ **David Myles**

   ○ **Anita Neal Powell**

   ○ **Paul Scott**

   ○ **Izola (Zola) Shaw**

   ○ ~~**Marissa Valeri**~~

   ○ **Adam Van Grack**

4. ballot_id: 3221

This is a ballot we find to be fascinating because it appears to have five clear votes. Although there is "scribble" over each mark, the underlying mark is absolutely perfect. Particularly this mark for Adam Van Grack.

The strange thing is that the vote for Richard Gottfried is completely missed by the voting system. However, as we look more closely at the mark we can see that both the perfect oval and the scribble did not actually cover the oval enough for the voting system to accept it as a vote.

AuditEngine accepted the vote for Richard Gottfried and the voting system did not.

5. **ballot_id: 3615**

    Now we see a hesitation mark which is accepted as a vote, completely invalidating all votes in the contest. This is an example of when the policy of an overvote causing a contest to be invalidated results in many people not counting correctly, and all their votes are invalidated. But it is also likely the case that a number of people would rather not vote on the contest, and so they overvote to ensure that no one can add a vote later in the process.

City Council
Consejo de la Ciudad

Vote for up to 6
Vote hasta por 6

○ **Danniel Belay**

◉ **Kate Fulton**

○ **Richard Gottfried**

○ **Harold Hodges**

◉ **Barry Jackson**

○ **Ricky F. Mui**

◉ **David Myles**

○ **Anita Neal Powell**

◉ **Paul Scott**

◉ **Izola (Zola) Shaw**

◉ **Marissa Valeri**

◉ **Adam Van Grack**

6. **Ballot_id: 9442**

   On this ballot, and only on the back, the ovals were circled rather than being correctly filled in. It is curious that the front of the ballot has ovals that are correctly filled in. When this is detected, all votes should be further reviewed. We now detect marks that "mostly are outside the oval" and gray-flag them.

5.4 Discrepancy Report -- Contest Discrepancy Report

The most effective report is the Contest Discrepancy Report because the disagreements can be related to the margin of victory in a specific contest. The AuditEngine report provides details on the top 10 contests and any contests that are "close" or are the top 5 in terms of the most variants or disagreements. Also, any contest can be highlighted if it is not otherwise close and is of public interest.

This portion of the report is at this URL:
https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Rockvillecity_20231107/reports/Discrepancy_Report.html#contest-discrepancy-report

Here is the Contest Discrepancy Report table from that report.

Contest	Total	Agreed & NonVariant	Agreed Overvotes	Agreed Write-ins	No CVR	Gray Only	Disagreed	All Variants	Disagreed% of Margin	Variant% of Margin	Vote Margin	Margin%
Mayor	12,636	12,410	0	49	0	175	2	226	0.09%	10.35%	2,184	17.83%
City Council	12,636	12,147	29	162	0	286	5	489	0.59%	57.46%	851	1.39%
Question 1 - Voting Age	12,636	12,499	14	0	0	121	2	137	0.04%	2.71%	5,051	41.62%
Question 2 - Non-Citizen Voting	12,636	12,496	8	0	0	130	2	140	0.05%	3.78%	3,707	30.87%
Question 3 - Term Limits	12,636	12,517	5	0	0	112	2	119	0.03%	1.86%	6,401	53.69%
Question 4 - Representative Districts	12,636	12,521	8	0	0	106	1	115	0.08%	8.80%	1,307	11.52%
Total:	75,816	74,590	64	211	0	930	14	1,226	0.07%	6.29%	19,501	

1. For any particular contest, we can focus on the "Disagreed% of Margin" or the "Variant% of Margin". The margin of victory in votes for the contest is between the last-winning candidate and the first-losing candidate. This is not the "pairwise" margin[7], but the actual margin including all other candidates. For ease of reading, the closest 5 contests are highlighted in terms of the Disagreed% of Margin and Variant% of Margin, and also contests with margins of victory below 10% are highlighted. These contests are also detailed and can be accessed by the contest name link. Other contests can be added to the report as needed.

2. None of these contests were close enough to be a serious concern as there were no disagreements above 0.6% of the margin.

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[7] The pairwise margin considers only the two ballot options and not all the other options in that contest. So if there are three candidates, A, B, C with votes of 50,40,10, then the actual margin is 10% = 100 * (50 - 40)/100 but the pairwise margin is 100 * (50 - 40)/90 = 9%.

5.5 Discrepancy Report -- Precinct Report

1. The Precinct Report provides a breakdown of the ballots in each precinct. The values in this report are ballot counts, and are not specific to any particular contest. This report can sometimes highlight issues that may be specific to specific precincts, but in our opinion is not as valuable as the Contest Discrepancy Report. Nonetheless, we include it because some states have requirements for this report. This report highlights the highest 5 Disagreed% of Margin precincts.

2. When using Cooperative Workflow, and without the information in the CVR to use for precinct information, it is not always a simple matter to get the precinct from the ballot images alone. One way to do it is to have a 1:1 relationship between the style definition and precincts. Another way for ES&S to provide precinct identification is that the precinct information can be encoded in the ballot image path name when exporting.

Precinct	Style	Total	Agreed & NonVariant	Agreed Overvotes	Agreed Write-ins	Agreed Blank	No CVR	Gray Only	Disagreed	All Variants	Disagreed% of Total	Variant% of Total	Disagreed Examples
1	['1']	1,130	1,064	0	0	2	0	0	1	66	0.09%	5.84%	[10490]
2	['2']	2,450	2,310	0	0	3	0	0	1	140	0.04%	5.71%	[11701]
3	['3']	734	697	0	0	2	0	0	2	37	0.27%	5.04%	[25, 8538]
4	['4']	919	864	0	0	0	0	0	1	55	0.11%	5.98%	[6318]
5	['1', '5']	1,009	953	0	0	1	0	0	3	56	0.30%	5.55%	[11050, 10343, 3639]
6	['6']	866	820	0	0	1	0	0	0	46	0.00%	5.31%	
7	['2', '7']	1,556	1,456	0	0	4	0	0	0	100	0.00%	6.43%	
8	['8']	1,167	1,079	0	0	2	0	0	3	88	0.26%	7.54%	[2149, 4187, 3615]
9	['3', '9']	1,001	930	0	0	0	0	0	0	71	0.00%	7.09%	
10	['10']	1,673	1,584	0	0	5	0	0	3	89	0.18%	5.32%	[3221, 10847, 5882]
11	['4']	4	3	0	0	0	0	0	0	1	0.00%	25.00%	
13	['5']	5	5	0	0	0	0	0	0	0	0.00%	0.00%	
15	['6']	4	3	0	0	0	0	0	0	1	0.00%	25.00%	
17	['7']	28	25	0	0	0	0	0	0	3	0.00%	10.71%	
19	['8']	31	30	0	0	0	0	0	0	1	0.00%	3.23%	
21	['9']	14	14	0	0	0	0	0	0	0	0.00%	0.00%	
23	['10']	45	41	0	0	0	0	0	0	4	0.00%	8.89%	
Total:		12,636	11,878	0	0	20	0	0	14	758	0.11%	6.00%	

The precinct report table is shown here for Rockville City. Although all ballots are exactly the same, this district provided an additional group "District" that is normally in the place of the precinct designation in the archives, with the value

from 1 to 10. But in the BMD ballots, the top barcode can encode the precinct, and they used similar numbers for precincts 5, 7, and 9, plus the precincts from 11 to 23. It would take additional work to attempt to separate these in this job, but in general, it is usually not that useful to clarify the reporting within individual precincts unless we see extreme discrepancies in a given precinct, and that will be apparent even with imperfect categorization.

Please note that the figures in this table are by ballot, rather than by contest, and the "Disagree% of Total" is the number of cases among the ballots in the group rather than the margin of victory (in votes), since these cases are among all the contests in the precinct.

6. Findings

The following findings are outlined which are a result of the pilot audit.

1. **Cooperative Workflow was Successfully Added:**
   AuditEngine was reconfigured to support the Cooperative Workflow so that live election data can be processed with limited information in each phase. Mapping could be completed prior to the availability of ballot image data, and the preliminary independent results from AuditEngine can be completed prior to including the CVR data for the final comparison. Cooperative Workflow is required to meet the quick-turnaround requirements, and they also have the side benefit of detecting mapping and configuration errors prior to the election itself. Cooperative Workflow has several phases:
   a. Phase 1 (pre-election): deriving the mapping from the ballot style masters and other data. Check this mapping with redline proofs.
   b. Phase 2 (post-election without CVR): Using the mapping derived in Phase 1, and BMD information from the images for OCR, evaluate the votes on all ballots and produce an independent report.
   c. Phase 3 (post-election with CVR): Compare the result for each ballot with the official result for that ballot and produce the Discrepancy Report.

   This new workflow methodology, we believe, works well. With further cooperation with the districts providing data, the data provided could be improved to include better BMD information.

2. **Used LAT Data used for EIF data:**
   Phase 1 used the Logic and Accuracy Test (LAT) data as the source of the

exact contest and option names used in the CVR to build the "Election Information File" (EIF). The information about the exact contest names and options should be available from a <u>voting-system export</u>, if we can locate an existing export or report. This source of the data worked without any problem but there may be a better source for the data without needing to parse the LAT data and be reliant on that data format.

Getting this EIF correct and as early as possible in the process will streamline our processing. As it stands, we don't get the BMD data until later in the game and thus have the BMDIF file to allow these changes to be added without changing this file, and then causing data built earlier in the process to be flagged as needing to be rebuilt.

3. **BMD Info Can Be Improved**

   There is currently no source of information for the contest and option names used on BMD (ExpressVote) summary cards prior to getting the ballot image data in Phase 2. And, without the CVR (which is not yet available in Cooperative Workflow until Phase 3), it is difficult to process this data to locate all BMD option names, in the general case.

   In this pilot, the elections were simple enough to allow manual inspections to be used to determine the strings used on BMD ballots coupled with feedback after the ballots were processed.

   Recommendation: It will be beneficial to find a report from the Voting System that can provide the exact text used on the BMDs for each contest and each option in those contests. This has not been an issue with the current Ballot Image Audit vendor because they do not process BMD ballots at all.

   It would be helpful to us if we could work with technical staff in Maryland to locate a source for this data from the voting system so we can avoid manual review of BMD ballot images only after the live images are available. Here are some ideas for future review.

   > For ES&S, a function that may provide the desired information is called "Export Ballot Translations Script" explained in Chapter 18 of ElectionWare Vol2[8].

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[8] These documents are not available on the Internet but the licensees of ElectionWare should have them.

There is also described in Chapter 17 "Import Election Data", which allows structured text files to provide information for the election, including "Contests", "Contest Level Text", "Candidates", and "Candidate Level Text" which may be the perfect information to obtain the text used for contests and options in three different places: official names in the CVR, on hand-marked ballots, and on BMD ballots. Unfortunately, we don't see the corresponding "Export Election Data" function in the documentation we reviewed, but it makes sense that such a function may exist and allow the election definition information to be exported.

4. **Very Consistent Contest and Option Names**
   The election data processed for Somerset County and Rockville City used consistent contest and option names which made mapping the election using our automatic approach either nearly or fully automatic.

   We appreciated the standard conversions from longer to shorter contest names. The conversions from the official names were to slightly longer contest names on full-face ballots while BMDs generally used the shorter names. For example, the official name might be "U.S. Representative (38A)" and the longer version is "U.S. Representative District 38A".

   Maintaining consistency of contest names and option names across the two formats of paper and BMD ballots is extremely important both to expedite configuration of AuditEngine, but also to avoid configuration errors. We have standardized our recommendations in Appendix 3.

5. **Automated Mapping Used Successfully**
   Our automated mapping solution uses a simple spreadsheet to provide the various versions of these names if they differ, combined with parsing the Ballot Style Master PDF files to create the target maps. Then later, when the BMD ballots can be viewed in the ballot images, a separate spreadsheet file is used so the initial files need not be rebuilt with the new data. As mentioned, if the Election Data were exported, then this would streamline our process.

6. **The Logic and Accuracy Test (LAT) is insufficient**
   This test is not only insufficient for use by the election staff, but it was not used as a check on our mapping because it is insufficient in several ways:

a. The LAT cannot discriminate between votes for different options
b. There was no ballot-level CVR provided, only totals for each style. This was provided in the form of a spreadsheet, which was actually the source of the data for creating the test files, rather than the result of processing them. (We don't mind getting this but it does not demonstrate that the test was used at all.)
c. There were no images provided of any LAT ballots scanned by the voting system.
d. BMD ballots were apparently not tested at all.
e. We have no evidence that the LAT was used at all, other than being provided the test data.

We believe it is critical that the LAT be improved in Maryland by making sure that no options have the same number of votes.

7. **BMD LAT Test Images Could be Used for BMD string mapping**
An earlier finding is that we have no source of data for BMD string mapping prior to getting the live images in the election. Yet, if BMDs were tested in the LAT, and if images were created of the BMD ballot summary cards, then those images could be used for configuration. In fact, those images would be very good for the purpose because the LAT should include at least one ballot with each option on the ballot. Unfortunately, there were no test images, other than the source PDF images from the LAT.

8. **Redundant Images Provided**
In the Somerset image data exported, we noted that the ballot images were repeated several times in the groups to allow "snapshots" of the election: Early Voting (EV), Election Day (ED), Mail-In Ballots, set 1 (MIB1), Mail-In Ballots, set 2 (MIB2), and Provisional Ballots (Prov). It is understandable that providing these in groups is necessary with the current vendor of Ballot Image Audits, because they do not include BMD ballots in their comparison. Therefore, comparing the totals for individual groups is necessary as a check on the total number of ballots without being able to process BMD ballots.

In our process, we don't actually need these snapshots to provide our results because we process all BMD ballots. Yet, we don't mind including these groups in our report so they can be compared with ES&S aggregated totals reports if that is something Maryland otherwise needs. We recommend that instead of uploading all the images with 70% redundancy, that a list of all ballot sheets (ballot_ids) in each snapshot is created and placed into a file,

and then we can place each ballot sheet into the appropriate group by processing those files rather than all the images.

9. **Precinct Information on Images would be helpful.**

   When using Cooperative Workflow, it is our desire to create comprehensive reports, including contest results by precinct. This is not a concern in Rockville City because there were 10 "Districts" and these can be regarded as precincts, and the districts are also described by the style. However, in the general case, there is not necessarily a separate style for every precinct. If there are multiple precincts in a style, then it is desirable to include a small DataMatrix barcode on the ballot sheet so the precinct can be easily read by machine without error. Such a DataMatrix barcode is commonly used for mail-in ballot operations to allow the precinct to be read on the ballot through a small hole in the envelope, to ensure that the correct precinct is being supplied to the voter. We recommend the datamatrix 2-D barcode because it is small and yet has exceptional error detection and correction. We find that using OCR to "read" the written text, like "Precinct 53" has too high of an error rate, because there is no redundancy in the numbers.

10. **"or Write-in" is a good idea**
    We find that in many elections, voters tend to get confused about what "write-in" means, and some will redundantly write-in names of listed candidates. Although the number of ballots we processed was quite small, it seems that the use of "or Write-in:" instead of just "Write-in:" (i.e. adding the word 'or'), is a good idea and it seems to reduce the number of redundantly written-in listed candidate names.

7. Conclusion

The audits in this pilot project demonstrate 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. Yet, ballot image audits, particularly when using *Cooperative Workflow*, will catch many issues early in the process, and many of these checks do not rely on the validity of ballot images at all. When compared with Risk Limiting Audits, which limit the additional risk of sampling ballots, ballot image audits have 0% sampling risk, and will detect mapping, configuration, and evaluation errors.

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

For further information, please visit https://auditengine.org. We appreciate funding by the public for these independent audits.

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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.

How to Comment

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

APPENDIX 1 -- Links to detailed reports

Auditing Elections Using Ballot Images and AuditEngine -- General Background:
📄 Auditing Elections Using Ballot Images and AuditEngine -- General Backgrou...

This Narrative Report:

📄 MD Pilot Audit 20231107 Narrative Report

Rockville City 2023-11-07 Election Final Report (using Cooperative Workflow) This contains links to all other generated reports.

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Rockvillecity_20231107/reports/Final_Report.html

Somerset County 2022-11-08 (using Cooperative Workflow) Election Final Report:

https://us-east-1-audit-engine-jobs.s3.amazonaws.com/US/MD/US_MD_Somerset_20221108_cwf/reports/Final_Report.html

APPENDIX 2 - Stage Reports

The following table summarizes the report available as a result of each stage.

Stage / Report	Report Description
precheck_phase1 precheck_phase1 Report	The precheck report for Phase 1 simply describes the settings in the JOB settings file regarding files used in this phase, and whether they can be properly found. The files available here will be those that are used for pre-election configuration.

parse_eif Election Information File (EIF) Parse Report	The Election Information File (EIF) contains the full description of the election in terms of what contests are included and what options are listed for each contest. The EIF file is usually generated from the CVR, if it is available (Public Oversight Workflow) or from other sources, such as the *Logic and Accuracy Test* results, in Cooperative Workflow. The EIF file can also be edited by hand, and commonly the number of write-ins need to be modified.
parse_style_masters Style_Masters_Report	After parsing the Style Masters, this report provides the contests in each style (the style_to_contests table), and whether the strings as specified by the EIF were captured in the parsing process for both Contests and Options.
create_option_proofs_report Option Proofs Report	This report is to allow human-eye review of each option on all styles. We find that human-perception is particularly adept at finding any deviations among many that are the same.
create_styles_report Style Redline Proofs Report	This report is also called the "Redline Proofs report" and it provides an image of every style with the oval outlined with a rectangle and then marked with the name of the contest and options of that contest. We have found this report is relatively hard for human perception to review, and thus we have also the Option Proofs Report, which is much easier to check that each option is correctly mapped. However, it may be the case that an oval is left out, and it would not be shown at all on the option proofs report. Therefore, we still need this report, which should be reviewed only to verify that all ovals have been redlined.

precheck_phase2 precheck_phase2 Report	The precheck report for Phase 2 simply describes the settings in the JOB settings file regarding files used in this phase, and whether they can be properly found. The files available here will include the ballot images, which are available immediately after the election.
gen_biabif Ballot Image Archive Metadata Report	This report details information about the ballot image archives provided by the election district in terms of the metadata regarding each image file and its size, as well as the number of images in each file, repeated image files, etc.
gen_fullbif_delegation_report gen_fullbif Delegation Report	This is an internal report that provides the total number of delegations, their run time, and estimated cost for this stage.
imagematch Image_Match_Report	This report is the result of a complete examination of all ballot images to create a cryptographic hash of each image file, to make it easy to locate duplicate image files. There will be a hash value for each side of each sheet, but sometimes no "back" image is provided, so these may not be the same. When repeated images are detected, the first images detected are kept and all repeats of those are "skipped". If repeated images are detected, then it could have been caused by uploading results from the same machine multiple times.

create_nocvr_bif_report nocvr_bif: Combined Metadata Report	This report is a reconciliation of all metadata captured from ballot image archives combined with what we learned from an initial review of the images. This report includes a metadata summary, sheet count summary, cardcode analysis, rare styles report hexstyle to style_num analysis, and ballot counts by precinct, batch, and tabulator. Also reports on unreadable ballots and provides the Ballot Image Archive Metadata Report contents at the end.
gen_extractvote_delegation_report extractvote Delegation Report	This is an internal report that provides the total number of delegations, their run time, and estimated cost for this stage.
gen_source_audit_report source_Totals_Report	This report provides a review of each contest in detail based on the ballot images in the 'source' archives. If the CVR is available when this report is created, then the totals from the CVR will be included with the difference provided.
auditvotes_to_contest_results_by_precinct Audit Totals Report by Contest Detailed by precinct	This report provides, for each contest, a table with one line per precinct, and in that line the number of: Ballots, Votes, Write-ins, Overvotes, Undervotes and then the votes for each option or candidate. This report is generated by examining ballot images and does not include any CVR data.
auditvotes_to_contest_results_by_group Audit Totals Report by Contest Detailed by group	This report provides, for each contest, a table with one line per precinct, and in that line the number of: Ballots, Votes, Write-ins, Overvotes, Undervotes and then the votes for each option or candidate. This report is generated by examining ballot images and does not include any CVR data.

import_adjudications_audit_variants import_adjudications_audit_variants Report	This report is available if adjudications have been imported regarding the audit system results.
gen_audit_variant_report audit_variants_Discrepancy Report	This report reflects the evaluation of the election by AuditEngine including reports of variants detected, such as write-ins, overvotes, and gray-flags, without the reference to the CVR.
precheck_phase3 precheck_phase3 Report	The precheck report for Phase 3 simply describes the settings in the JOB settings file regarding files used in this phase, and whether they can be properly found. The files available for this stage include the CVR, the Cast Vote Records files.
preparse_cvr CVR Parsed Report	This report describes the CVR files that have been parsed, showing the number of records in each file.
create_bif_report bif: Combined Metadata Report	This report is similar to the "nocvr_bif: Combined Metadata Report" but now the CVR information has been combined and correlated.
cvrvotes_to_contest_results_by_precinct CVR Totals Report by Contest Detailed by precinct	This report provides, for each contest, a table with one line per precinct, and in that line the number of: Ballots, Votes, Write-ins, Overvotes, Undervotes and then the votes for each option or candidate. This report is generated by examining the CVR only.
cvrvotes_to_contest_results_by_group CVR Totals Report by Contest Detailed by group	This report provides, for each contest, a table with one line per precinct, and in that line the number of: Ballots, Votes, Write-ins, Overvotes, Undervotes and then the votes for each option or candidate. This report is generated by examining the CVR only.

import_adjudications_cmpcvr import_adjudications_cmpcvr Report	This report is available if adjudications have been imported after the comparison process. Once data has been imported, an adjudicated column will appear which corrects the Audit system results.
gen_cmpcvr_delegation_report cmpcvr Delegation Report	This is an internal report that provides the total number of delegations, their run time, and estimated cost for this stage.
gen_cmpcvr_report Discrepancy Report	This report provides details of disagreements between the voting system and the auditing result, as well as variants, such as write-ins, overvotes, and ballots which are 'gray-flagged' by AuditEngine for potential further review. This version of this report includes comparisons with the CVR, any manual results, and any adjudications.
gen_final_report Final Consolidated Report	This report provides a list of all reports available in the Audit.
Pipeline Report Pipeline Report	This report is updated as the processing pipeline is run, and provides the versions of all input files and outputs from each stage.

APPENDIX 3 -- TECHNICAL BRIEF ON ELECTION DESIGN
AVOID CONFIGURATION ERRORS AND ENABLE IMAGE AUDITS

To expedite configuration of AuditEngine for ballot image audits, improve voter verifiability, and to avoid configuration errors, please follow these recommendations. These can be incorporated immediately in any voting systems to avoid human errors during configuration, make it easier to verify votes, and enable ballot image auditing.

1. **Naming Consistency.** Be consistent as much as possible in names, i.e. official contest and option names. Be consistent among cast-vote record (CVR), hand-marked ballot, and ballot marking device (BMD) representations, for contest names and option names. Use consistent names in state-wide contests among all counties.

2. **Concise.** Use shorter contest names and avoid long names, like "United States House of Representatives in the 119th Congress, District 38 in the state of Pennsylvania." Instead use: "**US House, PA-38**".

3. **Consistent Conversions are Okay.** If there are any differences between contest names in different formats, use as simple substitutions, such as "**(38A)**" becomes "**District 38A**", and try to be consistent among all contests.

4. **Avoid duplicate contest names.** <u>All contest names should be unique county- and state-wide.</u> Instead of "Mayor", use "Mayor of This Town" or "This Town Mayor". Same for Treasurer, Town Council, etc. For court seats, put the judge's name in the contest name.

5. **Do not use the description to establish contest uniqueness.** For example if the contest is for a position in Superior Court, use the contest name **"Superior Court - John Doe"** and do not rely on the description ("Should John Doe be retained as a Superior Court Judge").

   For long court names, use the description to describe the court. The contest and option name should describe the name of the judge. For example, instead of the non-unique contest name: "Judge, Court of Special Appeals At Large" which may be truncated by the BMD printer to read "JUDGE, COURT OF SPECIAL APPEALS AT LA", use **"Judge, John Doe"** as the contest name

and **"Yes John Doe"** and **"No John Doe"** as the option names. In the description place all the rest, like **"Should John Doe be retained as Judge, Court of Special Appeals At Large?"**

6. **Simple Referendum Contest Names.** Instead of using the entire official title of a referendum (some which have dozens of words), use a short contest name like "**Question 1**" or "**Amendment B**", "**Proposition 12**" etc. followed by the official title and text as needed.

7. **Avoid simple YES/NO options.** Instead, make them unique from contest to contest. If the measure is to approve John Doe, then use "**Yes John Doe**" and "**No John Doe**". If it is for Question 5, then use "**Yes Question 5**". Essentially, it should not be possible to mix up YES and NO between contests *when reading only the option.*

Using these rules of consistency and clarity can improve the ability of voters to verify the ballot, will enable improved ballot image audits with minimal configuration overhead, and will reduce the likelihood of mis-configuration such as that which occurred in Northampton County, PA in the 2023 Election[9].

Related references:
https://civicdesign.org/wp-content/uploads/2015/05/Legibility-of-printed-ballots-CCD-draft-2021-08-30.pdf -- "Legibility of paper ballots: What makes a printed summary-style ballot easy to verify?" -- NIST Voting Project, August 30, 2021

https://ballotpedia.org/Ballot_measure_readability_scores,_2023 -- "Ballot measure readability scores, 2023" Ballotpedia's readability report analyzes what level of education voters would need to understand the ballot titles and summaries of statewide ballot measures using Flesch Reading Ease (FRE) and Flesch-Kincaid Grade Level (FKGL).

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[9]

https://www.lehighvalleynews.com/elections/election-2023-widespread-voting-machine-problems-reported-in-northampton-county